MULTI NETWORK HANDOVER DECISION USING EXTENDED MULTI CRITERIA DECISION MAKING TECHNIQUE

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Abstract: *In a heterogeneous environment various wireless networks are coexisting simultaneously. This environment is formed by integrating various radio access technologies like Wireless in Local Loop (WLL/WLAN), WirelessWwide Area Network (WWAN), Cellular etc. These technologies offer users to connect to network at anytime and anywhere. Now the mobile devices are equipped with multiple interface terminals so that the devices can select the best network. Selecting a suitable network which satisfies the different need is very complex task in heterogeneous network. The decision is based on different network criteria and user's information. In this paper a handover decision technique is presented which is used to select most appropriate network among various networks.*
Keywords: *Heterogeneous wireless network, vertical handover, seamless mobility, mobile node, received signal strength.*

1. Introduction

Now a days with the advancement of wireless technology several wireless networks with different access technologies can coexist simultaneously and will try to satisfy the users need and requirement. In a heterogeneous wireless environment, different networks are integrated in order to provide the user with best services. Mobile devices equipped with multiple interface terminal avails the advantage of different types of networks present in heterogeneous environment. However, different issues such as authentication, quality of service, user's mobility, authorization etc. need to be considered during design & development of heterogeneous networks. Many mechanisms have been proposed which combines different wireless technologies [1-3]. However, seamless mobility in heterogeneous environment creates challenges such as vertical handoff, mobility management etc. Handoff is one of the chief issues that will be considered in heterogeneous environment.

Proper handover management must ensure that there is no interruption to running applications during handoff. In general, the handover operation can be separated in three phases Handover Initiation Phase, Handover Preparation Phase and Handover Execution. The handover initiation phase is used to collect the information about the network. It also collects some other information such as network properties, mobile devices, access points, and user preferences. In this phase, the information is collected and is to be used for making decisions in the handover preparation phase. The outcome of this phase is the selection of the target network. Based on the information collected from handover initiation phase, the handover preparation phase is used to give information about decision of "when" and "where" to trigger the handover. The "when" decision refers to the time to make an optimal handover, while the "where" refers to selecting the best network fulfilling the requirements for the switching. The handover execution phase is responsible for the handover execution and also guarantees a smooth session transition process. This includes the events concerning the disconnection from the previous network and the connection to the target one.

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The paper is organized as follows. Section 2 presents review of literature. Section 3 presents the proposed vertical handover decision algorithm. Section 4 focuses on simulation results and conclusion in present in section 5.

2. Litreature Review

Various approaches have been developed and proposed in order to facilitate and to improve the vertical handover decision. Duk Kyung Kim et al. [4] proposed a call admission control algorithm for multi environment wireless network. In their algorithm the user considers available resources & location of cellular users and based on theses preferences the WLAN changes adaptively. In [5] Taehoon Kim et al. proposed an algorithm that was based on service history. Their proposed vertical handover decision algorithm reduces the handoff dropping probability, number of handoffs, and reduces the cost. Y. Wu et al. [6] proposes a traffic/load aware handoff algorithm for multi network wireless environment. Their algorithm provides users a seamless mobility between cellular network & ad hoc network as compared to received signal strength based traditional algorithms. Their simulation result shows a lesser call drop rate as compared to traditional signal strength based handoff during the handoff procedure. In [7] Racha Ben Ali et al. proposed a vertical handover decision algorithm which considers multi region mobility model. The proposed region prevents degradation in quality of service for voice traffic during handoff. Manoj Sharma & R.K. Khola in [8] proposed a vertical handover decision algorithm that takes the advantage of predicted value of received signal strength. They consider Bandwidth, Predicted received signal strength & users preference as the input parameter for handoff decision. The simulation result shows that proposed algorithm makes accurate handoff decision and improves the performance result. Kaveh Shafiee et al. [9] propose a vertical handover decision algorithm for WLAN & Cellular System. Their simulation result shows that for lower speed mobile nodes they need vertical handover decision algorithm and for high speed nodes it is better to stay in cellular network and avoid the vertical handover decision algorithm. In [10] Sukyoung Lee et al. propose a vertical handover decision algorithm that optimize the cost, battery life time and load balancing. Their algorithm allows the proxy node to share the load. This sharing helps in balancing the power consumption of battery.

In [11] Manoj Sharma, R.K. Khola proposed a vertical handover algorithm in which they consider quality of service , bandwidth and cost as input parameters for handover decision. They use TOPSIS method to rank the available networks and based upon rank the optimal networks was selected. In [12] authors propose Sugeno Fuzzy Inference System based vertical handover decision algorithm. They consider available bandwidth, network load and signal strength as input parameter for handoff decision. The value of these inputs is feed into inference system and the output is handoff decision. In [13] Ali Çalhan and Celal Çeken propose an adaptive fuzzy based handoff decision algorithm. They consider data rate, cost and received signal strength indication as training elements for adaptive neuron fuzzy inference system. The simulation result shows that proposed algorithm reduces the number of handoff as compared to Fuzzy Logic & Simple Additive Weighting based algorithms. In [14] Manoj Sharma et al. present a handover algorithm for WWAN & WLAN heterogeneous wireless environment. They consider bandwidth, received signal strength & coverage area as input parameter for mamdani based fuzzy inference system. The output is handoff decision and by evaluating the output value one can decide whether to handoff or not.

3. AHP & TOPSIS Based Algorithm For Vertical Handover Decision

Vertical handover's ensures that a mobile terminal can seamlessly move from one base station to another base station when the conversation or data transfer is going on. Failure of handover leads to break in service. In order to ensure that the mobile terminal can chose the most suitable network amongst available networks, there is a need of intelligent handover algorithm. In this section a vertical handover based on AHP & TOPSIS is proposed. The AHP is used for determining the weight of different criteria's. On the basis of weights that are defined by AHP, TOPSIS is used for ranking the network. The network having highest rank will be selected as target network. So the handover algorithm is divided into two steps. First step is defining the weight of parameters by using AHP and in second step rank of network is obtained using TOPSIS & weight of parameters. The methodology can be explained as:

AHP

- ❖ Identify the criteria's/parameters
- ❖ Construct an AHP hierarchy
- ❖ Compute pair wise comparison of matrix for the identified parameters/criteria's
- ❖ Construct normalized matrix
- ❖ Calculate the eigen value and eigen vector
- ❖ Calculate weight & priority vector
- ❖ Calculate Consistency Index (C.I.) and Consistency Ratio (C.R.) and perform the Consistency Test

TOPSIS

- ❖ Construct decision matrix
- ❖ Normalize the decision matrix
- ❖ Construct weighted (calculated by AHP) normalized decision matrix
- ❖ Calculate the positive ideal and negative ideal solution
- ❖ Calculate the similarity distance of separation for each Criteria
- ❖ Rank the alternatives

4. Simulation Results & Discussion

We consider three wireless access technologies in our model namely UMTS, WIMAX & WLAN. We consider 2 types of traffic classes for various applications. These traffic classes are conversational class for application of voice traffic & video class for the application of multimedia traffic. Received Signal Strength (RSS), Available Bandwidth (BW), Cost (C) and Network Load (NL) are the parameters on which the handover decision is based. There may be some other parameters which may be considered. Figure 1 shows the simulation model of heterogeneous wireless environment consisting of UMTS, WIMAX & WLAN.

In this paper we present a comparison between our algorithm and standard deviation method based algorithm which is as follows-

- Standard Deviation Method (SDM): It is an approach in which the weight of each attribute is calculated by Standard Deviation method.
- AHP & TOPSIS (AT): It is proposed approach in which the weight of each attribute is calculated by AHP method.

The performance for conversational traffic & video traffic is evaluated.

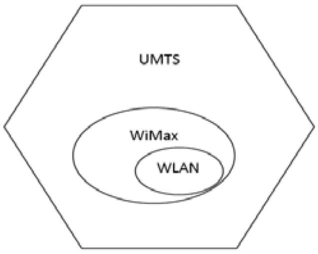

Figure 1. Simulation model of heterogeneous wireless environment

4.1. Case 1: Conversational Traffic

According to our proposed method the entire algorithm is divided into two steps. The first step, AHP method, is used for finding the weight of the given parameters. The second step, TOPSIS method, is used for ranking the available networks. A pairwise comparison matrix of parameters for conversational traffic is shown in Table 1.

Table 1. Pairwise comparison matrix for conversational traffic

Parameter	NL	RSS	BW	C
NL	1	½	2	1
RSS	2	1	4	3
BW	½	¼	1	½
C	1	1/3	2	1

Now we have to calculate the Weight (W) & Priority Vector (PV) for each parameter. These will be calculated with the help of standardized matrix which is shown in Table 2.

Table 2. Weight & priority vector

	NL	RSS	BW	C	W	PV
NL	0.2222	0.2400	0.2222	0.1818	0.2166	0.8690
RSS	0.4444	0.4800	0.4444	0.5454	0.4786	1.9345
BW	0.1111	0.1200	0.1111	0.0909	0.1083	0.4345
C	0.2222	0.1600	0.2222	0.1818	0.1966	0.7892

Consistency test has to be performed to validate the subjective judgment of the matrix. In this test if the value of Consistency Ratio (C.R) is less than 0.1 then only allowable otherwise we have revise the subjective judgment. The C.R can be calculated as

$$C.R = \frac{C.I}{R.I} \quad (1)$$

Where C.I is Consistency Index & R.I is Random Index.

From Table 2 the calculated value of C.I is 0.006873 & R.I is 0.09. For these values C.R is 0.0077 which is less than allowable value i.e. 0.1. Figure 2 shows a comparison of weights associated with parameters calculated by SDM & AT.

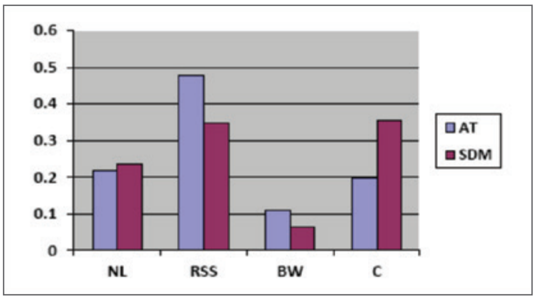

Figure 2. Weight associated with different parameters for conversational traffic

From Figure 2 we notice that proposed AHP method assigned highest weight to RSS and then to NL, whereas SDM assigned highest weight to cost parameter and then to RSS instead of giving priority to RSS which is most important criteria in handoff decision. After assigning weight to each parameter now we have to assign rank to each network on the basis of weights associated with each parameter. TOPSIS is used for assigning rank to each network & the network having highest rank will be selected as target network. As the mobile terminals are equipped with multiple terminal interface devices, the values of parameters (RSS, NL, B & C) for the three networks are collected. The parameters have different values and different unit of measurement so in order to compare the parameter it is necessary to normalize the parameters. Normalization ensures that the values in different units are meaningful. The normalization for cost parameter i.e. parameter where lowest value is considered as best can be given as

$$N(x) = \frac{xmax - x}{xmax - xmin} \quad (2)$$

Where x is actual value & x_{min} & x_{max} are minimum & maximum values respectively.

The normalization for B, RSS & NL i.e. for parameters where highest value is considered as best can be given as

$$N(x) = \frac{x - xmin}{xmax - xmin} \quad (3)$$

Table 3 shows the normalized matrix and weighted matrix for conversational traffic. From the weighted matrix positive ideal and negative non ideal solution is determined. These can be given as:

Ideal solution I^+ = {0.1732, 0.3637, 0.4000, 0.1376};

Non Ideal solution I^- = {0.0801, 0.0526, 0.0270, 0.0196};

Table 3. Normalized and weighted matrix

Normalized Matrix				
	NL	RSS	BW	C
UMTS	0.37	0.42	0.30	0.10
WIMAX	0.80	0.76	0.25	0.65
WLAN	0.50	0.11	0.37	0.70
Weight	0.2166	0.4786	0.1083	0.1966
Weighted Matrix				
UMTS	0.0801	0.2010	0.0324	0.0196
WIMAX	0.1732	0.3637	0.0270	0.1277
WLAN	0.1083	0.0526	0.0400	0.1376

With the help of these ideal and non ideal solutions the Euclid alternative distance is calculated. The corresponding rank of the candidate can be given as:

$$D_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad ; D \in (0, 1) \quad (4)$$

Where D^+ is the Euclid alternative distance for positive ideal solution & D^- is Euclid alternative distance for negative non ideal solution. The value of D_i for UMTS, WIMAX & WLAN is 0.4012, 0.9721 & 0.2753 respectively. Here WIMAX has highest value so it is selected as target network for conversational traffic.

4.2. Case 2: Video Traffic

Video traffic is considered in this case. Video traffic requires more bandwidth as compared to conversational traffic. Table 4 shows the pair wise comparison matrix for video traffic.

Table 4. Pair wise comparison matrix for video traffic

Parameter	BW	RSS	C	L
BW	1	3	5	3
RSS	1/3	1	5	3
C	1/5	1/5	1	1/3
NL	1/3	1/3	3	1

With the help of pair wise comparison matrix, standardized matrix, weight & priority vector for each parameter is calculated. Table 5 shows the weight & priority matrix for each parameter. Consistency test is performed and the value of C.R is 0.073 which is less than 0.1. Figure 3 shows comparison of weights associated with different parameters.

Table 5. Weight & priority vector

	BW	RSS	C	NL	W	PV
BW	0.5357	0.6617	0.3571	0.4090	0.4908	2.1455
RSS	0.1785	0.2205	0.3571	0.4090	0.2912	1.2358
C	0.1071	0.0441	0.0714	0.0454	0.0670	0.2728
NL	0.1785	0.0661	0.2142	0.1363	0.1487	0.6102

Highest weight is assigned to bandwidth in voice traffic. After assigning weight to each parameter, rank has to be assigned to each network. TOPSIS is used to assign rank to each network and the network having highest rank will be assigned as target network. Normalization of each parameter is performed which ensures that every parameter has meaningful values. Normalization can be done by eq. (2) & (3).

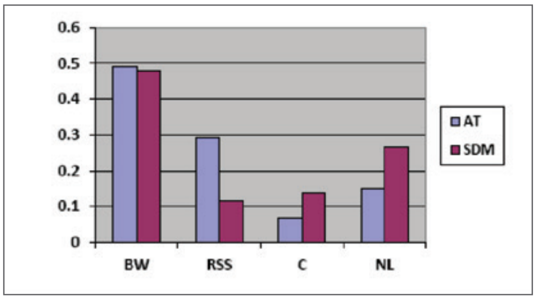

Figure 3. Weight associated with different parameters for video traffic

Table 6 shows the normalized matrix and weighted matrix for video traffic. From the weighted matrix positive ideal and negative non ideal solution is determined. These can be given as:

Ideal solution I+ = {0.1189, 0.1892, 0.4515, 0.0502};

Non Ideal solution I-= {0.0520, 0.1310, 0.0736, 0.0335};

With the help of these ideal and non ideal solutions the Euclid alternative distance is calculated using eq. (4). The value of Di for UMTS, WIMAX & WLAN is 0.1895, 0.0412 & 0.8724 respectively. Here WLAN has highest value so it is selected as target network for video traffic. Figure 4 shows the rank for both conversational & video traffic.

Table 6. Normalized and weighted matrix

Normalized Matrix				
	NL	RSS	BW	C
UMTS	0.80	0.60	0.20	0.50
WIMAX	0.35	0.45	0.15	0.75
WLAN	0.43	0.65	0.92	0.60
Weight	0.1487	0.2912	0.4908	0.067
Weighted Matrix				
UMTS	0.1189	0.1747	0.0981	0.0335
WIMAX	0.0520	0.1310	0.0736	0.0502
WLAN	0.0639	0.1892	0.4515	0.0402

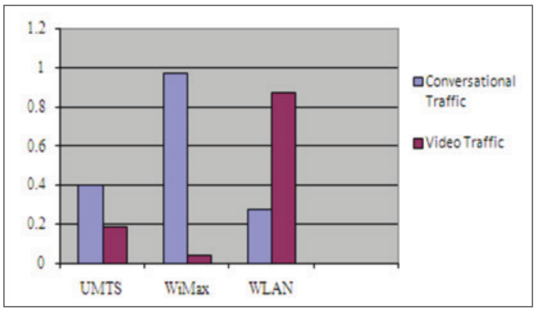

Figure 4. Rank of networks for conversational & video traffic

5. Conclusion

Vertical handover decision algorithm is proposed in this paper. Failure of vertical handover leads to breakup of ongoing call. The proposed algorithm takes the advantage of AHP & TOPSIS method for vertical handover decision. AHP shows better performance in assigning the weight to each parameter than standard devotion method of assigning the weights. In the algorithm TOPSIS is used to assign rank to each network. WIMAX is suitable for conversational traffic whereas WLAN is suitable for video traffic. An intelligent handover algorithm is proposed in this paper which is used for deciding "where" to handoff.

6. References

[1] Buddhikot M, Chandramenon G, Han S, Lee Y.W, Miller S, Salgarellim L, "Integration of 802.11 and Third –Generation Wireless Data Networks" *in proceedings of IEEE Infocom 03.Conference on Computer Communications;* San Francisco, USA, March 30-3 April 2003, vol. 1, pp. 503-512.

[2] Verma V, Ramesh S, Wong K, Friedhoffer J, "Mobility Management in Integrated UMTS/ WLAN Networks", *in proceedings of IEEE International Conference on Communications;* Ottawa, Canada, 11-15 May 2003, vol. 2, pp.1048-1053.

[3] Salkintzis A K, "Internetworking Techniques and Architectures for WLAN/3G Integration Toward 4G Mobile Data Networks", *IEEE Wireless Communications,* Vol. 11, No.3, pp 50-61. 2004.

[4] Kim D K, Griffith D, Golmie N, "A New Call Admission Control Scheme for Heterogeneous Wireless Networks", *IEEE Transitions on Wireless Communication,* Vol. 9, No. 10, pp. 3000-3005, 2010.

[5] Kim T, Han S W, Han Y, "A Qos-Aware Vertical Handoff Algorithm Based on Service History Information", *IEEE Communication Letter,* Vol. 14, No. 6, pp.527-529, June 2010.

[6] Wu Y, Yang K, Zhao L, Cheng X, "Congestion-Aware Proactive Vertical Handoff Algorithm in Heterogeneous Wireless Networks", *IET Communications,* Vol.3,No. 7, pp.1103–1114, 2009.

[7] Ali R B, Pierre S, "On The Impact of Mobility and Soft Vertical Handoff on Voice Admission Control in Loosely Coupled 3G/WLAN Networks", *IEEE Communication Letter,* Vol.13, No.5, pp.303-305, May 2009.

[8] Sharma M, Khola R K, "Fuzzy Logic Based Handover Decision System", *CiiT International Journal of Wireless Communication,* Vol.4, No.13, pp.801-806, August 2012.

[9] Shafiee K, Attar A, Leung V C M, "Optimal Distributed Vertical Handoff Strategies in Vehicular Heterogeneous Networks", *IEEE Journal on Selected Areas of Communication,* Vol. 29, No.3, pp.534-544, March 2011.

[10] Lee S K, Sriram K, Kim K, Kim Y H, Golmie N, "Vertical Handoff Decision Algorithms For Providing Optimized Performance in Heterogeneous Wireless Networks", *IEEE Transitions on Vehicular Technology,* Vol. 58, No. 2, pp.865-881, February 2009.

[11] Sharma M, Khola R K, "Pre Decision Based Handoff in Multi Network Environment", *Advances in Intelligent and Soft Computing,* Vol.167, pp.609-616, 2012.

[12] Sharma M, Khola R K, "An Intelligent Approach for Handover Decision in Heterogeneous Wireless Environment", *International Journal of Engineering,* Vol. 4, No.5, pp.452-462, December 2010.

[13] Çalhan A, Çeken C, "An Adaptive Neuro-Fuzzy Based Vertical Handoff Decision Algorithm for Wireless Heterogeneous Networks", *in proceedings of 21st Annual IEEE International symposium on Personal, Indoor and Mobile Radio Communication*; Istanbul, Turkey, 26-29 September 2010, pp. 2271-2276.

[14] Sharma M, Khola R K, "An Intelligent Handover Decision System for Multi Network Environment", *Istanbul University-Journal of Electrical & Electronics Engineering,* Vol.9, No. 2, pp.1067-1072, 2009.

[15] Saaty T.L.(1980). *The Analytic Hierarchy Process.* New York: McGraw-Hill,

[16] Hwang CL, Yoon K (1981). *Multiple Attribute Decision Making Methods and Applications,* Berlin Heidelberg: Springer.

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