International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 3 (2015) pp. 7875-7894

http://www.ripublication.com

Performance Analysis of QoS Based Vertical HandOff Decision Algorithms in Heterogeneous Next Generation Wireless Networks

Mesala Sravani[1], Shiwali Sonwani[2] and Ushus Elizebeth Zachariah[3]
[1, 2] M.Tech,(CSE) , [3]Assistant Professor, Department of CSE, VIT , VELLORE
[1]sravani.meesala@gmail.com, [2]shiwali.sonwani@gmail.com, [3]ushus@vit.ac.in

Abstract

The Next generation Wireless Networks(NGN) is envisage to integrate various heterogeneous wireless networks. The major challenging issue of the next generation wireless networks is to provide a quality of service(QOS) which is guaranteed and quality of experience(QOE).This specifies the QOS provided by the network & the QOS experienced by the user. The efficiency of the next generation wireless networks mainly depends upon the architecture and design of the future wireless networks . The most challenging task is to design various algorithms which provide best quality of service (QOS) and to efficiently support the mechanism of vertical handoff so as to provide seamless continuity of the calls even when the user is moving from one network to the other. This paper elucidates a comprehensive survey of the performance of various vertical handoff algorithms to decide the mechanism of selecting the best network among several available networks is discussed. A new algorithm Maximum Network Utility-Vertical Hand Off (MNU-VHO)algorithm is proposed. The investigation and results suggests that the proposed algorithm has better performance than other algorithms because it is more efficient, simple to implement and more dynamic (application oriented).

Keywords: QOS, NGN test beds, VHO mechanism, MNUA, comparison.

Introduction

The next Generation Wireless Networks are expected to provide multiple access networks to the user. Hence the user has the provision of accessing a wide range of applications and services provided by multiple wireless networks. In Next Generation Networks(NGN) all the classes of traffic in terms of voice, video and data is to be managed to give the better quality of service (QOS) requirements, such as band width, delay, jitter, pathloss, Cost parameter. In the evolving networks the main criteria is selection of network that is best suitable to satisfy all the QOS parameters. Network selection is the process of selecting the best network for establishing a connection [1]. Network selection basically plays a prominent role during the process of handing over a service to a new network. Hand off process involves the important decision making strategy of disconnecting from a particular network and deciding which network to handover to. Hand off is traditionally performed when the existing network to which user is connected does not meet the requirements of the user handset. The architecture of NGN is shown in Figure.1 [2]

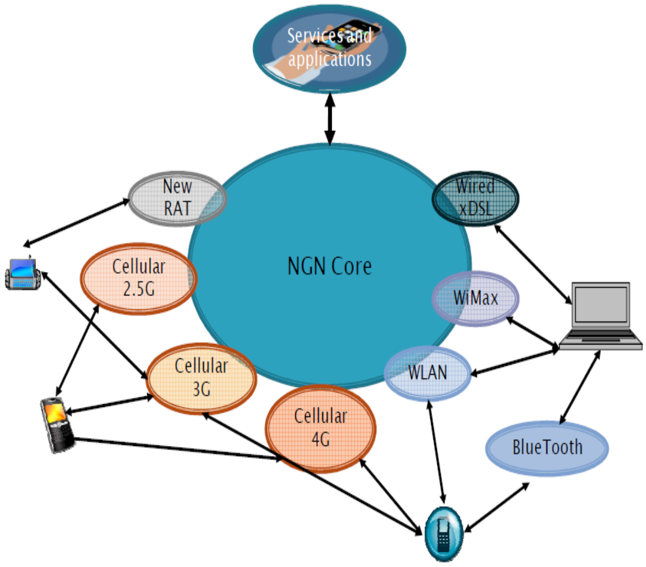

Figure 1: Architecture of Next Generation Networks

Handoff Mechanism in NGN(4G) Networks

The mechanism of handoff is categorized into 4 phases. Hand off initiation, Handoff decision making process, network selection process, handoff execution process.

- Initiation of handoff: The QOS parameter like strength of the signal and quality of the network link etc.. and base on these values the handoff initiation is done.
- Handoff decision making: In this phase the hand off decision making is done according to an algorithm and calculation and measurement of the signal strength and QOS parameters of the neighboring networks and a decision is taken to select the most suitable network for performing handoff.
- Network selection phase: The most suitable network among all the available networks is chosen based on the above measurements and calculations to perform handoff.
- Execution of handoff: In this phase the user active connection is switched over from existing network to the best network that satisfies the required conditions. Connection establishment, connection release, security and other important aspects are the main functions of this phase. `

Hand off mechanism is categorized as Horizontal handoff (HHO) and Vertical handoff (VHO). This is shown in figure.2. In contrast Horizontal handoff is a technique which is performed between two networks of same technology Wi-Fi to Wi-Fi. Vertical handoff is the handoff between network interfaces representing different technologies and architecture like Wi-Fi to Wi-max. The most prominently used handoff mechanismis Vertical handoff (VHO) .

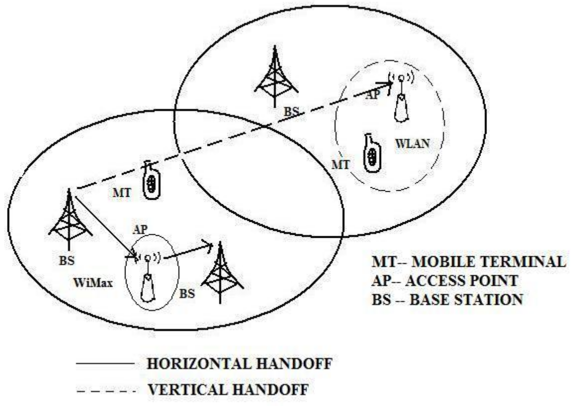

Figure 2: Horizontal and Vertical handoff

Taxonomy of Vertical Handoff

Upward and Downward Handoffs

Vertical handoff is classified into upward and downward vertical handoffs basing on the factor of area of coverage of existing and target networks. Upward Handoff is the process where the mobile switches from a small coverage area network to a large coverage area network. On the other hand, if switching is from a larger network to a smaller network the process is termed as downward handoff.

Hard handoff and Soft handoffs

Hard handoff is the process where a mobile device gets disconnected from the previous base station and then gets associated with a new base station. This is termed as hard handoff or break before make. If a mobile device gets connected and associated with new base station maintaining its association with the previous base station till it is completely associated with the new base station, it is termed as soft handoff or make before break. The mobile station maintains connection simultaneously with both the base stations during this period. Soft handoff is practically more preferred as it ensures continuous service without any disruption of service. The Classification of vertical handoff is shown in fig.3

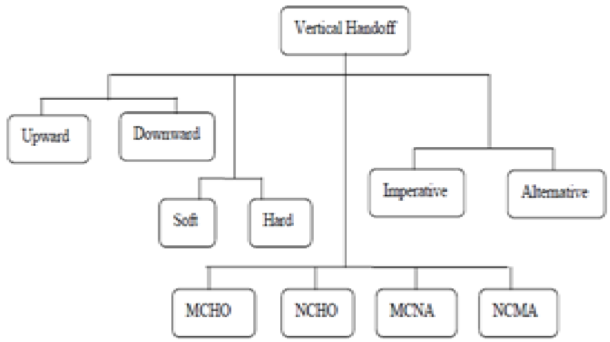

Figure 3: Classification of vertical handoff

Next Generation Networks (NGN)

The evolution of next generation network standards laid emphasis four important parameters that are mainly considered to classify various wireless mobile networks. These parameters are namely data rate, available bandwidth, area of coverage, mobility[1]. Band width and mobility are the factors which specify the data rate which in turn is associated with coverage. Based on these factors various networks are classified as Wi-Fi, Wi-Max, UMTS etc..

1. **Wi-Fi**: It is a IEEE 802.11 specification standard abbreviated as Wireless-Fidelity. It allows wireless access to internet by the user to connect through the local area networks. It is more flexible to the user in terms of connectivity and total band width and is faster than a typical cable modem connection.
2. **WiMAX :** WiMAX is the latest emerging technology which meets the requirements of customer in terms of QOS parameters. It supports worldwide interconnectivity for Microwave Access. It is adaptable to any atmospheric conditions. The EM waves in WiMAX are suitable for adaptive coding and various modes of operation. Hence voice and data can be efficiently transmitted by a WiMAX network.
3. **UMTS** :It is abbreviated as Universal Mobile Telecommunication System. It is 3G mobile communication system which provides broadband wireless and mobile service. The main services and features of UMTS are extended 2G(GSM/GPRS) which makes use of CDMA, ATM(Asynchronous Transfer Mode), and IP(Internet Protocol).

The Generic QOS parameters:

In the Next Generation Network (NGN) wireless systems the various parameters that QOS parameters are Available band width, Total band width, Packet delay, Packet Jitter, Packet Loss, Monetary Cost .

1. **Available Bandwidth**: It is the major criterion in data communication. A system capacity and efficiency basically depends on the bandwidth. It is a measure of the resources of data communication that are available with the system. It is expressed in bit/s

2. **Packet delay** : It is a measure of the amount of time taken for a data packet to reach the destination from a source with constant bit rate(CBR). It is defined as the average delay that is experienced by a user or an application entity while transmitting data. It is measured in seconds.

$$Packet\ Delay = \frac{Sum\ of\ individual\ delays\ of\ all\ the\ transmitted\ packets}{Number\ of\ received\ packets}$$

3. **Packet Jitter:** It is a delay that is experienced by a data packet during the transit due to network contusion parameters like contention ,queuing, the effect of serialization of data packets on the transmission path. Jitter mainly occurs in links that are congested due to timeout of the connection, time lags of the connection, traffic congestion of data and interference.

$$Total\ Jitter = \frac{Total\ delay\ due\ to\ jitter\ of\ all\ recieved\ packets}{Total\ number\ of\ recieved\ packets}$$

4. **Packet loss:** It is the a major factor in computer communication which specifies the total number of packets that are lost during transmission from source to destination. It is mainly due to network congestion and noise factors during transmission of data packets.

5. **Monetary Cost:** Because of various charging policies employed by various networks, the cost factor of a network service is a major issue to be considered while making the decision of handoff.

Weighted Sum Method (Wsm)

Weighted Sum Method (WSM) also termed as Simple Additive weight(SAW) or scoring method [3]. It is the simplest and most prominent multi attribute decision technique that is used to select a network for Handoff. The basis for this algorithm is weighted average method. For each alternative an evaluation score is calculated. This done by the multiplication of the scaled value given to the alternative of that attribute with the weights of relative importance , directly assigned by decision maker followed by summing of the products for all criteria. The usage of the scores of WSM mainly rely on identifying objectives and alternatives, evaluating the alternatives, determining of sub-objective weights, adding the aggregate of weighted partial preference values and sensitive analysis. The scores are calculated by normalizing the values which have to match the standardised scale. The WSM algorithm is used as a comparitive scale for all elements in the decision matrix.

$$X_{ij}=\frac{V_{ij}}{V_j^{max}} \text{........} \qquad (1)$$

$$X_{ij}=\frac{V_j^{min}}{Vx_j} \text{........} \qquad (2)$$

The WSM method, underlying additive values function and alternative score X=X(A_i) are calculated by addition of weighting normalized values $W_j X_{ij} \forall_j$={1,....m} before eventually ranking alternatives.

$$X_i=\sum_{j=1}^{m} w_j X_{ij} \quad .... \tag{3}$$

For X$\varepsilon R^{n*m}$with i={$1, \dots . n$}, j={$1, \dots . . m$};X_{ij}, W_j,$W_j \varepsilon(0.1)$

Weighted Product Method (Wpm)

An innovative MADM scoring method which is similar to WSM method is Weighted Product Method (WPM). The methods are basically differentiated by the factor that multiplication is applied rather than addition. This algorithm was previously proposed for vertical handoff in [6]. This algorithm decides and calculates the scores of the networks by the weighted product of the attributes. The score X*i of* network *i* in equation (4) is determined by the weighted product of the following attributes:

$$X_i=\prod_{j \in N} y_{ij}^{w_j} \quad .... \tag{4}$$

Here y_{ij} denotes attribute j of the home network i, $w_j$denotes the weight of attributed j, *and* $\sum_{j=1}^{N} W_j$=1. In equation (4), $w_j$is a positive power for benefit metrics $y_{ij}^{w_j}$, and a negative power for cost metrics$y_{ij}^{-w_j}$. Here the concept of parameter normalization is not required in the sense that it is optional, the network score obtained by WPM does not have an upper bound [4], thus it is better to compare the score of each network with that of a positive ideal network A**. This network is decided to be the network with the best values in each metric. The best value is the largest in case of a benefit metric.The best value is the lowest in case of a cost metric.

(TOPSIS)Technique For Order Preference By Similarity To Ideal Solution

The relative efficiency of alternatives can be best calculated using an effective MADM instrument named TOPSIS. The order of preference is determined based on the nearest similarity to a positive ideal solution and the highest dissimilarity to a negative solution. TOPSIS algorithm [5] is a technique in which normalized decision matrix is constructed. Each element is calculated as

$$m_{ij}=\frac{c_{ij}}{\left(\sum c_{ij}^2\right)^{\frac{1}{2}}},$$

where i=1,....m; and j=1,.....n

The weighted normalized decision matrix is calculated and constructed by usingX_{ij}= $W_j m_{ij}$

The Positive and negative ideal solution are determined as below.

Positive ideal solution.
$P^{*}=\{X_1^{*}, \ldots \ldots \ldots \ldots, X_n^{*}\}$,

where , $X_j^{*}=\{max_i(X_{ij}) if j \in J; min_i(X_{ij}) if j \in J'\}$

Negative ideal solution
$P^{'}=\{X, \ldots \ldots \ldots \ldots, X_n^{*}\}$,

where $X_j^{*}=\{min_i(X_{ij}) if j \in J;\ max_i(X_{ij}) if j \in J'\}$

The distance between each alternative and the positive ideal solution is:
$D_i^{*}=\left[\sum_j (X_j^{*} - X_{ij})^2\right]^{1/2}$, i=1,......, m Each alternative and the negative ideal solution are separated by a distance given as:

$D_i^{'}=\left[\sum_j (X_j^{'} - X_{ij})^2\right]^{1/2}$, i=1,......,m

Ultimately the relative closeness to ideal solution Z_i^{*} is calculated as

$Z_i^{*}=D_i^{'}/(D_i^{*} + D_i^{'})$, $0 < Z_i^{*} < 1$

Analytical Hierarchy Process (Ahp):

This algorithm is mathematical technique for decision making when multiple number of criteria are considered. Each decision alternative is given a numerical score which is based on the factor of how well a criteria is specified by each alternative which is provided by the decision maker. AHP algorithm helps in simplifying a complex problem into simple pair wise comparisons and is combined to give the best possible solution. AHP method is used to make a decision of selecting an access network which will decide the network to which the mobile has to perform the handoff decision based on QOS parameters of the networks that are available. The AHP algorithm calculation involves the following steps.

1. The relative importance of one criterion over the other is determined by using the technique of pair wise comparison.
2. The ranking is obtained by a short computational procedure which involves raising the powers of the pair wise matrix that are successfully squared every time.
3. Normalization is done by calculating the row and sum of the matrix.
4. Iterations are done till there is no change in the previous and present Eigen Vector solution.
5. The iteration is stopped when the difference between the sums in two consecutive calculations is less than a prescribed value.

Grey Relation Analysis:

According to Grey system theory the random process is believed to be a grey quantity variable in an area of certain amplitude and time zone. The correlations among factors and candidates of a system can be determined using Grey relational analysis. The major advantage of this method is that with insufficient information, the qualitative and quantitative relationships are calculated from numerous factors[8]. The Grey relational analysis is calculated as follows.

1. Initialize the Original system A_o which is 6x6 matrix.
2. The ideal value from the initial original sequence is identified.

$$I^+\big(A_o(n)\big) = \{A_i^+, A_2^+, \dots . A_i^+(n)\} =$$

$$\{(Max_n . A_i(n)/l \in L_1), (Min_n . X_i(K)/l \in L_2)\},$$

i=1,2,…7; n= 1,2, …16

L_1 is a set of benefit attributes and L_2 is a set of cost attributes.

i) Normalize the Original sequence

$$A_i^*(n) = \frac{A_i(n)}{I^+\big(A_o(n)\big)}$$

ii) Determine the Grey relational deviation sequence

$$\Delta_{oi} = \|A_o(n) - A_i(n)\|$$

iii) Identify Maximum and Minimum deviation

$$\Delta_{max} = |A_o(n) - A_i(n)| ; \Delta_{min} = |A_o(n) - A_i(n)|$$

iv) Calculate the Grey relational coefficient as

$$\beta\big(A_o(n), A_i(n)\big) = \frac{\Delta_{min} + \eta\Delta_{max}}{\Delta_{01}(n) + \eta\Delta_{max}}$$

v) Calculate the Grey relational grade for 6 alternatives as

$$\beta(A_i, A_l) = \sum_{m=1}^{n} \alpha_m \, \beta\big(A_i(n), A_l(n)\big);$$

Here the total probability $\sum_{m=1}^{n} \alpha_m = 1$;

Hence $\beta(A_i, A_l) = \frac{1}{n}\sum_{m=1}^{n} \beta\big(A_i(n), A_l(n)\big)$

Proposed Algorithm:

Maximum Network Utility-Vertical handoff algorithm (MNU-VHO)algorithm.
In the Maximum Network Utility Algorithm each alternative is evaluated according to individual criterion function. By comparison of the measure of regret(i.e., nearness to the ideal alternative), the compromise ranking is calculated.. The measure of multi-criteria for raking of compromise is developed from the A_f- norm which is used as an aggregating function in a MNU algorithm. Various alternatives, denoted by X are denoted as $a_1, a_2, a_3 \ldots, a_x$ for alternative a_x. The y_{th} criterion rating is given as S_{yx}, i.e., S_{yx} takes the value of the x_{th} criterion function for the alternative a_y and m denotes the the number of criteria. In MNU-VHO algorithm the levels of regrets are defined as:

$$A_{f,y} = \left\{\sum_{x=1}^{m}\left[w_j\left(S_x^* - S_{yx}\right)/S_x^* - S_x^{'}\right]^f\right\}^{\frac{1}{f}},\ 1 \leq f \leq \infty;\ y = 1,2,\ldots..Y.$$

Where the factor $A_{f,y}$ is defined as the maximum group utility. The maximum individual regret of the opponent is given by $A_{\infty, y}$.

The ranking alternatives of MNU-VHO are calculated as follows.

i) First we determine the best value S_x^* and the worst value as $S_x^{'}$ for all criterion functions, where x=1,2,…..m. If the benefit is represented by X_{th} function, then $S_x^* = max_y S_{yx}, S_x^{'} = min_y S_{yx}$.
ii) Now the value U_y(maximum Group utility) and I_y (minimum individual regret of the opponent) are computed, y=1,2,…Y,

By the mathematical relations

$$U_y = A_{1,j} = \sum_{x=1}^{m}\left[w_j\left(S_x^* - S_{yx}\right)/S_x^* - S_x^{'}\right]$$

$$I_y = A_{\infty} = \sum_{x=1}^{m}\left[w_j\left(S_x^* - S_{yx}\right)/S_x^* - S_x^{'}\right]$$

Here the weight of the x^{th} criterion is w_j , which expresses the relative importance of criteria.

i) The value

$$Q_y = w_s(U_y-U^*)/(U^{'}-U^*)+(1-W_s)(I_y-I^*)/(I^{'}-I^*)$$

Here $U^* = min_y U_y, U^{'}, I^* = min_y I_y, I^{'} = max_y I_y$ and w_s is taken as the weight of the strategy of U_y and R_y.

ii) The alternatives are given a rank basing on sorting of U,I and Q values in descending order. All the six ranking are shown in the result.
iii) The alternative $(a^{'})$ which is a compromise solution is ranked as the best solution based on the condition that the following conditions are satisfied.

Z1. " Acceptable advantage":
$Q(a'') - Q(a') \geq DQ, where\ a''$ is the alternative with second position in the list of ranking by Q, DQ =1/(Y-1) and Y is the number of alternatives.

Z2. "Acceptable stability in decision making":
a' which is the alternative should ranked as the best by U or/ and I . This is stable compromise solution within a decision making process, which is selected by the criteria "voting by majority rule"(when w_s> 0.5 is required), or " by consensus" w_s approximately equal to 0.5, or " with vote"(w_s<0.5). Here w_s is the weight of decision making strategy which is " maximum group utility".

Case Study

The above section a detailed description of various vertical hand off decision schemes and MADM methods like WSM, WPM , TOPSIS, AHP , Grey Relational algorithm and a new algorithm which was proposed MNU-VHO(Maximum Network Utility-Vertical Hand Off) algorithm that are used for selection of a suitable network in this paper. As an example the case of a mobile terminal currently connected to a Wi-Fi cell is considered. It has to make decision among six candidate networks Wi-Fi 1,Wi-Fi 2, UMTS-1, UMTS-2, W-LAN 1, W-LAN 2 . Vertical handover QOS criteria that are considered here are Packet delay, bandwidth , cost, Packet jitter , Packet loss. The above said algorithms are applied to the data below for six different networks for different QOS parameters in Table.1

The weights for the above data are calculated and taken as
W_j = [0.0860 0.1672 0.4319 0.0531 0.2593 0.0021]

Table 1:

Parameter /Network	Available Band Width (Mbps)	Total Band Width (Mbps)	Packet Delay (ms)	Packet Jitter (ms)	Path Loss (per 10^6)	Cost per Byte (price)
UMTS 1	1	2	37	7	50	0.6
UMTS 2	1.2	2	38	8	51	0.8
WiLan 1	6	11	125	15	50	0.1
WiLan 2	27	54	126	16	49	0.05
WiMax 1	32	60	80	6	48	0.5
WiMax 2	30	60	82	8	45	0.4

Table 2:

	WLAN	W iMAX	UMTS
Peak Data Rate	802.11a,g=54Mbps 802.11b=11Mbps	UL:70Mbps DL:70Mbps	DL:2Mbps UL:2Mbps
Band Width	20Mhz	5-6Ghz	5Mhz
Multiple Access	CSMA/CA	OFDM/OFDMA	CDMA
Duplex	TDD	TDD	FDD
Mobility	Low	Low	High
Coverage	Small	Mid	Large
Standardization	IEEE802.11x	802.16	3GPP
Target Market	Home/Enterprises	Home/Enterprises	Public

A comparative analysis of the networks Wi-Fi, Wi MAX, UMTS which are considered in this paper is given in table.2. Various parameters that are compared are based on related technologies, penetrations in the market, difficulties of the vendor, buyers capacity, threat from new substitutes in the market.[12]

Results

a) Weighted Sum Method (WSM):

Table 3:

Network	UMTS 1	UMTS 2	WiLan 1	WiLan 2	WiMax 1	WiMax 2
Score	0.0901	0.0925	0.2125	0.2405	0.1824	0.1823
Rank	6	5	2	1	4	3

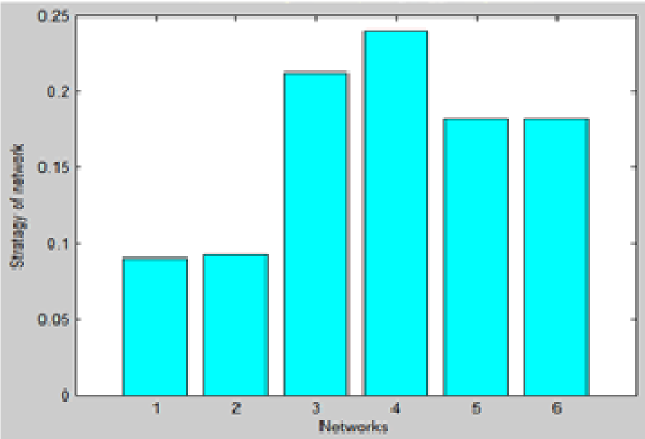

Figure 4: Network selection barchart for WSM

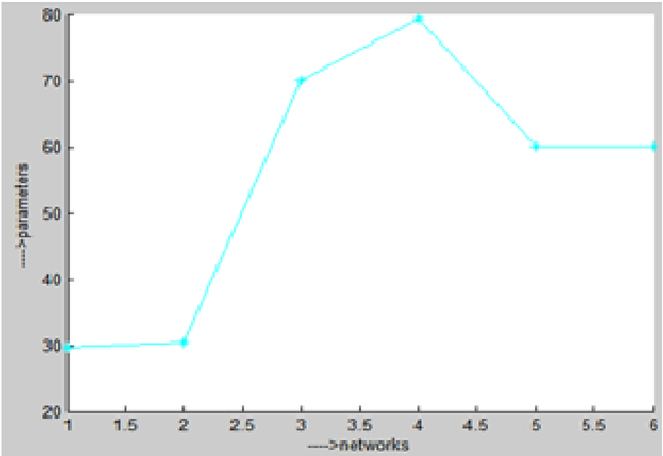

Figure 5: WSM plot

The WPM method simulation results show that Wi-LAN is the best network as it has ranked Wi-LAN-2 as the best network with rank 1in table.3.

b) Weighted Product Method (WPM) :

Table 4:

Network	UMTS 1	UMTS 2	WiLan 1	WiLan 2	WiMax 1	WiMax 2
Score	0.0652	0.0678	0.1776	0.2638	0.2124	0.2131
Rank	6	5	4	1	3	2

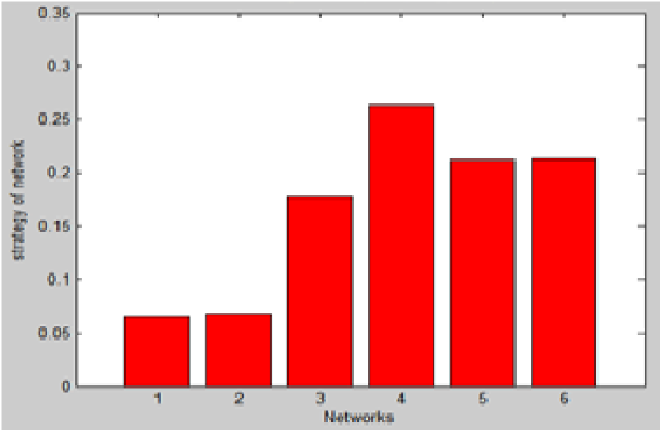

Figure 6: Network selection barchart for WPM

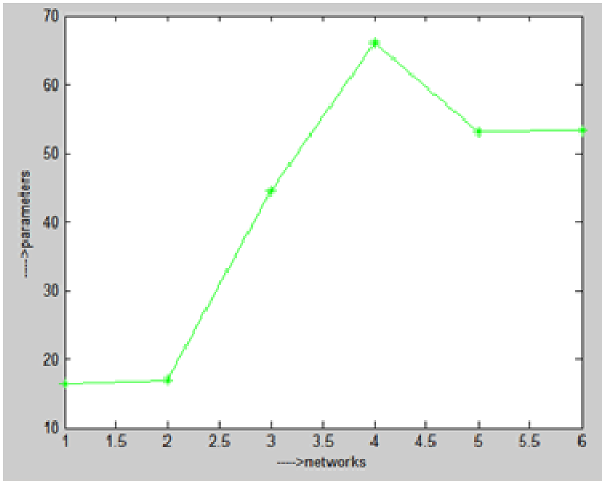

Figure 7: WPM Plot

The WSM method simulation results show that Wi-LAN is the best network as it has ranked Wi-LAN-2 as the best network with rank 1 in table.4.

c) Technique for Order Preference by Similarity to Ideal Solution (TOPSIS):

Table 5:

Network	UMTS 1	UMTS 2	WiLan 1	WiLan 2	WiMax 1	WiMax 2
Score	0.6187	0.6155	0.0809	0.3506	0.6266	0.6100
Rank	2	3	6	5	1	4

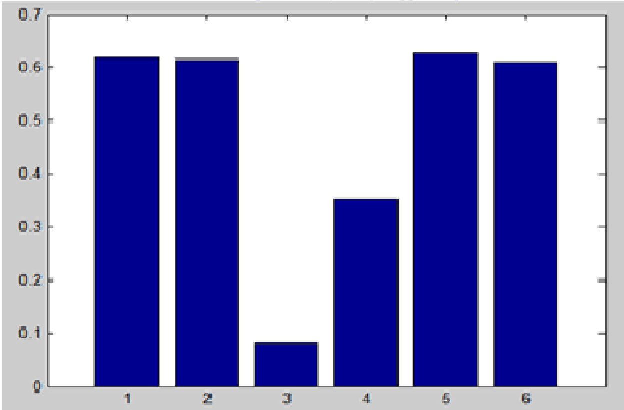

Figure 8: Network selection barchart for TOPSIS

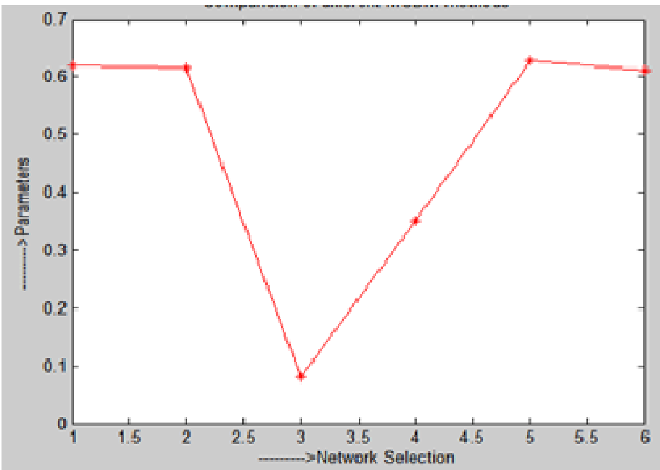

Figure 9: TOPSIS plot

The TOPSIS method simulation results show that Wi-MAX is the best network as it has ranked Wi-MAX-1 as the best network with rank 1 in table.5.

d) Analytical Hierarchy Process (AHP):

Table 6:

Network	UMTS 1	UMTS 2	WiLan 1	WiLan 2	WiMax 1	WiMax 2
Score	0.0520	0.0546	0.2454	0.2941	0.1772	0.1766
Rank	6	5	2	1	3	4

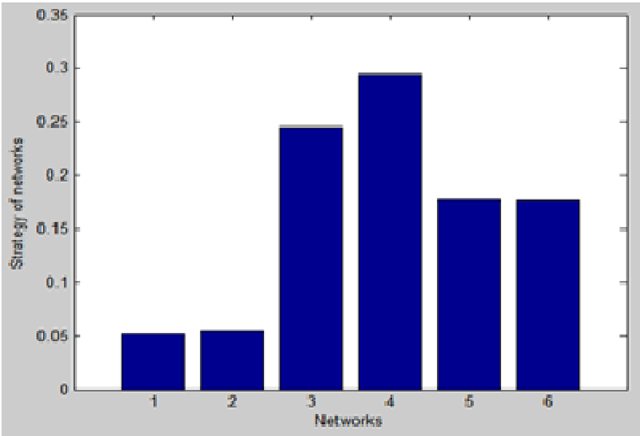

Figure 10: Network selection bar chart for AHP

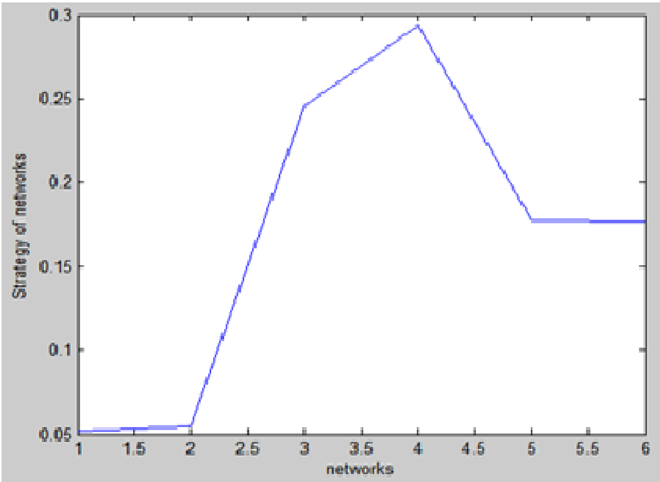

Figure 11: AHP plot

The TOPSIS method simulation results show that Wi-LAN is the best network as it has ranked Wi-LAN-2 as the best network with rank 1 in table.6.

e) Grey Relational Analysis:

Table 7:

Network	UMTS 1	UMTS 2	WiLan 1	WiLan 2	WiMax 1	WiMax 2
Score	0.0520	0.0546	0.2454	0.2941	0.1772	0.1766
Rank	6	5	2	1	3	4

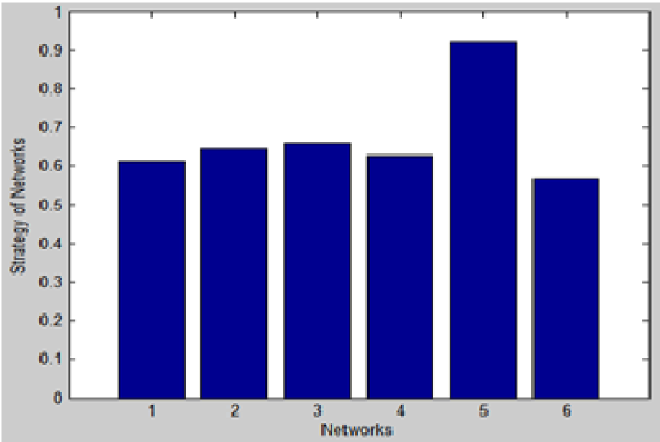

Figure 12: Network selection for Grey relation analysis

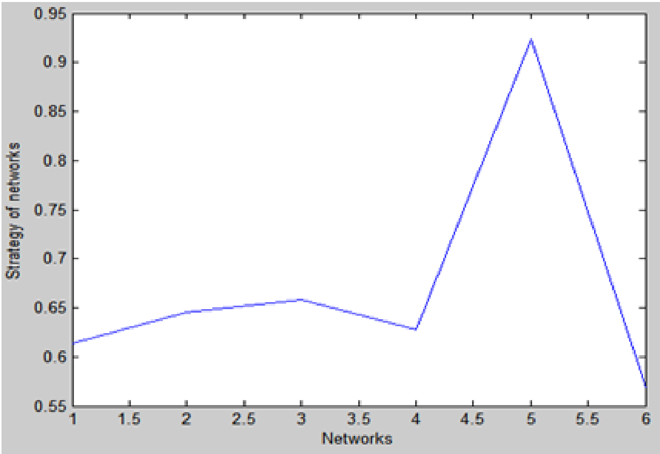

Figure 13: Grey relation analysis plot

The Grey relational analysis method, the simulation results show that Wi-LAN is the best network as it has ranked Wi-LAN-2 as the best network with rank 1 in table.7.

f) Maximum Network Utility-Vertical Handoff algorithm(MNU-VHO) :

Table 8:

Network	UMTS 1	UMTS 2	WiLan 1	WiLan 2	WiMax 1	WiMax 2
U	0.7768	0.7223	0.2688	0.1197	0.4068	0.5220
I	0.4319	0.4270	0.1413	0.0864	0.2232	0.2593
Q	1	0.9343	0.2099	0	0.4267	0.5843
Rank	1	2	5	6	4	3

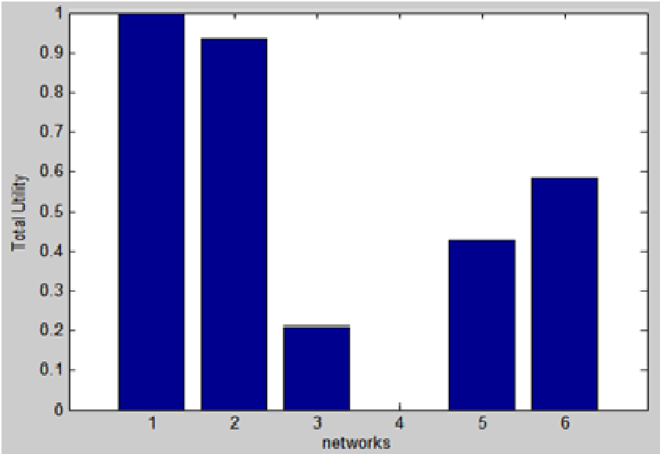

Figure 14: Network selection using MNU-VHO

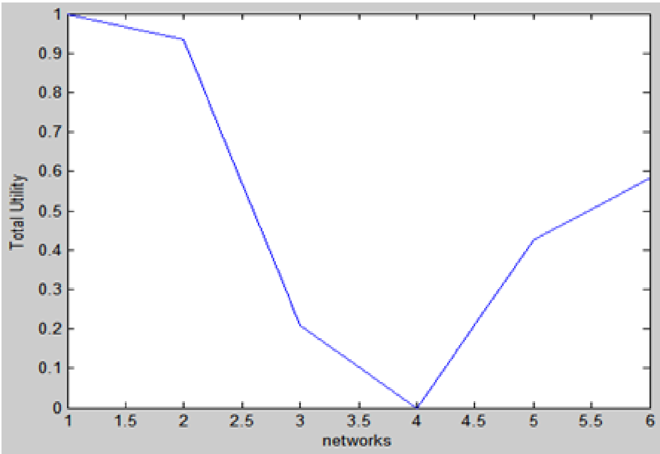

Figure 15: MNU-VHO plot

The New proposed algorithm MNU-VHO algorithm , the simulation results show that UMTS is the best network as it has ranked UMTS-1 as the best network with rank 1 in table.8.

Network Selection Plot for all the Algorithms

The plot for various network selection algorithms is shown in figure.16.

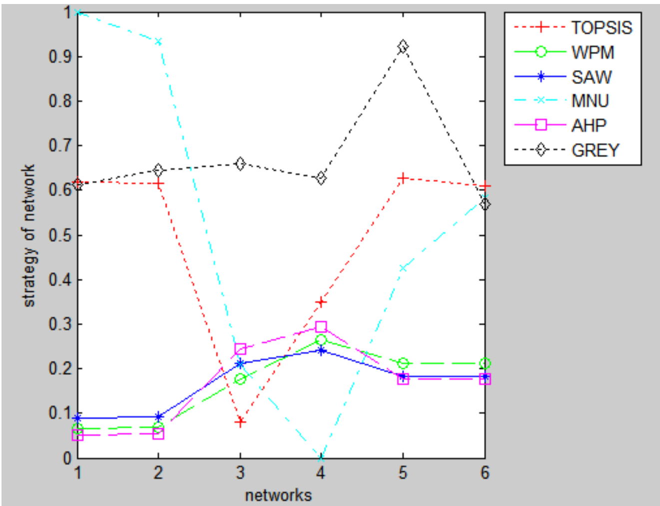

Figure 16: Overall Plot for all methods

Efficiency Table

Table.9

MADM	WSM	WPM	TOPSIS	AHP	GRA	MNU
Efficiency	20.5470	20.5884	22.4491	8.9786	11.5719	36.0834

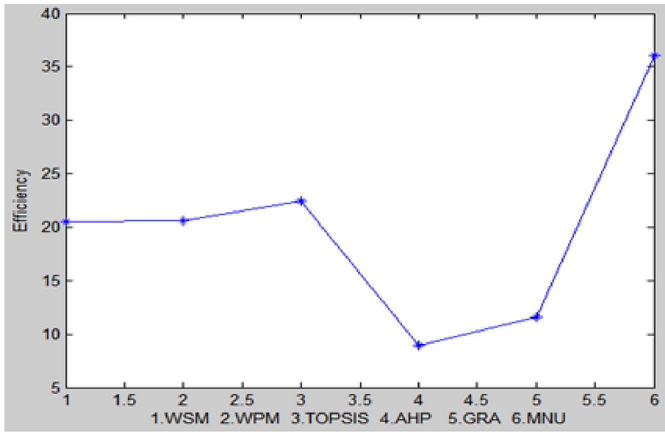

Figure 17: Efficiency Plot for all methods

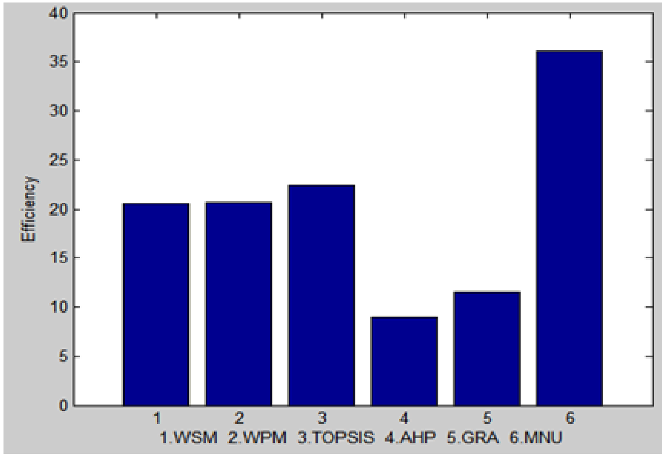

Figure 18: Bar chart for all methods

Conclusion

The paper explores the multiple criteria approach based on QOS to initiate the process of handoff. This paper lays emphasis on the investigation of performance of various handoff algorithms. The performance analysis of the Maximum Network Utility-Vertical Handoff algorithm (MNU-VHO) suggests that this algorithm is the best suited among the various handoff algorithms that are available for handoff decision making process in selecting the best network among various networks that are available for a mobile user to perform handoff. Results show that this algorithm ranks UMTS-1 as the best network as it requires less bandwidth which is major advantage in communication and is having the highest Efficiency (36.0834) when compared with other algorithms for making a handoff decision. This is shown in table.9. The future scope of this specifies that the utility of Vertical Hand Off (VHO) and mobility management can be improved by proposing new test beds.

References:

[1] Yaw Nkansah-Gyekye, "An Intelligent Vertical Handoff Decision Algorithm In Next Generation Wireless Networks" a dissertation submitted in fulfillment of requirements for the degree of Doctor Of Philosophy in the department of computer science, University of the Western Cape, May 2010.

[2] Rajender Kumar, Brahmjit Singh, "Comparison Of Vertical Handover Mechanisms Using Generic QoS Trigger For Next Generation Network", International Journal of next generation Networks(IJNGN),vol2,NO.3, September 2010.

[3] Shanthy Menezas, S. Venkatesan, " A Generic Handover Decision Management Framework For Next Generation Networks", International

Journal of Computer Networks & Communication (IJCNC) Vol.3, No.2, March 2011.

[4] K.Savitha, Dr.C.Chandrasekhar, "Vertical Handover decision schemes using SAW and WPM for Network selection in Heterogeneous Wireless Networks" Global Journal of Computer Science and Technology, Vol 11, issue 9, version 1.0, May2011.

[5] R.Tawil, J.Demerjain and G.Pujolle, " A Trusted Handover Decision Scheme For The Next Generation Wireless Networks", IJCSNS, Vol.8, pp.174-182, June 2008.

[6] K.Savitha, C.Chandrasekhar, " Trusted Network selection using SAW and TOPSIS Algorithms for Heterogeneous Wireless Networks", International Journal of Computer Applications(0975-8887) , Volume 26-No.8,July 2011.

[7] Savitha, K. and Chandrasekar, C.. "Network Selection Using TOPSIS in Vertical Handover Decision Schemes for Heterogeneous Wireless Networks", International Journal of Computer Science Issues (IJCSI), 2011

[8] K. Radhika , Dr.A.Venugopal Reddy, "AHP and Group Decision making for Access Network Selection in Multi-Homed Mobile Terminals", International Journal on Computer Science and Engineering(IJCSE).

[9] K.Savitha, C.Chandrasekhar, "Grey Relation Analysis for Vertical Handover decision Schemes in Heterogeneous Wireless Networks", European Journal of Scientific Research, ISSN 1450-216X Vol.54,No.4(2011),pp.560-568.

[10] E.S. Navarro, V.W.S. Wong, Comparison between vertical handoff decision algorithms for heterogeneous wirelss networks, IEEE 63rd Vehicular Technology Conference, Melbourne, 2006.

[12] LiuSheng-mei; Pan Su; Xu Ming-hai; "An Improved TOPSIS Vertical Handoff Algorithm for Heterogeneous Wireless Networks", 12th IEEE International Conference on Communication Technology (ICCT), 11-14 Nov. 2010, Nanjing; doi:10.11.09/ICCT.2010.5688617

[13] T. Ahmed, K. Kyamakya, M Ludwig, " A context-aware vertical handover decision algorithm for multimode mobile terminals and its performance", in: Proceedings of the IEEE/ACM Euro American Conference on Telematics and Information Systems (EATIS 2006), pp. 19-28.

[14] Aktul Kavas, " Comparative Analysis of WLAN, WiMAX and UMTS Technologies", PIERS Proceedings, August 27-30,Prague,Czech Republic, 2007