

An ANN Based Call Handoff Management Scheme for Mobile Cellular Network

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Abstract

Handoff decisions are usually signal strength based because of simplicity and effectiveness. Apart from the conventional techniques, such as threshold and hysteresis based schemes, recently many artificial intelligent techniques such as Fuzzy Logic, Artificial Neural Network (ANN) etc. are also used for taking handoff decision. In this paper, an Artificial Neural Network based handoff algorithm is proposed and its performance is studied. We have used ANN here for taking fast and accurate handoff decision. In our proposed handoff algorithm, Backpropagation Neural Network model is used. The advantages of Backpropagation method are its simplicity and reasonable speed. The algorithm is designed, tested and found to give optimum results.

Keywords

Handoff; Backpropagation; Artificial Neural Network; Received Signal Strengths; Traffic Intensities.

1. INTRODUCTION

In mobile cellular communication, maintaining continuous communication when the user migrates from one cell to another is done by changing the controlling base station – a process called call Handoff. Handoff involves measurement, decision and execution. In present generation mobile cellular systems, Mobile Station (MS) estimates the signal strengths from each base station and the value of the received signal level is generally affected by three parameters : path loss, shadow fading and small scale fading. Small scale fading has much shorter correlation distance and averaged out over the time scale under consideration [1] and also anti-multipath fading techniques are available now-a-days [2, 3]. Hence, in a system with anti-multipath technique the effect of small scale fading is not normally considered. But in the present work, multipath fading is considered for considering practical scenarios.

In practice, the low speed mobiles may stop after the handoff execution resulting unnecessary handoff. Similarly, the high speed mobiles may move well into the next cell before the handoff execution resulting call termination. Moreover, the signal strength from base station decreases as $\exp(-\gamma d)$ where d is the distance of the mobile station from base station and γ is the path loss exponent. In uniform propagation environment, γ can be taken as constant. But in real environment γ may have different values at different places varying from 2 to 6. So, an algorithm based on path loss exponent and user velocity is essential.

As discussed above, handoff characteristics are user velocity dependent. The effect of mobile velocity on handoff performance has been studied by many workers [4,5,6]. Performance metrics such as probability of handoff, average number of handoff, call blocking probability and call completion probability change significantly as user velocity changes. The traffic density in an average urban area generally follows normal distribution [7]. In our country, the average speed in four metro cities e.g, Delhi, Mumbai, Chennai and Kolkata were found to be 30 Km/hr, 25 Km/hr, 25 Km/hr and 22 Km/hr respectively [8]. Due to the sensitivity of handoff performance to path loss exponent, as discussed in the previous section, a variable hysteresis scheme is already proposed [9] where the hysteresis margin is determined as a function of path loss exponent.

In our work, signal strength from the serving and target base stations and traffic intensities of the serving and target base stations are considered. A three layer ANN model [10] is chosen in the design. Signal strengths from the serving and target base stations are estimated using least square estimation method incorporating Rayleigh fading [11]. A Threshold and hysteresis margin based scheme is chosen where handoff decision is taken only when the signal strength from the current base falls below some threshold value and also the signal strength difference between the current and the serving base station is higher than the hysteresis margin so as to avoid ping – pong effect. In the proposed handoff scheme different signal strengths and traffic intensities are considered to find out the position of handoff. Simulation is carried out using C++ language.

2. BACK PROPAGATION NEURAL NETWORK

An ANN which is an information-processing paradigm is configured for a particular application through a learning process. In our proposed algorithm, Backpropagation Neural Network is used which is an iterative method that starts with the last layer and moves backward through the layers until the first layer is reached. In this method, the outputs and the errors in outputs are calculated and the weights on the output units are altered. Then the errors in the hidden nodes are calculated and the weights in the hidden nodes are altered. The Backpropagation algorithm changes the weights to minimize the errors. The Backpropagation (**BP**) structure shown in Fig.1 consists of three groups, or layers, of units: a layer of "**input**" units is connected to a layer of "**hidden**" units, which is connected to a layer of "**output**" units. The activity of the input units represents the raw information that is fed into the network. The activity of each hidden unit is determined by both the activities of the input units and the connectivity weights between the input and the hidden units. The behavior of the output units depends on the activity of the hidden units and the weights between the hidden and output units.

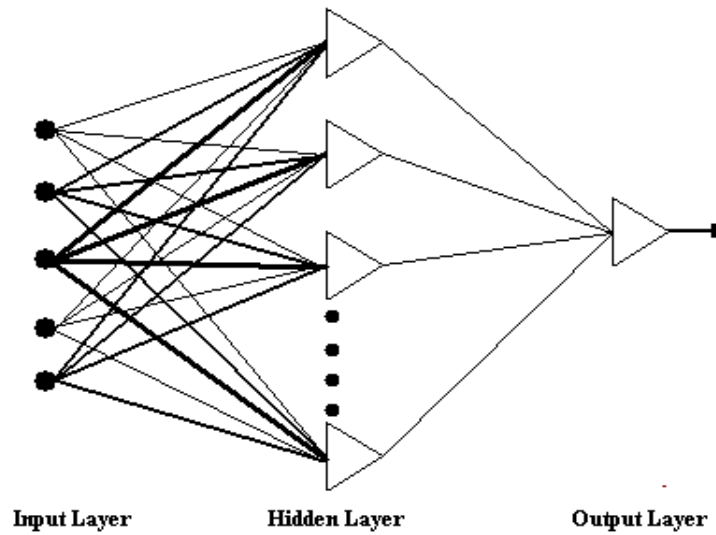


Fig. 1 Backpropagation Neural Network

The number of nodes used in the hidden layer is 20. This number is found after training the network and the errors were found to converge using the value [12]. The output node is a linearly weighted sum of the hidden unit outputs. The outputs decide whether the system needs a handoff or not. If output is -1, no handoff decision will be taken. If output is +1, then handoff decision will be taken. This simple type of network is interesting because the hidden units are free to construct their own representations of the input. The weights between the input and hidden units determine when each hidden unit is active, and so by modifying these weights, a hidden unit can choose what it represents. The advantages of back propagation method are its simplicity and reasonable speed.

Selection of a good activation function is very important because it should be symmetric, and the neural network should be trained to a value that is lower than the limits of the function. One good selection for the activation function is the hyperbolic tangent, or $F(y) = \tanh(y)$, because it is completely symmetric, as shown in Fig 2.

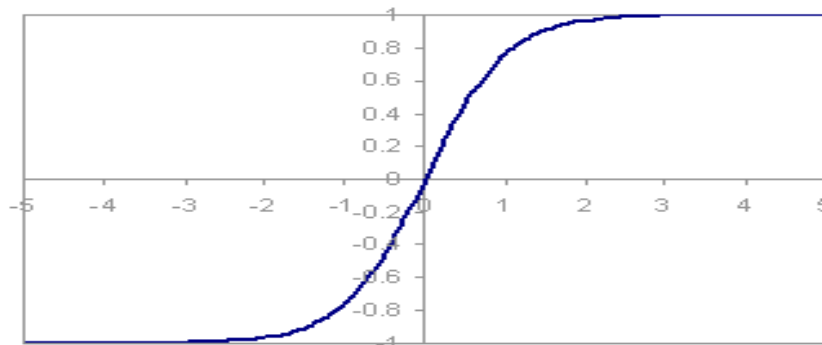


Fig. 2 Hyperbolic tangent function

Another reason for choosing it is that it's easy to obtain its derivative and also the value of derivative can be expressed in terms of the output value (i.e., as opposed to the input value). In our work, this hyperbolic tangent function is chosen.

3. PROPOSED HANDOFF ALGORITHM

Two base stations are considered in our paper and the cell radius is assumed to be 500 meter. Fig 3 is the flow chart illustrating the proposed handoff algorithm. Signal strengths of the serving and target base stations are monitored. When the received signal strength from the serving BS less than the threshold value and the received signal strength (**RSS**) from the serving BS is lower than the target BS by hysteresis margin, then a handoff is done to continue the call in progress. Otherwise no Handoff decision will be taken. Then Artificial Neural Network is used to take the handoff decision depending on both **RSSs** and **TIs** [1] of the serving and target BSs. If output of the neural network is +1 then handoff decision should be taken, where as for -1 no handoff will be taken. The threshold value and the hysteresis margin are chosen to be -85 dBm and -5 dBm respectively.

The inputs to the neural network are listed below -

1. x_1 is the signal strength of mobile received from the serving BS.
2. x_2 is the signal strength of mobile received from the target BS.
3. x_3 is the traffic intensity (TI) of the serving BS.
4. x_4 is the TI of the target BS.
5. x_5 is the bias.

The received signal strength (**RSS**) is considered as:

Low (L): $RSS \leq -85$ dBm and **High (H):** $RSS > -85$ dBm.

The Traffic Intensity is considered as follow:

Low (L): $TI < 0.66$ Erlangs/Channel,

Medium (M): $0.66 \geq TI \geq 0.76$ Erlangs/ Channel,

High (H): $TI > 0.76$ Erlangs/Channel,

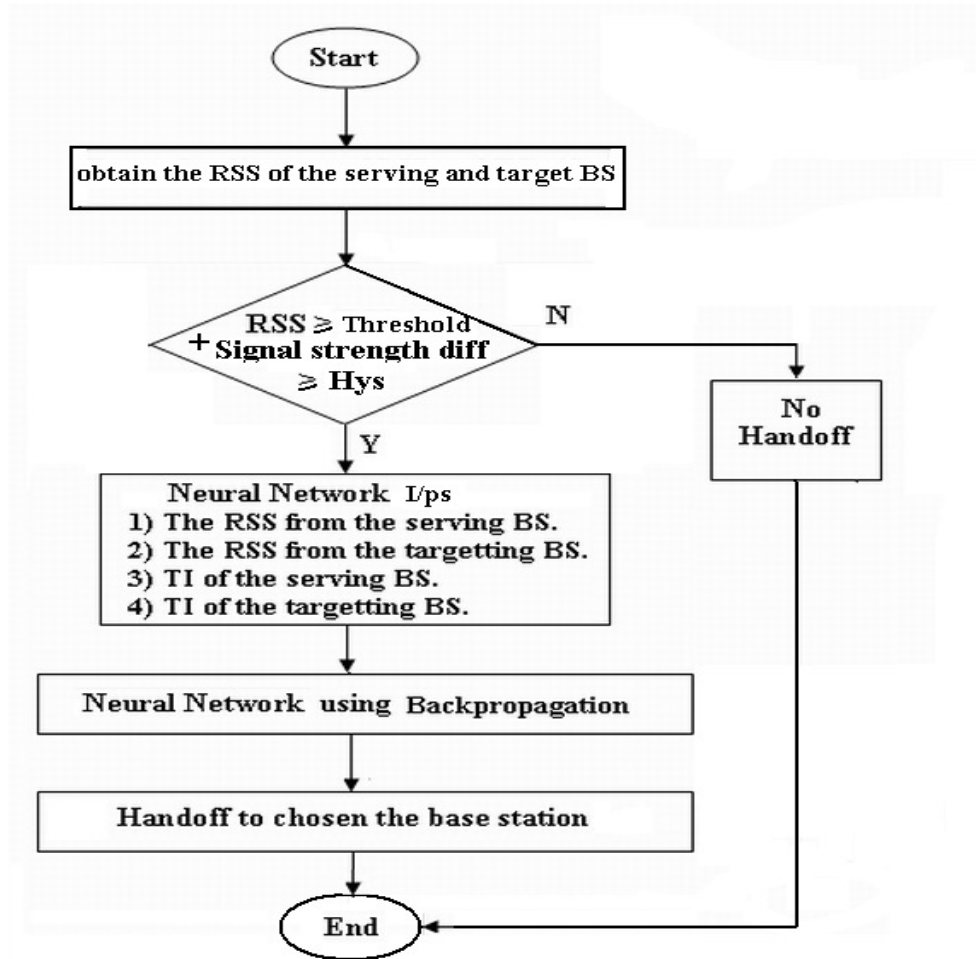


Fig.3 Neural Network based Handoff Algorithm

In this paper four different cases are considered as mentioned in Table 1, such as:

- 1) Both the **RSSs** from the serving and target **BSs** are low.
- 2) The **RSS** from the serving **BS** is low while the **RSS** of the target **BS** is high.
- 3) Both the **RSSs** from the serving and target **BSs** are high.
- 4) The **RSS** from the serving **BS** is high while the **RSS** from the target **BS** is low.

In each case handoff decisions (**HO**: handoff or **NOHO**: no-handoff) will be taken depending on the different levels of traffic intensities. Let us consider that **RSS** from the serving cell is low and the **RSS** of target cell is high and their traffic intensities are low and high respectively. It is observed that neural network decides not to initiate handoff, as it is desired.

RSS from the target BS : LOW	RSS from the serving BS : LOW			
	TI : S TI : T	LOW	MEDIUM	HIGH
	LOW	NOHO	HO	HO
	MEDIUM	NOHO	NOHO	HO
	HIGH	NOHO	NOHO	NOHO
RSS from the target BS : HIGH	RSS from the serving BS : HIGH			
	TI : S TI : T	LOW	MEDIUM	HIGH
	LOW	NOHO	HO	HO
	MEDIUM	NOHO	NOHO	HO
	HIGH	NOHO	NOHO	NOHO
RSS from the target BS : HIGH	RSS from the serving BS : LOW			
	TI : S TI : T	LOW	MEDIUM	HIGH
	LOW	HO	HO	HO
	MEDIUM	HO	HO	HO
	HIGH	NOHO	NOHO	HO
RSS from the target BS : LOW	RSS from the serving BS : HIGH			
	TI : S TI : T	LOW	MEDIUM	HIGH
	LOW	NOHO	NOHO	HO
	MEDIUM	NOHO	NOHO	HO
	HIGH	NOHO	NOHO	NOHO

Table 1. Handoff decision

4. RESULTS AND DISCUSSIONS

The estimated signal strengths [5] from serving and target BS are shown in Fig.4. It is observed that received signal strengths fluctuate in a random manner in a Rayleigh fading environment. For different values of hysteresis margin and threshold value, the possibilities of handoff against distance from serving base station are calculated for different traffic intensities (Fig.5, 6, 7). It is observed from the Fig.5, that for L/L or M/M or H/H or L/M (**Low :L, Medium :M, High :H**) traffic intensity combinations the distance at which handoff decision is taken remain same. Again for H/L or H/M or M/L traffic intensity combinations the distance at which handoff decision is taken remain same as shown in Fig.6. While for L/H or M/H traffic intensity combinations no handoff will be initiated as shown in Fig.7. The results show quick response and minimum fluctuations in handoff decision. Moreover, average numbers of handoffs versus different hysteresis margins and threshold values are calculated for different sets of traffic intensities (Fig.8.). It is observed from the Fig.8.(a), that for L/L or M/M or H/H or L/M traffic intensity combinations the average numbers of handoffs is same for different hysteresis margins and different threshold values. Again for H/L or H/M or M/L traffic intensity combinations the average numbers of handoffs is same for different hysteresis margins and different threshold values as shown in Fig.8.(b). While for L/H or M/H traffic intensity combinations no handoff will be initiated as shown in Fig.8(c). Thus the algorithm works well under all possible situations.

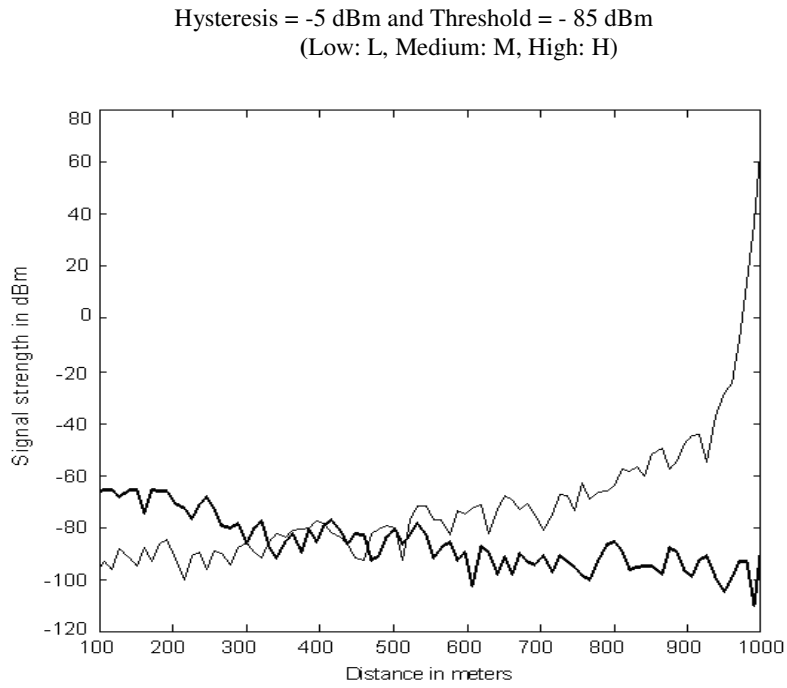


Fig.4 Received signal strengths of serving and target base stations

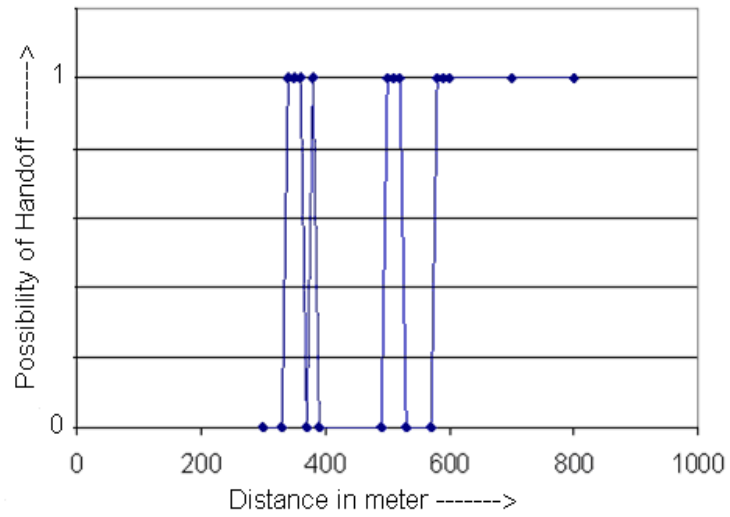


Fig. 5 For L/L or M/M or H/H or L/M Traffic Intensities

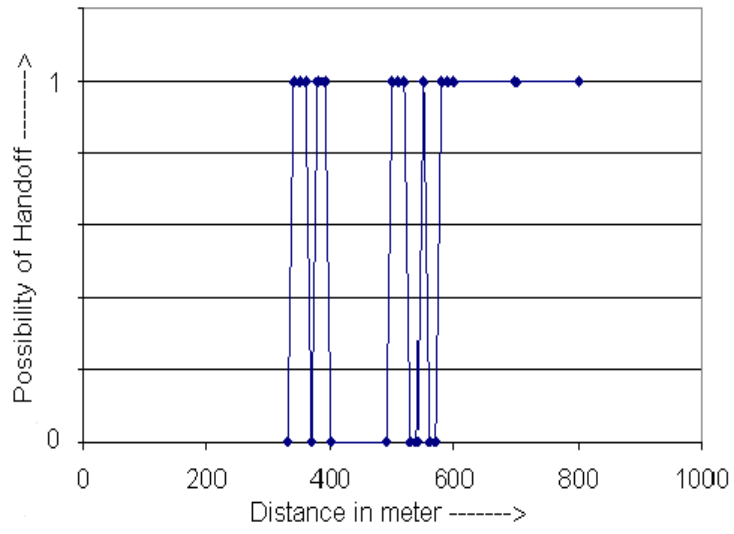


Fig. 6 For H/L or H/M or M/L Traffic Intensities

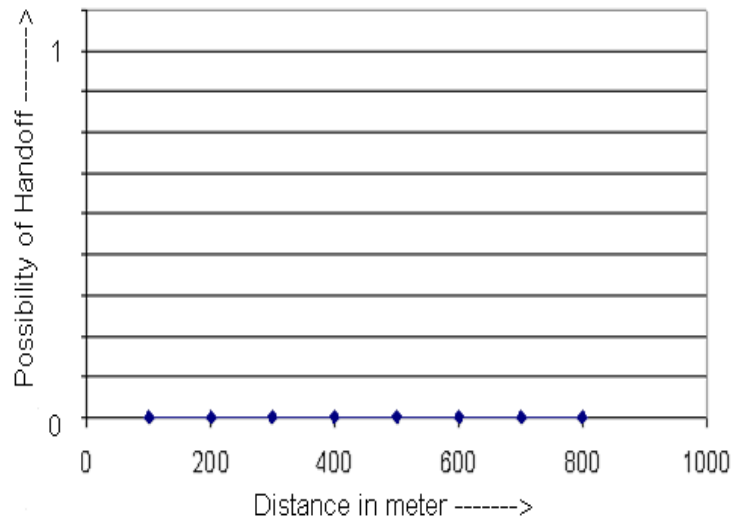


Fig. 7 For L/H or M/H Traffic Intensities

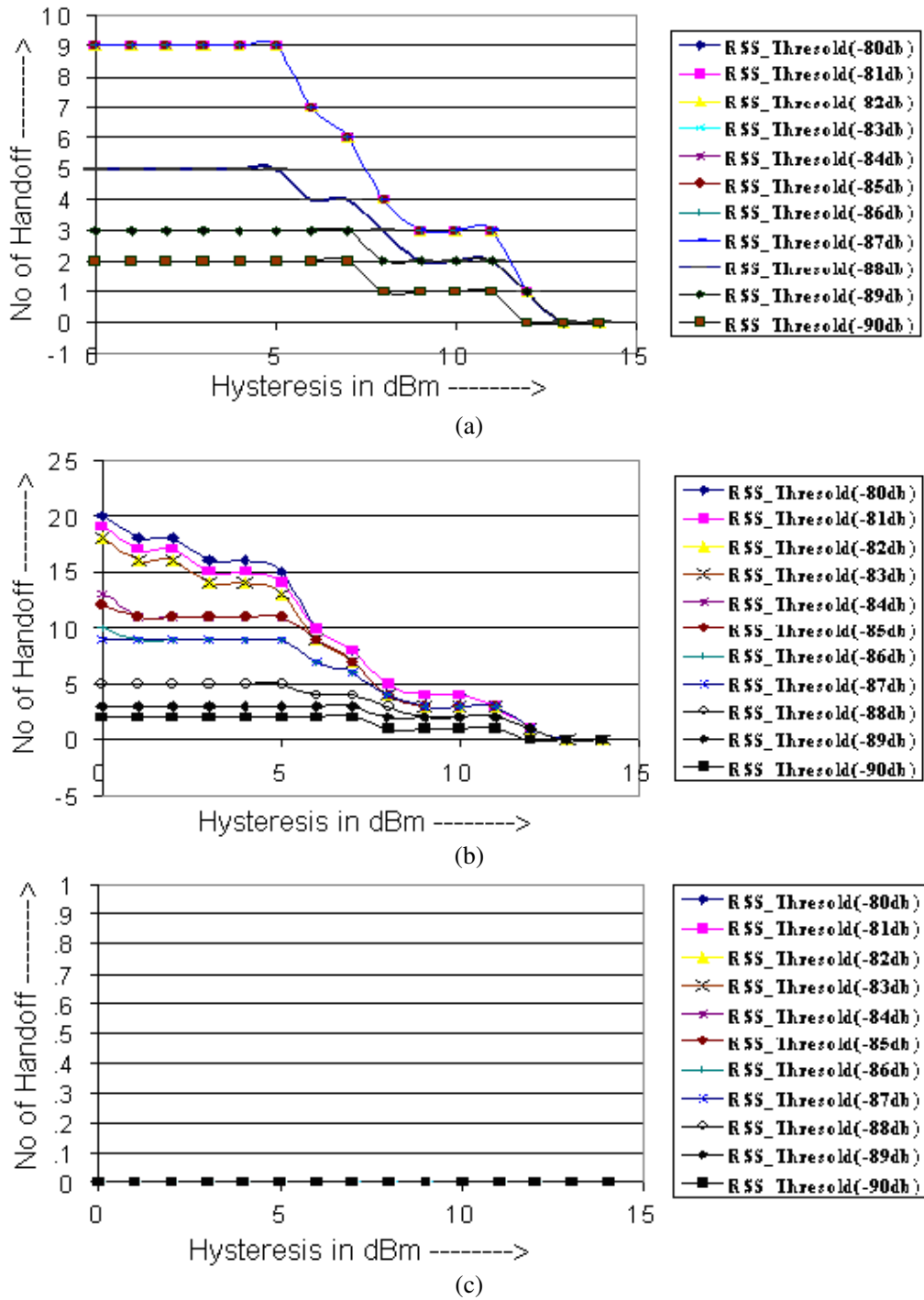


Fig. 8 No of Handoff vs. different Hysteresis margin for different Threshold value (a) For L/L or M/M or H/H or L/M Traffic Intensities (b) For H/L or H/M Traffic Intensities (c) For L/H or M/H Traffic Intensities

5. CONCLUSIONS

A handoff algorithm using Artificial Neural Network is designed and the performance of the algorithm is studied in this paper. It is observed from the results that the handoff decisions are taken in appropriate positions and the number of fluctuations are also low. Average number of handoffs is also low which minimizes base station and mobile switching centre processor loading. The designed algorithm can be easily embedded and applied to practical mobile cellular networks.

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