Fuzzy Logic Based Handover Decision Procedure Involving Multiple Matrices

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ABSTRACT:
Handover is a very common event in cellular mobile network. It is the procedure that transfers an ongoing call from one cell to another as the user's moves through the coverage area of cellular system. One way to improve the Cellular network performance is to use efficient handover prioritization schemes when user is switching between the cells. Handover decision should be precise by taking into account all the possible options. More handover cause more signaling traffic. Therefore, it is desired that handover should be done only when it is necessary. In this paper we propose fuzzy expert system to avoid the unnecessary handovers and also to avoid the ping pong effect. We have used signal strength, distance, cell load, speed, direction and signal to interference ratio as the input metrics and handover as an output of fuzzy system.

Keywords- cellular mobile network, Handover, ping pong effect, Fuzzy inference system, cell load.

I. INTRODUCTION

A cellular network is made up of number of radio cells. Each cell is allocated with a band of frequencies and is served by a base station. Adjacent cells are assigned different frequencies to avoid interference. As more customers use the cellular network with single base station, traffic may be build up so there are not enough frequency bands assigned to a cell to handle its calls. One solution of this problem is frequency reuse concept. The obstruction in cellular network involves the problem when a mobile user travels from one cell to another during a call. As adjacent cell do not use the same radio channels, a call must be transferred from one radio channel to another when a user crosses the line between the adjacent cells. The process of handover takes place that transfer an ongoing call from one cell to another cell as the user (MS) moves through the coverage area of a cellular network. In handover process cellular network automatically transfer a call from one radio channel to another radio channel while maintaining
quality of services (QoS) of a call. (Theodore S. Rappaport 2012)

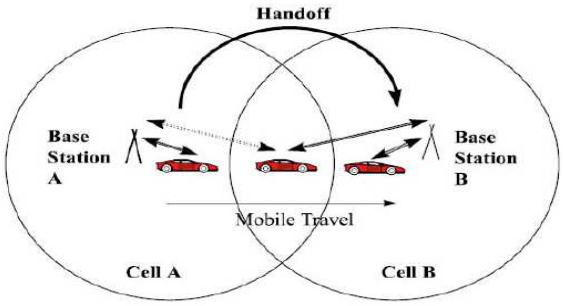

Fig.1. Handover

Handover mechanism is extremely important in cellular mobile network because of the cellular architecture employed to maximize spectrum utilization. However, to ensure more frequency reuse, cell size is getting smaller and as a result more handover is taking place as users roam. If proper handover mechanism is not used there may be huge ping pong at the cell border area or ping pong can take place because of fading. If the metrics are not balanced then unnecessary handover attempt will be there which will increase system load or lead to bad handover decision. As a result QoS will be hampered; even call drop can be occurred. (Mohammad Alaul Haque Monil, Romasa Qasim, Rashedur M Rahman 2013)

Conventional Handover depends mostly on signal strength. Like in Fig.1, if MS moves away from BTS, signal gets weaker and after reaching a certain threshold, control of that call is transferred to another base station with strong signal. The conventional RSS based handoff method always selects the Base Station (BS) with strongest signal. However, the fluctuations of signal strength due to shadowing and fading cause ping-pong effect. (Mohammad Alaul Haque Monil, Romasa Qasim, Rashedur M Rahman 2013)

A) Ping Pong Effect –

Radio signal fluctuates due to environmental disruption which may result in signal fading. Signal strength received by MS depends on these effects. In the boundary of two cells, MS can find strong signal from different cell alternatively in each measurement period because of the signal fluctuation for shadowing fading effect. If a handover algorithm is completely dependent on signal

strength, it will give alternative handover decision, so number of handovers will be increased. This scenario is called ping pong in handover.

There are various reasons needed to be known to determine whether a handover is required. The signal strength of the base station, along with the signal strengths of the surrounding stations, the availability of the channels, the distance of mobile station (MS) from base station (BS) etc. needs to be known.

In this paper we have used fuzzy logic along with the combination of several different metrics for accurate handover decision. MAHO (mobile assisted handover) is used along with Fuzzy Logic to make handover decision more efficiently. (Gjergji Mino, Leonard Barolli, Arjan Durresi, Fatos Xhafa, Akio Koyama 2009)

In this study, we present a Fuzzy Expert System for handover decision. Fuzzy Inference System (FIS) is used as an estimation method which has fuzzy input and output parameters.

This paper is organized as follows: section 2 describes the handover decision procedure using fuzzy logic section 3 describes design and development of FIS (fuzzy inference system) for handover, results are shown in section 4 and hence conclusion is drawn in section 5.

II. HANDOVER DECISION PROCEDURE USING FUZZY LOGIC

The Basic fuzzy system which is used for handover is depicted in Fig. 2. Different combination of metrics has been used in this paper for better handover decision. (Mohammad Alaul Haque Monil, Romasa Qasim, Rashedur M Rahman 2013)

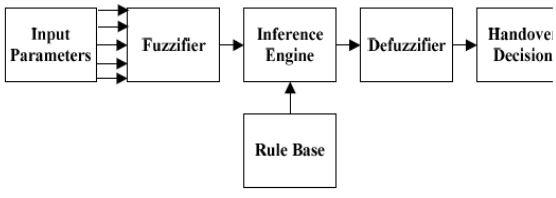

Fig.2. Fuzzy inference system for Handover

A) Metrics For Handover

We use seven metrics in total to calculate the handover probability of different cells and accordingly the best neighboring cell will be chosen as serving. (Mohammad Alaul Haque Monil, Romasa Qasim, Rashedur M Rahman 2013) (Theodore S. Rappaport 2012)

The metrics are

1) Signal Strength (dbm)
2) Distance from Base station (m)
3) Cell Traffic Load (%)
4) Speed (kmph)
5) Direction
6) Signal to co-channel interference ratio (C/I)
7) Signal to adjacent channel interference ratio (C/A)

Mobile station (MS) continuously provides status report to BTS and sends a report which is called Radio link measurement Report or SACCH (Slow Associated Control Channel) Measurement reports transmitted periodically every 480ms interleaved over 4 SACCHs. In Mobile Assisted Handover – MAHO, handover decision is dependent on this report. Normally, MS sends report of 6 neighbor cell to BTS and then BSS processes it to make decision.

Signal strength - Signal strength can be found from measurement Report (MR) of mobile station (MS). The Received Signal Strength (RSS) based handoff algorithm associates mobile station to the access point, which has the strongest perceived signal strength at the mobile station side. The signal received from an access point degrades as the distance between the mobile and the access point increases. Signal strength is considered from -110dBm to - 48dBm with relative accuracy of 1dB and absolute accuracy of 4dB (up to -70dBm) and 6dB and average is calculated over SACCH multiframes (480ms).

Distance from Base station – Distance is the second metric that we have used. It is important to know how far the MS is from the BTS. Distance-based algorithms relate the mobile with the closest access point. Distance can be calculated from the received signal strength. From measurement report, TA (Timing Advance) is found. It can also be converted into distance and be used. Distance measurement can improve the handover performance.

Cell Traffic Load – Handoff should be successful; a free channel should be available at the candidate BS. Efficient channel allocation algorithms and some traffic balancing can maximize the probability of a successful handoff. Handoff should maintain the planned cellular borders to avoid congestion, high interference, and use of assigned channels inside the new cell. Each BS can carry only its planned traffic load. The handovers are carried out only if the receiving cells have a low enough load. The load in every cell is monitored in the BSC.

Speed- speed is an important input parameter we have included in handover decision. It considers mobiles with different velocities, i.e. the handoff needs of fast moving

mobiles should be determined immediately. This can be achieved by adjusting the effective length of the averaging window in which received signal strengths from the access point are averaged.

Direction- In direction biased algorithms handoffs to the access points towards which the mobile is moving are encouraged, while handoffs to the access points from which the mobile is receding is discouraged . In pre-selection handoff algorithm, a mobile hands off to the access point towards which the mobile is moving even though measured handoff decision metrics of that access point is not the best. Considering that these metrics will improve as the mobile gets closer to the access point.

Speed and direction plays an important role in selecting the best candidate for handover. As it is the measure of relative speed with the BTS, it shows how fast the MS is coming towards the BTS or how fast it is going away from the BTS. So it provides a prediction, after some time MS will be coming closer to a BTS or going farther from a BTS and selects candidate based on that prediction. Based on this metric, there are reduced number of handovers Occurs and it avoid unnecessary intermittent handovers.

Carrier to co-channel interference ratio (C/I) - Interference, is a limiting factors in the performance, of cellular radio systems .it causes cross talk where the subscriber hears noise in the background due to an undesired transmission. Interference leads to blocked calls due to errors in the digital signaling. It is more severe in urban areas, due to the greater High Frequency (HF) noise floor and the large number of base stations and mobiles. Frequency reuse implies that in a given coverage area there are several cells that use the same set of frequencies, these cells are called co-channel cells and the interference between signals from these cells is called co-channel interference. Carrier-to-Interference (C/I) ratio expresses the relative strengths of the wanted signal and interfering signals. At lower (C/I) the Bit Error Rate (BER) becomes very high and the channel coding is unable to provide adequate error correction. A high C/I ratio yields quality communication. A good C/I ratio is achieved in cellular systems by using optimum power levels through the power control of most links The GSM recommendations specify a minimum working C/I of 9 dB. So in handover decision it is necessary to know how good will be the quality of call when we transfer the call to some new BTS. When we transfer the ongoing call to some new BTS quality of the call should not be hampered.

Carrier to adjacent channel interference ratio (C/A) - Interference resulting from signals which are adjacent in frequency to the desired signal is called adjacent channel interference. Adjacent channel interference results from imperfect receiver filters which allow nearby frequencies to leak into the pass band. The more selective the receiver is the less will be its response to adjacent channels. The carrier to adjacent channel (C/A) ratio expresses the strength of the wanted channel to that of the adjacent channel. GSM channel coding includes error detection and correction; there is a limit to the interference it can deal with successfully. The GSM recommendations specify a working minimum C/A of -9 dB. The greater the distance between the source of the wanted signals and the source of the adjacent signal, the better will be the C/A.

III. FUZZY INFERENCE SYSTEM FOR HANDOVER

A FIS (Fuzzy Inference System) is developed to provide fuzzy handover decision using the seven metrics as input. To design the system, the FIS tool in MATLAB R2010a is used. Membership function needs to be defined to develop the FIS. We have used total of 8 linguistic variables including Handover as output. We have used Z shaped, Gaussian and S shaped membership function as they are appropriate for their smooth

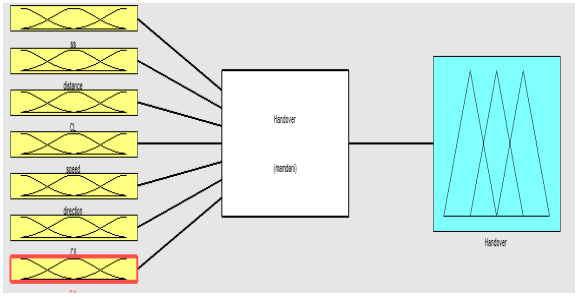

Fig.3. Fuzzy inference system (FIS)

transition rather than triangular or trapezoidal function. Range of the membership functions are chosen following other literatures [2, 3] and based on practical scenario. The membership functions of a fuzzy system are designed based on heuristic experience. The parameters are decided as per other research conducted in these arena and heuristic experience. Membership functions of the linguistic variables are given below:

1)Signal Strength (SS) = {Weak, Normal, Strong};

Signal strength of -95 dbm is acceptable as normal signal strength in telecom industry and used in other literature, therefore it is considered as normal signal strength.

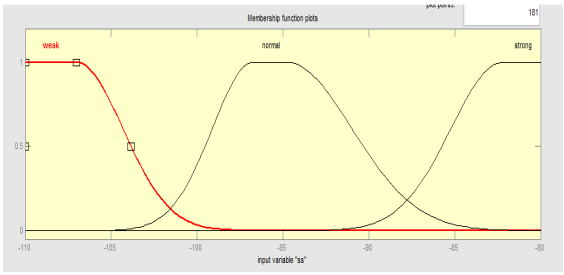

Fig.4. Member ship functions of Signal Strength (SS)

2) Distance from Base station (Distance) = {Near, medium, Far};

For distance, half kilometer distance is considered as medium.

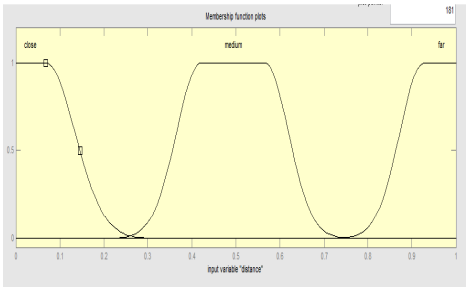

Fig.5. Member ship functions of Distance

3)Cell Traffic Load (CL) = {Low, Medium, High};

For cell load, 50% cell load is considered medium.

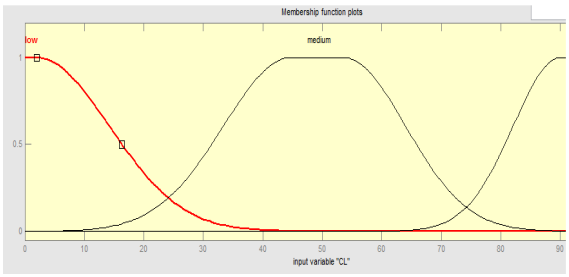

Fig.6. Member ship functions of cell load(CL)

4)Speed = {Slow, medium, Fast};

For speed more than 60 kmph is considered as fast.

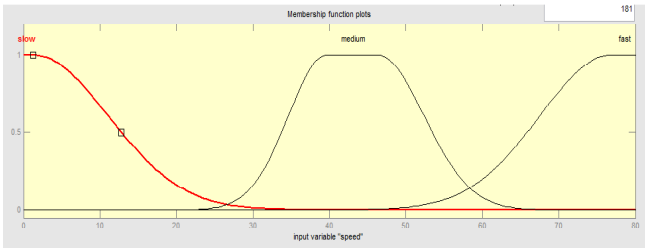

Fig.7. Member ship functions of Speed

5)Direction (D) = {towards, away};

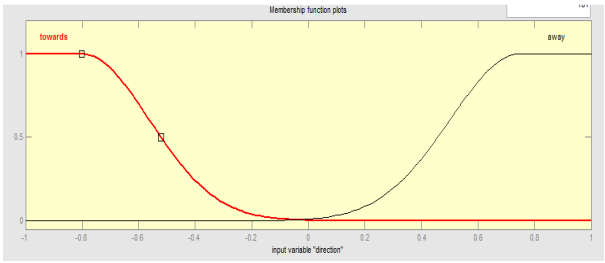

Fig.8. Member ship functions of Direction

6)Carrier To Co-Channel Interference Ratio (C/I) = {low, medium, high};

The GSM recommendations specify a working minimum C/A of -9 dB, so C/I of 9 dB is considered as low.

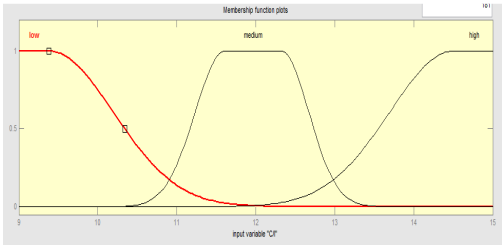

Fig.9. Member ship functions of C/I

7)Carrier to adjacent channel Interference Ratio (C/A) = {low, medium, high};

For C/A -9dB is considered as low.

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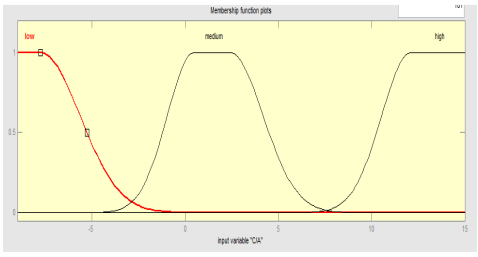

Fig.10. Member ship functions of C/A

8) Handover (HD) = {Low, Medium, High};

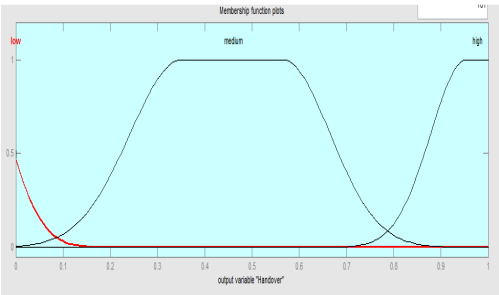

Fig.11. Member ship functions of Handover

The fuzzy inference engine is a group of rules developed using expert knowledge. We have designed the knowledge-based rules that connect the inputs and the outputs based on a careful understanding of the philosophy behind the handover behaviors. Fuzzy rule base is shown in Table 1. Five rules are used in this system. The rules have been developed using *if-then* method. Using these rules, the result Hanover probability has been computed.

Table 1: Fuzzy Rule Base

INPUTS							OUTPUTS
SS	DIS	CL	SP	DIR	C/I	C/A	HANDOVER
S	C	L	F	T	H	H	H
S	M	M	F	T	H	M	H
N	M	H	S	T	L	M	L
W	F	H	F	A	M	M	L
S	M	L	M	A	H	M	M

IV. RESULTS AND DISCUSSION

Figure 12 shows the result for the Handover i.e. output at input1 (signal strength) -84.8, input2 (distance) is 0.207, input3 (cell load) is 23.2 and input4 (speed) is 63.4, input5 (direction) is -0.439, input6 (carrier to co-channel interference ratio) is 14.2 and input7 (carrier to adjacent channel interference ratio) is 8.85. Hence, the output probability of handover occurring is 0.883.

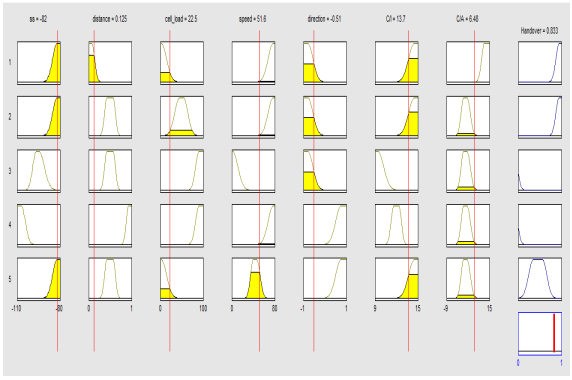

Fig.12. The result rules of FIS

The surface view of fuzzy inference system in three dimensions as shown in Fig. 13 .

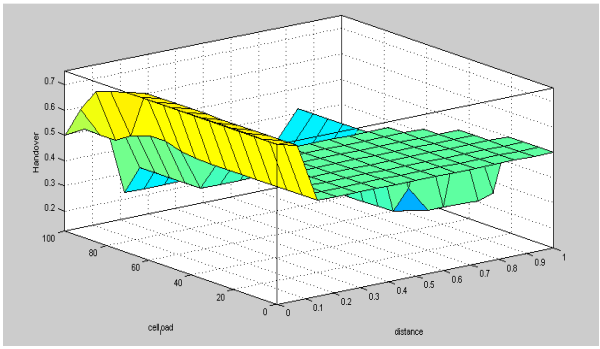

Fig.13. Surface view of FIS

V. CONCLUSION

As handover is dependent on fading and other environmental factors, fuzzy logic gives good result as it can work with imprecise data. In our proposed algorithm, it has been found that, maintaining other parameters in an acceptable level handover is decreased for high speed MS, which avoids ping pong effect successfully. In this paper a fuzzy logic rule base is created using the known sensitivities of handoff parameters. It uses mobile‘s speed, direction of motion, distance from BTS, signal strength receives from BTS, cell traffic load and interference to enhance the performance of handoff initiation significantly. It also significantly reduces the cost associated with the false handoff initiation because it achieves lower false handoff initiation probability. However it is essentially complex to make handoff decision considering multiple criteria. Sometimes, the trade-off of some criteria should be considered. Therefore heuristic approaches based on Neural network (NN), Genetic algorithm (GA) and fuzzy

logic (FL) can prove to be efficient for wireless networks.

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