A Handover Scheme Based on Fuzzy Logic Approach

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Abstract-Handover initiation demands special attention in cellular mobile systems to provide uninterrupted services to the dedicated end users. Though many handover schemes have been proposed yet it has been a big ask to deliver the desired quality of service. In this paper, an efficient handover scheme has been proposed which makes use of fuzzy logic theory. The proposed system uses four parameters to make the handover decision. These parameters are signal strength from the home base station (SSH), signal strength from the neighboring base station (SSN), distance between the mobile user (MU) and the home base station and the available network bandwidth (BW) in the neighboring cells. Higher bandwidth helps in achieving high data rates. The simulation results reveal that the proposed system executes an efficient handoff taking care of the probability of the false handover.

Key Words-Available network bandwidth, Defuzzification, Fuzzification, Membership functions.

1. Introduction

A user initiates a call in one cell and is quite likely to move to another cell while the user in unaware of the fact that the serving base station has changed. This process of changing the base station in order to maintain the required signal level is termed as handover i.e. the old serving base station handovers the call to a new base station. The handover enables a user to continue his call in a new cell without any interruption. Handover not only involves looking for a new base station in a cell but also allocating voice and control signals to the channel which is to be allocated the new entrant in the cell. It should provide the desired quality of service (QoS) to the MU. Handover can be classified into 2 main types:

1. Hard Handover: In hard handover, A MU is connected to only one base station throughout the entire call and is mostly used GSM and GPRS systems.
2. Soft Handover: A soft handoff allows two or more connections to neighboring base stations to be monitored i.e. the network is overlapped.

Handoff may also be classified as Vertical handoff and horizontal handoff [2].

The signal strength from MU is continuously monitored through a reverse channel by the cell site. As MU moves away from the base station, there is a gradual decrease in the signal strength from the base station. The cell site begins to look for newer base stations to handover the call when the signal strength decreases continuously. When the signal strength reaches a threshold level, the call is transferred to a new base which presents the maximum signal strength to the MU.

Figure 1. A cellular mobile system

The traditional schemes generally makes use of the received signal strength from the home base station (SSH) and that of the neighboring base station (SSN) while ignoring the other parameters such as the available network bandwidth, distance which changes continuously according to the velocity of the MU and play an important role in the handover decision making.

In this paper, we have proposed a handover scheme using fuzzy logic approach considering four parameters stated below

1. SSH – denotes the signal strength from the home base station. It indicates the availability of the network.
2. SSN – denotes the signal strength from the neighboring base station. It indicates the availability in the neighboring network.

3. Distance (D) – denotes how far the mobile unit is from the home base station.

4. Network Bandwidth (BW) – denotes the availability of channels the neighboring cells.

2. Related Work

In the past, several schemes have been suggested in order to provide a seamless handoff.

Leonard Barolli, Fatos Xhafa, Arjan Koyama, Akio Koyama, Makota Takizawa [1] proposed an intelligent handoff system using fuzzy logic and random walk model considering parameters signal strength from present and neighboring base station and the distance between mobile station and base station. It removes the ping-pong effect during handover.

Presila Israt, Namvi Chakma and M.M.A Hashem[2] proposed adaptive handoff management protocol using fuzzy logic approach considering parameters received signal strength, distance and speed. They provide simulation for both inter and intra-system handoff.

Qing He[3] proposed vertical handoff decision algorithm between WWAN and WLAN using fuzzy logic approach considering parameters received signal strength, available network bandwidth, monetary cost and user preferences. It reduces redundant handoffs and balanced network resources.

3. Handoff decision problem

To enhance the system capacity and efficient utilization of the channel bandwidth, the cells have been divided into smaller micro cells. In such a case, the handoff occurrence is inversely proportional to the cell size. Such conditions demand the triggering of handoff only if necessary. Due to the fading effects in cellular environment, it is hard to design an appropriate algorithm which executes the handoff at that instant.

To eliminate the unwanted handoff’s, a value greater than the threshold value is set. If the threshold level at the cell boundary is -90dB, we set up a value higher than -90dB say -90dB+α such that the handoff is triggered at this threshold. The handover decision depends upon the value of α. Selecting an appropriate value of α reduces the unnecessary handoff’s.

The above proposition does not give good results all the time so we have to consider some other parameters to make the accurate handover decision. Since the available channels are limited and all the users cannot be the accommodated at same time, so the base station looks for those neighbor which have sufficient bandwidth and best signal strength.

4. Fuzzy logic approach

Fuzzy logic tool is a mathematical tool for dealing with uncertainty. FL methods offer advantages since they can operate with imprecision data and several non linear functions with lesser complexity. These methods help to make the system dynamic and are capable of decision making to provide an intelligent output [4]. It has 3 main components:

1. Fuzzification: is the process where the crisp values are converted into fuzzy. The uncertainty in crisp values forms the fuzzy values. This conversion is represented by the Member functions. Hence fuzzification process gives the membership values for the given crisp quantities. Figure 2 represents an example of a membership function.

2. Fuzzy interference system: It is the heart of the fuzzy logic system. It is also called as fuzzy rule based systems. The FIS formulates suitable rules and makes the decision based upon the set of rules.

3. De-fuzzification: De-fuzzification performs the inverse function of the fuzzifier. It involves fuzzy to crisp conversions so that the crisp quantities may be utilized for further processing. It is also called as “rounding off” method. Several methods are available for defuzzifying like centroid method, weighted average method, center of sums etc. Figure 3 represents an entire fuzzy logic system.

In the proposed fuzzy logic system, the input to the FIS are the signal strength from the home base station (SSH) and the neighbor base station (SSN) , the distance of mobile unit from the home base station (D) and the available network bandwidth in the neighbor cells. The output is the handover decision (HO).
In this paper, the handover threshold is set as 0.937.

\[
\text{HO}_{TH} = 0.937
\]

The FIS allocates the membership values to the input and the output parameters. The following fuzzy sets are formed:

- \( \mu (\text{SSH}) = \{ \text{Weak (W), Not So Weak (NSW), Good (G) and Excellent (E)} \} \)
- \( \mu (\text{SSN}) = \{ \text{Weak (W), Not So Weak (NSW), Good (G) and Excellent (E)} \} \)
- \( \mu (D) = \{ \text{Near (N), Not So Near (NSN), Not So Far (NSF), Far (F)} \} \)
- \( \mu (\text{ABW}) = \{ \text{Very Low (VL), Low (L), High (H), Very High (VH)} \} \)
- \( \mu (\text{HO}) = \{ \text{Low (L), Medium (M), High (H), Very High (VH)} \} \)

The FIS houses a system called Fuzzy Rule Base (FRB) which consists of several rules. These rules are formed by several if-then statements which are responsible for the decision making and producing the requisite output. Such rule based systems are called universal approximators.

![Figure 3. A fuzzy logic system](image)

![Graphs showing membership functions](image)

![Flowchart for handover decision](image)

**Figure 4.** Membership functions for (a) SSH, (b) SSN, (c) Distance, (d) ABW, (e) Handover decision

**Figure 5.** Flowchart for handover decision

Figure 5 represents the flow chart which is the basis of the simulation in order to produce an efficient handover decision. The base station continuously monitors the signal strength through a reverse channel. A high received signal strength in the home cell with a minimal distance from the base station eliminates any need for handover. As the signal strength reduces to a value below a prescribed level, then the system looks for the signal strength of neighboring base stations and the distance between the MU and the home station. If the MU is nearing the cell boundary and the distance...
Table 1. Fuzzy rules set

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<th>Bandwidth</th>
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<th>SSH</th>
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from the home cell is increasing rapidly, it looks for the new base stations in the new cell and measures their receiver signal strength and the bandwidth available in the new cells.

The handover criteria is based on the fact that the new base station should not only have a good signal strength but also sufficient bandwidth to accommodate high data rates. If the signal strength of neighboring base station is excellent but the available network bandwidth is very low, then a search for a new base station begins which has good signal strength as well as high available bandwidth. If the MU is near the base station in home cell but the signal strength is quite low i.e. the MU is in hole, the base station waits for some time. If the user remains in a hole for a longer period, the call drop may occur.

Table 1 represents the set of rules which have been formulated to calculate the handover decision.

On the basis of these rules we have calculated the handoff values in various situations considering the other parameters also. We have taken lesser number of rules in order to minimize latency and take the handover decision at accurate time.

5. Simulation results

a. Relation between SSH, D and HO: Figure 6 represents the relation between the parameters. As the distance from the BS increases and the SSH decreases, we see a gradual increase in the value of handover.

![Figure 6. Relation between SSH, D and HO](image)

b. Relation between SSH, SSN and HO: Figure 7 represents the relation between the parameters. As the SSN>>>SSH, the probability of handover is more.
c. Relation between SSN, BW and HO: Figure 8 represents the relation between the parameters. As the SSN >> SSH, the probability of handover is more.

Table 2 shows the minimum and maximum values of various parameters to make the accurate handover decision and Table 3 shows the results of the simulation. The handover threshold has been set to 0.937.

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<tr>
<td>BW</td>
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<td>100kbps</td>
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<tr>
<td>SSN</td>
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<table>
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<th>BW (kbps)</th>
<th>SSN (dBm)</th>
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Table 3. Simulation results

6. Conclusion

The proposed fuzzy logic system that we have used to demonstrate the handover decision making, emphasis on the available bandwidth from the neighboring cells. The simulation results show that a better handover decision can be made by selecting the required threshold limits. The simulation results vary depending upon the varying user requirements. However, in real situations the fuzzy sets can be modified to achieve better effects.

7. References