POWER EFFICIENT VERTICAL HANDOFF USING NEURAL FUZZY LOGIC

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ABSTRACT
Seamless handoff is the need of new generation wireless system (NGWS). A recent vertical handoff scheme is based on signal to interference and noise ratio (SNR) may not be the best scheme for selecting service access point or base station. Although this SINR based scheme has higher system throughput and lower disconnection probability as compared with other vertical handoff schemes, we presume that the distance is a good criterion for decreasing service disconnection probability and increasing system throughput. In this paper a vertical handoff decision scheme is defined which is based on received signal strength (RSS).A handoff decision is made with distance and velocity as input and RSS as output. This paper is compared with handoff decision by using velocity and distance using fuzzy logic. By using neural fuzzy logic RSS threshold values in dB are minimised for certain distance and velocity i.e. power loss is reduced so, system performance increases.

KEYWORDS: *rss ,neural fuzzy logic ,membership function.*

I. INTRODUCTION

In a cellular telephone network, handoff is the transition for any given user of signal transmission from one base station to a geographically adjacent base station as the user moves around. In an ideal cellular telephone network, each end user's telephone set or modem (the subscriber's hardware) is always within range of a base station. The region covered by each base station is known as its cell. The size and shape of each cell in a network depends on the nature of the terrain in the region, the number of base stations, and the transmit/receive range of each base station. In theory, the cells in a network overlap; for much of the time, a subscriber's hardware is within range of more than one base station. The network must decide, from moment to moment, which base station will handle the signals to and from each and every subscriber's hardware.

Each time a mobile or portable cellular subscriber passes from one cell into another, the network automatically switches coverage responsibility from one base station to another. Each base-station transition, as well as the switching processor sequence itself, is called handoff. In a properly functioning network, handoff occurs smoothly, without gaps in communications and without confusion about which base station should be dealing with the subscriber. Subscribers to a network need not do anything to make handoff take place, nor should they have to think about the process or about which base station is dealing with the signals at any given moment.

In new generation wireless system user can move between different environments of wireless system such as WLAN, Wi-Max, cellular network etc [1]. Therefore, architecture of NGWS must be flexible i.e. while moving from one network to another there should not be any call drop. Mobility management contains two parameters (1).Location management and (2).handoff management. Location management enables the system to track the locations of mobile users between consecutive communications. On the other hand, handoff management is the process by which users keep their connections active when they move from one Base Station (BS) to another. Fig. 1 shows a typical handoff scenario in the NGWS [2] where two types of handoff scenarios may arise: horizontal handoff and vertical handoff [3-4].

Horizontal handoff: Handoff between two BSs of the same system. Horizontal handoff can be further classified into Link-Layer Handoff: Horizontal handoff between two BSs that are under the same Foreign Agent (FA). e.g., the handoff of a Mobile Terminal (MT) from BS10 to BS11 in Fig. 1

Intrasystem Handoff: Horizontal handoff between two BSs that belong to two different FAs and both the FAs belong to the same system and hence, to same Gateway Foreign Agent (GFA), e.g., the handoff of the MT from BS11 to BS12 in Fig. 1.

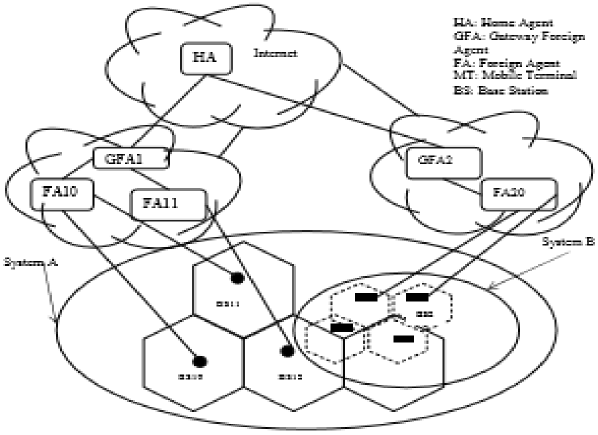

Figure 1. Handoff in integrated NGWS

Vertical Handoff (Intersystem Handoff): Handoff between two BSs that belong to two different systems and, hence, to two different GFAs, e.g., the handoff of the MT from BS12 to BS2 in Fig. 1.

The main capabilities of Vertical handovers over Horizontal handovers are:(1)Vertical handovers use different access technology.(2) Vertical handovers use multiple network interfaces.(3) Multiple IP addresses are used in Vertical handovers.(4) QoS parameters can be changed in Vertical handovers and multiple parameters are used.(5) Multiple network connections are used in Vertical handovers.

However seamless handoff is still an open research issue. The existing handoff methods or management protocols are not sufficient to guarantee handoff support. Application layer[6],transport layer[7],network layer and link layer [8],[9],are proposed to provide fluent and excellent services.

So cross layer management is improved by using techniques [2]. The remainder of the paper is organized as follows: We will start by presenting some related works in section II followed by handoff process in section III. Fuzzy logic details and implementations are described in section IV. Then we will discuss neural fuzzy system and results of simulation in V and VI, followed by conclusion.

II. RELATED WORK

Many attempts were made to improve vertical handoff methodology. As it is the handoff between two different enviornments(e.g. WLAN and Wi Max), it is neceesary to pay attention towards all parameters. Initially handoff management protocol is proposed in[3], which describes various layers of TCP/IP protocols for different networks transport layer handoff management protocol is proposed. These protocols eliminates need of tunneling of data packets.[7]. Link Layer is used to reduce handoff requirement detection delay[8]. Different link layer assisted handoff algorithm that use receieved signal strength (RSS) information to reduce handoff latency and failure probability are proposed in[8],[10]. In[11] fuzzy logic based adaptive handoff algorithm is proposed which describes the improvements in handoff initiation and reduction in handoff failure rate. It also gives the relation between velocity and receieved signal strength. The threshold value of receieved signal strength changes with velocity. This paper proposes a neural fuzzy logic by using which we get RSS threshold value which is much lower for same velocity, thereby increasing the efficiency of system. Delay is calculated using [12],[13]. In [15] fuzzy logic is used to deal with imprecise handover criteria and user preference. For handover decision, imprecise data are first converted to crisp numbers, and then, classical multiple attribute decision making (MADM) methods are applied. By considering all proposed works the flow of system is to design fuzzy interference system to which velocity and distance are input parameters and RSS is output. Furthur neural fuzzy system is developed to improve system performance.

III. HANDOFF PROCESS

"As a mobile instrument proceeds from one cell to another during the course of a call, a central controller automatically reroutes the call from the old cell to the new cell without a noticeable interruption in the signal reception. This process is known as handoff. [5]"

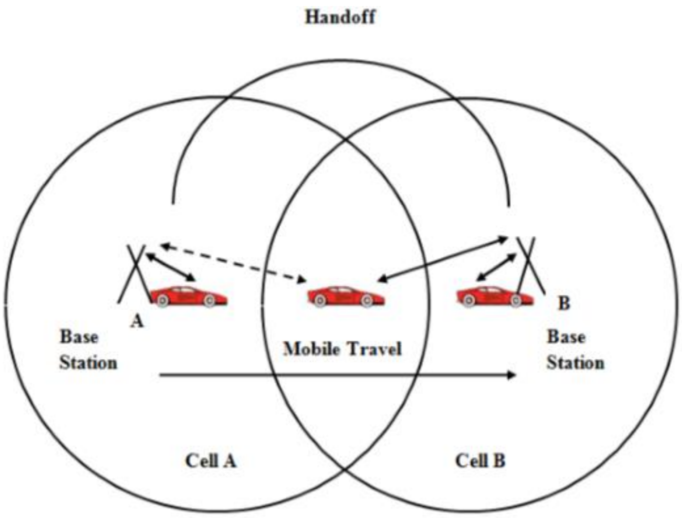

Figure 2.Handoff process

Figure2 shows a simple handoff scenario in which a Mobile Station (MS) travels from BaseStation (BS) A to BS B. Initially, the MS is connected to BS A. The overlap between the two cells is the handoff region in which the mobile may be connected to either BS A or BS B. At a certain time during the travel, the mobile is handed off from BS A to BS B. When the MS is close to BS B, it remains connected to BS B. The process of handoff has to be completed in the overlap region.

Handoff Initiation: Handoff initiation can be explained by figure 3.

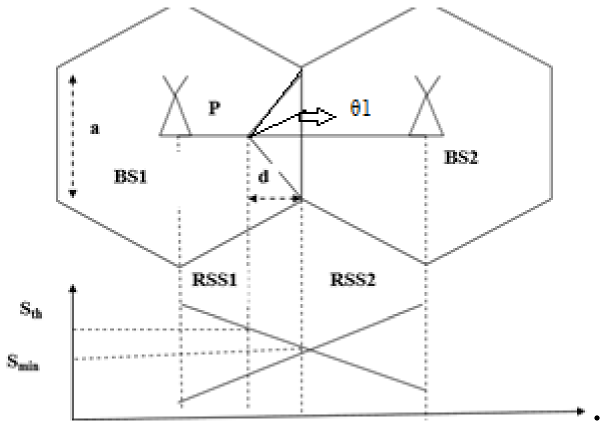

Figure3. Handoff initiation process.

Consider mobile travelling from Base Station 1 (BS1) to Base Station 2(BS2) .RSS1 and RSS2 indicates the received signal strength for BS1 and BS2.

Smin: It is the minimum Received signal strength (RSS) for acceptable voice quality for communication between Mobile Terminal (MT) and BS1.

S_{th}: The threshold value of RSS to initiate handoff. Therefore when RSS of BS1 drops below Sth the MT initiate handoff to new base station i.e. BS2

$\Delta = S_{th} - Smin$: This margin is called Δ should not be very large (for unnecessary handoff) or too small (leading to call drop due to weak signal before handoff is completed).

While entering in base station2 Mobile terminal has to perform hierarchical Mobile IP (HMIP) registration in base station 2 . The MT may learn about the possibility of moving into another cell when the RSS of BS1 decreases continuously. Once the MT discovers that it may enter into the coverage area of the BS2, the next challenge is to decide the right time to initiate HMIP registration procedures with the BS2. The existing link-layer-assisted HMIP protocols propose to initiate the HMIP registration when the RSS from the serving BS, e.g., BS1 in Figure-3 drops below a fixed threshold value (S_{th}). Below, we analyze the performance of these solutions. We assume that, during the course of its movement, when the MT reaches the point P (the distance of P from the cell boundary is d) as shown in Figure-3 the RSS from the BS1 drops below S_{th}. Therefore, when the MT reaches P, it initiates the HMIP registration with the BS2. At this point, the RSS received by the MT from BS2 shown as RSS2 in Figure-2 may not be sufficient for the MT to send the HMIP registration messages to BS2. Hence, the MT may send the HMIP registration messages to BS2 through BS1. This is called pre-registration . For a smooth and successful handoff from BS1 to BS2, MT‘s HMIP registration with BS2 and link and MAC layer associations with BS2 must be completed before the RSS of BS1 drops below Smin, i.e., before the MT moves beyond the coverage area of BS2.

IV. ALGORITHM USING FUZZY LOGIC

Fuzzy logic is a form of many-valued logic that deals with approximate, rather than fixed and exact reasoning. Compared to traditional binary logic (where variables may take on true or false values), fuzzy logic variables may have a truth value that ranges in degree between 0 and 1.This algorithm uses fuzzy logic to initiate handoff process. For this distance (m) and velocity in (km/h) are inputs and received signal strength is output. It is adaptive to velocity interference and distances resulting in less number of dropped calls, improves power efficiency of system.

4.1 Design procedure:

Design procedure involves:
1. link layer(Layer 2) 2.Network Layer (layer3) [2].The handoff management protocol is developed from this architecture. This handoff management protocol uses information derived from different layers. (e.g., speeds information from link layer and handoff signalling delay information from network layer), we call it cross-layer handoff management protocol. This architecture is shown in figure4.

Scan for neighbour unit:

This unit force MT to know more about neighbour base station. The neighbour base station may belong to serving FA whereas other may belong to different FA’s. When the MT moves into the coverage of a neighbouring BS that belongs to its serving FA, the resulting handoff is a link layer handoff. In this case, the MT uses the existing link layer handoff algorithms. When the neighbouring BS belongs to a different FA under the serving system, the corresponding handoff is an intrasystem handoff. On the other hand, when the neighbouring BS belongs to a different system, the resulting handoff is an intersystem handoff [2]. We use fuzzy logic based adaptive handoff management protocol for both intra and intersystem handoffs. Using the neighbour discovery protocol, the MT learns the details of its neighbouring BSs, such as the IP addresses of the FAs that serve these BSs.

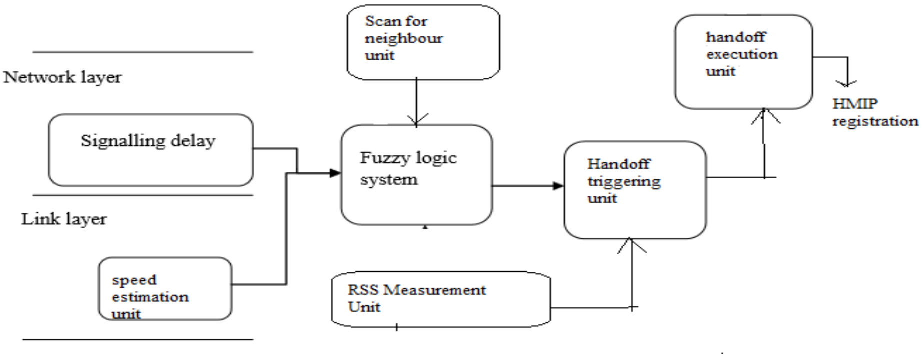

Figure 4. Fuzzy logic handoff architecture.

Signalling delay Unit:

The handoff signalling delay estimation unit estimates the delay associated with intra and intersystem handoffs. It is difficult to predict which particular BS the MT will move unless the handoff instance is very close. Our objective is to estimate the handoff signalling delay in advance without knowing which particular BS the MT will move. This can be done in many ways. For example techniques such as [12-13] can be used to estimate the delay between different network entities that are involved in the handoff process and, using this information, the handoff signalling delay for intra and intersystem handoff can be estimated.

The speed estimation unit The most significant feature of mobile cellular system is that the users are moving. The velocity block of Figure-3 estimates the velocity of mobile using VEPSD [14]. Doppler frequency (fm) is related to speed (v) of a mobile user, speed of light in free space (c), and carrier frequency of the received signal (fc) through

$$v = (c/fc)*fm \quad (1)$$

VEPSD uses fm of received signal envelope to estimate speed of a mobile user. It estimates fm using the slope of power spectral density (PSD) of the received signal envelope. The slope of PSD of received signal envelope has maxima at frequencies fc ± fm in mobile environments. VEPSD detects the maximum value of received signal envelopes PSD that corresponds to the highest frequency component (fc + fm) to estimate fm Fuzzy logic system unit uses speed and handoff signalling delay information to estimate adaptive RSS threshold (corresponds to the highest frequency component (fc + fm) to estimate fm Fuzzy logic system unit uses speed and handoff signalling delay information to estimate adaptive RSS threshold (S_{th}) as discussed earlier in this section. Handoff trigger unit collects information from RSS measurement unit and when the RSS of the serving BS drops below S_{th}, the handoff trigger unit sends a trigger to the handoff execution unit to start the HMIP handoff procedures. Finally, the handoff execution unit starts the HMIP registration process at the handoff initiation time calculated by the handoff trigger unit) as discussed earlier in this section. Handoff trigger unit collects information from RSS measurement unit and when the RSS of the serving BS drops below S_{th}, the handoff trigger unit sends a trigger to the handoff execution unit to start the HMIP handoff procedures. Finally, the handoff execution unit starts the HMIP registration process at the handoff initiation time calculated by the handoff trigger unit

4.2 Design of fuzzy logic system:

Fuzzy system is designed using fuzzy rules which are created based on known sensitivity of handoff algorithm parameters. The membership functions for input and output variables are shown in fig.5-7.

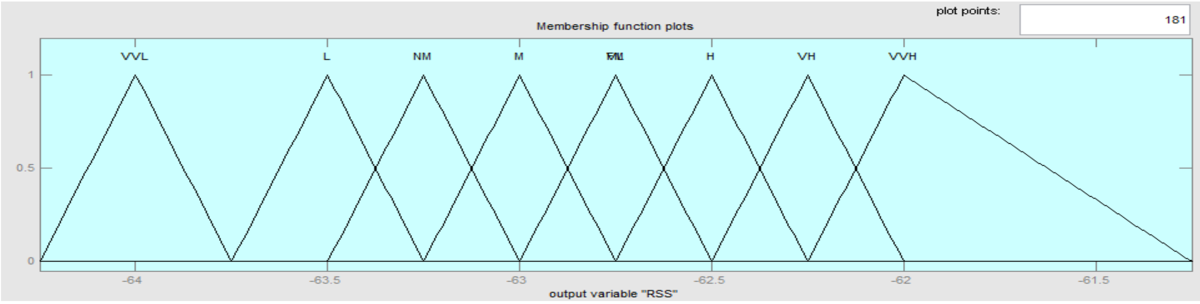

Figure 5. Membership Function Of Fuzzy variable RSS Threshold.

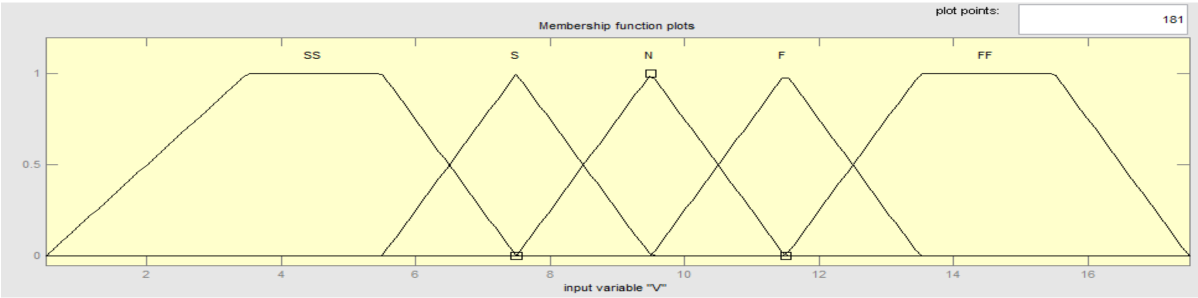

Figure 6. Membership Function Of Fuzzy variable velocity(microcellular system)

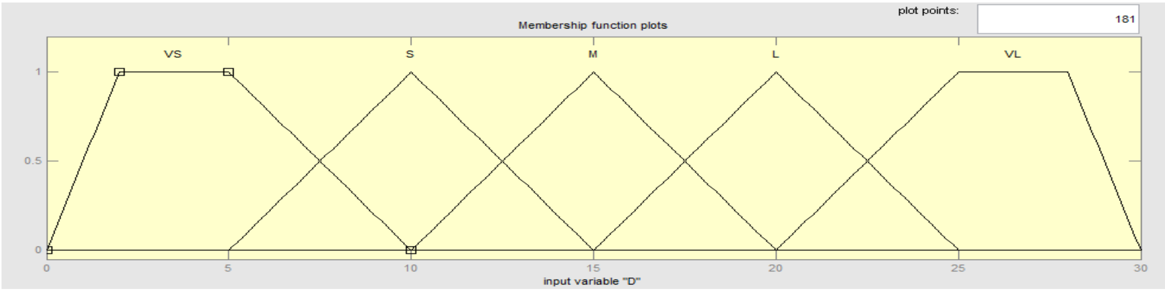

Figure7 ..Membership Function Of Fuzzy variable velocity(microcellular system)

The system has two inputs and one output. Each of the input is fuzzified at the input stage of FIS. The input variable 'v' is divided into five categories of fuzzy i.e. slowest (SS),slow(S),Normal(N),Fast (F), fastest (FF).Similarly Distance Variable 'D' is also divided into five categories i.e. Very short(VS),Short(S),Medium(M),Large(L),Very large(VL).
In this work we use "Mamdani" Fuzzy Logic System. Triangular and trapezoidal membership functions with 50% overlap of assigned fuzzy sets were considered. Trapezoidal membership function is considered for edges and the centre part is described using triangular membership function. Table 1 shows rules for microcellular system. The non singleton fuzzifier and the centre of area (COA) defuzzification method are used. The crisp output of the COA defuzzification method is

$$Z\ COA = \frac{\sum_{i=1}^{n} \mu A(xi)xi}{\sum_{i=1}^{n} \mu A(xi)} \qquad (2)$$

In Equation (2), μA(xi) is the area of a membership function modified by the fuzzy interference result (for example, 0.2 or 0.8) and xi are the positions of the centroids of the individual membership functions. For example, when the value of velocity is "Slowest" and the value of distance is "Short", this condition indicates that handoff should be encouraged immediately. Hence, output threshold RSS is "Low".

V. SIMULATION

5.1 Criteria

By using fuzzy logic the output is generated it is nothing but receieved signal strength RSS threshold (Sath)to initiate handoff registration process. Sath is the threshold value of power required to initiate handoff process.The main aim of this paper is to minimise the threshold power and thereby increasing the efficiency of the system.Here microcellular system is considered.The simulation parameters for this system are given in table 1.we can implement the same for macrocellular system.[2].The fuzzy rule set is defined in table2.

Table1.Simulation parameters

Sr.no.	Parameters	Microcellular system	Macrocellular system
1	Cell size (a)	30m	1km
2	Refrence distance($d_{o)}$	1m	100m
3	velocity	-17.5 km/hr	0-140km/hr.
4	Smin (RSS)	-64dBm	-64dBm

Table 2. Fuzzy rule set

Intrasystem			Intersystem		
Input		Output	Input		Output
Velocity	Distance	RSS Threshold	Velocity	Distance	RSS Threshold
slowest	Very short	Near Medium	slowest	Very short	Low
slowest	Short	Low	slowest	Short	Low
slowest	Medium	Low	slowest	Medium	Low
slowest	Long	Very Low	slowest	Long	Very Low
slowest	Very Long	VeryVery Low	slowest	Very Long	VeryVery Low
slow	Very short	Medium	slow	Very short	Medium
slow	Short	Near Medium	slow	Short	Near Medium
Slow	Medium	Near Medium	Slow	Medium	Near Medium
Slow	Long	Low	Slow	Long	Low
Slow	Very Long	Low	Slow	Very Long	Low
Medium	Very short	Far Medium	Medium	Very short	Far Medium
Medium	Short	Far Medium	Medium	Short	Far Medium
Medium	Medium	Medium	Medium	Medium	Medium
Medium	Long	Medium	Medium	Long	Medium
Medium	Very Long	Near Medium	Medium	Very Long	Near Medium
Fast	Very short	Very High	Fast	Very short	Very High
Fast	Short	Very High	Fast	Short	Very High
Fast	Medium	High	Fast	Medium	High
Fast	Long	High	Fast	Long	High
Fast	Very Long	Far Medium	Fast	Very Long	Far Medium
Fastest	Very short	VeryVery High	Fastest	Very short	Very Very High
Fastest	Short	VeryVery High	Fastest	Short	Very Very High
Fastest	Medium	Very High	Fastest	Medium	Very High
Fastest	Long	Very High	Fastest	Long	Very High
Fastest	Very Long	Very High	Fastest	Very Long	Very High

Using above rules fuzzy system gives RSS output. This output indicates minimum signal strength required to sustain voice capability.i.e.it is threshold required to prevent call drop.
Figure 8 indicates output

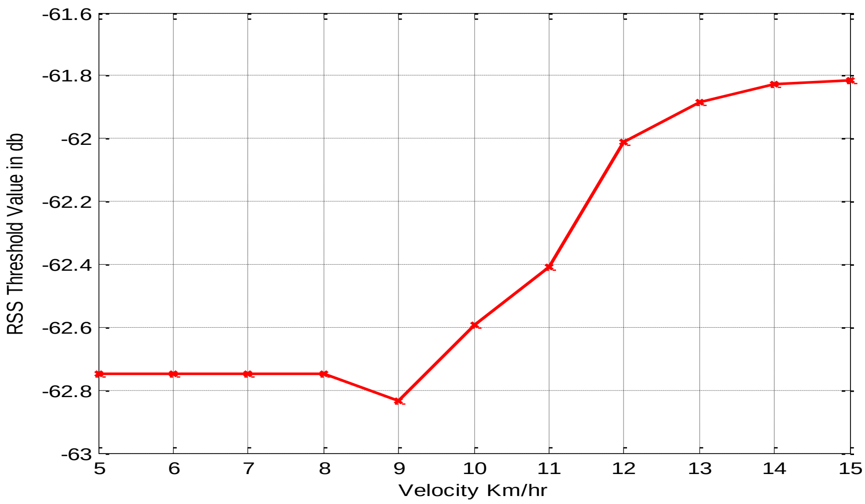

Figure 8 .RSS Threshold (S_{th}) output for different velocities for microcellular system

From figure 8 it can be seen that threshold goes on increasing as velocity increases therefore handoff must start earlier to avoid call drop. Therefore fuzzy logic system calculates the Threshold value which is adaptive to velocity.

VI. NEURAL FUZZY APPROACH

Artificial Neural Networks attempt to model the functioning of the human brain. Neural network is made up of interconnected artificial neurons which are having similar properties of biological neurons such a network can be utilized for solving artificial intelligence problems for e.g. Machine learning [15]. In the decision making operation output of FLS is applied to the multilayer perceptron. The MLP is feed forward neural network. It is composed of an interconnection of basic neuron processing units. The basic structure of the multilayer peceptron is shown is in Figure 9 It mainly consists of three-layer peceptron model since there are three stages of neural processing between the inputs and outputs. More layers can be added by concatenating additional hidden layers of neurons.

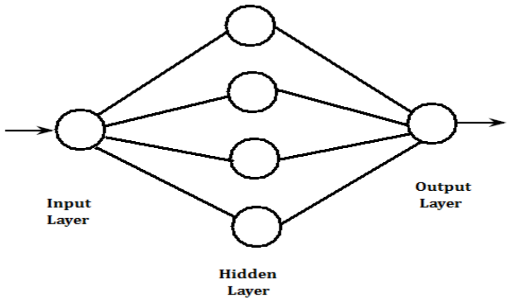

Figure 9.. Basic structure of multilayered perceptron model.

The multilayer perceptron has inputs x_i where i = 1, 2 …… n and outputs y_p where p =1, 2….l. The number of neurons in the hidden layer is m_j where j =1, 2…… k. The neurons in the first layer of the multilayer perceptron perform computation and the outputs of these neurons are given by second stage of neural network model.

$$m_j^{(1)} = f_j(\sum_{i=1}^{n} w_{ij} x_i) - \theta_j \quad (3)$$

with =1,2…… . The neurons in the second layer of multi perceptron performer computation and the outputs of these neurons are given by

$$y = f_p(\sum_{j=1}^{k} v_{jp} m_j - \theta_j) \quad (4)$$

Where w_{ij} are called the weights in between hidden layer and input. v_{jp} are called the weights in between hidden layer and output

θ_j is bias of first stage. θ_p is bias of second stage . f_j and f_p represents activation functions The activation function can be different from each neuron in the multilayer perceptron [34].

The generalized equation of the sigmoid function as

$$f(y) = \frac{1}{1 + \exp(-by)} \quad (5)$$

The output of multilayered perceptron model is nothing but optimum value of RSS .

6.1 Simulation result:

To validate our approach, we have to simulate FLS in first stage due to simulate FLS in first stage due to which we can provide decision making surface in accessing the proper handoff for the user with fixed velocity. Figure 9 indicates relation between RSS (S_{th}) and Velocity output of neural fuzzy logic .it can be seen that the threshold value required is reduced to certain extent as compared with fuzzy logic system (FLS). Therefore it is efficient method of power saving.Fig.10 indicates the performance of neural network.fig.11 indicates the control surface of velocity and distance it shows the optimum threshold value for higher velocity is high. As velocity increases RSS also increases. This decision making surface uses 25 rules to decide value of RSS Threshold.

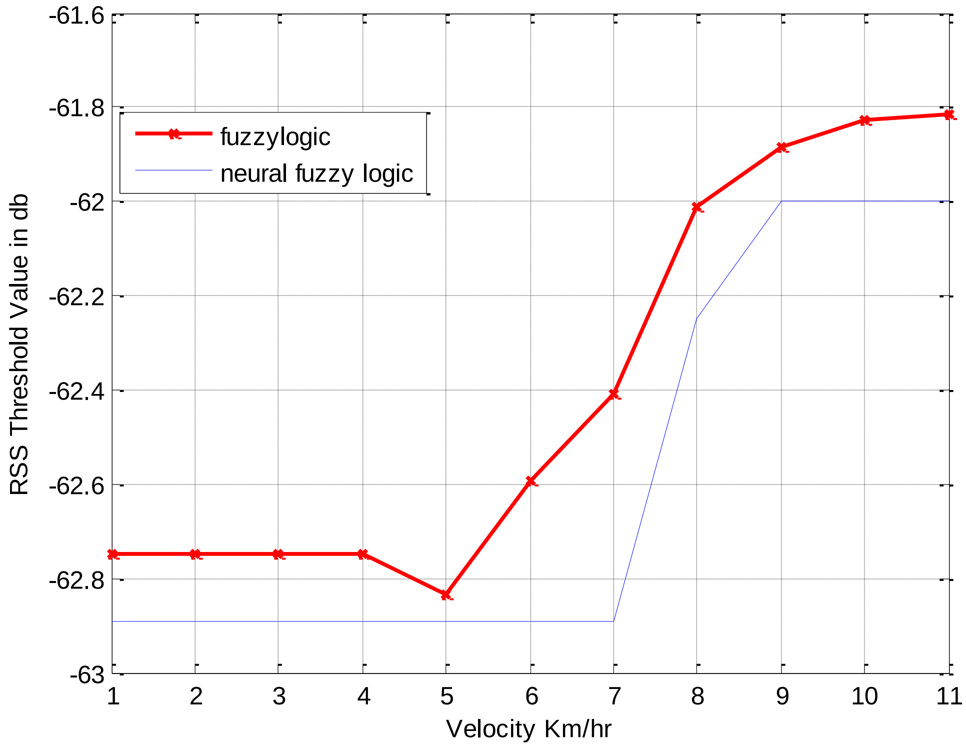

Figure 9 .RSS Threshold (S_{th}) output for different velocities for microcellular system using neural fuzzyapproach.

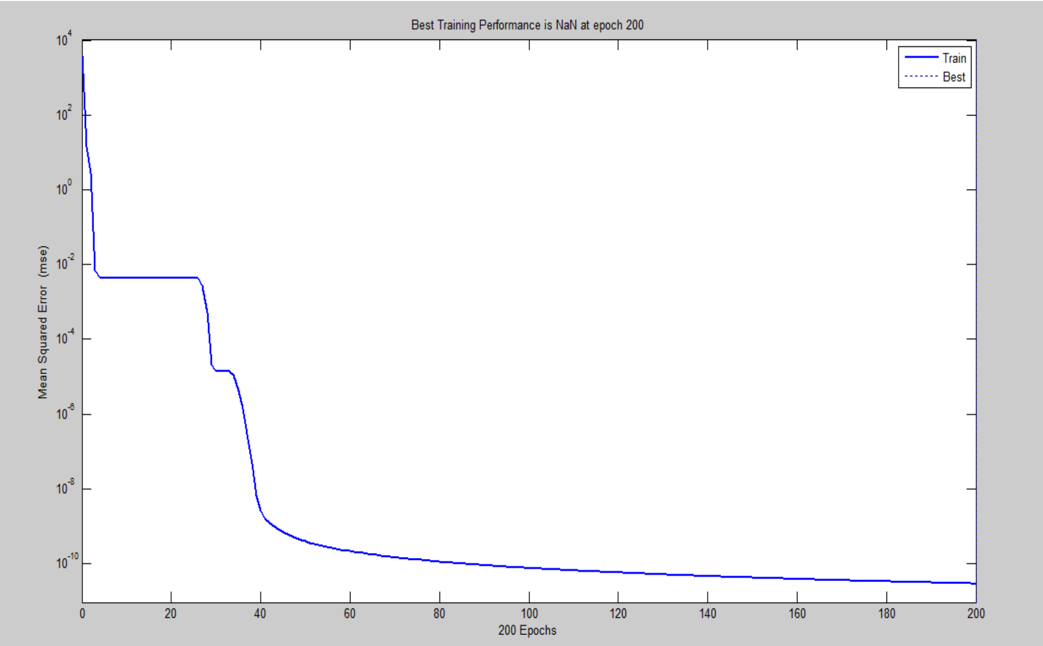

Figure 10 .Performance of neural network

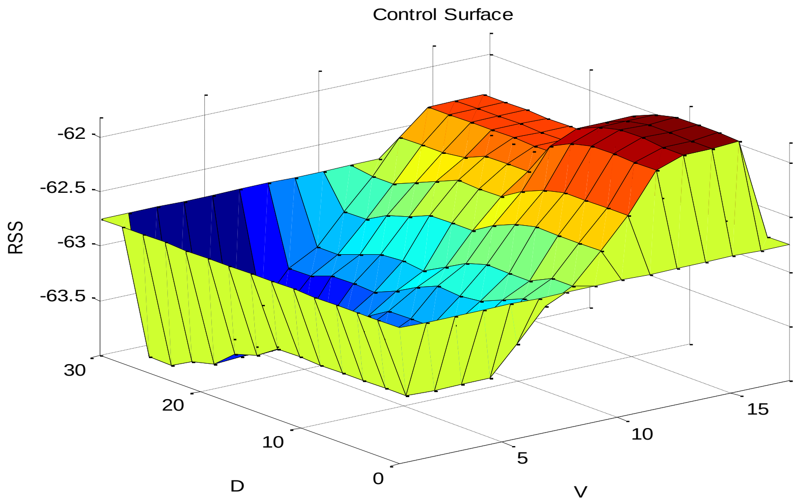

Figure 11. Control surface of velocity and distance

VII. CONCLUSION

In this paper, we proposed a neural fuzzy logic for NGWS which uses user's mobile speed to decide whether handoff is necessary or not. By using neural fuzzy logic it is seen that the threshold value of received signal strength required for sustaining voice capability is much less as compared with fuzzy system. We can conclude that the power required is less by using neural fuzzy approach. The same method can be used for macro cellular system, so it enhances the performance of system.

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