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FUZZY LOGIC IN MOBILE HANDOFF DECISION

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ABSTRACT: *This paper presents an implementation of fuzzy logic in mobile handoff decision. In a cellular network, the radio and fixed links required are not permanently allocated for the duration of a call. Indeed, this ability for transference is a design matter in mobile cellular system design and is called handoff. Handoff Processes are necessary and unavoidable in wireless network environments. In this paper I describes and analyzes handoff decision techniques, parameter on which handoff depends and handoff decision using fuzzy logic.*

KEY WORDS *: Handoff, Parameter, Signal Strength, Network Load, Distance etc.*

1. Introduction

In cellular networks, when a mobile terminal (MT) moves away from a base station the signal level degrades and there is a need to switch to another base station. HO is the mechanism by which an ongoing connection between MT and its correspondent terminal or host is transferred from one point of access to the fixed network to another. Handoff is the process of changing the channel (frequency, time slot, spreading code, or combination of them) associated with current connection while a call is in progress [1]. It is often initiated either by crossing a cell boundary or by deterioration in the quality of signal in the current channel. Handoff is classified into two broad categories-hard and soft handoffs. Hard handoff is characterized by break before make" i.e. current resources are released before new resources are used. Soft handoff is characterized by "make before break" i.e. both existing and new resources are released before new resources are used during the handoff process. Soft handoff is used in Code Division Multiple Access (CDMA), while hard handoff is implemented in Global system for Mobile (GSM)[2].

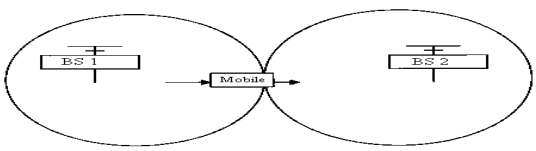

Fig1: Handoff

With hard handoff, the link to the prior base station is terminated before or as the user is transferred to the new cell's base station. That is to say that the mobile is linked to no more than one base station at a given time. Initiation of the handoff may begin when the signal strength at the mobile received from base station 2 is greater than that of base station 1. The signal strength measures are really signal levels averaged over a chosen amount of time. This averaging is necessary because of the Rayleigh fading nature of the environment in which the cellular network resides. A major problem with this approach to handoff decision is that the received signals of both base stations often fluctuate. When the mobile is between the base stations, the effect is to cause the mobile to wildly switch links with either base station. The base stations bounce the link with the mobile back and forth. Hence the phenomenon is called ping- ponging. Besides ping ponging this simple approach allows too many handoffs [1].It has been shown in early studies that much of the time the previous link was well adequate and that handoffs occurred unnecessarily. A better method is to use the averaged signal levels relative to a threshold and hysteresis margin for handoff decision. Furthermore, the condition should be imposed that the target base station's signal level should be greater than that of the current base station.

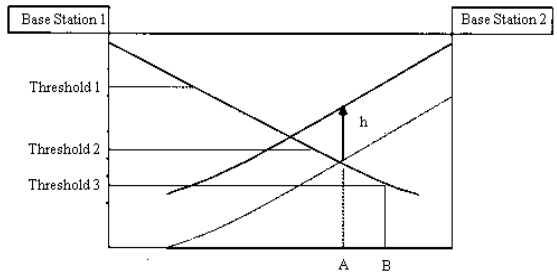

Fig2: Handoff Process using graph

The handoff should take place at point A for the choice of Threshold 1 or Threshold 2. The handoff should take place at point B for Threshold 3. It has now been shown in practice that using the hysteresis margin greatly reduces the number of unneeded handoffs. However, there is a delay factor involved here. It will be shown later that one may set up optimum trade off values for the parameters threshold and hysteresis to obtain a tolerable delay.

2. Handover Techniques

Handover refers to the transfer of a user's connection from one radio channel to another (can be the same or different cell). Handover can be categorized as hard handover and soft handover also known as Break-Before-Connect (BBC) and Connect (Entry)-Before-Break (CBB), respectively. Soft and hard handover followed by handover in LTE are discussed in the following subsections.

2.1. Soft Handover – Connect-Before-Break Handover

Soft handover is a category of handover procedures where the radio links are added and abandoned in such manner that the UE always keeps at least one radio link to the UTRAN. Soft and softer handover were introduced in WCDMA architecture. There is a centralized controller called Radio Network Controller (RNC) to perform handover control for each UE in the architecture of WCDMA. It is possible for a UE to simultaneously connect to two or more cells (or cell sectors) during a call. If the cells the UE connected are from the same physical site, it is referred as softer handover. In handover aspect, soft handover is suitable for maintaining an active session, preventing voice call dropping, and resetting a packet session.
However, the soft handover requires much more complicated signalling, procedures and system architecture such as in the WCDMA network.

2.2. Hard Handover – Break-Before-Connect Handover

Hard handover is a category of handover procedures where all the old radio links in the UE are abandoned before the new radio links are established. The hard handover is commonly used when dealing with handovers in the legacy wireless systems. The hard handover requires a user to break the existing connection with the current cell (source cell) and make a new connection to the target cell.

3. Parameter that affect the Handoff Decision

Handoff occurs because of network coverage of the operator. The parameters which affect the handoff decision are:
a) Signal Strength (Input Parameter)
b) Network Load (Input Parameter)
c) Distance (Input Parameter)
d) Handoff Decision (Output Parameter)

With the help of above parameters we design our fuzzy control system.

3.1 Signal Strength:
The signal strength determines the total amount of network bandwidth available along that connection.

3.2 Network Load:
It determines the number of users present in the neighbouring cell.

3.3 Distance:
It determines the percentage of present cell radius.

3.4 Handoff Decision:
It is the output parameter which decide the handoff is to be done or not on the basis of above three parameters.

4. Mobile Handoff Decision using Fuzzy Logic

In actual there are many parameters which are to decide whether the handoff decision takes place or not, but most important parameters are signal strength, network load, distance, threshold, velocity and hysteresis. Now we are taking three parameters signal strength, network load and distance for handoff decision using Fuzzy Logic.

On the basis of these three parameter we are deciding handoff is to be occurring or not. Here signal strength, network load, distance are input parameter and handoff decision is output parameter.
Input parameter signal strength gives the information of network bandwidth. In this we are taking signal strength from minimum -90db to maximum -10db. The whole range is distributed in three levels low, moderate and high. The membership function of signal strength is as shown in Fig3.

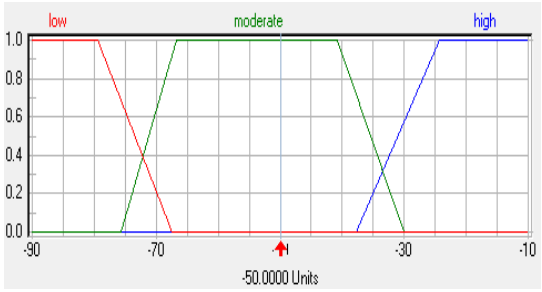

Fig3: Membership function of Signal Strength

Next Input parameter is network load that gives the information of number of users in neighbouring cell and ranging from minimum 0 to maximum 40.
The whole range is distributed in three levels small, medium, large. The membership function of network load is as shown in Fig4.

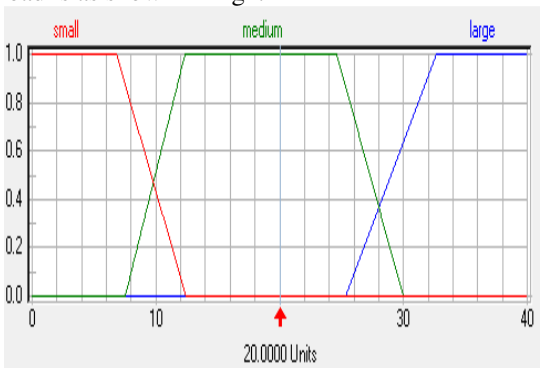

Fig4: Membership function of Network Load

Next Input Parameter is Distance that determines the percentage of present cell radius and ranging from minimum 70 and maximum 110.

The Whole range is distributed in three levels decrease, steady, increase. The membership function of distance is as shown in Fig5.

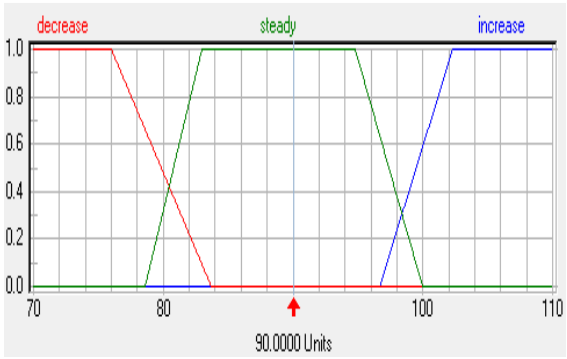

Fig5: Membership function of Distance

The output parameter Handoff Decision gives information of decision. In this we are taking range from minimum 0 to maximum 1. The whole range is distributed in five levels very_low, low, medium, high, very_high. The membership function for output parameter of Handoff Decision is shown in Fig6.

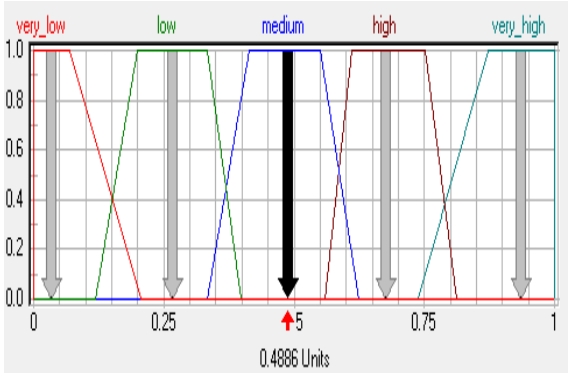

Fig6: Membership function of Handoff Decision

Now we are correlating 3 input parameters with 1 output parameter by using If-Then rule. Some of these rules shown in Fig7:

IF			THEN	
SignalStrength	**NetworkLoad**	**Distance**	**DoS**	**HandoffDecision**
Low	Small	Near	1.00	Medium
Low	Small	Near	1.00	High
Low	Small	Near	1.00	High
Low	Small	Average	1.00	High
Low	Small	Average	1.00	High
Low	Small	Average	1.00	very_high
Low	Small	Far	1.00	High
Low	Small	Far	1.00	very_high
Low	Small	Far	1.00	very_high
Low	Medium	Near	1.00	Low
Low	Medium	Near	1.00	Medium
Low	Medium	Near	1.00	High
Low	Medium	Average	1.00	Medium
Low	Medium	Average	1.00	High
Low	Medium	Average	1.00	High
Low	Medium	Far	1.00	High

Fig7: Rule Block

5. Results and Conclusion

We have used software fuzzyTECH Version 5.7.1.7 launched by company INFORM Gmbh. A sample is taken when network coverage of signal strength -50 db, network load 20, distance 90 then Handoff Decision will be 0.4594 Fig8.

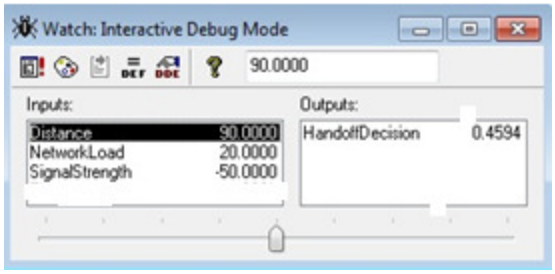

Fig8: Interactive Debug

The 3D graphs showing both input parameters and output parameter is shown in Fig9.

In this paper we have considered three input parameters and got the graphs showing the required probability of handoff. By using 3D graphs we can find out handoff for various input values.

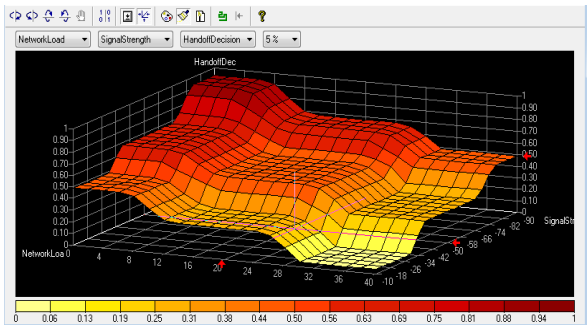

Fig9.1: 3D Graph between network load, signal strength and handoff decision

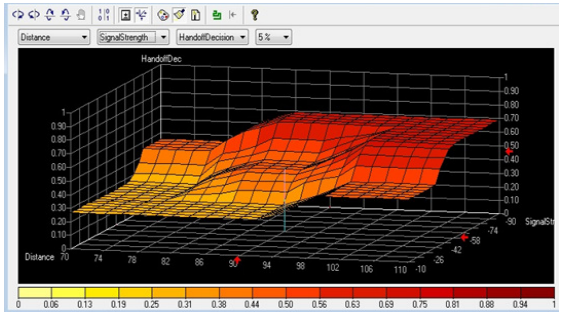

Fig9.2: 3D Graph between distance, signal strength and handoff decision

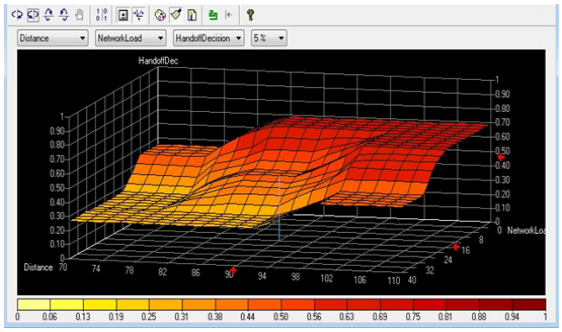

Fig9.3: 3D Graph between distance, network load and handoff decision

6. Future scope

This system can be further improved by considering many more parameter which is responsible for handoff. These parameters are Threshold Difference Value, Velocity, Hysteresis etc.

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