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Fuzzy Logic Based Handover decision and Necessity Estimation Scheme for Heterogeneous Wireless Networks

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Abstract: Seamless and reliable switching across different technologies is the basic requirement of heterogeneous wireless networks. In order to be always best connected for various applications, the network selection procedure in heterogeneous environment during vertical handover decision is intended to choose the most suitable network for mobile user. In this paper fuzzy rule based handover decision scheme is proposed that will help to choose the correct network among WLAN, WWAN and Cellular network and also finds the necessity of handoff. Fuzzy logic concept is applied to find necessity of handoff and for handoff decision by considering all the possible network parameters such as RSS, bandwidth, user preference, MS-velocity, MS-AP distance, delay, cost, security and no. of users. To calculate the handoff factor four fuzzy logic controllers are designed in parallel fashion which reduces the number of rule and system complexity. In this work only 27 rules are used instead of 3^9 rules that are needed for 9 attributes to find the value of final vertical handoff factor (VHO) for all the three networks i.e. WLAN, WWAN and cellular network. Also less number of unnecessary handoffs is resulted for the proposed scheme.

Keywords: Vertical handover decision, Fuzzy logic, Heterogeneous networks, WLAN, WWAN, VHO.

1. 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 are existing in the today's heterogeneous environment. 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)[2]. Since handoff initiation and network selection along with handoff necessity are the main aspects of handoff process therefore the easiest way to determine when to perform a handoff can be estimated by using the fuzzy logic concept. The handoff process using fuzzy logic contains three steps: First step is Fuzzification in which the input value is fuzzified in the form of membership functions. The second step is to design if-then rules requires for implement the vertical handoff. The third step is Defuzzification in which the membership functions are defuzzified in output values. In executing handover decisions, received signal strength (RSS) is not only significant parameter. In order to overcome this drawback, other metrics such as bandwidth availability, MS-velocity, distance between MS-AP etc. along with RSS must be considered while initiating a handover process. In this paper multiple parameters such as RSS, bandwidth, velocity, distance, cost, delay, security, no. of users and user preference are considered as inputs to FIS. To calculate the value handover decision factor and handoff necessity four different fuzzy logic controllers are utilized. As by parallel combination of fuzzy logic controllers the number of rules and system complexity can be minimized [8]. In this paper, vertical handoff is implemented for the heterogeneous network consisted of WLAN, WWAN and cellular network with the help of FIS (Fuzzy Interference System) and simulation is performed by using SIMULINK model in MATLAB. The rest of paper is organized as: related work; proposed scheme; results which is followed by simulation and conclusion.

2. RELATED WORK

A lot of work has been done from recent years on the vertical handover in order to enhance the QOS by using various types of techniques and algorithms. In [1] 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 which able to determine when a handoff is required, by selecting best access network that is optimized to network conditions, quality of service requirements, mobile terminal conditions, user preferences, and service cost. In [2] the author presented an intelligent approach to optimize vertical handover so that optimized and application specific (QoS based) 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 [3] the author proposed to use a Fuzzy Inference System in order to select an appropriate network and make a handover decision towards that using the input parameters of RSS, available bandwidth and the distance from the access point. The proposed scheme between WLAN and WiMAX, 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 [4] proposed 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. This is based on the information of false handoff probability effect on mobile speed and handoff signal delayed. In [5] fuzzy logic based handoff controller for intelligent vertical handoff decision proposed, 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 was computed and compared which 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 [6] author presented a multi-parameter based adaptive algorithm with six parameters for vertical handoff decision between WLAN and cellular overlay structure. Since there is an element of uncertainty, the inputs are taken as fuzzy and neural networks are used for training of decision vector. The vertical handoff QoS requirements involve reduction in ping-pong effect, improvement in end-point service accessibility (ESA) and enhancement of throughput. In [7] provided a seamless handoff by selecting the appropriate network in order to be always best connected for various applications, the network selection has been done to choose the most suitable network for mobile user. A handoff decision scheme was proposed that will help to choose the correct network and fuzzy logic is applied to deal with the imprecise information of some criteria and user preference. Due to traffic offloading the decisions for vertical handovers in heterogeneous wireless networks the QoS of the mobile users is very important issue, especially when they are using real time services. In [8] author proposed a novel vertical handover decision mechanism namely FUZZY-technique for order preference by similarity to ideal solution (FUZZY-TOP), obtained by combining a fuzzy rule-based mechanism with the technique for order preference by similarity to ideal solution approach. Markov chain modal had been used for simulation that compared with existing vertical handover decision algorithms. The proposed FUZZY-TOP decision algorithm was performed better for different traffic classes. Several parallel FLCs are designed to make the computation of the proposed scheme efficient by minimizing the number of required inference rules. In [9] intelligent decision algorithm was proposed that detects new network which offers best connectivity than current network and does authentication and mobile IP registration. It reduced the packet loss to ensure high quality of service. Forwarded data packets to appropriate attachment point to maximize battery lifetime with this algorithm, also maintain load balancing. The proposed algorithm efficiently used the network resources by switching between 3G and Wi-Fi under the different RF environmental conditions with minimal service cost to the users. The proposed intelligent decision algorithm reduced the call dropping rate (<0.006) and call blocking probability (<0.00607) as well as unnecessary handover in heterogeneous networks. In [10] the author presented a method for vertical handover decision, which consider six input parameters. Handoff decision making .is divided in two sections, First section calculates system obtained value (SOV) considering RSS, C, BW and BC. SOV is calculated using fuzzy logic theory. User preferred network is choose from user priority list is called User obtained value (UOV). Then handoff decisions are made based on SOV & UOV to select the most appropriate network for the mobile nodes (MNs). This scheme was able to make accurate handoff decisions, reduce unnecessary handoffs decrease handoff calculation time and decrease the probability of call blocking. In [11] presented two vertical handover scheme based on fuzzy interference system and subtracting clustering method in a heterogeneous environment, which is a method for easy and fast handover between different protocol users according to priority based. To make handover decision , RSSI, BW and probe response time (PR) are taken as input parameter .This proposal was useful whenever there are many users using individual protocol according to their needs and whenever needs to be handover between them. In [12] author presented a new fuzzy based handover decision scheme which 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. This technique reduces the number of handoffs by 27% as compared to existing fuzzy and by 42% as compared to classical approach.

3. PROPOSED FUZZY LOGIC BASED APPROACH:

The fuzzy based handoff decision and handoff necessity decision approach deals with a network selection based on fuzzy theory taking into account some parameters. The parameters are like RSS, speed of mobile terminal and some other factors [8]. In this proposed approach, multiple input parameters: RSS, velocity of Mobile Terminal, bandwidth available and number of users, user's preference, delay, security, cost, distance between MS and AP are considered. Fuzzy approach is chosen because of its ability to handle the non-precise and uncertain data. The fuzzy logic also has the advantage of adding rules in simple language. The proposed technique uses fuzzy inference system (FIS) graphic user interface editor and reviewer to implement all the steps involved in fuzzy system, such as defining membership

functions, building the rules and analyzing the results in fuzzy inference engine. A fuzzy inference system is composed of four functional blocks:

1. **Fuzzifier**-The fuzzifier transforms the crisp inputs into degree of match with linguistic values in form of membership function (MF).

2. **Fuzzy rule base**- It contains a number of fuzzy IF-THEN rules. Number of rules are depends upon the number of parameters used and set of membership function. Rules can be calculated with the expression or formula that is:

$$[x]^m$$

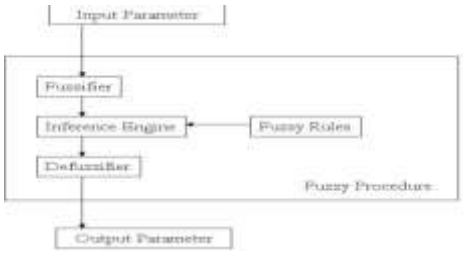

Fig.1 Basic Fuzzy Logic Decision System

In this work the listed parameters are used for vertical handover decision. For this purpose four different fuzzy logic controllers are designed to calculate the value of Handoff Factor and determine the necessity of handoff based on the current conditions of serving access point. In order to reduce the number of rules and system complexity, three fuzzy logic controllers (FLC) are combined in a parallel fashion. The outputs of these three FLCs are then fed into the fourth fuzzy logic controller that produces the final vertical handoff (VHO) factor. Fig.2 shows the overall design of these FLCs that are used to calculate the VHO factor.

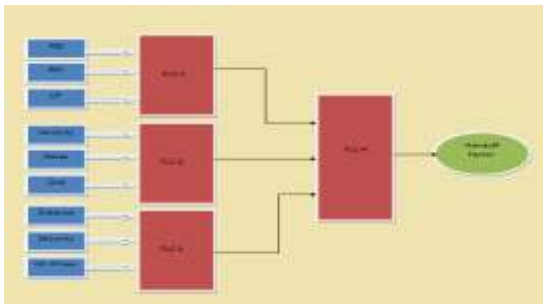

Fig.2 Fuzzy Logic Controllers for VHO factor calculation

To design these fuzzy logic controllers, nine parameters are grouped into three for each FLC and taken as input to fuzzy inference system (FIS). The A Sugeno based FIS with three inputs and three outputs for three networks i.e. WLAN, WWAN and cellular network is utilized. The input variable has three membership functions (Low, Medium, and High) and each of the output variables has three singleton membership functions (Low, Medium, Where x= number of sets and m= number of parameters. For example if number of sets used are three and number of parameters are also three, then the total number of rules are:

$$[3]^3=27$$

3. **Fuzzy inference engine**-The fuzzy inference engine performs the inference operations on the fuzzy rules.
4. **De-fuzzifier**-A defuzzifier transforms the fuzzy results of the inference into crisp output.

The block diagram of basic fuzzy logic decision system is shown in fig. 1 and the parameters list with their range for three types of Networks, utilized in this work are given in Table1.

Table1: Parameter List

Parameter	WLAN	WWAN	Cellular Network
Received signal strength(RSS)	(-110,-55)	(-150,-90)	(-85,-95)
Velocity		0-10	
Bandwidth(BW)	56Mbps	5Mbps	2Mbps
Network Coverage	(0-100)	(0-750)	(0-2000)
Delay	(100-150)	(10-75)	(25-30)
security		0-10	
No of users		0-50	
cost		0-10	
User preference(UP)		0-1	

and High).According to general expression to find the no. of rules, the total no. of rules for nine parameters can be calculated as: $[3]^9=19683$

Here 3 are the no of sets used for inputs i.e. membership functions (low, medium, high) and 9 is the total no of parameters taken as inputs to FIS. The membership functions for some inputs and outputs are shown in fig. 3(a)-3(b).

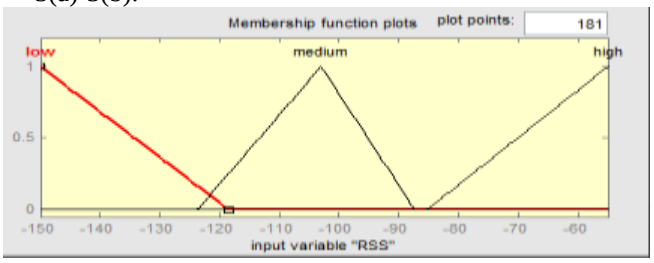

Fig.3 (a) Membership function for input variable RSS

Fig.3 (b) Membership function for output variable WLAN-HOD-factor

4. RESULTS AND SIMULATION

The proposed scheme is simulated in MATLAB by using SIMULINK model and fuzzy based system is designed in fuzzy logic toolbox. This scheme needs to define some parameters based upon information of the user equipment and the network condition. The parameters used are RSS, bandwidth, Velocity, Distance, Cost, Delay, Security, no. of users and user preference. These parameters are grouped

into three and then used as inputs to three different fuzzy logic controllers in parallel. The outputs of these three fuzzy logic controllers are then used as input to a new fuzzy logic controller which generates the final handoff factor. The FIS editor displays general information about the fuzzy inference system and shows the names of each input variable on the left, and those of each output variable on the right. The FIS editor window for VHO factor calculation for all the three networks WLAN, WWAN and cellular is shown in fig.4:

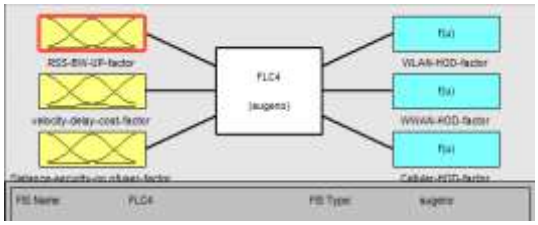

Fig. 4 FIS Editor Window of Vertical Handoff Decision

After applying the rules in rule editor the performance of the fuzzy system can see on the rule viewer. These Rules in the fuzzy interface system works as a condition in which the system has to perform the task. The simulation model used for this scheme is shown in fig. 2.

Here with the help of this simulation model instead of 3^9 (as rules required for 9 parameters), only 27 rules are sufficient for final vertical handoff factor with nine parameters. These rules can be shown by rule viewer as in Fig 5. For the whole process total number of if-than rules required are 100 i.e. 19 for FLC-1, 27 for FLC-2, FLC-3 and FLC-4 individually.

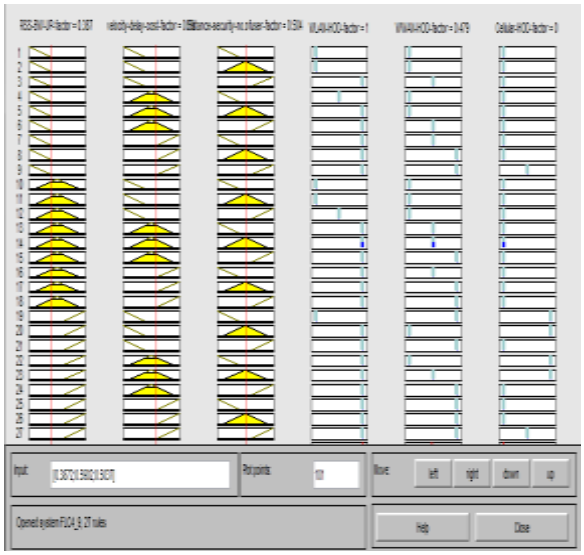

Fig .5 Rules Evaluation for FLC-4

The output obtained from the FLC-4 generates the handoff factor; a high value of VHO-Factor is generated, indicating a high probability of handoff. To determine if a handoff is required from the serving network or not, obtained final handoff factor is compared against a threshold value. The range of the handoff factor is from 0 to 1 and the threshold value used in this work is 0.70 for all the three types of networks. The result obtained shows that; considering current access network WLAN

(a) When handoff factor is less than 0.5, the handoff probability will be low i.e. MN remains in the same network technology, means no handoff.

(b) When handoff factor is lies between 0.5 to o.7, the handoff probability for that network is medium.

(c) When handoff factor is greater than 0.7, the handoff probability is high i.e. an immediate handoff from WLAN is must.

The comparison is made between the results obtained with 9 parameter based model, 5 parameter based model and 7 parameter based model, which indicated that with the increase in attributes the no. of handoffs are reduced and hence performance of the decision model will improves.

Table 2: Performance Comparison

No. of Parameters Used	Total No. of Handoffs Required
5	8
7	7
9	6

The surface output for all the three networks used in this system is shown in fig .6, which represents the mapping between different input parameters and shows the performance of the system in 3-D.

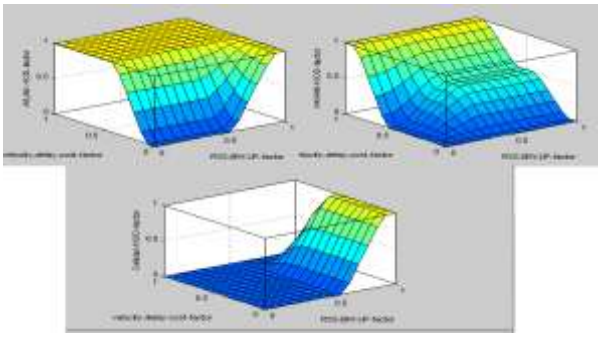

Fig .6 Surface Viewers for WLAN, WWAN and cellular handoff factor

5. CONCLUSION

In this work a fuzzy rule based vertical handoff decision and necessity estimation scheme is proposed which uses the multiple input parameters to calculate the handoff factor which determine the handoff necessity to ensure the seamless mobility in integration of WLAN, WWAN and cellular networks. Simulation results with reduced rules and system complexity for large number of parameters. The use of large no. of attributes improves the handoff decision in heterogeneous networks, also resulted in lesser no of unnecessary handoffs as compared to traditional fuzzy

approach. The future aspect of this technique is to enhance the mobility and also to further reduce the number of if-than rules for multiple attributes.

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