International Journal of Engineering Research and General Science Volume 3, Issue 3, May-June, 2015
ISSN 2091-2730

Vertical Handover Decision Approaches in Heterogeneous Wireless Networks Using Fuzzy Logic System: A Survey

Er Sunita Swami[1], Er Sonika Soni[2]

[1]M.tech Student, ECE Department, JCDM College of Engineering, Sirsa
[2]Asstt. Professor, ECE Department, JCDM College of Engineering, Sirsa
Email:sunitaswami79@gmail.com

Abstract-Now a day's varying wireless technologies are driving today's wireless networks to become heterogeneous, i.e., the network comprised of two or more different access network technologies. Heterogeneous networks have created many challenges such as mobility management, handoff, resource management, location management, providing QoS, security and pricing. Switching between heterogeneous networks requires seamless vertical handoff. Therefore to ensure seamless roam across heterogeneous wireless technologies, efficient vertical handoff algorithms (VHA) are required to enhance QoS and offer reliable pervasive computing environment. The selection of parameters plays an important role in the decision of vertical handoff. The parameters like bandwidth signal strength, velocity, power consumption, throughput, cost, user preferences and network load are considered during vertical handoff in all the available works .This study reviews some recently done works on vertical handover implementation using traditional and classical fuzzy logic based approaches for heterogeneous networks. The researches that considered the multi parameter based fuzzy logic concept to implement the vertical handover are discussed in this paper.

Keywords- Heterogeneous wireless networks, vertical handover, seamless mobility, Quality of service (Qos), VHA, seamless mobility.

INTRODUCTION

Large number of disparate wireless technologies like cellular networks, wireless metropolitan area network (WMAN), wireless local area network (WLAN) with their own specification and parameters based performance. Thus, to roam seamlessly in between these networks there is an urgent need that a mobile terminal must be able to transfer to best access network among all available candidates with no interruption to ongoing conversation .Such ability to hand over between heterogeneous networks is known as seamless vertical handovers [1].So, The term "handoff", or "handover", refers to the process of transferring a mobile station from one base station or channel to another. A handoff process can be thought of as having two major stages: handoff initiation and handoff execution. In the first phase, a decision is made regarding the selection of the new Base Station (BS), or Access Point (AP), to which the MS will be transferred. In the execution phase, new radio links are formed between the BS/AP and MS, and resources are allocated. When a mobile station moves between same networks e.g. WLAN to WLAN then the handoff performed is named as horizontal handoff (HHO). On the other hand, when mobile station moves between two different networks or technologies e.g. WLAN to WMAN, vertical handoff is performed. The main objective of handoff algorithm is to maintain best-connected scenario along with good quality of service (QoS) [1]. Since handoff initiation and network selection along with handoff necessity are the main aspects of handoff process therefore the easiest way to estimate the handoff necessity is by using the fuzzy logic concept. This paper presents a brief introduction along with vertical handover overview, in next section reviews the fuzzy control theory based vertical handover decision algorithms which is followed by discussion and conclusion.

VERTICAL HANDOVER

An event when a mobile station (MS) moves from one wireless cell to another is called Handoff or in other words handoff is the process of maintaining a mobile user's active connections as it moves within a wireless network. Different handoff strategies [2] are:

- Horizontal Handoff
- Vertical Handoff

In case of Horizontal Handoff, handoff is between two network access points that use the same wireless access network technology. For example, the mobile devices moves in and out of various 802.11 network domains. The handoff is purely due to mobility of mobile station. In case of vertical Handoff, handoff is between two network access points that use the different access network technologies. For example, mobile device moves out of 802.11b network coverage into 3G cellular network. A truly seamless mobile environment can be realized by considering Vertical and Horizontal handoff together [3]. The vertical handoff process can be divided into three main steps namely:

- **System Discovery**: Mobile terminals equipped with multiple interfaces have to determine which networks can be used and the services available in each Network.
- **Handoff decision:** The mobile devices determine which network it should connect to.

- **Handoff execution:** The connections are re routed from the existing network to the new network in a seamless manner.

The overall handoff management concept provided in [4] and depicted in Fig.1

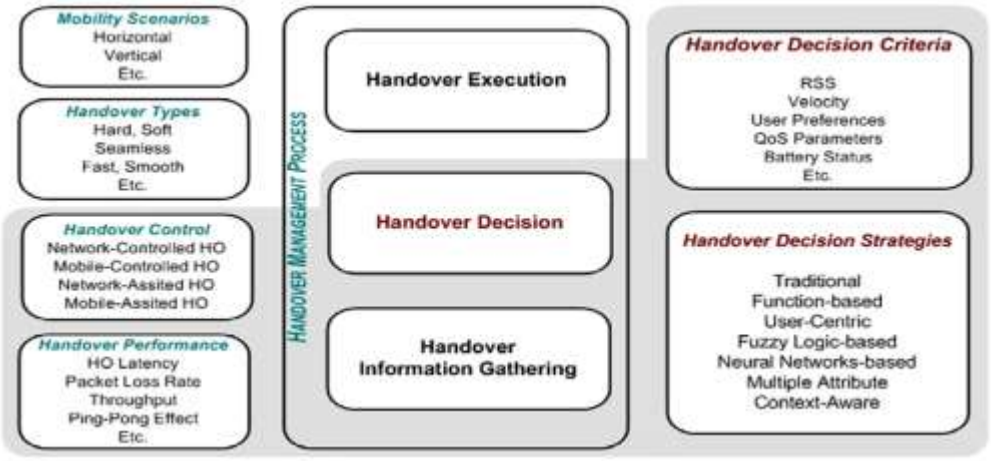

Fig.1 Handoff Management Concept [4]

VERTICAL HANDOFF DECISION ALGORITHMS

VHD algorithms help mobile terminals to choose the best network to connect to among all the available candidates. In conventional handoff decision only Received Signal strength (RSS) and/or power level received from candidate base stations is compared. However, to optimize a handoff decision, other factors like bandwidth and cost, velocity of mobile terminal ,distance between mobile station and access point etc are also to taken into consideration to maximize user satisfaction [11].There are several vertical handover methods like :

- Traditional technique (RSSI based),
- Context-aware strategies (CA),
- multiple attribute decision Strategies (MAD),
- User-centric strategies (UC),
- Decision function-based strategies (DF),
- Neural networks based strategies (NN),
- Fuzzy logic (FL) based.

Among them the use of FL allows analyzing complex problems. It answers well to vertical handover decision problem by giving the best and accurate solution with regrouping all the decision factors. However, FL and NN based strategies together consider only a few context parameters and can be more complex to be suitable for practical multimode mobile terminal with limited resources [10]. Beside that fuzzy logic has several advantages like conceptually easy to understand, flexible, tolerant of imprecise data, built on top of the experience of experts, based on natural language etc.In normal algorithm the network parameter contains only 0 and 1 values after normalization whereas fuzzy system based algorithm considers grey shades also, along with the crisp values, 0 and 1. The fuzzy vertical Handoff Decision Algorithm [5] realizes the vertical handover by evaluating and analyzing various Handoff Metrics which in turn are primarily dependent on input parameters.

RELATED WORK

Work on implementation of vertical handover decision algorithm (VHDA) has been carried out by many researchers using various techniques based on handoff decision criteria [4]. The author Majlesi and Khalaj in [1] made network selection based on a fuzzy multiple criteria decision-making, where all the selected criteria are normalized by a normalization function and the result is fuzzified, generating a degree of membership between 0 and 1, which will be used to give weights to these criteria. Finally, the selection of the best access network is made by a cost function.

In [2] the author presented an adaptive multiple attribute vertical handover decision algorithms for UMTS-WLAN that enables wireless access network selection at a mobile terminal using fuzzy logic concepts and a genetic algorithm. This vertical handoff decision algorithm is able to determine when a handoff is required, and selects the best access network that is optimized to network conditions, quality of service requirements, mobile terminal conditions, user preferences, and service cost. In [3] the author presented a novel vertical handoff decision algorithm for overlay wireless networks consisting of cellular and wireless local area networks

(WLANs). The target network is selected using a fuzzy logic-based normalized quantitative decision algorithm which, in addition to usual parameters such as the current received signal strength (RSS) and the available bandwidth, also takes a prediction of the RSS into account, resulting in a more accurate handoff. The RSS prediction is obtained using a differential prediction algorithm that has good accuracy. Furthermore, to reduce system load, a pre decision method is employed before actual handoff decision to filter out users with high mobility or low RSS from using the WLAN. Simulation results show that the algorithm can reduce the call dropping probability as well as unnecessary handoffs in heterogeneous network environments. In [4] the author presented a new fuzzy decision making approach that considers a variety of context parameters (RSS and variation of RSS (VRSS), Bandwidth, and traffic status and handover preference to trigger handoffs and choose an optimal network destination with respect to mobile terminal requirements and nearby network capabilities. The obtained results show that this decision making approach maximize user preferences compared to the RSS based decision methods since a lot of network parameters are taken. In [5] the author presented an intelligent approach to optimize vertical handover that is optimized and application specific (QoS based). The fuzzy logic based decision making is used to select among the available networks. Triggers and events are used to generate the input which is sent to fuzzy expert system. In this way, the intelligent selection of networks can optimize vertical handover and improve QoS of real-time application running on mobile device which is roaming around heterogeneous wireless networks.

In [7] the authors proposed to use a Fuzzy Inference System in order to select an appropriate network and make a handover decision by using the input parameters of RSS, available bandwidth and the distance from the access point. Input parameters are fed into a fuzzifier that converts them into fuzzy sets by determining the degree to which they belong to each of the appropriate fuzzy sets via membership functions. Next, the fuzzy sets are sent to a fuzzy inference engine for the application of IF-THEN rules to attain fuzzy decision sets. The output fuzzy decision sets are accumulated into a single fuzzy set and delivered to the de-fuzzifier for conversion to an accurate quantity in final stage of the handover decision. For analyzing the performance of proposed scheme, a handover was performed between WLAN and WiMAX and, vice versa. The proposed scheme reduced handover delay and packet loss but somehow, the procedure seems to increase the decision processing delay because of fuzzification and de-fuzzification processes. Also, this scheme lacks the inputs from users about their priorities or specific needs. In [8] the author presented a method to enhance the handoff performance of mobile IP in wireless IP networks by reducing the false handoff probability in the NGWS handoff management protocol. Then they analyzed the performance of handoff management protocols that use a fixed value of RSS threshold (Sth) to initiate the handoff process. Through analysis it is observed that when a fixed value of Sth is used, handoff failure probability increases when either speed or handoff signaling delay increases. Based on this analysis, suggested a method by which handoff failure probability can be kept constant and within limit. In [9] an adaptive fuzzy logic based vertical handoff decision making algorithm is presented for wireless overlay networks which consist of GSM/GPRS/Wi-Fi/UMTS/WiMAX technologies. Data rate, monetary cost, speed of mobile, battery level and RSSI parameters are considered as inputs of the proposed fuzzy based system. The results show that, proposed adaptive fuzzy based algorithm can provide enhanced outcomes for both user and network. In [10] the author proposed fuzzy logic based handoff controller for intelligent vertical handoff decision in which three input parameters: Distance between BS and MS, Received signal strength from BS and network load on the cell are evaluated and feed to the fuzzy inference system. The output of the fuzzy inference system is handoff decision .The handoff factor for the current base station and target base station may be computed and compared. The results show that the handoff factor increases as the mobile station moves away from current base station. The handoff factor also increases as the network load (number of users) in the current cell increases.

In [12] the author presented a handoff decision scheme that was able to choose the correct network and fuzzy logic is applied to deal with the imprecise information of some criteria and user preference. This algorithm is used for predetermination of reverse signal strength (PRSS), which is used to decide when to start a vertical handoff. If and only if the PRs in the networks fit to the Reverse Signal Strength (RSS) thresholds of the networks, then vertical handoff procedure will be triggered. This algorithm was able to reduce the call dropping probability in vertical handoff with the help of pre detection of signal. To implement this algorithm WWAN and WLAN networks are used. The network parameters which are used along with PRSS for handoff decisions are Available bandwidth (B), and Users Preference (UP). Based upon these three input parameters the value of handoff decision is calculated by the handoff decision algorithm. In [13] the author presented a multi-parameter-based adaptive algorithm with six parameters has been proposed for vertical handoff decision. Since there is an element of uncertainty, the inputs are taken as fuzzy and neural networks are used for training of decision vector. The number of vertical handoffs for the proposed algorithm is measured in the simulated Environment and the results are compared with the classical technique and the existing fuzzy technique. The vertical handoff QoS requirements involve reduction in ping-pong effect, improvement in end-point service accessibility (ESA) and enhancement of throughput. In this VHDA, six input parameters: RSS, velocity of MT, bandwidth available, number of users, battery level and coverage area are considered and the performance is studied in WLAN and cellular overlay structure.

In [14] a novel multi-criteria VHO algorithm is presented with two modules, namely VHITS Handoff Necessity Estimation, and VHITS Handoff Target Network Selection. The fuzzy logic-based VHITS Handoff Necessity Estimation module determines whether a handoff is necessary by taking into consideration the predicted RSS values provided by the current PoA, the degree of the provided QoS based on the requested traffic class (Conversational, Streaming, Background, and Interactive), and the speed of the vehicle including the direction (toward/away from the PoA) in which the MS is travelling. The future value of RSS predicted using GPT is used to minimize call dropping probabilities due to sudden loss of signal in a lognormal fading environment that is inherent in wireless networks. Several parallel FLCs are designed to make the computation of the proposed scheme efficient by minimizing the number of required inference rules. The VHITS Target Selection scheme also utilizes fuzzy logic in addition to different ranking algorithms and weight elicitation techniques that are implemented to Select the best target network that can fulfill end-users' preferences. The VHITS

necessity estimation scheme is able to reduce the number of handoffs, and the VHITS target network selection scheme based on FTOPSIS outperforms the other schemes implemented and simulated in terms of intelligent and efficient handoff decisions. In [15] the author proposed a QoS aware fuzzy rule based vertical handoff mechanism using fuzzy logic quantitative decision algorithm (FQDA) is used as a handoff decision criteria to choose which network to handover among different available access networks. The QoS parameters considered are available bandwidth, end-to-end delay, jitter, and bit error rate (BER). Simulation results show that fuzzy rule based approach gives better delay, availability, with moderate performance of available bandwidth. Hence, QoS aware fuzzy rule based algorithm gives better QoS performance for delay sensitive applications like conversational, interactive and live streaming applications. In [16] the author proposed two vertical handover scheme based on fuzzy interference system and subtracting clustering method in a heterogeneous environment and simulates to verify performance. This was a method for easy and fast handover between different protocol users according to priority based. To make handover decision in heterogeneous environment considered the RSSI, BW and probe response time (PR) as input parameter in fuzzy inference system (FIS). This proposal is useful whenever there are many users using individual protocol according to their needs and whenever needs to be handover between them. In [17] author proposed fuzzy normalized Handoff initiation algorithm (FUN_HOI) module which considers the combination of different input criteria along with RSS to initiate handoff in time to reduce unnecessary handover and handoff failure probability. The special function of FUN_HOI is to take fuzzy normalization of all input criteria after fed in to the Fuzzy inference system (FIS). An importance of fuzzy normalization is to filter unsuitable candidate networks and thus improves the efficiency of an algorithm. This handover is applied to perform a handoff between WLAN and WMAN networks.

In [18] the author presented a new fuzzy based handover decision scheme. The parameters used are available bandwidth, speed of mobile terminal, number of user and received signal strength. In these parameters the speed of mobile terminal and RSS are related to source information of user equipment and available bandwidth and number of user are related to source information of the network condition. This approach ensures the seamless mobility in the integration of Wi-Fi, WiMax hotspots and cellular networks in a better way as compared to IEEE 802.21.

However further optimization should be done for better resource utilization, latency minimization .The future aspect of this technique is to enhance the mobility of the user and fulfill the expectation of anywhere, anytime connectivity with the network.

CONCLUSION

A thorough study of existing VHD algorithm using fuzzy logic concept revels that, use of fuzzy logic concepts to design a multi criteria vertical handoff decision algorithm is both cost-effective and highly useful. For the handoffs initiated by mobile nodes, fuzzy logic based vertical handoff decision algorithm (VHDA) is employed to select the most appropriate network for the mobile nodes. Still currently proposed VHD Algorithms either lack a comprehensive consideration of various network Parameters or lack enough details for implementation. Research into vertical handover decision algorithms in heterogeneous networks is still a challenging area. The main difficulty is to design an algorithm which is truly useful in wide ranging conditions and utilize all the useful network parameters.

REFERENCES:

[1] Majlesi A., Khalaj B.H., "An Adaptive Fuzzy Logic Based Handover Algorithm For Interworking Between WLANs And Mobile Networks", Personal, Indoor and Mobile Radio Communications, Vol. 5, pp. 2446-2451, September 2002.

[2] Yaw Nkansah-Gyekyz and Johnson I. Agbinya"Vertical Handoff Decision Algorithm Based on Fuzzy Logic and Genetic Algorithm", 2nd international conference on wireless broadband communication, IEEE 2007.

[3] Liu Xia , Ling-ge Jiang and Chen He "A Novel Fuzzy Logic Vertical Handoff Algorithm with Aid of Differential Prediction and Pre- Decision Method", IEEE International Conference on Communications, 2007. ICC '07.

[4] Ezzouhairi, A., Quintero, A. and Pierre, S. "A Fuzzy Decision Making Strategy For Vertical Handoffs", Canadian Conference on Electrical and Computer Engineering, IEEE 2008.

[5] Attaullah, H, Iqbal, F. and Javed, M.Y. "Intelligent Vertical Handover Decision Model To Improve Qos", Third International Conference on Digital Information Management, ICDIM 2008(IEEE).

[6] T. Jun, Y. Zhang, Z. Zhang, Z. Ye, and Z. Chen, "Performance Analysis Of Vertical Handoff In WIFI And WIMAX Heterogeneous Networks," in International Symposium on Computer Network and Multimedia Technology, IEEE Computer Society, 2009.

[7] Xiaohuan Yan a, Y. Ahmet S_ekerciog˘lu and Sathya Narayanan "A Survey Of Vertical Handover Decision Algorithms In Fourth Generation Heterogeneous Wireless Networks", Computer Networks , 2010 Elsevier.

[8] Debabrata Sarddar, Tapas Jana, Souvik Kumar Saha, Joydeep Banerjee, Utpal Biswas, M.K. Naskar "Minimization Of Handoff Failure Probability For Next-Generation Wireless Systems", International Journal of Next-Generation Networks ,Vol.2, No.2, June 2010.

[9] Calhan, A. and Ceken, C. " Speed Sensitive-Energy Aware Adaptive Fuzzy Logic Based Vertical Handoff Decision Algorithm", 18th International Conference on Systems, Signals and Image Processing, IEEE 2011.

[10] Dayal C. Sati1, Pardeep Kumar2, Yogesh Misra3 "Fuzzy Logic Based Handoff Controller for Microcellular Mobile Networks", International Journal of Computational Engineering & Management, Vol. 13, July 2011.

[11] Radhika, K.; Reddy, A. V. "Network Selection In Heterogeneous Wireless Networks Based On Fuzzy Multiple Criteria Decision Making" , International Journal of Computer Applications, Foundation of Computer Science , Vol. 2, No.1, p. 7–10, 2011.

[12] Manoj Sharma, Dr. R.K.Khola "Fuzzy Logic Based Handover Decision System" , International Journal of Ad hoc, Sensor & Ubiquitous Computing , Vol.3, No.4, August 2012.

[13] A. Singhrova1 N. Prakash "Vertical Handoff Decision Algorithm For Improved Quality Of Service In Heterogeneous Wireless Networks", IET Communication, Vol. 6, Issue 2, pp. 211–223,2012.

[14] Faisal Kaleem1, Abolfazl Mehbodniya2, Arif Islam1, Kang K. Yen1, Fumiyuki Adachi2 "Dynamic Target Wireless Network Selection Technique Using Fuzzy Linguistic Variables", china communication , IEEE January 2013.

[15] M.Sazeeda Kausar,Dhanaraj Cheelu " Context Aware Fuzzy Rule Based Vertical Handoff Decision Strategies for Heterogeneous Wireless Networks", International Journal of Engineering and Science, Vol.3, Issue 7, PP 06-12,August 2013.

[16] Md. Tajul Islam, Md. Liton Hossain, Md. Ahasan Kabir, Md. Tawabur Rahman, Shirazus Salekin, Sk. Shariful Alam, Abu Farzan Mitul "Vertical Handover Decision Using Fuzzy Logic in a Heterogeneous Environment" , IEEE 2013.

[17] Sivakami Thiyagarajan1 and Shanmugavel Sedhu2 " Fuzzy Normalized Handoff Initiation Algorithm For Heterogeneous Networks" , International Journal of Hybrid Information Technology Vol.7, No.5, pp.155-166,2014

[18] NitinGoel, Neetesh Purohit and B.R.Singh "A New Scheme for Network Selection in Heterogeneous Wireless Network using Fuzzy Logic" , International Journal of Computer Applications (0975 – 8887) Volume-88,No.3,Feb.2014