Neural Network Handoff Decision in Mobile Cellular using Received Signal Strength and Traffic Intensity

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ABSTRACT

This paper proposes the handoff approach by means of Neural Network for mobile telephone system, such as Global System for Mobile communication (GSM), especially focus on received signal strength (RSS) and traffic intensity (TI). A model of Base Transceiver Station (BTS) or cell, 7 cells, that have several traffic intensity. And using the principle of the mobiles in the hysteresis area can connect to more than one cell for handoff to the lower traffic intensity cell. The result shown that the proposal can reduce the drop calls, keeps the call blocking for acceptation of Grade of Service (GOS) and decreases the unnecessary handoffs)

Keywords : *Neural Network, Hystersis area, Received Signal Strength and Traffic Intensity, Handoff Decision.*

I. INTRODUCTION

Since the need of mobile telephone have been increased rapidly than the mobile station (MS) installation. The problem is the channel not enough for provide the user, it cause the high drop call and sometime can not make a connection. The solution of this problem has been presented such as Direct Retry [1] method, which load sharing when the channel in the cell fully used and the mobile telephone using in the hystersis area or cells. If the new called occur outside this area it cause the high call blocking. In case of telephone moved out of the cell but the channel in the cell not fully used, the load sharing not occur until the signal strength from the previous cell lower than the sensitivity limited it cause the call drop. The Load Sharing [2] method, which handoff occur when there are two empty channels between cells. The resulted is handoff rate occur even the cell still have many empty channel. This paper presented the handoff method by using Neural Network. Since it suitable for solve problem which has a huge number of data and can be processed the output very fast. By consider the traffic intensity and the received signal strength, for reduce the drop call and call block into the standard gain including decrease the number of handoff that not necessary, then compare with Direct Retry and Load Sharing method.

II. PRINCIPLE OF HANDOFF

A. Consider the signal strength (Conventional)

While the mobile telephone moving it will measured the signal strength of the cell which it's connected to and the neighbor cells. These signal level will be sent to the using cell every 0.48 seconds [3]. The BSC will be make the order of the signal strength by using 10 data [3] then calculate the average level, which can be reduce the variance of signal level.

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The GSM decision the handoff as presented in [5]:

$$RSS\_AVG = RSS\_AVG_T - RSS\_AVG_S \geq HYS \quad (1)$$

Where RSS_AVG=different value between RSS_AVG_T and RSS_AVG_S

RSS_AVG_T = the average level of neighbor cells

RSS_AVG_S = the signal level of the connected cell

HYS= hysteresis level (margin of handover)

- **The area and hysteresis level,** Hysteresis area is the area that the mobile telephone in this area do not need to handoff The handoff occur when it moving from this area. By determine the area from hysteresis level, which considered the neighbor signal level that more than this level (how much), is can be handoff. The hysteresis level can be reduced the Ping-Pong effect of the handoff. Especially the cell margins, which the signal will be sensitive to the fading, that make it cause the handoff easily.

B. Handoff by using Neural Network method

- **The structure of Neural Network,** Neural Network is the algorithm, which design like a human brain. It consisted of the basic structure as node or unit, input layer, hidden layer and output layer. The input layer consisted of (X_1,X_2) (X_3,X_4) (X_5,X_6), which are the traffic intensity data of cell S, N_1 and N_2 respectively. While X_7, X_8, X_9 are the received signal strength from cell S, N_1 and N_2 respectively. The cell S is the service cell (or cell A). The cell N_1 and N_2 are the neighbor cells, which can be selected as B C D E F and G depend on the direction of moving. There are 10 hidden layer nodes consisted of Z_1 to Z_{10}. The output layer separated into 2 Nodes, there are Y_1 and Y_2, which are the handoff decision level and weight value.

The simulation of Neural Network can be separate into 3 models. There are Perceptron Network, Associative Memory and Biological model. In this paper chosse the Back Propagation Multilayer Perceptron model, which structure is (9-10-2) as shown in Fig. 1[4].

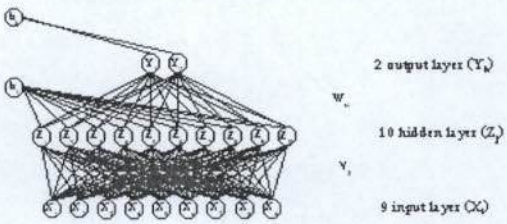

Fig. 1 Backpropagation Neural Network structure

There are to steps when using Neural Network: training and testing. The training step must be have the data format good enough for provide the network to classify the differential of input data. This step separate into 2 types, there are forward propagation and backward propagation.

In forward propagation, the input data are feed to the Neural Network, then the network will be calculate from the input layer to the output layer. The correct output determine by $X_p=(\chi_{P1},\chi_{P2},\chi_{P3},\ldots,\chi_{PN})$, which is the received signal strength and traffic intensity that feed to input layer. Where p stand for the order of training step. The result is the net input at j of hidden layer as:

$$net^h_{pj} = \sum_{i=1}^{N} v^h_{ji} x_{pi} + b^h_j \quad (2)$$

The output of hidden layer calculate from:

$$Z_{pj} = f(net^h_{pj}) \quad (3)$$

And the output layer equation is:

$$net^0_{pk} = \sum_{j=1}^{L} w^0_{kj} z_{pj} + b^0_k \quad (4)$$

$$Y_{pk} = f(net^0_{pk}) \quad (5)$$

Where $f(X)$ is the sigmoid function of $f(X) = \frac{1}{1+e^{-x}}$, X is input node, Y is output node, Z is hidden node, b is bias value, W is weight value of output node and V is weight value of hidden node.

The another type, backward propagation is calculate from the output layer to the input layer for get the error value in order to improve the weight value of hidden and output layer.

The compensate value of output layer calculate from:

$$\delta_{pk} = f'(net^0_{pk})(tk - Y_{pk}) \quad (6)$$

Where $(tk - Y_{pk})$ is the error value at the output layer.

$$\Delta W_{kj}(t+1) = \eta \delta_{pk} Z_{pj} + \mu \Delta W_{kj}(t) \quad (7)$$

$$_{kj}(t+1) = W_{kj}(t) + \Delta W_{kj}(t+1) \quad (8)$$

And the compensate value of hidden layer calculate from:

$$\delta_{pj} = f'(net^h_{pj}) \sum_k \delta_{pk} W_{kj} \quad (9)$$

Where $\sum_k \delta_{pk} W_{kj}$ is the error at hidden layer.

$$\Delta V_{ji}(t+1) = \eta \delta_{pj} X_{pi} + \mu \Delta V_{ji}(t) \quad (10)$$

$$_{ji}(t+1) = V_{ji}(t) + \Delta V_{ji}(t+1) \quad (11)$$

Repeat the calculated by using equation (2) until get the correct output value as require.

- **The Neural Network handoff step,** The handoff decision consist of 2 parts, first is decision by the receive signal strength when the mobile telephone at these condition area:

$$RSS\_AVG_T - RSS\_AVG_S \geq HYS.$$

The other is decision occur when the mobile telephone at the hysteresis area.

III. THE EXPERIMENT

A. *Wave propagation model*

This paper used the wave propagation model as Hata [5], which the path loss equation is:

$$P_L = 69.55 + 26.16 \log f_c - 13.82 \log h_b - a(h) + (44.9 - 6.55 \log h_m) \log R \quad (12)$$

Where f_c is carrier frequency (MHz)

h_b is the cell height (m)

hm is the telephone mobile height (m)

R is the distance between telephone mobile and cell (km)

a(h) is the factor for compensate the telephone mobile height, which related to the size of service area in the city.

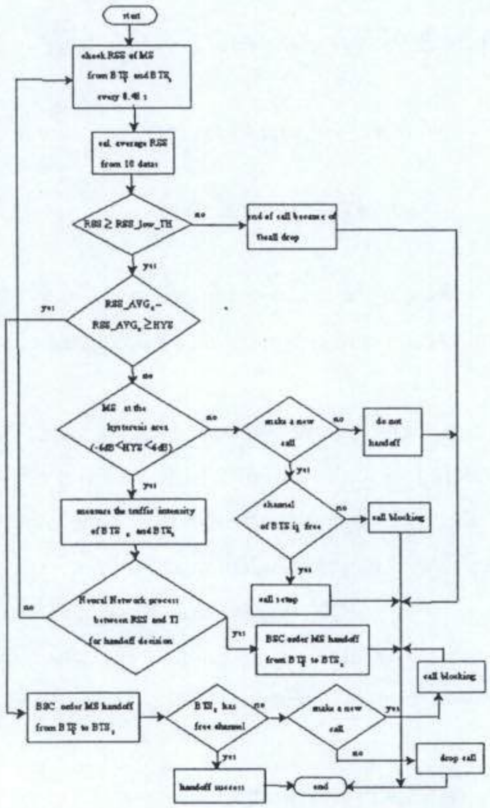

Fig. 2 The Neural Network handoff step flowchart

$$a(h) = 3.26(\log 11.75h_m)^2 - 4.97 \quad (13)$$

For $f_c \geq 400$ MHz

B. Call model

Call model consisted of the call position, which is Uniform distribution. There has traffic equal to 12 Erlang at cell A, but for cell B to G the traffic equal to 0.7 of cell A. The call occur as Poisson distribution and the calling time is Exponential distribution as averaged 120 second [5].

C. Cell station characteristic model

There are 7 cells of A to G in cell station characteristic model. They are used 900 MHz for carrier frequency and transmitted 10 watts (40dBm) at each cell. The height of cell station antenna is 30 meters while the telephone mobile is 1.5 meters, which the cell radius 4.676 kilometers [2] control by base station control (BSC) of any cell. Each cell send the omnidirection wave propagation with the received signal strength low threshold (RSS_low_TH) equal to -110 dB. There are 14 channels in each cell and the hysteresis area 30% as shown in Fig. 3 [2].

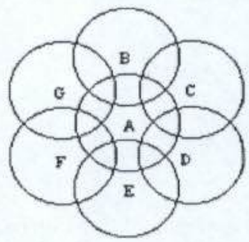

Fig. 3 Cell station model

D. Input parameter

There is 2 Input parameters of Neural Network as following.

- **The received signal strength (RSS),** which have 2 value (1. low = -105 to -100 dBm, 2. high for greater than -100 dBm).
- **The traffic intensity (TI),** which have 3 value (1. low for less than 0.58 Erl/ch 2. medium for 0.58 Erl/ch to 0.69 Erl/ch and 3. high for greater than 0.69 Erl/ch).

E. The moving model of mobile telephone

The moving model assign as the move strength forward from BTSS to BTST at the average speed 50 kilometer per hour with 30% of user moving direction as Uniform distribution.

F. Decision parameters of Neural Network

Table 1 Decision parameters of Neural Network

RSS N_1 : Low , RSS N_2 : Low							
RSS S		RSS S : Low			RSS S : High		
TI : N_2	TI : S / TI : N_1	Low	Medium	High	Low	Medium	High
Low	Low	No	No	No	No	No	N_2
	Medium	No	No	No	No	No	N_2
	High	No	No	No	No	No	N_2
Medium	Low	No	No	No	No	No	N_1
	Medium	No	No	No	No	No	N_2
	High	No	No	No	No	No	N_2
High	Low	No	No	No	No	No	N_1
	Medium	No	No	No	No	No	N_1
	High	No	No	No	No	No	No

(a)

RSS N_1 : Low , RSS N_2 : High							
RSS S		RSS S : Low			RSS S : High		
TI : N_2	TI : S / TI : N_1	Low	Medium	High	Low	Medium	High
Low	Low	N_2	N_2	N_2	No	No	N_2
	Medium	N_2	N_2	N_2	No	No	N_2
	High	N_2	N_2	N_2	No	No	N_2
Medium	Low	N_2	N_2	N_2	No	No	N_2
	Medium	N_2	N_2	N_2	No	No	N_2
	High	N_2	N_2	N_2	No	No	N_2
High	Low	No	No	N_1	No	No	N_1
	Medium	No	No	N_1	No	No	N_1
	High	No	No	N_2	No	No	No

(b)

RSS N_1 : High , RSS N_2 : Low							
RSS S		RSS S : Low			RSS S : High		
TI : N_2	TI : S / TI : N_1	Low	Medium	High	Low	Medium	High
Low	Low	N_1	N_1	N_1	No	No	N_1
	Medium	N_1	N_1	N_1	No	No	N_1
	High	No	No	N_2	No	No	N_2
Medium	Low	N_1	N_1	N_1	No	No	N_1
	Medium	N_1	N_1	N_1	No	No	N_1
	High	No	No	N_2	No	No	N_2
High	Low	N_1	N_1	N_1	No	No	N_1
	Medium	N_1	N_1	N_1	No	No	N_1
	High	No	No	N1	No	No	No

(c)

RSS N_1 : High , RSS N_2 : High							
RSS S		RSS S : Low			RSS S : High		
TI : N_2	TI : S / TI : N_1	Low	Medium	High	Low	Medium	High
Low	Low	N_2	N_2	N_2	No	No	N_1
	Medium	N_2	N_2	N_2	No	No	N_2
	High	N_2	N_2	N_2	No	No	N_2
Medium	Low	N_1	N_1	N_1	No	No	N_1
	Medium	N_2	N_2	N_2	No	No	N_2
	High	N_2	N_2	N_2	No	No	N_2
High	Low	N_1	N_1	N_1	No	No	N_1
	Medium	N_1	N_1	N_1	No	No	N_1
	High	No	No	N_1	No	No	No

(d)

IV. EXPERIMENT RESULTS

The experiment measured the call blocking rate, call drop rate and handoff rate of cell A. By comparing with direct retry and load sharing method as shown in Fig. 4.

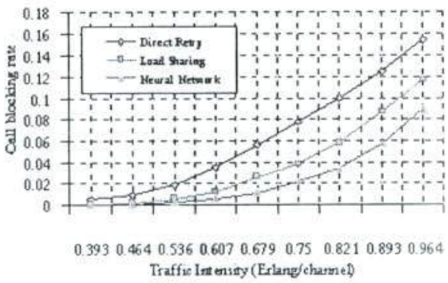

Fig. 4 Compare the call block

Fig. 4 shown the direct retry had the highest call block, because this method will be handoff when the channel fully used only and must be in the hysteresis area. It make the new call outside this area blocking, as the traffic increase the call blocking rate increase.

The load sharing method has the call blocking rate lower than the direct retry, because it will be handoff when the neighbor cells has free channel more than 2 channels. But the as traffic increased the opportunity to has free channel more than 2 channels will be decrease, so the call blocking rate still high at the area.

As the method, which the paper presented can be improved the call blocking rate from the other methods. By considering the traffic intensity and the received signal from the changeable cells for the suitable handoff. As the traffic increase the call blocking rate increase also.

Fig. 5 shown the drop call is very similar to call blocking, because they are related together. If the handoff cell destination block cause the low opportunity of handoff success until the received signal less than RSS_low_TH. As the result the call drop rate of neighbor cell similar to cell A.

Fig. 6 shown the number of handoff rate of the load sharing method is higher than the other, because it consider the differential between 2 cells only. It cause the handoff even does not necessary. For the presented method, the number of handoff lower, because it does not waiting until the channel fully use. However it is higher than the direct retry method, which handoff when the channel fully use only and at the hysteresis area.

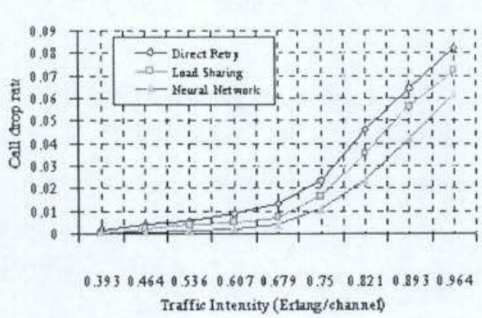

Fig. 5 Comparison the call drop

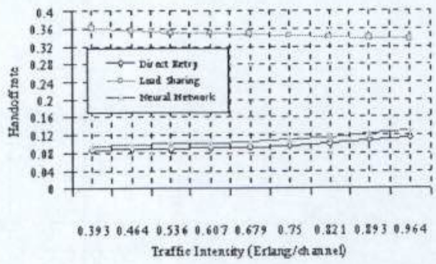

Fig. 6 Comparison the handoff

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