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A Velocity Based Vertical Handover Decision Technique Using TOPSIS Method

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Abstract

With the growth of wireless technology, different types of networks are available to the mobile users. A mobile node (MN) can connect to these heterogeneous wireless networks with multiple interfaces. When a mobile device is moving at a high speed, the performance of running applications on a MN gets affected. In this paper, a velocity based Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) is analysed. Analytic Hierarchy Process (AHP) is used for relative important weights of different attributes with respect to the objective of selection of a network. Along with velocity, data rate, delay, cost and jitter are considered for handover decision in Wireless LAN (WLAN), Universal Mobile Telecommunication Systems (UMTS), and Worldwide Interoperability for Microwave Access (WiMax) networks. Four classes of applications are analysed that includes VOIP, video streaming, and video conferencing and background applications. Results show that for VOIP application, UMTS network is preferred while for the other applications WLAN is chosen in slow moving nodes, WiMax for moderate speeds and UMTS for very fast moving nodes.

Keywords: Vertical Handover, heterogeneous networks, TOPSIS, mobility, velocity.

Introduction

Internet can be accessed by small hosts like cell phones, tablets, laptops etc. These small hosts are portable and can be used to access the Internet in vehicles. Therefore, demand of internet connectivity on the move is arising. A user wants to connect to the network that provides his/her quality of service (QoS) requirements. These QoS parameters will vary from one application to another. When anode is moving between the ranges of different networks, selecting the best network is a challenge. When the selection of network is between same types of networks, it is called horizontal handover. If this selection is to be made on different types of networks, it is called vertical handover [1]. Vertical handover occurs in heterogeneous networks. A typical scenario of vertical handover is illustrated in Figure 1. A MN is moving within the ranges of heterogeneous networks WLAN, WiMax and UMTS. Traditional handover schemes make the handover decision based on received signal strength (RSS) only. But other QoS parameters are needed to make this decision to provide smooth handover. Also velocity should be included in decision parameters to provide seamless handover. When a node is moving at high speeds, it does not have enough time to complete the handover. So, there is a need of velocity based handover mechanism to achieve smooth and seamless handover.

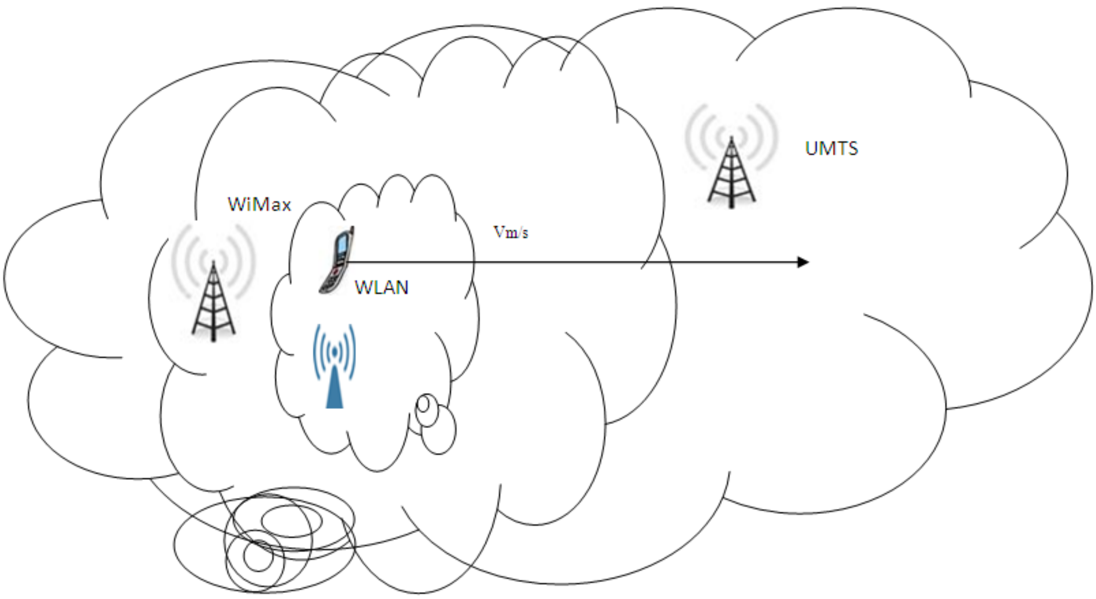

Figure 1: Scenario of mobile user moving within the ranges of heterogeneous networks

In this paper, aTOPSIS based vertical handover decision technique based on velocity and other QoS parameters is proposed. Relative importance of different attributes is decided by AHP. Four types of applications are evaluated *i.e.* VOIP, streaming, video conferencing and background. Ratio of each network is calculated for all the networks for each application at different velocities. A suitable network is chosen for the specific application type based on these ratios. Rest of the paper is organized as follows. Section 2 illustrates the related work in network selection. In section 3 TOPSIS based network selection mechanism is proposed. A network is selected having velocity as a critical attribute, *i.e.*, it has given more importance with respect to other attributes. In Section 4, results of the proposed scheme is shown and discussed. Conclusion of the paper is shown in section 5.

Related Works

Many MADM (Multiple Attribute Decision Making) methods are available in literature [3]. Many researchers have applied these methods for making vertical handover decision. AHP and GRA (Grey Rational Analysis) based technique where AHP is used for selection criteria and GRA evaluates heterogeneous networks is presented in [4]. Mohamed Lahby et al. [5] have proposed an enhanced TOPSIS method by using the Analytic Network Process to weigh the criteria and then apply the TOPSIS method. Different fuzzy based MADM methods have also been used for vertical handovers [6]. Fuzzy logic and TOPSIS method is used to reduce the number of handovers and increase user satisfaction [7]. Xinjun Liu et al. [8] have proposed fuzzy TOPSIS based network selection for heterogeneous networks based on connection number a+bi where a denotes the certainty number and bi denotes the uncertainty number in the fuzzy language number. Falwo et al. [9] have presented TOPSIS based network solution considering maximum data rate, security, delay, battery power consumption and cost. This method selects the network based on single application or multiple applications.. Mohamed Lahby et al. [10] have presented the novel validation approach for network selection by considering the group weighting techniques for MADM methods. AHP method is applied to determine the weight of interclass and intra class attributes.

All the above mentioned techniques considered various attributes like data rate, delay, jitter, cost, security, battery consumption or energy *etc.* But these methods ignore mobility of mobile device which is an important attribute while accessing Internet inside vehicles. Some researchers have tried to incorporate velocity of the device while taking network selection decision. Abolfazi et al. [11] have incorporated velocity in fuzzy extension to VIKOR for network selection. But velocity of the device is varied for 0-10 (m/s), which is not appropriate for fast moving vehicles. S. Dhar et al. [12] have also proposed mobility based AHP method for selecting the network. Also, an intelligent system based on neural networks has been presented.

In this paper we have demonstrated the affect of mobility in four traffic classes. Mobility is calculated as 10 point scalability based on the different ranges that a specific network can support. Detailed network selection scheme is presented in section 3.

Proposed Technique

The vertical handover decision is based on five attributes namely data rate, mobility, cost, delay and jitter. The basis of selection of these attributes is obtained from literature [5-12]. Hwang and Yoon [13] had developed the TOPSIS method in 1981.Three networks are considered for network selection i.e., WLAN, WiMAX and UMTS. Four types of applications are considered namely, conversational, interactive, streaming and background. We assumed that the maximum mobility that a network can provide is 15 m/s, 60 m/s and 100 m/s for WLAN, WiMAX and UMTS respectively. Mobility is calculated on 10 point scale as follows 10-9*(velocity/maximum mobility of network). The TOPSIS process for the network selection process is as follows:

Step1: The first step is objective formulation. In our case, objective is to select the best network from the alternatives of three networks.

Step2: Obtain the matrix based on the information of all the alternatives. Matrix for our problem is as shown in Table 1.

Table 1: Network Selection metrics for candidate networks

Network	Data rate (Mbps)	Mobility (m/s)	Cost	Delay (ms)	Jitter (ms)
WLAN	50	10-9*(v/15)	1	110	10
WiMAX	25	10-9*(v/60)	3	100	3
UMTS	2	10-9*(v/100)	5	35	5

Step 3: Obtained the normalized decision matrix as shown in equation (1), where $m_{i,j}$ is the element of the matrix gives the jth attribute of ith alternative. M is the order of the matrix.

$$R_{i,j} = \frac{m_{i,j}}{[\sum_{j=1}^{M} m_{i,j}^2]^{1/2}} \tag{1}$$

Step4: Make the relative importance matrix using AHP. Every application will have different relative importance matrix. For conversational applications, bandwidth and cost requires less data rate as compared to delay and jitter. Interactive applications require higher data rate and lower delay. For video streaming and background applications, data rate has given more importance than delay and jitter.

Table 2: Relative importance of different attributes in conversational applications

	Data rate	Mobility	Cost	Delay	Jitter
Data rate	1	0.11	1	0.14	0.20
Mobility	9	1	9	3	5
Cost	1	0.11	1	0.33	0.33
Delay	7	0.33	5	1	2
Jitter	5	0.2	5	0.5	1

Table 3: Relative importance of different attributes in interactive applications

	Data rate	Mobility	Cost	Delay	Jitter
Data rate	1	0.33	5	1	2
Mobility	3	1	9	3	5
Cost	0.20	0.11	1	0.2	0.33
Delay	1	0.33	5	1	2
Jitter	0.50	0.2	5	0.5	1

Table 4: Relative importance of different attributes in streaming applications

	Data rate	**Mobility**	**Cost**	**Delay**	**Jitter**
Data rate	1	0.33	7	2	3
Mobility	3	1	9	5	7
Cost	0.14	0.11	1	0.33	0.5
Delay	0.5	0.20	5	1	2
Jitter	0.33	0.14	3	0.5	1

Table 5: Relative importance of different attributes in background applications

	Data rate	**Mobility**	**Cost**	**Delay**	**Jitter**
Data rate	1	0.33	7	3	3
Mobility	3	1	9	5	5
Cost	0.14	0.11	1	0.33	0.33
Delay	0.33	0.20	5	1	1
Jitter	0.33	0.2	5	1	1

Delay attribute is more important to video streaming than in background applications. Relative importance matrices for different type of applications are shown in Table 2, Table3, Table 4 and Table 5 respectively.

Consistency Ratio (CR) values is shown in Table 6. A *CR* of 0.1 or less is acceptable. From Table 6, it is evident that all the considered matrices are consistent.

Table 8: CR values for different applications

Application	**Conversational**	**Interactive**	**Streaming**	**Background**
CR	0.084842	0.041265	0.084842	0.081734

Step 5: Obtain the weighted normalized matrix $V_{i,j}$ as shown in equation (2). w_j is the weight given by AHP method in each application.

$$V_{i,j} = w_j R_{i,j} \tag{2}$$

Step 6: Obtain the ideal best (V^+) and ideal worst (V^-).

$$V^+ = \{(\textstyle\sum_i^{max} V_{i,j/j\in J}), (\textstyle\sum_i^{min} V_{i,j/j\in J'})\},\ i = 1,2,3 \dots \dots N\}, \tag{3}$$

$$= \{V_1^+, V_2^+, V_3^+, \dots . V_M^+\}$$

$$V^- = \{(\textstyle\sum_i^{min} V_{i,j/j\in J}), (\textstyle\sum_i^{max} V_{i,j/j\in J'})\},\ i = 1,2,3 \dots \dots N\}, \tag{4}$$

$$= \{V_1^-, V_2^-, V_3^-, \dots . V_M^-\}$$

J is associated with beneficial attributes like data rate and mobility and J' is associated with non beneficial attributes like cost, delay and jitter. V_j^+ indicates the ideal value of the specific attribute of all the alternatives. V_j^- indicates the worst value of the attribute among alternatives.

Step 7: The separation measures from ideal solution are given by the Euclidian distance as shown in the following equations.

$$S_i^+ = \{\sum_{j=1}^{M}(V_{i,j} - V_j^+)^2\}^{.5},\quad \text{i=1,2,.....N} \tag{5}$$

$$S_i^- = \{\sum_{j=1}^{M}(V_{i,j} - V_j^-)^2\}^{.5} ,\ \text{i=1,2,.....N} \tag{6}$$

Step 8: The relative closeness of alternative to the ideal solution P_i can be expressed as follows.

$$P_i = \frac{S_i^-}{S_i^+ + S_i^-} \tag{7}$$

Step 9: A set of alternatives in descending order is obtained from the ratio P_i.

Results and Discussion

Based on the ratios obtained from TOPSIS method, handover decision is made. When a MN is not moving, the WLAN is most preferred network due to high data rates, but in case of VOIP application where data rate is not important, UMTS is the most preferred network as shown in Figure 2. When the nodes are moving at more than

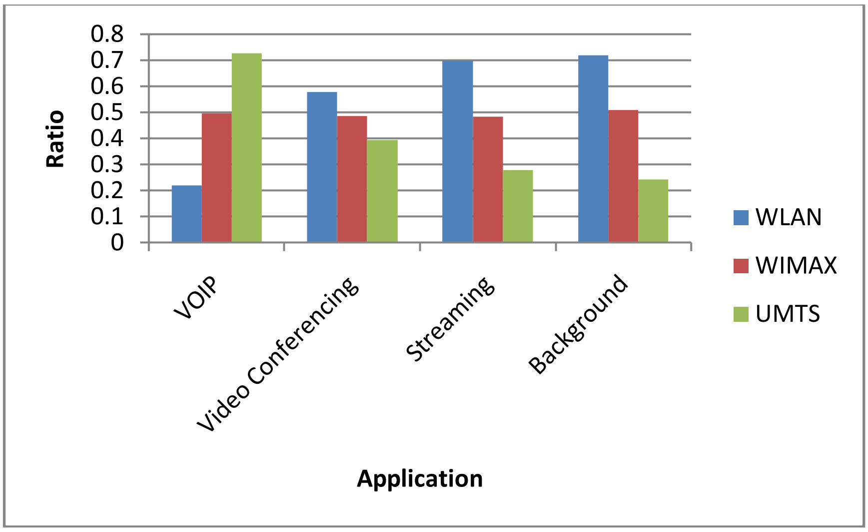

Figure 2: TOPSIS ratio of different applications in stationary nodes.

10m/s, the ratios of WLAN are no more the best. Wimax is the preferred choice in video conferencing application up-to 25m/s, while in streaming and background applications it remains the best choice up-to 30m/s. For higher speeds UMTS is ranked above in all of the applications. The various TOPSIS ratios of mobile nodes at different velocities are shown in Figure 3-6.

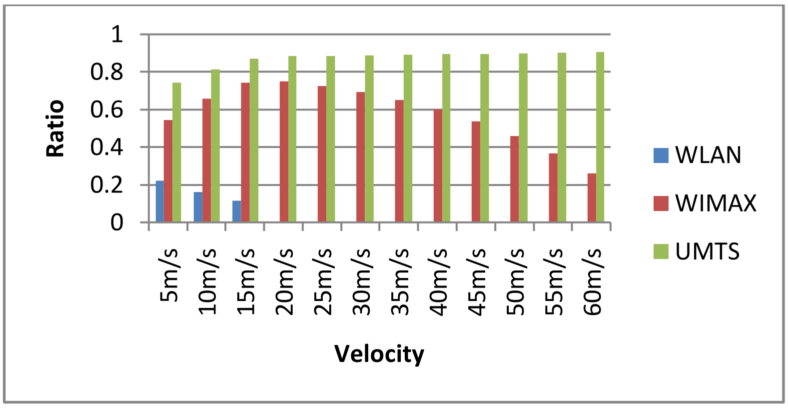

Figure 3: TOPSIS ratio of networks for VOIP application at different velocities.

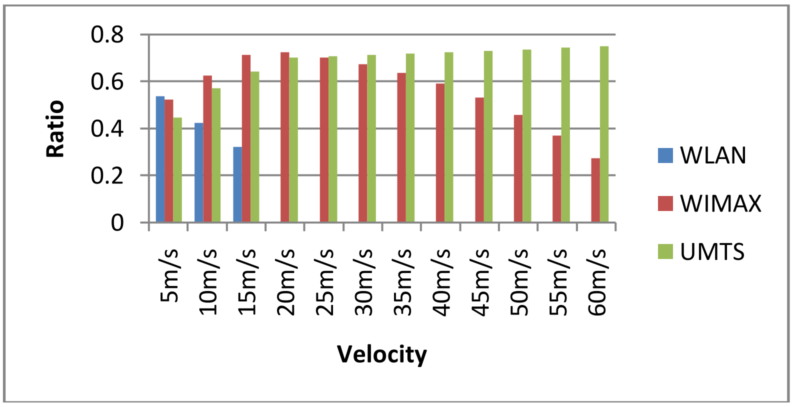

Figure 4: TOPSIS ratio of networks for video conferencing application at different velocities.

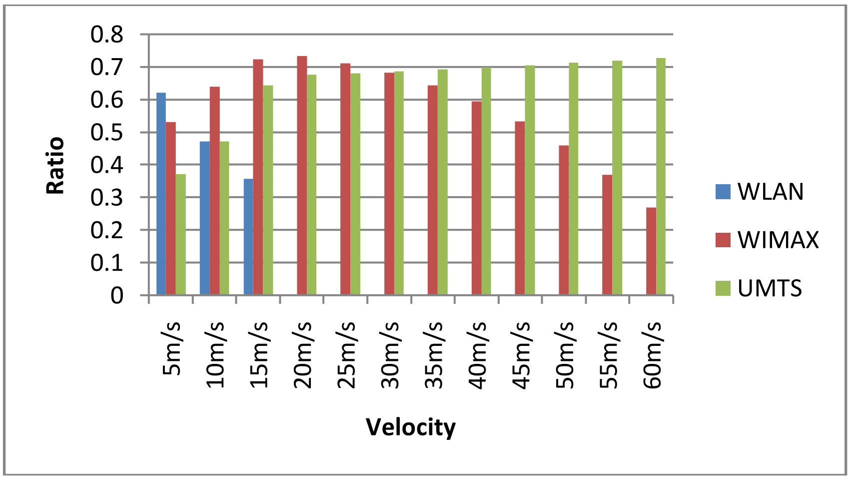

Figure 5: TOPSIS ratio of networks for video streaming application at different velocities.

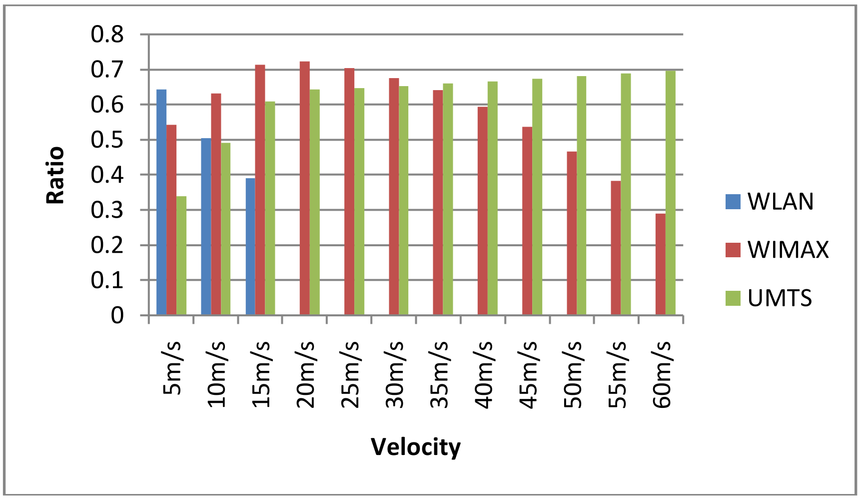

Figure 6: TOPSIS ratio of networks for background application at different velocities.

Conclusion

Smooth and seamless handover is a challenge in high speed nodes. A MN needs to switch to a network that meets its QoS requirements. In this paper, a TOPSIS based method is applied on the heterogeneous networks to rank the different alternatives. AHP technique is applied to weigh the attributes. Results show that UMTS is the most suitable alternative for VOIP applications. WLAN is the choice for stationary to low speed MNs. WiMax performs best for moderate speed MNs but its performance degrades at very high speeds. UMTS is the preferred over WLAN and Wimax networks in case of fast moving MNs.

References

[1] Budisz, L., Ferrus, R., Brunstorm, A., Grinnemo, K., Fracchia, R., Galante, G. and Casadevall, F, 2008, Towards Transport-Layer Mobility: Evolution of SCTP Multihoming. In Computer Communications, 31(5), 980-998.

[2] Goyal, R.K. and Kaushal, S., 2013, “A survey of msctp for transport layer mobility management”, Journal of Advances in Information Technology, 20-27.

[3] Rao, R.V., 2007, “Decision Making in Manufacturing Environment Using Graph Theory and Fuzzy Multiple Attribute Decision Making Methods”, Springer, London.

[4] Song, Q. and Jamalipour, A., 2005, “An adaptive quality-of-service network selection mechanism for heterogeneous mobile networks”, Wireless Communications and Mobile Computing, 5 (6), 697-708.

[5] Lahby, M., Cherkaoui, L., and Adib, A., 2013, "An Enhanced-TOPSIS Based Network Selection Technique for Next Generation Wireless Networks. IEEE 20th International Conference on Telecommunications", pp. 1-5.
[6] Ismail, A. and Roh, B., 2011, "Adaptive Handovers in heterogeneous networks using fuzzy MADM", IEEE International Conference on Mobile IT convergence, pp.99-104.
[7] Alkhawini M.M., Alslam K.A., and Hussein A.A., 2011, "Multi Criteria Vertical Handover by TOPSIS and Fuzzy Logic", IEEE International Conference on Communications & Information Technology, pp. 96-102.
[8] Liu ,X., and Chang, C "The TOPSIS algorithm based on a + bi type connection numbers for decision-making in the convergence of heterogeneous networks". IEEE 3rd International Conference on Advanced Computer Theory and Engineering (ICACTE), pp. 323-327.
[9] Falowo, O. E., and Chan, H. A, 2012, "Dynamic RAT selection for multiple calls in heterogeneous wireless networks using group decision-making technique", Computer Networks, 56 (4), 1390-401.
[10] Lahby, M., Cherkaoui, L., and Adib, A.,"Novel validation approach for network selection algorithm by applying the group MADM", IEEE ACS International Conference on Computer Systems and Applications (AICCSA), pp. 1-4.
[11] Mehbodniya, A., Kaleem, F., Yen, K..K. and Adachi, F., 2013, "A fuzzy extension of VIKOR for target network selection in heterogeneous wireless environments", Physical Communication, 7, 145–155.
[12] Dhar, S., Ray, A., and Bera,R., 2013, " Cognitive Vertical Handover Engine for Vehicular Communication", Peer to Peer Netw. and Appl, 6(3), 305-324.
[13] Hwang, C.L., and Yoon K., 1981, "Multiple Attribute Decision Making Methods and Applications", Springer- Verlag, Berlin.