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Seamless Mobility Using GRA and WPM Methods for Heterogeneous Mobile Networks

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Abstract. Handoff refers to the process of transferring an active call or data session from one Base Station to another in the cellular environment. A well-implemented handoff is important for delivering continuous service to the users. Wireless network consist of different types of networks with different types access technologies known as heterogeneous network. The handoff process done between two or more different types of network is known as vertical handoffs. There are several possible criteria's are available for handoff decision making in the heterogeneous network. Multiple Attribute Decision making to helps choose the best network by computing highest performance rating. GRA and WPM techniques in MADM method are analyzed for select the best network for handoff based on the Qos Parameters. Here, three networks such as Wi-Fi, WIMAX, and UMTS networks are considered for the simulation environment. The vertical handoff can be done with the help of GRA and WPM methods. GRA methods ranks the network for the given situation, WPM methods compute overall score based on the performance of the network. Both GRA and WPM are used for selecting the best network for vertical handoff has been done with the help of NS-2 .By the simulation results the WIMAX network is selected as best network compared with Wi-Fi and UMTS based on the Values of given parameters such as Bandwidth, Delay, and Cost.

1. Introduction

Wireless Communications: Wireless communication involves the transmission of information over a distance without the help of wires, cables or any other forms of electrical conductors. Wireless communication is a broad term that incorporates all procedures and forms of connecting and communicating between two or more devices using a wireless signal through wireless communication technologies and devices. In the field of wireless communications, ongoing development in wireless technology has been coupled with a remarkable increase in roaming computing activities, with users demanding improved network connectivity and services for supporting high-speed multimedia services like interactive video telephone and voice over IP (VoIP) Heterogeneous Wireless Access Networks: The next generation of cellular/wireless communications (B3G or 4G) is expected to be purely IP-based and consist of access networks and a converged core network. The evolving 4G network will seamlessly integrate various types of wireless access networks, including the following Wireless personal area networks (WPANs), such as ultra-wideband and Bluetooth, that provide a range-limited ad hoc wireless service to users.

- Wireless local area networks (WLANs), such as 802.11x (Wi-Fi), that provide high-throughput connections for stationary/quasi-stationary wireless users without the costly infrastructure of 3G.
- Wireless metropolitan area networks (WMANs), such as 802.16 (WiMax), that provide wireless services requiring high-rate transmission and strict quality of service requirements in both indoor and outdoor environments.
- Wireless wide area networks (WWANs), such as Universal Mobile Telecommunications System UMTS), that provide long-range cellular voice and limited-throughput data services to users with high mobility; (e.g., radio and television broadcasting, satellite communications).

2. Type of Handoff

Handoffs are broadly classified into two categories hard and soft handoffs. Usually, the hard handoff can be further divided into two different types intra and inter cell handoffs. The soft handoff can also be divided into two different types' multi way soft handoffs and softer handoffs.

- Hard handoff means "break before make" means that the connection to the source is broken before the connection to the target is made. In a hard handoff, the link to the prior BS is terminated before or as the user is transferred to the new cell's BS. In this case, the MS is linked to no more than one BS at any given time.
- Softhandoff is a "Make before break" handoff. That is, the mobile station (MS) is up on a call and moves from one base station (BS) to another, but the MS starts communicating with a new BS before terminating communications with the old BS. Soft handoffs can only be used between BSs on the same frequency. The technique improves reception as MSs Move between cells (on cell boundaries).

3. Literature Survey

- Ram Kumar Singh, Amit Asthana, AkankshaBalyan, ShyamJi Gupta, and PradeepKumar, proposed “Vertical Handoffs in Fourth Generation Wireless Networks”. Vertical handoff methods in the evolving 4G wireless communication networks. Integration architectures for various wireless access networks are described. Then handoff classification, desirable handoff features, the handoff process, and Multimode mobile terminals are discussed. A section is devoted to some recently proposed vertical handoff techniques. We propose a vertical handoff decision algorithm that determines whether a vertical handoff should be initiated and dynamically selects the optimum network connection from the available access network technologies to continue with an existing service or begin another service.
- GaganPreet Kaur, Joni Birla, JitenderAhlawat, proposed [2] **“**Generations of Wireless Technology”. Various generations of mobile wireless technology along with their significance and advantages of one over the other. In the past few decades, the mobile wireless technologies have experience of various generations of technology revolution & evolution, namely from 0G to 4G. An advance implementation of 5G technology which are being made on the development of World Wide Wireless Web (WWW).

4. Multiple Attribute Decision Making (MADM)

- Decision-making processes involve a series of steps: identifying the problems, constructing the preferences, evaluating the alternatives, and determining the best alternatives

Table 1.Measures of Alternatives Based on Criteria

Networks	**Bandwidth (A1)**	**Delay (A2)**	**Cost (A3)**
Wi-Fi(X1)	20	60	10
WIMAX(X2)	30	62	20
UMTS(X3)	15	50	8

Grey Relational Analysis: The main procedure of GRA [1] 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, based 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.

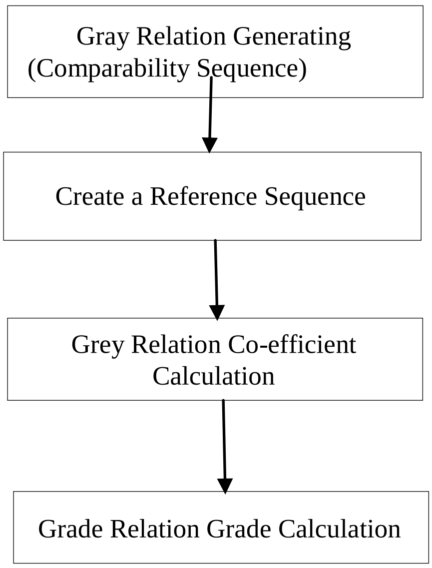

FIGURE 1. Procedure of Gray Relational Analysis

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 [1]. 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 nattributes, the ith alternative can be expressed as $y_i = (y_{i1}, y_{i2} \ldots\ldots\ldots y_{ij} \ldots y_{in})$ where ij y is the performance value of attribute j of alternative i. The term iY can be translated into the comparability sequence $X_i = (x_{i1}, x_{i2} \ldots\ldots\ldots x_{ij} \ldots x_{in})$.

$$x_{ij} = \frac{y_{ij} - min\{y_{ij}, i=1\ldots m\}}{max\{y_{ij}, i=1\ldots m\} - min\{y_{ij}, i=1\ldots m\}} \quad (1)$$

$$x_{ij} = \frac{max\{y_{ij}, i=1\ldots m\} - y_{ij}}{max\{y_{ij}, i=1\ldots m\} - min\{y_{ij}, i=1\ldots m\}} \quad (2)$$

fori = 1…m, j = 1…n

$$x_{ij} = 1 - \frac{\left|y_{ij} - y_j^*\right|}{Max\{Max\{y_{ij}, i=1\ldots m\} - y_{ij}^*, y_{ij}^* - Min\{y_{ij}, i=1\ldots m\}\}} \quad (3)$$

fori = 1…m, j = 1…n

Eq. (1) is used for the-larger-the-better attributes, Eq. (2) is used for the-smaller-the-better attributes and Eq.(3) is used for the closer to the desired value.

Reference sequence definition: After the grey relational generating procedure using Eq. (1), (2) or Eq. (3), 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 $(x_{01\ldots}, x_{02\ldots}, x_{0j\ldots}, x_{0n}) = (1,1,\ldots\ldots 1,\ldots\ldots 1)$ and then aims to find the alternative whose comparability sequence is the closest to the reference sequence.

$$\gamma(x_{0j}, x_{ij}) = \frac{\Delta_{min} + \Delta_{max}}{\Delta_{ij} + \Delta_{max}} \quad (4)$$

$\gamma(x_{0j}, x_{ij})$ Is the grey relational co-efficient between x_{0j} and x_{ij}.
$\Delta_{ij} = |x_{0j} - x_{ij}|$,
Δ_{min} = Min { i = 1…m, j = 1…n }
Δ_{max} = Max { i = 1…m, j = 1…n }

The purpose of the distinguishing coefficient is to expand or compress the range of the grey relational coefficient. After grey relational generating using Eq. (1),(2) or (3), Δ_{max} will be equal to 1 and Δ_{min} will be equal to 0. Fig. 2 shows the grey relational coefficient results when different distinguishing coefficients are adopted.

Grey relational grade calculation:The Grey Relational Grade can be calculated by

$$\beta(x_0, x_i) = \sum_{j=1}^{n} w_j \, \gamma(x_{0j}, x_{ij}) \quad (5)$$

$\beta(x_0, x_i)$ 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 weight has been given by w_j.The grey relational grade represents the degree of similarity between the comparability sequence and the reference sequence.

Calculating the Grey Relational Reference for the networks

$$\text{Wifi} \quad x_{ij} = \frac{20-15}{30-15}, \quad x_{ij} = 0.333$$

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

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 coefficient 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.

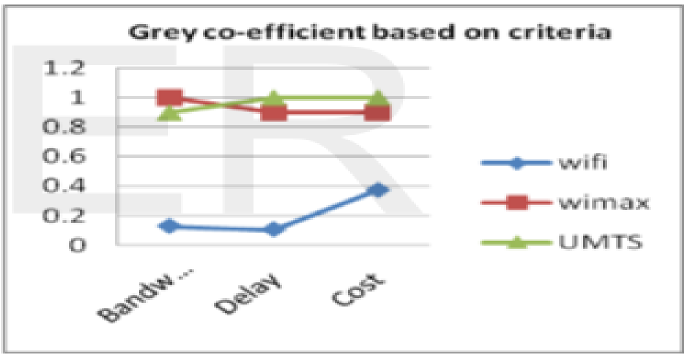

FIGURE 2. Grey relational co-efficient (distinguishing co-efficient 0.1)

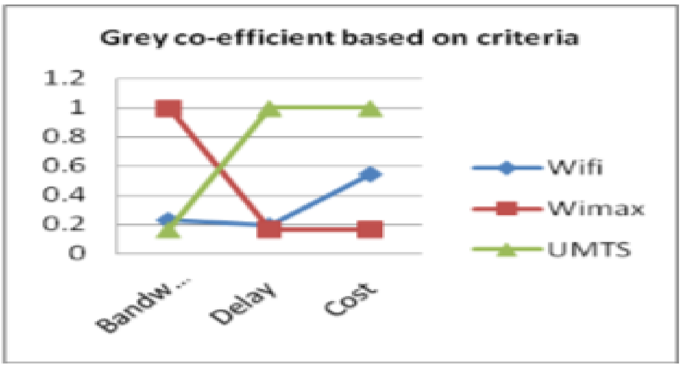

FIGURE 3. Grey Relational co-efficient (Distinguishing co-efficient 0.2)

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.

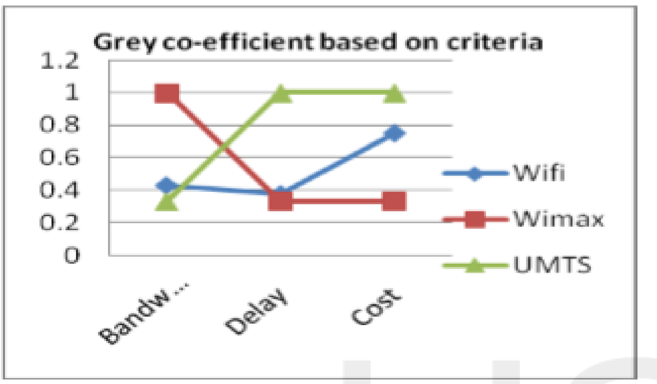

FIGURE 4: Grey Relational co-efficient (Distinguishing co-efficient 0.5)

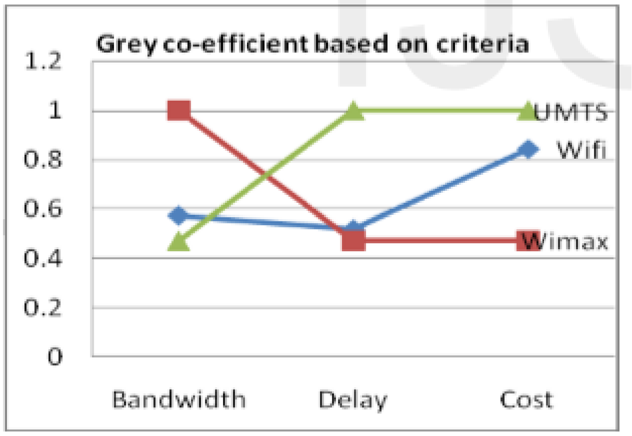

FIGURE 5. Grey Relational co-efficient (Distinguishing co-efficient 0.7)

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 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.

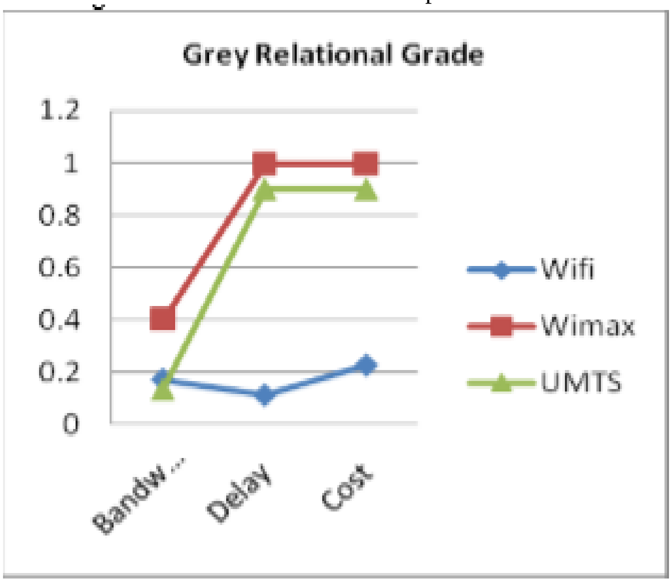

FIGURE 6. Gray Relation Grade

Weighted Product Method:Weighted Product Method (WPM) [2] is another scoring method wherever the weighted produce of the measure is used to choice the greatest alternate.

TABLE 5. WPMAlgorithm

Algorithm : WPM method for Handoff Decision
Input: Mobile Terminals with limited transmission Range, base stations of wifi, wimax, UMTS networks with parameters such as bandwidth, delay, cost.
Output: Selection of Base Station for Handoff decision
Step 1: For each and every attributes in given Bandwidth, delay and cost.
Step 2: Compute a decision matrix.
Step 3: Compute maximum value of the attributes using eq1.
Step 4: Construct weight standardized decision using eq2.
Step 5: Compute Network Score using eq3.
Step 6: The network with highest score is consider as best network and it's consider for handoff.

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

$$\begin{bmatrix} d_{11} & \cdots & d_{1m} \\ \dots & \dots & \dots \\ d_{n1} & \cdots & d_{nm} \end{bmatrix}$$

Weight cast matrix: computes the product of the normalized network attributes and the respective attribute weights. Construct the normalized decision matrix (r_{ij}):

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

- r_{ij}normalized value for the element in thithrowjthcolumn.
- d_{ij} is the element in $_i$throwjthcolumn in the decision matrix.
- d_{ij}^{max}represents the maximum value of the attributes in the decision matrix.

Construct weighted standardized decision (V_{ij}):

$$v_{ij} = r_{ij}{}^{wj} \quad (7)$$

- r_{ij}^{wj} weighted normalized decision (or) weighted standardized decision.

Network score: Computes the score of individual networks by adding the respective network weight cost matrix entries. Analyze the score of every alternate (S_i)

$$S_i = \sum_{j\neq 1}^{m} v_{ij} \quad (8)$$

- S_i analyze the score of every alternate in network score.

TABLE 6. Score of Every Alternate Weights

NETWORK	WiFi	WIMAX	UMTS
Value	0.681	1	0.538

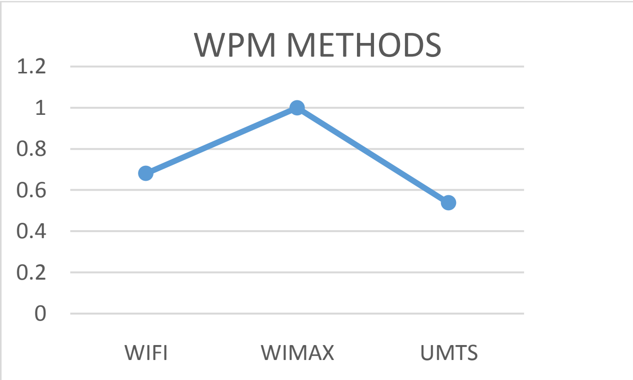

FIGURE 7.WPM Methods

Comparison Result: In this research work, three networks have been considered to design heterogeneous environment. These networks are WLAN, WiMax and UMTS having three attributes as bandwidth, delay and cost. The values of various attributes vary randomly methods in Step6. The weights of various attributes have been assigned using two MADM in GRA and WPM method analysis. When the connection from the current network is becoming weak or if strong signals are being received from the available networks, the multi-mode terminal will make a decision to change its connection to the most suitable network. In this paper the target network selected depending on the application Qos requirement of the parameters. In figure (1) discuss WiMax is the highest value another networks of Wi-Fi and UMTS values are lowest. In figure (2) discuss, Bandwidth is the highest value another parameter of Delay and cost is lowest value. Finally we compared in figure (3) that is GRAand WPM, in this two Bandwidth is the highest value. In the above two GRA and WPM method, WPM is the good result.Based on these parameters all the two networks performance is measured.

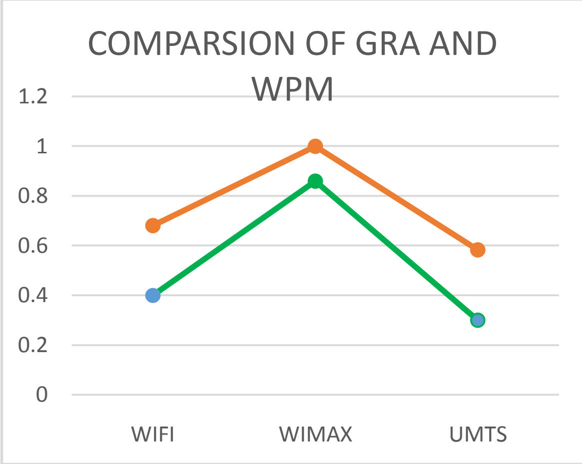

FIGURE 8. Comparison of different MADM method with different networks

5. Conclusion

Handoff is a major decision making process in the wireless networks. It is a critical issues for selecting the best network in the heterogeneous network environment. There are several criteria and several methods are available for selecting the best network. Here, this research work considered three networks such as WiFi, WiMax, and UMTS Networks. Here, Bandwidth, delay and Cost are considered as the quality of service parameters for vertical hand off decision making process. GRA and WPM in the MADM techniques are analysed for select the handoff techniques based on the QoS parameters. By this work, the simulation shows that the GRA method and WPM methods ranks the networks for handoff process. Based on the simulation results, WIMAX network is treated as the best network when compared with the WIFI and UMTS network based on the given situation.

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