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Improved Handover Decision Algorithm Using Multiple Criteria

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Abstract

The transfer of massive data between varied network positions links of network relies on data rate, as well as the traffic capacity of the network. Conventionally, a device that is mobile can be used to attain vertical handover functional by weighing in only an aspect, which refers to Received Signal Strength (RSS). The application of this particular criterion could lead to interruption in services, ineffective vertical handover, and a network load that is not balanced. Hence, this paper proposes an improvised vertical handover decision algorithm by integrating multi-criteria within a wireless network that is heterogeneous. The proposed algorithm comprised of three vertical handover decision algorithms, namely: mobile weight, network weight, and equal weight. Additionally, three technology interfaces were embedded in this study including Worldwide interoperability for Microwave Access (WiMAX), Wireless Local Area Network (WLAN), and Long-Term Evolution (LTE). As a result, the simulation outcomes demonstrated that the handover decision algorithm for network weight generated exceptional outputs, in comparison to mobile and equal weights, as well as the conventional network decision algorithm from the aspects of handover failure and handover number probabilities.

Keywords: Handover operation; Wireless sensor network; Mobility management; PMIPv6

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1. Introduction

It had been reported that traffic capacity and rate of data transfer for mobile communication are in high demand. As such, the idea of a network with heterogeneous attribute has been initiated to cater to the escalating demand. The mobile feature is important in a heterogeneous network due to its abilities in connecting with varied radio access advancements and in roaming within the network. Prior to this, a mobile device only served as an attachment point for single criterion, for example, Received Signal Strength (RSS). Although it has been opined that a non-intricate algorithm should be sufficient in determining RSS-based handover [1]; RSS has been reported as unreliable due to its fluctuating nature [2]. This appears to be as a result of the varied RSS thresholds within the heterogeneous network, which lead to excessive handover, high packet delay and handover failure probability, as well as reduced overall throughput in the algorithm that is based on RSS. On top of that, the vertical handover has some shortcomings that need to be highlighted, as listed in the following. (i) a reliable algorithm is essential because vertical handover decision that is inaccurate could cost the resources of network, (ii) the algorithm should fairly disseminate the mobile devices so as to balance the loads of traffic in the networks, and (iii) an accurate algorithm is vital in order to determine increment of data transfer rate to the mobile devices within the networks. Furthermore, the implementation of multiple criteria for vertical handover algorithm offers a new network that could be the best target network.

The rest of the paper is organized as follows. Section 2 presents an overview of studies within the network selection arena, while Section 3 describes the algorithm of multiple criteria handover decision. Next, Section 4 elaborates the methodology related to simulation, and Section 5 concludes the paper by depicting the outcomes, related discussion, and the conclusion.

2. Related Work

This section explains the discusses the existing approaches related to vertical handover decision algorithm.

- Algorithms based on RSS - In this approach, the algorithm, which is based on RSS, is employed as handover trigger [3], as well as to determine handover [4]. This particular algorithm has gone through optimisation by applying thresholds of RSS [5], besides integrating the thresholds with the location and velocity of the user [6].
- Algorithms based on context awareness: The signal quality, the context of mobile device, and the network dictate handover [1]. Such context is based on the definition of an entity for a scenario [7], identity, location, time, and environment [8].
- Algorithms based on cost function: This approach can be applied in two ways, which are 1) user-related cost function, and 2) network-related cost function [9], [10]. The parameters applied for user-related cost function are power consumption, security, and monetary cost [11], [12].
- Algorithms based on fuzzy logic: This method employs two approaches, which are: 1) decision-making, as well as 2) fuzzication and weighting steps [13]. Additionally, this approach also applies the Multi-Attribute Decision Making (MADM) method [14], [15].
- Algorithms based on multiple criteria: This approach integrates algorithms that are based on multiple criteria in order to decrease consumption of power [16], [17], [18].

In general, algorithms that are based on RSS have low levels of intricacy and accuracy. On the other hand, cost function and fuzzy logic algorithms have high levels of intricacy, accuracy, and efficiency of network. In fact, many studies have investigated the algorithms of multiple criteria vertical handover decision. It has been revealed that several criteria of candidates are required to generate decision that is calculated in a quantitative manner [19]. Such conclusion is drawn after making comparisons between the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Grey Relational Analysis (GRA), Simple Additive Weighting (SAW) and Multiple criteria Exponent Weighting (MEW) [20]. Furthermore, their handover efficiency based on performances had been assessed [21], [22].

The simulation comparison was carried out within the heterogeneous network setting of GPRS, WLAN, and Universal Mobile Telecommunications Systems (UMTS). Besides, the performances exerted by several networks, such as delay, BER, bandwidth, and jitter, were compared as well. Next, the performance of SAW was compared with Weighted Product Model (WPM) in Worldwide interoperability for Microwave Access (WiMAX) and WLAN to look into processing delay [23]. The findings show that WPM displayed higher accuracy than SAW in selecting the target network. Meanwhile, Elimination et Croix Traduisant la Realite (ELECTRE), another algorithm of multiple criteria, was applied as the vertical handover decision in the assessment via numerical analysis, which was compared with TOPSIS and SAW [24], [25]. Hence, suitable criteria (e.g. mobility, RSS, bandwidth, and application) are significant in ascertaining the accuracy of a decision.

3. Multiple Criteria Handover Decision Algorithm

TOPSIS seems to have some benefits over other algorithms of multiple criteria due to its concepts, which are: 1) the ability to assess the performance of alternatives, and 2) effective computing features [26]. Moreover, the TOPSIS approach demands a single subjective input for decision calculation. Furthermore, at simulation, TOPSIS resulted in lower packet loss and higher throughput [27]. From a varied stance, the algorithm of handover decision is comprised of four aspects, which are: cost function, network occupancy, RSS, and mobile speed. The algorithms require mobile (mobile speed and cost function) and network (radio and network topology) to serve as inputs. Further information regarding the parameters of the network is elaborated in the following section. Mobile speed and cost function are the two parameters for mobile station. The three kinds of cost function are as follows:

- **Gold cost:** Premier subscription that permits users to apply the highest Quality of Service (QoS). In this case, the cost function becomes irrelevant.
- **Silver cost:** Medium subscription that balances cost function and QoS.
- **Bronze cost:** Lower subscription that gives more emphasis to cost function than QoS.

The mobile speed consists of five values with the highest speed for vehicular mobile station at 25 m/s, while 5 m/s for the lowest speed [25]. The flowchart of the algorithm for handover decision in selecting networks is portrayed in Fig. 1.

The approach of TOPSIS offers flexibility to determine the multiple criteria weights. As mentioned earlier, the three related algorithms are network, equal, and mobile weights. The network weight highlights network occupancy, whereas the algorithm emphasises the mobile parameter. Table 1 shows the weight of every algorithm.

Table 1. The weight algorithms.

Criteria	Equal weight	Mobile weight	Network weight
Cost function	0.25	0.4	0.1
Mobile speed	0.25	0.4	0.1
RSS	0.25	0.1	0.4
Network occupancy	0.25	0.1	0.4

This paper employed the weights to calculate the impact of every criterion to select the most suitable network for handover purpose. This was carried out by applying the TOPSIS approach in order to compare the networks at hand. The related procedures are listed in [25].

4. Simulation Algorithm

In order to gain performance outcomes, NS-2 simulation was used for implementation of the suggested algorithm [28]. The RSS approach was employed in the conventional network via vertical mode. Many studies have investigated single metric, such as RSS, mainly because the information is available in almost every mobile device, which is cost-effective and non-intricate. Hence, in order to analyse the efficacy of the proposed approach, comparisons were conducted in the simulation to serve as the yardstick. Next, handover efficiency was assessed by looking into the probability of failure or success in handover.

The handovers were determined by examining the occurrence of total vertical handover during active call due to influence by QoS delivery and signalling load. Unimportant handover would become wasteful network resources thus inefficient. The probability of handover failure refers to the average of requests from incoming handover that goes unserved because of limited resources.

The topology of network was comprised of WiMAX (radius=2500m), LET (radius=1000m), and WLAN (radius=300m) networks. The WiMAX and WLAN blanketed 75% of the simulation area each, while 65% by LTE. Table 1 presents the parameters for radio. The MN tracks had random paths [28]. Besides, the User Datagram Protocol (UDP) was applied to transmit 320 bytes of audio traffic and 4960 bytes of video between MN and CN. The duration of inter-packet transfer was 0.004 s, whereas 480 s was the simulation time. The outcomes were determined by applying the average speed of 10-fold performing the situation. The simulations were performed by using 15 random mobile node trajectories across LET, WiMAX, and WLAN networks.

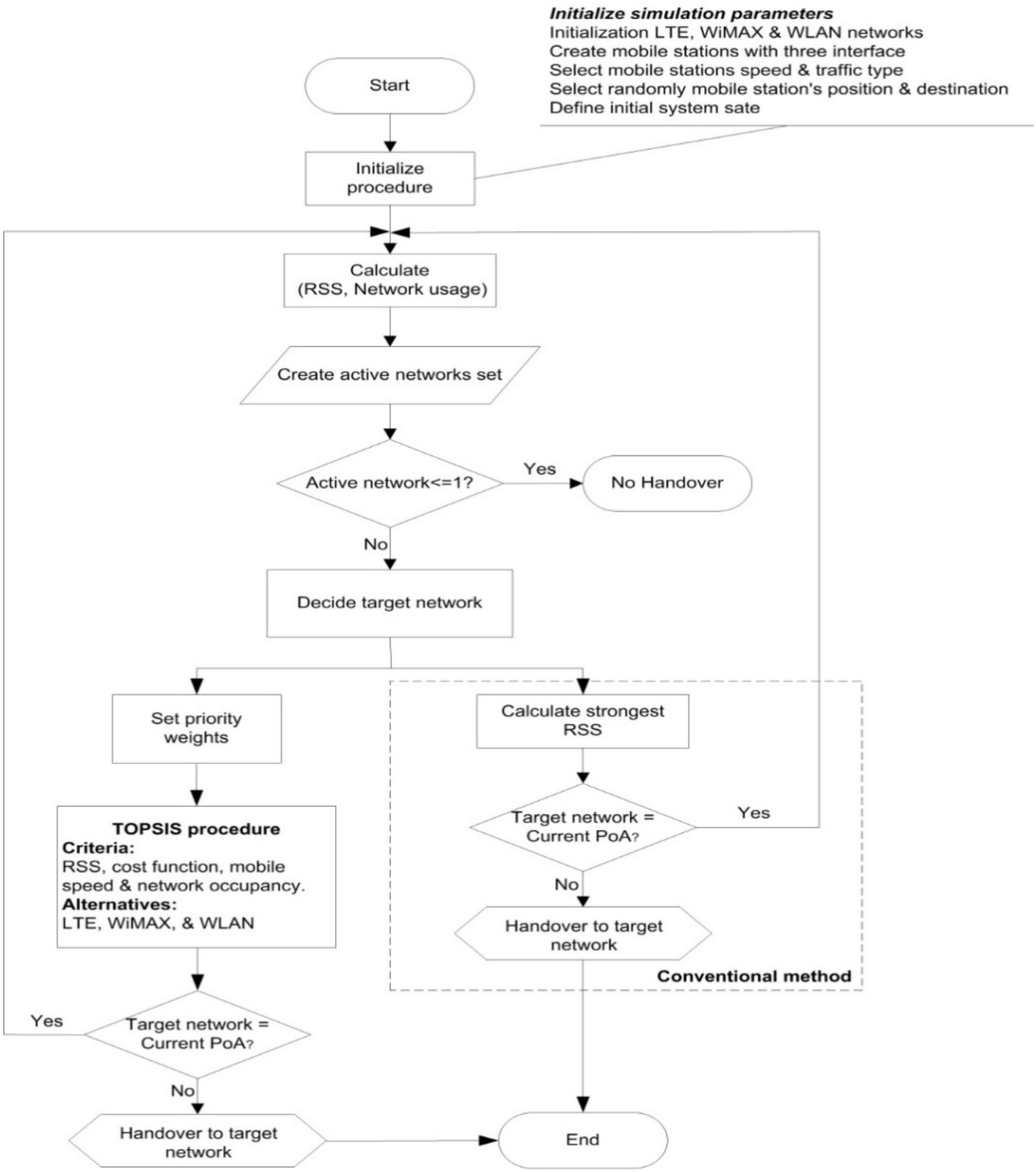

Fig. 1. The message flow diagram.

5. Results and Analyses

Three algorithms were weighed in for multiple criteria handover decision: equal, mobile, and network weights, which were applied in a heterogeneous network setting. The performance of each algorithm was compared with that of conventional approach by having RSS as the sole criterion, while the multiple criteria approach had cost function, mobile speed, and network occupancy aspects. Fig. 2 illustrates the handover allocations for equal weight multiple criteria amongst 100 mobile users. The equal weight reduced the amount of handover by 22.9%; which decreased the handovers to 33 from 44 upon implementation of equal property multiple criteria. Hence, the network efficiency is improved and the resource availability is increased.

Fig. 3 illustrates the handovers upon using mobile weight multiple criteria. The mobile weight minimised the amount of handovers by 40.29% or a reduction from 44 to 30 upon application of mobile weight multiple criteria.

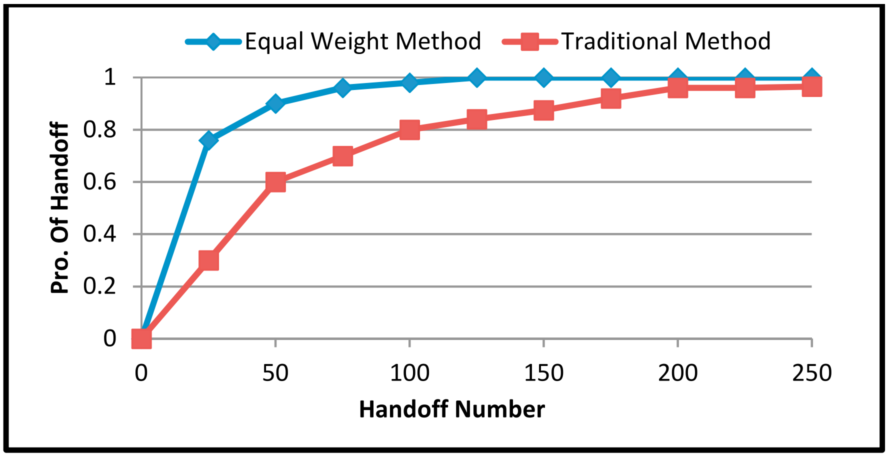

Fig. 2. Handover number probability of equal weight method.

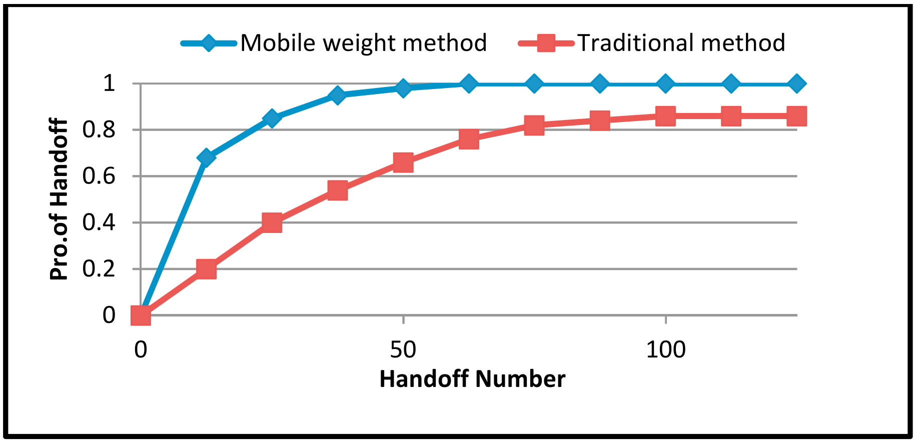

Fig. 3. Handover number probability of mobile weight method.

Fig. 4 demonstrates the handovers for network weight multiple criteria. The enhancement was recorded at 60%, whereby the average of handover for the conventional approach was 44, while that for network weight multiple criteria was 25. Based on prior depiction, the conventional approach of vertical handover decision generated more handovers, which increased the network's signalling load. Besides, the mobile weight multiple criteria technique displayed better performance than the other weights due to larger ratios recorded for mobile speed and cost function. The aspect of mobile speed was related to handovers amount, whereas those with higher speed experienced a ping-pong effect. Hence, mobile speed and cost function reduced unwanted handovers.

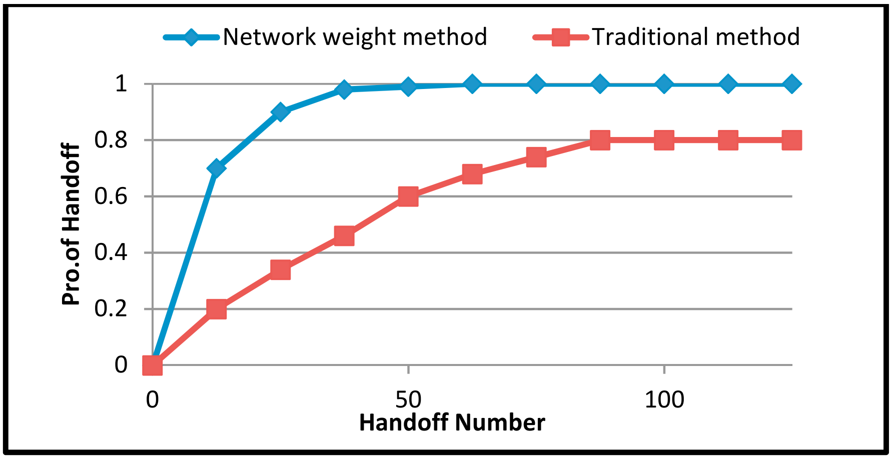

Fig. 4. Handover number probability of network weight method.

Fig. 5 presents the average handover failure probability for equal weight multiple criteria approach. The handover failure probability refers to a basic performance metric as it shows the capability of a network in serving incoming mobile users. Nevertheless, the equal weight multiple criteria seemed to enhance the average handover failure probability by 24.62%. The average handover failure probability recorded for the conventional approach was 0.24, while 0.18 for that of equal weight multiple criteria. Besides, the equal weight shows equal proportion for mobile and network criteria, whereas handover failure probability was closely linked to network.

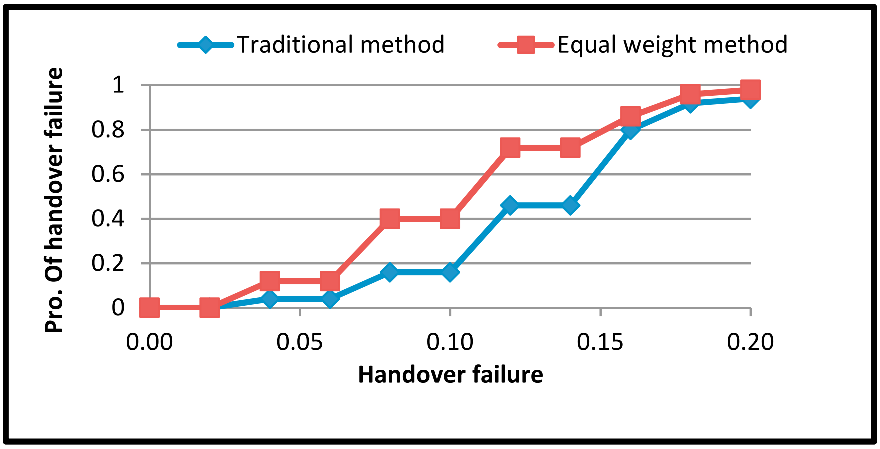

Fig. 5. Average handover failure probability of equal weight method.

Larger network occupancy and mobile weight multiple criteria appeared to enhance failure probability with average increment by 33.79%. Fig. 6 depicts the value of average probability for conventional approach recoded at 0.27, while 0.18 for mobile weight multiple criteria. Furthermore, the network weight multiple criteria substantially increased the average handover failure probability by 43%. The average handover failure probability was 0.27 for conventional approach, while 0.15 for network weight multiple criteria technique. Hence, the average handover failure probability could be said to have link with network occupancy. Besides, in the network weight multiple criteria technique, the network load was higher than in cost function, RSS, and mobile speed. Therefore, selecting the suitable network can minimise average failure probability (see Fig. 7).

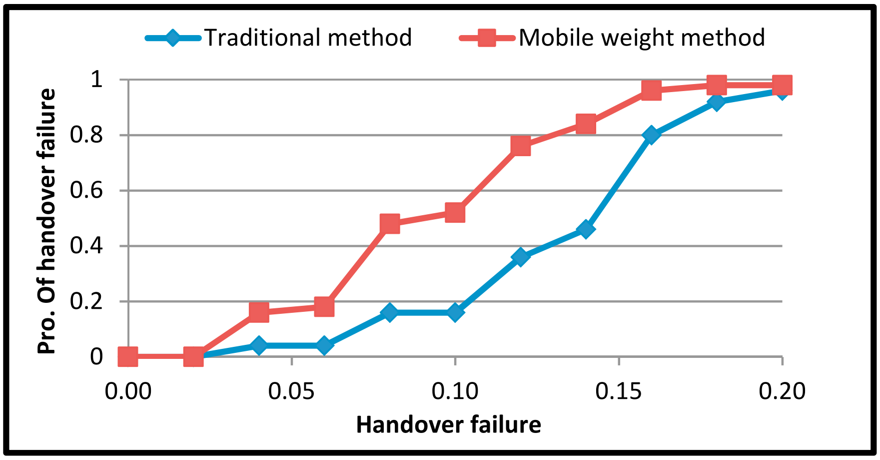

Fig. 6. Average handover failure probability of mobile weight method.

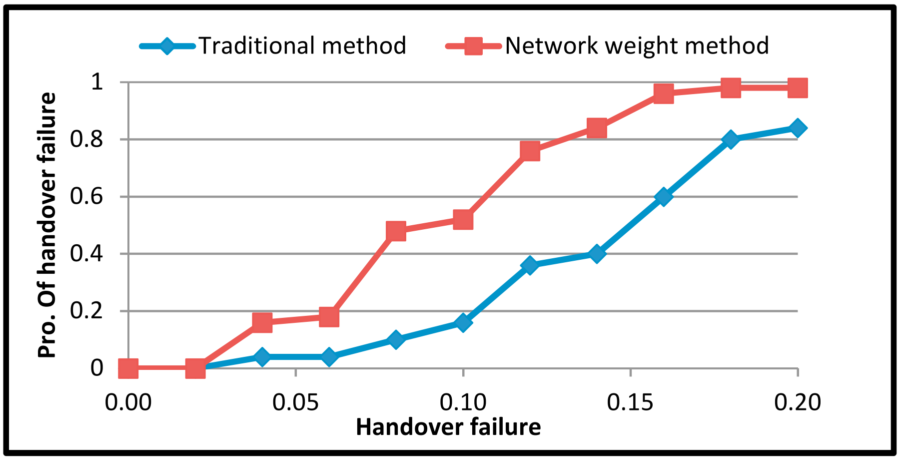

Fig. 7. Average handover failure probability of network weight method.

6. Conclusion

In addressing the issue of exceeding handovers in mobile devices in a heterogeneous network setting, this study proposes an enhanced algorithm for vertical handover decision based on multiple criteria, thus enabling the devices to opt for the correct and accurate handover decision. The outcomes from the simulation performed exhibited that the proposed algorithm enhanced the probabilities of handovers, when compared to the conventional algorithm for network decision. In conclusion, the algorithm of network weight handover decision generated exceptional outcomes, when compared to algorithms for equal and mobile weight handover decision.

References

[1] M. Zekri, B. Jouaber and D. Zeghlache. Context aware vertical handover decision making in heterogeneous wireless networks, *in Proceedings of the 35th IEEE International Workshop on Performance and Management of Wireless and Mobile Networks,* Denver, Colorado, USA, 2010, p. 764–768.

[2] Xiaohuan Yan, Y. Ahmet Sekercioglu, and Narayanan, S. (2010) "A survey of vertical handover decision algorithms in fourth generation heterogeneous wireless networks." *Computer Networks* **54 (11)**: 1848–1863.

[3] Omar M. Eshanta, Ismail M., Jumari K., and Yahaya P. (2009) "VHO strategy for QoS-provisioning in theWiMAX/WLAN interworking system." *Asian Journal of Applied Sciences* **2(6)**: 511– 520.

[4] Xiaohuan Yan, Nallasamy Mani, and Y. Ahmet Sekercioglu (2008) "A traveling distance prediction based method to minimize unnecessary handovers from cellular networks to WLANs." *IEEE Communications Letters* **12(1)**: 14–16.

[5] S. Mohanty and I.F. Akyildiz. (2006) "A cross-layer (layer 2 + 3) handoff management protocol for next-generation wireless systems." *IEEE Transactions on Mobile Computing* **5(10)**: 1347–1360.

[6] Sassi Maaloul, Afif Mériem, and Sami Tabbane. (2012) "Context awareness and class of service satisfaction for modelling handover decision making" *International Journal of Computer* **47(20)**: 6–15.

[7] T. Ahmed, K. Kyamakya, and 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'06)*, Santa Marta, Colombia, 2006. p. 19-28.

[8] Eng Hwee Ong and Jamil Y. Khan (2010) "On optimal network selection in a dynamic multi-RAT environment" *IEEE Communications Letters* **14 (3):** 217–219.

[9] R. Tawil, Guy Pujolle and O. Salazar. A vertical handoff decision scheme in heterogeneous wireless systems, *in Proceedings of the IEEE Vehicular Technology Conference,* Singapore, 2008, p. 2626–2630.

[10] A. Hasswa, N. Nasser, H. Hassanein. Tramcar: a context-aware cross-layer architecture for next generation heterogeneous wireless networks, *in Proceedings of the 2006 IEEE International Conference on Communications (ICC'06)*, Istanbul, Turkey, 2006. p. 240–245.

[11] L. Xia, L.-G. Jiang, C. He. A novel fuzzy logic vertical handoff algorithm with aid of differential prediction and pre-decision method, *in Proceedings of the 2007 IEEE International Conference on Communications (ICC'07)*, Glasgow, Scotland, 2007, p. 5665–5670.

[12] N. Nasser, S. Guizani, E. Al-Masri. Middleware vertical handoff manager: a neural network-based solution, *in Proceedings of the 2007 IEEE International Conference on Communications (ICC'07),* Glasgow, Scotland, 2007, p. 5671–5676.

[13] K. Pahlavan, P. Krishnamurthy, A. Hatami. (2000) "Handoff in hybrid mobile data networks." *IEEE Personal Communications* **7(2)**: 34–47.

[14] Mohammed M. Alkhawlani, Kasim A. Alsalem and Aref A. Hussein. Multicriteria vertical handover by TOPSIS and fuzzy logic*, in Proceedings of the International Conference on Communications and Information Technology (ICCIT '11)*, Aqaba, Jordan, 2011, p. 96–102.

[15] Gita Mahardhika, Mahamod Ismail, and Rosdiadee Nordin. (2013) "Multi-criteria vertical handover decision algorithm in heterogeneous wireless network." *Journal of Theoretical and Applied Information Technology* **54(2)**:339–345.

[16] G. Mahardhika, M. Ismail, and K. Mat. Multi-Criteria Vertical Handover Decision in Heterogeneous Network, *in Proceedings of the IEEE Symposium on Wireless Technology and Applications (ISWTA)*, Bandung, Indonesia, 2012. P. 1-4.

[17] M. Liu, Z. Li, X. Guo, and H. Lach. Design and evaluation of vertical handoff decision algorithm in heterogeneous wireless networks, *in Proceedings of the 14th IEEE International Conference on Networks (ICON '06)*, Singapore, 2006, p. 1–6.

[18] Radhwan M. Abdullah, Azizol Abdullah, Nor Asilah Hamid, Mohamed Othman, and Shamala Subramaniam. (2014) "A network selection algorithm based on enhanced access router discovery in heterogeneous wireless networks." *Wireless Personal Communications* **77(3)**: 1733–1750.

[19] Meriem Kassar, Brigitte Kervella, and Guy Pujolle. (2008) "An overview of vertical handover decision strategies in heterogeneous wireless networks." *Computer Communications* **31(10)**: 2607–2620.

[20] Manjaiah, D. and Payaswini, P. (2013) "A review of vertical handoff algorithms based on multi attribute decision method." *International Journal of Advanced Research in Computer Engineering and Technology* **2(6)**: 2005–2008.

[21] Wei-Liang Tai, Ya-Fen Chang, and Yung-Chi Chen. (2016) "A fast-handover-supported authentication protocol for vehicular ad hoc networks." *Journal of Information Hiding and Multimedia Signal Processing* **7(5)**: 960–969.

[22] Chin-Chen Chang, Ya-Chieh Huang, and Hao-Chuan Tsai. (2014) "Design and analysis of chameleon hashing based handover authentication scheme for wireless networks." *Journal of Information Hiding and Multimedia Signal Processing* **5(1)**: 107–116.

[23] K.Savitha and C.Chandrasekar. (2011) "Vertical handover decision schemes using SAW and WPM for network selection in heterogeneous wireless networks." *Global Journal of Computer Science and Technology* **11(9)**: 19–24.

[24] E. Stevens-Navarro and V. W. S. Wong. Comparison between vertical handoff decision algorithms for heterogeneous wireless networks, *in Proceedings of the 63rd IEEE Vehicular Technology Conference (VTC '06)*. Melbourne, Australia, 2006, p. 947–951.

[25] Atif Ismail and B. Roh. Adaptive handovers in heterogeneous networks using fuzzy MADM, *in Proceedings of the International Conference on Mobile IT-Convergence (ICMIC '11)*, Gyeongsangbuk-do, South Korea, 2011, p. 99–104.

[26] C. Hung and L. Chen. A fuzzy TOPSIS decision making model with entropy weight under intuitionistic fuzzy environment, *in Proceedings of the International MultiConference of Engineers and Computer Scientists*. Hong Kong, 2009, p. 1–4.

[27] Hwang, Ching-Lai and Yoon, Kwangsun. (1981) "Multiple attribute decision making: methods and applications: a state-of-the-art survey." *Lecture Notes in Economics and Mathematical Systems*.

[28] Project, N. Seamless and Secure Mobility too, 2009. http://www.antd.nist.gov/seamlessandsecure/doc.html.