Handoff between heterogeneous networks based on MADM methods

G.A.Preethi, Dr. C. Chandrasekar, N.Priya

Abstract— Mobile and wireless networks play a vital role in our current trend. Networks have their own frequency levels to provide signals for communication between their mobile nodes. Each and every network have their own coverage area which is called a cell. When a node moves from one cell to another cell within the same network, a handoff occurs. If a node moves out of its own network, and attempt to connect to another network there comes vertical handoff. The handoff should be in a seamless manner. For handoff decision making we use Multiple Attribute Decision Making(MADM) method to select the best network. Selection will be based on the criteria of the given networks. In this paper we have used three different MADM methods such as Technique for Order Preference by Similarity to Ideal Solution(TOPSIS), Elimination and Choice translating Reality(ELECTRE) and Grey Relational Analysis(GRA) for handoff decision. Wifi, Wimax and UMTS are the networks applied for handoff selection. Different parameters such as Bandwidth, Delay and Cost of the network has been used for analyzation.

Index Terms— ELECTRE, GRA, handoff, TOPSIS, Concordance, Discordance and Grade.

1 Introduction

A Wireless mobile is not only used for communication, also used for data transfer, video conferencing, net-surfing etc,. For all these utility, high bandwidth and rapid transfer of data is needed. In case of mobility of a wireless device, signal reception will be a challenge in dense areas. In this juncture it is recommended to afford different networks. Each network will have a range of coverage. When a wireless node moves beyond its cell-limitation, it should change over to another base station which belongs to different network. Since its old network no longer supports it. This is termed as heterogeneous-handoff. In the event of Horizontal handoff, which involves the same network, Received signal strength measure is the only significant thing to consider. For the heterogeneity , we need to analyse different parameters such as bandwidth, delay, Signal to Noise ratio etc,. We should also consider the User preferences such as wide coverage, low cost, security etc,. When a user using a low-cost network is handed over to another high-cost network, then it will be an issue. So we have to analyse different types of issues while considering heterogeneous network. In [4] we have compared two MADM methods such as TOPSIS and AHP for handoff decision. In this paper we have related ELECTRE and GRA methods with TOPSIS and also extended our work for efficiency analyzation and measurements of bandwidth, end-to-end delay for the networks.

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This paper consists of Section II Related work, III discusses about MADM Methods IV is the Efficiency analyzation, V Simulation output and Discusssion. Finally Section VI concludes the work.

2 Related Work

Faouzi zarai et al [3] formulated a new architecture for handoff decision making which considers the resource utilization and the user preference for the network. Hui zeng et al [5] approach was based on integrated framework through multi-layer. The proposed algorithm provides a holistic handoff solution to the ad-hoc networks. Hyun-ho choi et al [6] presented scheme which requires a pre-registration and pre-authentication of networks before handoff. It also used packet buffering procedure for preventing the packet loss. Lahby Mohammed et al [7] gave a different approach by combining the ANP and TOPSIS methods. Their approach also given by considering and eliminating the differentiated weights of criterions and history attributes for handoff. Nirmala Shenoy [8] presented a framework for seamless roaming which overlays network comprising of Inter-System Interface Control Units (IICU) to support inter-network communication and control for Location Management. It optimizes the call delays, traffic and other QOS parameters. Y.Wu et al [10] experimented a congestion aware vertical handoff which reduced the packet loss and delay.

3. Multiple Attribute Decision Making (MADM)

The MADM method is based on “GRA”, “ELECTRE” and “TOPSIS” however we apply it in a distributed manner. Thus, we place the computing processing in the visited networks rather than on the mobile terminal. MADM allows the mobile terminal to choose the "best" network towards which it will be connected.

The MADM consists of the following steps:

Here,

- Candidate networks are A1, A2, and A3
- Criteria are X1, X2, and X3
- Calculates Voice Application

Simulation Parameters

In this section illustrating the usage of the selected methods and the results are compared,

TABLE 1: MEASURES OF ALTERNATIVES BASED ON CRITERIA.

Networks		Bandwidth	Delay	Cost
		X1	X2	X3
WIFI	A1	20	60	10
WIMAX	A2	30	62	20
UMTS	A3	15	50	8

User preference for Voice application is also converted to crisp numbers and normalized so that is equal to 1. The normalized preference, i.e. the weighting factors for the voice Wv application is:

$$W_v = \begin{bmatrix} 0.4 & 0.3 & 0.3 \end{bmatrix}$$

3.1 TOPSIS METHOD

In this proposed method the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is taken and it is analysed. This method considers three types of attributes,

- Qualitative benefit attributes/ criteria
- Quantitative benefit attributes
- Cost attributes

The basic principle of the TOPSIS is that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution. TOPSIS[4] method is used to select the network that satisfies the given criteria after performing six sequential steps listed below. The network with maximum value from the rank order is the one that is close to the positive ideal solution and far away from the negative solution. The criteria for selecting the network are maximum bandwidth, handoff signaling delay, battery and minimum cost.

Input for TOPSIS

Step 1:

Construction of the decision matrix: the decision matrix is expressed as

$$D = \begin{bmatrix} d_{11} & .. & d_{1m} \\ .. & .. & .. \\ d_{n1} & .. & d_{nm} \end{bmatrix}$$

Where d_{ij} is the rating of the alternative A_i with respect to the criterion C_i

Step 2:

Construct the normalized decision matrix: each element r_{ij} is obtained by the Euclidean normalization

$$r_{ij} = \frac{d_{ij}}{\sqrt{\sum_{i=1}^{m} d_{ij}^2}} \qquad (1)$$

$$r_{ij} = \begin{pmatrix} 0.512 & 0.602 & 0.421 \\ 0.767 & 0.622 & 0.842 \\ 0.384 & 0.502 & 0.337 \end{pmatrix}$$

Step 3:

Construct the weighted normalized decision matrix

- Assume a set of weights for each criteria w_j for j=1….n
- Multiply each column of the normalized decision matrix by its associate weight
- The weighted normalized decision matrix v_{ij} is computed as

$$v_{ij} = w_j * r_{ij}$$

$$v_{ij} = \begin{pmatrix} 0.205 & 0.181 & 0.126 \\ 0.307 & 0.187 & 0.253 \\ 0.154 & 0.151 & 0.101 \end{pmatrix}$$

Step 4:

Determine the positive ideal solution and negative ideal solution

- Positive ideal solution

$$A^* = \{v_1^* ... v_n^*\} = \{(\max_i v_{ij} \mid j \in J), (\min_i v_{ij} \mid j \in J^{'})\}$$
$$i = 1..3, \quad j = 1..3 \qquad (2)$$

- Negative deal solution

$$A' = \{v_1'...v_n'\} = \{(\min_i v_{ij} \mid j \in J),$$
$$(\max_i v_{ij} \mid j \in J')\}$$
$$i = 1..3, \quad j = 1..3 \qquad (3)$$
$$A^* = [0.307 \quad 0.187 \quad 0.253]$$
$$A' = [0.154 \quad 0.151 \quad 0.101]$$

Step 5:

Calculate the similarity distance measures for each alternative.

- Similarity distance from the positive ideal alternative is :

$$S_i^* = \sqrt{\sum_{i=1}^{m} (v_1^* - v_{ij})^2} \quad j = 1..m \qquad (4)$$

- Similarity distance from the negative ideal alternative is :

$$S_i' = \sqrt{\sum_{i=1}^{m} (v_{ij} - v_i')^2} \quad j = 1..m \qquad (5)$$

$$S_i^* = [0.163 \quad 0 \quad 0.219]$$

$$S_i' = [0.064 \quad 0.219 \quad 0.011]$$

Step 6:

- Ranking : Calculate the relative closeness to the ideal solution $C_i^* = \frac{S_j'}{S_j^* + S_j'}$. For the voice application,

$$C_i^* = [0.281 \quad 0.589 \quad 0.047]$$

3.2 ELECTRE METHOD

To rank a set of alternatives, the ELECTRE method as outranking relation theory was used to analyze the data of a decision matrix. The Elimination and Choice Translating Reality (ELECTRE) method was the most extensively used outranking methods reflecting the decision maker's preferences in many fields. The ELECTRE I approach was then developed by a number of variants. We have ELECTRE II, III, V and many types. ELECTRE method reflects the dominance of relations among alternatives by outranking relations[2].

Input for ELECTRE

Step 1: Construction of the decision matrix: the decision matrix is expressed as

$$D = \begin{bmatrix} d_{11} & .. & d_{1m} \\ .. & .. & .. \\ d_{n1} & .. & d_{nm} \end{bmatrix}$$

Step 2: Construct the normalized decision matrix: each element r_{ii} is obtained by the min, max Method normalization

- For bandwidth attribute, the normalized value of r_{ii} is computed as:

$$r_{ij} = \frac{d_{ij}}{d_j^{\max}} \qquad (6)$$

- For delay and cost attribute, the normalized value of r_{ij} is computed as:

$$r_{ij} = \frac{d_j^{\min}}{d_{ij}} \qquad (7)$$

$$r_{ij} = \begin{pmatrix} 0.666 & 0.833 & 0.800 \\ 1 & 0.806 & 0.400 \\ 0.500 & 1 & 1 \end{pmatrix}$$

Step 3: Construct the weighted normalized decision matrix

- Assume a set of weights for each criteria w_j for j=1....n
- Multiply each column of the normalized decision matrix by its associate weight
- The weighted normalized decision matrix v_{ij} is computed as

$$v_{ij} = w_j * r_{ij}$$

$$v_{ij} = \begin{pmatrix} 0.266 & 0.249 & 0.240 \\ 0.400 & 0.242 & 0.120 \\ 0.200 & 0.300 & 0.300 \end{pmatrix}$$

Step 4: To find the concordance and discordance interval sets , Let M= {a,b,c,….} denote a finite set of alternatives, in the following formulation we divide the attribute sets into two different sets of concordance interval set C_{pq} and discordance interval set D_{pq}.

$$C_{pq} = \{j \mid x_{pj} \geq x_{qj}\}$$
$$D_{pq} = \{j \mid x_{pj} \geq x_{qj}\}$$

Step 5: Calculation of the concordance matrix

$$C_{pq} = \sum\nolimits_{j \in C_{pq}} W_j$$

The concordance matrix can be framed as

$$C = \begin{pmatrix} - & \dots & c(1,m) \\ \dots & \dots & \dots \\ c(m,1) & \dots & \dots \end{pmatrix}$$

$$C = \begin{pmatrix} - & 0 & 0.4 \\ 0.7 & - & 0 \\ 0.3 & 0.6 & - \end{pmatrix}$$

Step 6: Determine the concordance index matrix

$$\bar{C} = \sum\nolimits_{p=1}^{m} \sum\nolimits_{q=1}^{m} C(pq) / m(m-1) \quad (8)$$

$$\bar{C} = 0.333$$

Here $\bar{C}$ is the critical value, which can be determined by average dominance index. Thus, a Boolean matrix (E) is given by:

$$\begin{cases} e(p,q) = 1, C(p,q)x \geq \bar{C} \\ e(p,q) = 0, C(p,q) \leq \bar{C} \end{cases} \quad (9)$$

$$E = \begin{pmatrix} - & 0 & 1 \\ 1 & - & 0 \\ 1 & 1 & - \end{pmatrix}$$

Step 7: Calculation of the discordance matrix.

$$d(p,q) = \frac{\max[v_{pj} - v_{qj}]_{j \in D_{pq}}}{\max[|v_{pj} - v_{qj}|]_{j \in D_{pq}}} \quad (10)$$

$$D = \begin{pmatrix} \cdots & \cdots & d(1,m) \\ \vdots & \ddots & \vdots \\ d(m,1) & \cdots & \cdots \end{pmatrix}$$

$$D = \begin{pmatrix} - & 0.896 & 0.85 \\ 1 & - & 1 \\ 0.775 & 1 & - \end{pmatrix}$$

Step 8: Determine the discordance index matrix

$$\bar{d} = \sum\nolimits_{p=1}^{m} \sum\nolimits_{q=1}^{m} C(pq) / m(m-1) \quad (11)$$

$$\bar{d} = 0.919$$

Here $\bar{d}$ is the critical value, which can be determined byaverage dominance index. Thus, a Boolean matrix (F) is given by:

$$F = \begin{pmatrix} - & 1 & 1 \\ 0 & - & 0 \\ 1 & 0 & - \end{pmatrix}$$

Step 9: Calculate the net superior and inferior value Let C_a and D_a be the net superior and net inferior value respectively. C_a sums together the number of competitive superiority for all alternatives, and the more and bigger, the better. The C_a is given by:

$$C_a = \sum\nolimits_{b=1}^{n} C(p,q) - \sum\nolimits_{b=1}^{n} C(q,p) \quad (12)$$

$$C_1 = 0.4 - 1 = -0.6$$

$$C_2 = 0.7 - 0.6 = 0.1$$

$$C_3 = 0.9 - 0.4 = 0.5$$

On the contrary, d_a is used to determine the number of inferiority ranking the alternatives:

$$d_a = \sum\nolimits_{b=1}^{n} d(p,q) - \sum\nolimits_{b=1}^{n} d(q,p) \quad (13)$$

$$d_1 = -0.027$$

$$d_2 = 0.104$$

$$d_3 = -0.077$$

Smaller is better. This is the biggest reason that smaller net inferior value gets better dominant than larger net inferior value by sequence order.

3.3 Grey Relational Analysis

The main procedure of GRA[9] is firstly translating the performance of all alternatives into a comparability sequence. This step is called grey relational generating. According to these sequences, a reference sequence (ideal target sequence) is defined. Then, the grey relational coefficient between all comparability sequences and the reference sequence is calculated. Finally, base on these grey relational coefficients, the grey relational grade between the reference sequence and every comparability sequences is calculated. If a comparability sequence translated from an alternative has the highest grey relational grade between the reference sequence and itself, that alternative will be the best choice. The procedures of grey relational analysis are shown in Fig 1.

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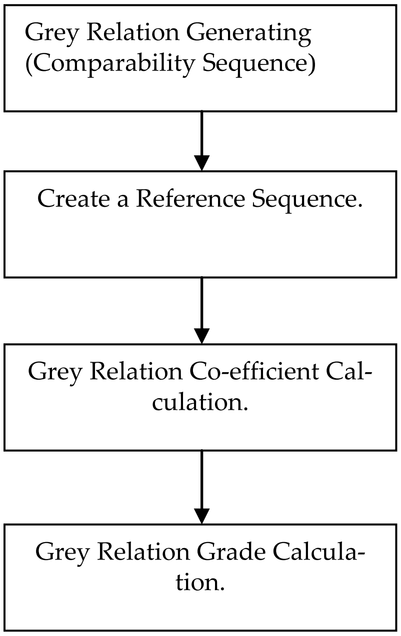

Fig 1 : Procedure of Grey Relational Analysis.

3.3.1. Grey relational generating

When the units in which performance is measured are different for different attributes, the influence of some attributes may be neglected. This may also happen if some performance attributes have a very large range. In addition, if the goals and directions of these attributes are different, it will cause incorrect results in the analysis [9]. Therefore, processing all performance values for every alternative into a comparability sequence, in a process analogous to normalization, is necessary. This processing is called grey relational generating in GRA. For a MADM problem, if there are m alternatives and n attributes, the i th alternative can be expressed as $Y_i = (y_{i1}, y_{i2}, ... y_{ij}, .. y_{in})$ where y_{ij} is the performance value of attribute j of alternative i. The term Y_i can be translated into the comparability sequence $X_i = (x_{i1}, x_{i2}, ... x_{ij}, .. x_{in})$ by use of one of equations 1,2,3.

$$x_{ij} = \frac{y_{ij} - Min\{y_{ij}, i = 1...m\}}{Max\{y_{ij}, i = 1...m\} - Min\{y_{ij}, i = 1...m\}}$$

for i = 1…m, j = 1…n (14)

$$x_{ij} = \frac{Max\{y_{ij}, i = 1...m\} - y_{ij}}{Max\{y_{ij}, i = 1...m\} - Min\{y_{ij}, i = 1...m\}}$$

for i = 1…m, j = 1…n (15)

$$x_{ij} = 1 - \frac{\left|y_{ij} - y_j^*\right|}{Max\{Max\{y_{ij}, i = 1...m\} - y_{ij}^*, y_{ij}^* - Min\{y_{ij}, i = 1...m\}\}}$$

for i = 1…m, j = 1…n (16)

Eq. (14) is used for the-larger-the-better attributes, Eq. (15) is used for the-smaller-the-better attributes and Eq.(16) is used for the closer to the desired value.

3.3.2. Reference sequence definition

After the grey relational generating procedure using Eq. (14), (15) or Eq. (16), all performance values will be scaled into [0, 1]. For an attribute j of alternative i, if the value x_{ij} which has been processed by grey relational generating procedure, is equal to 1, or nearer to 1 than the value for any other alternative, that means the performance of alternative i is the best one for the attribute j. Therefore an alternative will be the best choice if all of its performance values are closest to or equal to 1. However, this kind of alternative does not usually exist. This paper then defines the reference sequence X_0 as $(x_{01}, x_{02}, ... x_{0j}, ... x_{on}) = (1,1,...1,...1)$ and then aims to find the alternative whose comparability sequence is the closest to the reference sequence.

3.3.3. Grey relational coefficient calculation

Grey relational coefficient is used for determining how close x_{ij} is to x_{0j}. The larger the grey relational coefficient, the closer x_{ij} and x_{oj}. The grey relational coefficient can be calculated by Eq. (4).

$$\gamma(x_{0j}, x_{ij}) = \frac{\Delta_{\min} + \zeta\Delta_{\max}}{\Delta_{ij} + \zeta\Delta_{\max}}$$

for $i = 1,...m,\ j = 1,...n$ (17)

In Eq. (17), $\gamma(x_{0j}, x_{ij})$ is the grey relational co-efficient between x_{0j} and x_{ij}. and

$\Delta_{ij} = \left|x_{oj} - x_{ij}\right|,$

$\Delta_{\min} = Min\{i = 1,...m;\ j = 1,...n\},$

$\Delta_{\max} = Max\{i = 1,...m;\ j = 1,...n\},$

ζ is the distinguishing co-efficient, $\zeta \in [0,1]$.

The purpose of the distinguishing coefficient is to expand or compress the range of the grey relational coefficient. After grey relational generating using Eq. (14),(15) or (16), $\Delta_{\max}$ will be equal to 1 and $\Delta_{\min}$ will be equal to 0. Fig. 2 shows the grey relational coefficient results when different distinguishing coefficients are adopted.

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In Fig. 2, the differences between $\gamma(x_{0j}, x_{pj})$, $\gamma(x_{0j}, x_{qj})$ and $\gamma(x_{0j}, x_{rj})$ always change when different distinguishing coefficients are adopted. In our paper, we have kept the distinguishing co-efficient as 0.5.

2.4. Grey relational grade calculation

The Grey Relational Grade can be calculated by Eq.(18)

$$\beta(X_0, X_i) = \sum_{j=1}^{n} w_j \gamma(x_{0j}, x_{ij})$$

for i = 1,…m (18)

In Eq.(18), $\beta(X_0, X_i)$ is the grey relational grade between X_0 and X_i. The level of correlation between reference sequence and comparability sequence has been represented. The weights has been given by w_j. The grey relational grade represents the degree of similarity between the comparability sequence and the reference sequence. The Reference sequence represents the best attribute by among the comparability sequence. If a comparability sequence gets the highest grey relational grade with the reference sequence, then that will be the best choice.

Calculating the Grey Relational Reference for the networks

For Wifi $x_{ij} = \dfrac{20-15}{30-15}$, $x_{ij} = 0.333$, Likewise we calculate for each and every alternative.

TABLE:2 GREY RELATIONAL REFERENCE SEQUENCE

	Bandwidth (X1)	Delay (X2)	Cost (X3)
Wifi (A1)	0.333	0.166	0.833
Wimax (A2)	1	0	0
UMTS (A3)	0	1	1

We have assumed our distinguishing co-efficient as 0.5. Anyhow we have calculated for different values and analyzed the results.

TABLE: 3 GREY RELATIONAL CO-EFFICIENT

	Bandwidth (X1)	Delay (X2)	Cost (X3)
Wifi (A1)	0.428	0.374	0.749
Wimax (A2)	1	0.333	0.333
UMTS (A3)	0.333	1	1

From the above Table:3 we have measured the co-efficient values based on 0.5. From the Fig:2 we assign 0.1 as distinguishing co-efficient value, then wifi bandwidth as well as delay has decreased heavily. And cost has increased, so it will not be a good option to choose. Wimax has the highest value for bandwidth and its transmission delay and cost has little decrease. UMTS has decreased bandwidth , increased delay and cost. So here comes Wimax as the best option for handoff selection when compared to other networks.

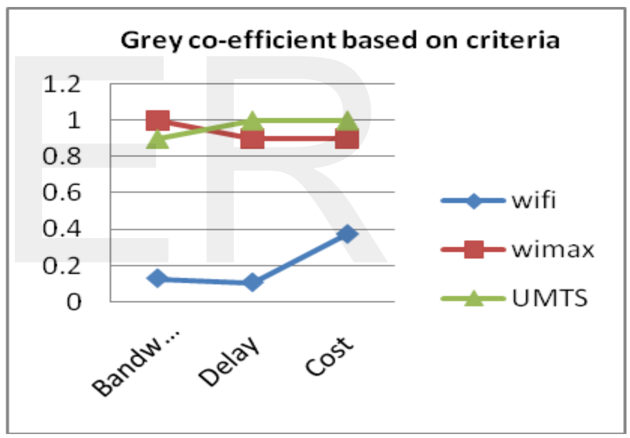

Fig 2: Grey relational co-efficient (distinguishing co-efficient 0.1)

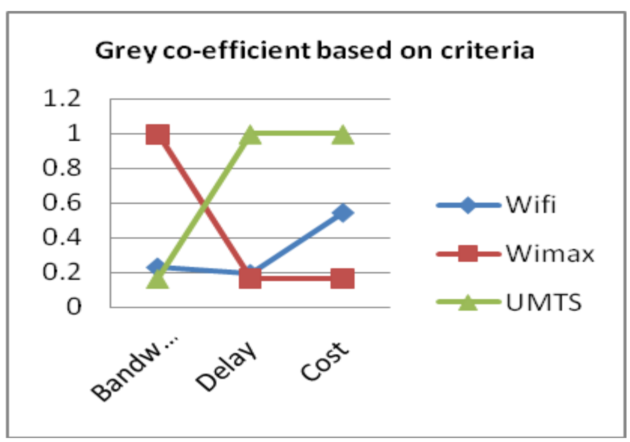

Fig 3: Grey Relational co-efficient (Distinguishing co-efficient 0.2)

From the Fig: 3 Wimax has higher bandwidth , lesser delay and cost. UMTS bandwidth is very low and its delay and cost has increased very highly. Wifi cost shows increased rank, bandwidth and delay are comparatively very low rank. From Fig:4 and Fig:5, the Grey relational grade for Wimax has shown augment result with higher value and considerably diminished values of delay and cost. Both wifi and UMTS has lesser measures for Bandwidth and higher measures for delay and cost.

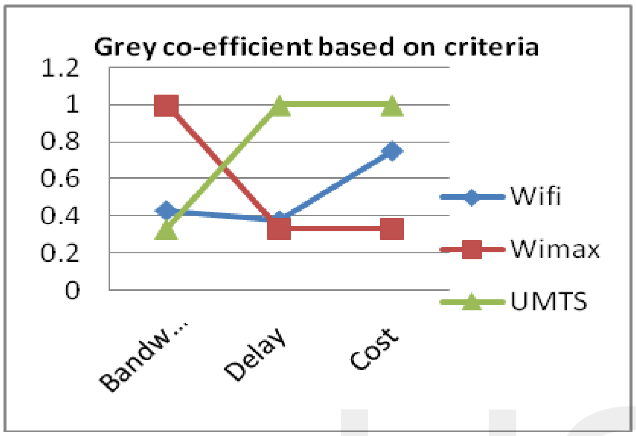

Fig 4: Grey Relational co-efficient (Distinguishing co-efficient 0.5)

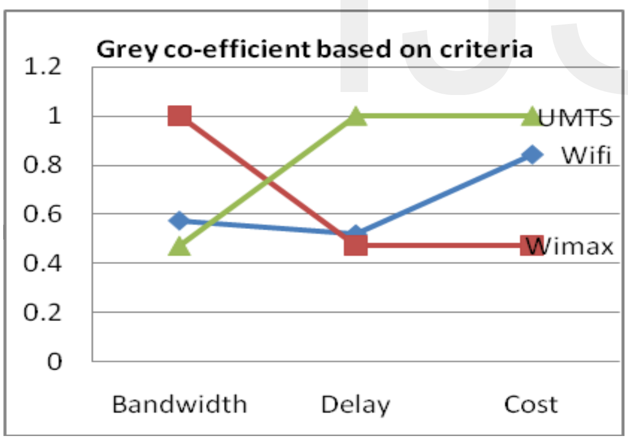

Fig 5: Grey Relational co-efficient (Distinguishing co-efficient 0.7)

TABLE:4 GREY RELATIONAL GRADE.

	Bandwidth	Delay	Cost
Wifi	0.1712	0.1122	0.2247
Wimax	0.4	0.999	0.999
UMTS	0.1332	0.3	0.3

From the above Table:4, we have obtained the grey relational grade for all the alternatives by propagating with their corresponding weights. Wimax reference sequence is closer to the comparability sequence in bandwidth criteria. Thus it is the best option for handoff , but its delay and cost shows higher values in which it should be lesser the better. Wifi delay and cost is lesser compared to other two alternatives. But it does not have larger coverage, thus it needs too many handoffs which is not a good option. UMTS results are not considerable here since it shows poor measures still its delay and cost is average.

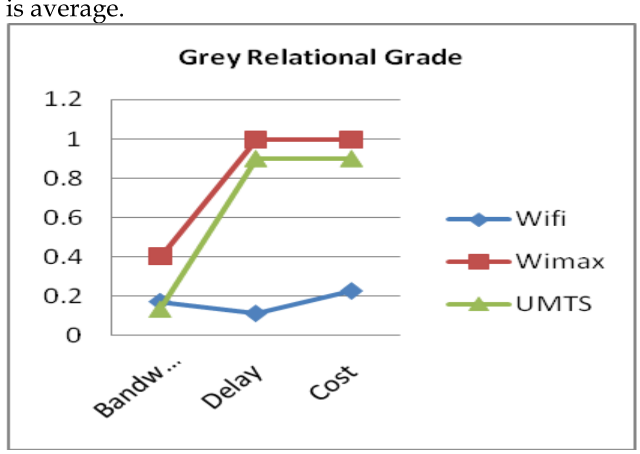

Fig: 6 Grade based on criterion weights.

From the above Fig:6, the grey relational grade values are represented by multiplying the criterion co-efficient values with their corresponding weights. Eventhough the delay and cost of the Wimax is increased, it shows good performance for bandwidth while compared with other alternatives.

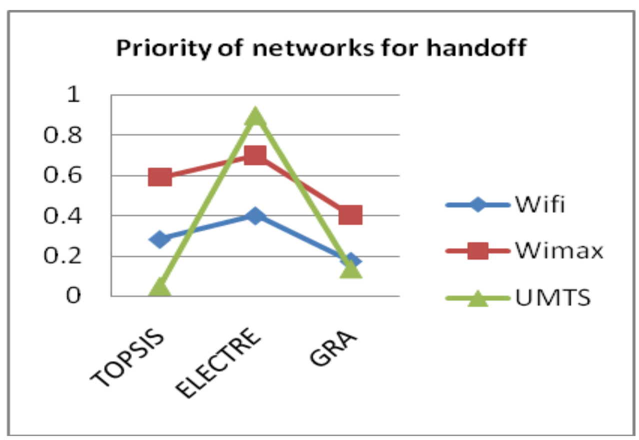

Fig: 7 Comparison of MADM measures.

From the above Fig:7, the ELECTRE method shows high values for UMTS network. These measures are based on Concordance value. For TOPSIS and GRA, Wimax shows higher values for handoff decision making. So, Wimax can be selected as a better choice for roaming after successful handoff. In another aspect, TOPSIS and ELECTRE shows higher values for Wifi and Wimax

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compared to GRA. Though GRA method is efficient while compared with TOPSIS and ELECTRE. Whilst in terms of MADM methods, ELECTRE and TOPSIS methods are time consuming. GRA method is efficient compared with other 2 methods.

4. Efficiency Analysation

All the three methods efficiency has been analyzed. For analyzing a method's efficiency, we need to know what are all its basic operations [1], how much time it takes to execute and how many times it repeats the basic operation to get the required output. Based on the input size the efficiency will get affected. First we take TOPSIS method. Find its basic operations. In the first step, input is 3X3 matrix 9 numbers. Output: 3 numbers.

Step1: $r_{ij} = \dfrac{d_{ij}}{\sqrt{\sum_{i=1}^{m} d_{ij}^2}}$, Normalize the given matrix.

Here Division and Square root operation performed 9 times.

Step2: $v_{ij} = w_j * r_{ij}$, Weighted normalized decision matrix is calculated. Multiplication 9 times.

Step3: $A^* = \{Max_i v_{ij} \mid Min_i v_{ij}\}$,

$A^{'} = \{Min_i v_{ij} \mid Max_i v_{ij}\}$. Calculate Maximum and Minimum values for each column. Here we compare 6 times.

Step4: $S_i^* = \sqrt{\sum_{i=1}^{m} (v_i^* - v_{ij})^2}$, $S_i^{'} = \sqrt{\sum_{i=1}^{m} (v_{ij} - v_i^{'})^2}$,

Measure Positive and Negative ideal solutions. Square root and Subtraction performed 18 times.

Step 5: $C_i^* = \dfrac{S_j^{'}}{S_j^* + S_j^{'}}$, Calculate the relative closeness to the ideal Solution. Division and Addition operations performed 3 times.

ELECTRE:

Step 1: Construct the Decision Matrix.

Step 2: Normalized Decision Matrix $r_{ij} = \dfrac{d_{ij}}{d_j^{Max}}$ for

Bandwidth, $r_{ij} = \dfrac{d_j^{Min}}{d_{ij}}$ for Delay and Cost. Here we do 9 comparisons, 9 division operations.

Step 3: For receiving normalized decision matrix, we multiply the weights. So 9 Multiplications.

Step 4: For finding the Concordance and Discordance Matrix, again 9 comparisons, additions and division takes place.

Step 5: For measuring the Superior and inferior value again compare the attributes.

Finally we get, $T(n) \approx c_m M(n) + c_a A(n) + c_d D(n)$

where c_m represents one multiplication, c_a represents one addition and c_d represents one division. $M(n), A(n) and D(n)$ represents Multiplication , Addition and Divisions respectively. $T(n)$ represents approximate time efficiency of the algorithm.

Grey Relational Co-efficient

Step 1: For Reference Sequence , we perform 18 Subtractions , 9 Divisions and 3 Comparisons.

Step 2: For calculating Grey Relational Co-efficient we accomplish 18 additions, 18 Multiplications and 9 Divisions.

Step 3: For Measuring the Grey Relational Grade , we carryout 9 Multiplications (with their corresponding weights).

5. Simulation output and Discussion

Fig: 8 Bandwidths of Networks

From the above Fig:8, Wimax throughput is slightly higher compared with WLAN. UMTS shows low bit-rate. The Throughput mainly depends on the data rate, since wimax supports higher data rate it gets acceptable results. All the three networks simulation executed at same time and the data transfer rate is set as 2MB. Simulation topology is set on 500X500 geometry. The Mobile node sends request to all three networks such as WLAN, Wimax and UMTS when its signal range goes down the threshold value. It Handovers to the network which fullfills its requirements.

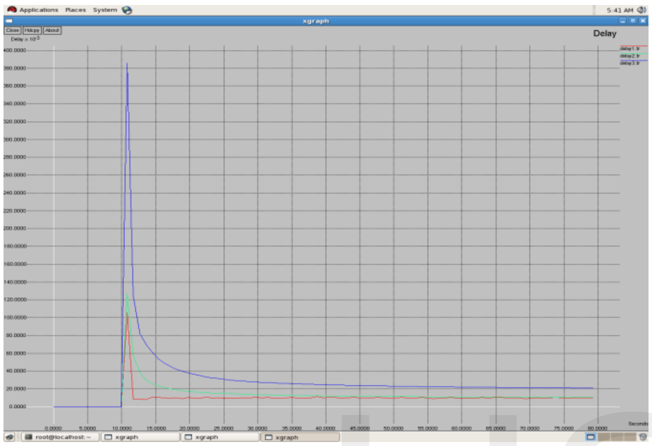

Fig: 9 End-to-end Delay of Networks.

From the above Fig:9, UMTS shows very high delay related to other two networks. Here WLAN shows low delay since its coverage area is small and bandwidth is comparitvely high. Based on the simulation results and MADM methods measurements, Wimax Shows optimum output for Handoff Decision. In the aspect of efficiency, that is the number of operations performed and the number of times measured, ELECTRE Method has minimum estimations to be performed while GRA and TOPSIS has numerous calculations. If we take many networks and parameters, the rate of basic operation will reduce gradually.

6. Conclusion

Habitually mobile nodes will undergo horizontal handoff. In case of coverage problems it will have information about its nearby service providers. In our case we have taken 3 different networks and analyzed its performance based on simulation results. And for handoff decision making we have taken 3 different MADM methods to investigate and wrap up the network which gives favourable outcomes for handoff. We have analyzed about the efficiency of MADM methods in which ELECTRE method is efficient, But on the other hand it shows totally different measures for networks. In the network side, Wimax and on the Decision making scheme GRA gives optimum results. In our future work we will consider packet delivery ratio and analyze about the packet drops.

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