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Fuzzy Logic Redeemed Handoff Controller for Microcellular System

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***Abstract*— Efficient handoff algorithms cost effectively enhances the capacity and Quality of Service (QoS) of cellular systems. This research presents novel approaches for the design of high performance handoff algorithms that exploit attractive features of several existing algorithms, provide adaptation to dynamic cellular environment, and allow systematic tradeoffs among different system characteristics.In mobile cellular systems the handoff is a very important process, which refers to a mechanism that transfers an ongoing call from one Base Station (BS) to another. The performance of the handover mechanism is very important to maintain the desired Quality of Service (QoS). The conventional handoff decisions are normally signal strength based, which are not suitable for modern small sized microcellular networks. In order to maintain reliable communication in microcellular mobile systems, new and better handoff algorithms must be needed to keep Quality of Service, as high as possible. The fuzzy handoff algorithm based on Received Signal Strength (RSS), absolute threshold value, hysteresis level, slope ratios and speed of Mobile Terminal (MT) have been previously developed for conventional cellular networks. The purpose of this research work is to design an intelligent handoff controller, using fuzzy logic. The results show that fuzzy is a viable option for handoff.**

***Index Terms* —Handoff, Cellular networks, Fuzzy Logic, Quality of Service (QoS), Signal strength.**

I. INTRODUCTION

Cellular communications provides communication facility to users called mobile stations (MSs). Handoff is a process of transferring a mobile station from one base station or channel to another. In cellular networks it is required to perform handoff successfully and as fast as possible to provide reasonable Quality of service (QoS) levels to the end users. It is necessary to ensure that handoff should be performed reliably and without disruption to any calls. Failing which, leads to dropped calls and customer dissatisfaction. Thus it is necessary to revive the handoff issues in cellular mobile systems.

The process of handoff can be divided into three stages: decision stage, planning stage and execution stage [1]. Handoff in the older generation systems was not difficult to achieve efficiently as the cell size in those systems taken large enough, but in modern cellular systems the cell size is kept small to accommodate maximum users by implementing frequency reuse concept .In the case of the smaller cell size-with increased probability of the mobile system (MS) crossing a cell boundary, the handoff decision becomes more challenging. This problem becomes further complicated by the fact that there is an overlap of the signals from different base stations in the vicinity of the cell boundary. Therefore Soft Computing approaches based on Genetic Algorithm (GA), Fuzzy Logic (FL), and Artificial Neural Networks (ANN) can prove to be efficient for next generation wireless networks.

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The work reported here focuses on the decision stage of handoff process. Many of the existing handoff algorithms do not exploit the advantage of multi-criteria handoff, which can provide better performance than single criterion algorithms. This is due to the flexible and complementary nature of handoff criteria.

A fuzzy based multi-criteria handoff algorithm is proposed as a solution to handoff decision. Fuzzy techniques are becoming an attractive approach to handle uncertain, imprecise, or un-modeled data in solving control and intelligent decision-making problems [2]

II. HANDOFF ALGORITHM

Several steps involved in the handoff algorithm design are outlined. Different metrics that have been used to measure handoff related system performance are briefly touched upon here. Three basic mechanisms used to evaluate performance of handoff algorithms.

A. Analysis of Handoff Related System Goals

Study handoff related cellular system goals. Analyze desirable features of a handoff algorithm, and determine the required attributes of a handoff algorithm.

B. Determination and Preprocessing of Handoff Criteria

Determine handoff criteria based on desired goals, system requirements, and availability of measurements. Preprocess handoff criteria before using them in a handoff algorithm. For example, some criteria, such as RSS, may need averaging.

C. Handoff strategy and Simulation

Adapt the parameters of the handoff strategy by considering the performance metrics and the desired goals. Evaluate the developed algorithm using a suitable simulation model.

Normally signal strength based measurements are considered due to its simplicity. The conventional handoff decision compares the Received signal strength (RSS) from the serving base station with that from one of the target base station, using a constant handoff threshold [2]. However the fluctuations of signal strength cause ping pong effect. Some of the main signal strength metrics used to support handoff decisions are: Relative signal strength, Relative signal strength with threshold, Relative signal strength with hysteresis, Relative signal strength with threshold and hysteresis.

The conventional RSS based handoff method selects the Base station (BS) with strongest received signal at all times.

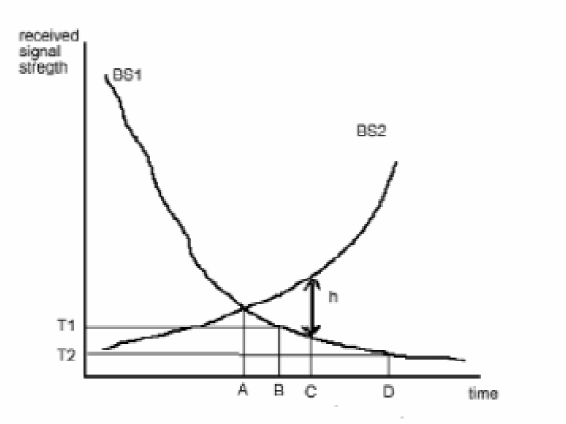

Figure 1. Conventional handoff based on RSS [3]

In figure 1 the hand off would occur at point A [2]. This method is observed many unnecessary handoffs even when the signal strength of the current BS is still at an acceptable level, which results poor quality of service (QOS) of the whole system.

III. Fuzzy Logic based handoff Algorithm

Figure 2 shows the structure of the proposed fuzzy inference system for designing the handoff controller.

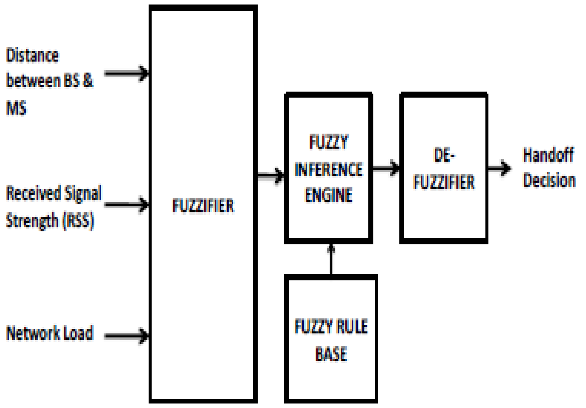

Figure 2. Block diagram proposed fuzzy logic based handoff mechanism.

A. *Designing of Fuzzy Inference System (FIS)*

In order to design a fuzzy logic system the following steps are used:

1. Identify the inputs and outputs using linguistic variables. In this step we have to define the number of inputs and output terms linguistically.

2. Assign membership functions to the variables. In this step we will assign membership functions to the input and output variables.

3. Build a rule base. In this step we will build a rule base between input and output variables. The rule base in a fuzzy system takes the form of IFANDOR, THEN with the operations AND, OR, etc.

B. *Description of Proposed System*

As shown in figure 2, the main parts of the proposed system are: Input parameters, Fuzzifier, Fuzzy Inference Engine, Rule Base and De-fuzzifier.
The three input parameters, which we have considered, are:

- Distance between Base station (BS) & Mobile station (MS),
- Received Signal Strength (RSS)
- Network Load.

The only output parameter of the fuzzy inference system is Handoff Decision.

In our proposed model the range for distance between base station and mobile station is taken 0 to 8 km., the range for received signal strength is taken 0 to 10 mW and the range for network load i.e. number of users in the cell is taken 0 to 15.

The membership functions of input parameters for the proposed fuzzy logic controlled handoff mechanism are shown in figure 3, 4 and 5.These figure show as a membership function as distance, RSS and load. Figure 6 shows a member function of Handoff as an output variable. The output parameter i.e. fuzzy handoff decision (FHD) is divided in four levels: Handoff, Be-careful, Wait and No- handoff.

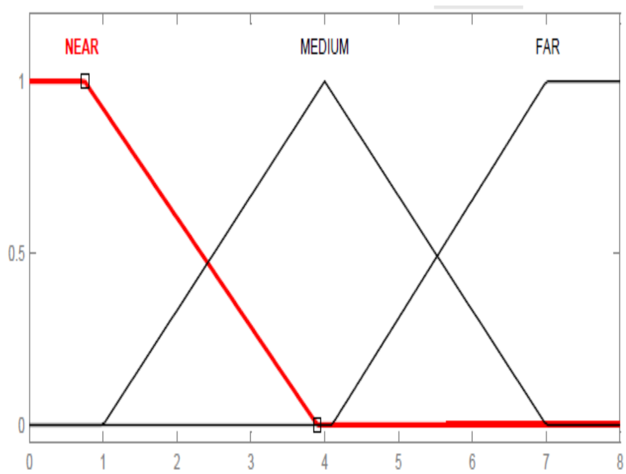

Figure 3. Membership functions of Distance between BS & MS (input variable 'DISTANCE').

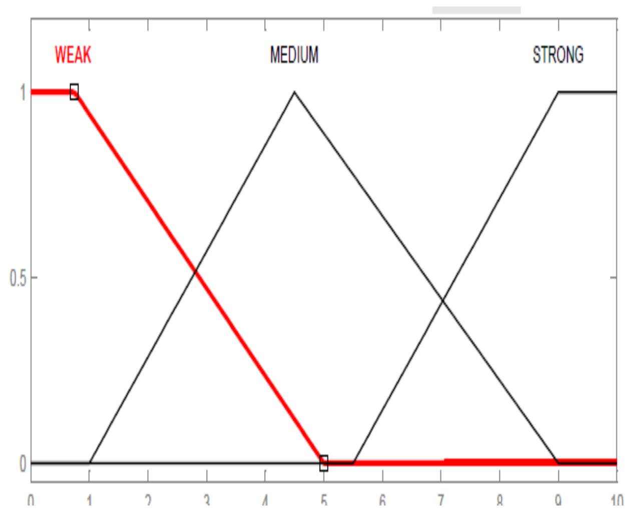

Figure 4. Membership functions of Received Signal Strength (input variable 'RSS').

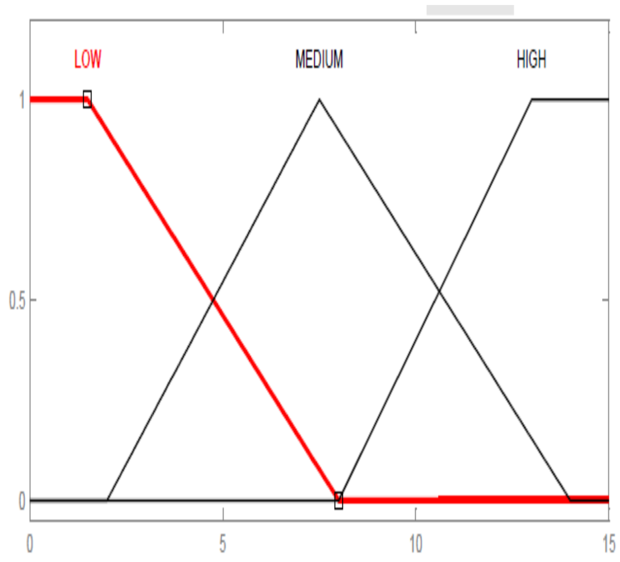

Figure5. Membership functions of Network Load (input variable 'LOAD').

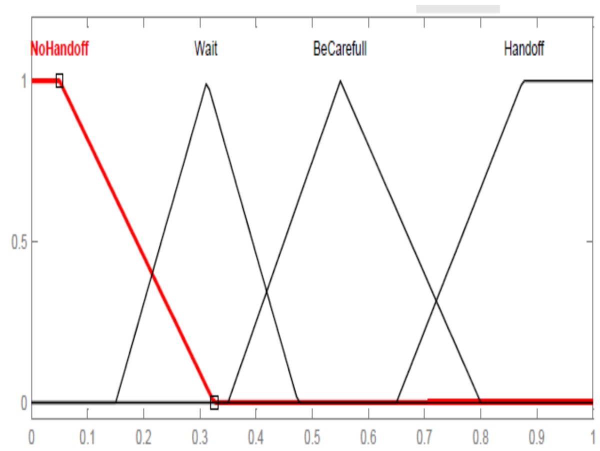

Figure 6. Membership functions of Handoff (output variable 'Handoff')

Data to the fuzzy system is first applied to the fuzzifier, which takes the inputs and fuzzified the information [4, 5].The fuzzified information is then passed to the fuzzy Inference Engine. The Inference Engine will take the fuzzified input and perform operations on it according to the Fuzzy Rules. These operations will produce output fuzzy sets for each fired rule. The Output of Inference Engine will be passed to the Defuzzifier. The Defuzzifier will compute a crisp value, i.e., converts the fuzzy domain back to the real world domain. There are several methods for defuzzification such as left max operation, right max operation, center of gravity etc. The Center of Gravity (COG) technique is mostly used method for defuzzification.

The fuzzy rule base (FRB) for the proposed Mamdani's FIS model for handoff mechanism is shown in Table 1. Total 27 rules are formulated based on the different combinations of the 3 input parameters and 1 output parameter. The rules have the form like: IF "Condition" THEN "Control action". The fuzzy IF- THEN rule provides knowledge base to the system and decides whether handoff is necessary or not.

Table 1: Fuzzy Rule Base for Proposed Handoff Controller

Rule No.	**DISTANCE**	**RSS**	**NETWORK LOAD**	**HANDOFF STATUS**
1	Near	Strong	High	Wait
2	Near	Strong	Medium	No Handoff
3	Near	Strong	Low	No Handoff
4	Near	Medium	High	Wait
5	Near	Medium	Medium	No Handoff
6	Near	Medium	Low	No Handoff
7	Near	Weak	High	Handoff
8	Near	Weak	Medium	Wait
9	Near	Weak	Low	Wait
10	Medium	Strong	High	Be Careful
11	Medium	Strong	Medium	No Handoff
12	Medium	Strong	Low	No Handoff
13	Medium	Medium	High	Handoff
14	Medium	Medium	Medium	Wait
15	Medium	Medium	Low	No Handoff
16	Medium	Weak	High	Handoff
17	Medium	Weak	Medium	Be Careful
18	Medium	Weak	Low	Wait
19	Far	Strong	High	Handoff
20	Far	Strong	Medium	Be Careful
21	Far	Strong	Low	No Handoff
22	Far	Medium	High	Handoff
23	Far	Medium	Medium	Be Careful
24	Far	Medium	Low	Wait
25	Far	Weak	High	Handoff
26	Far	Weak	Medium	Handoff
27	Far	Weak	Low	Handoff

IV. RESULT AND DISCUSSIONS

In this section we present and discuss the obtained results of the proposed fuzzy logic based handoff controller. The algorithm was implemented in MATLAB simulation tool. Fuzzy logic toolbox of MATLAB 7.10.0 is used for designing FIS. This simulation showed as graphical representation of relation between handoff distances and network load and handoff decision.

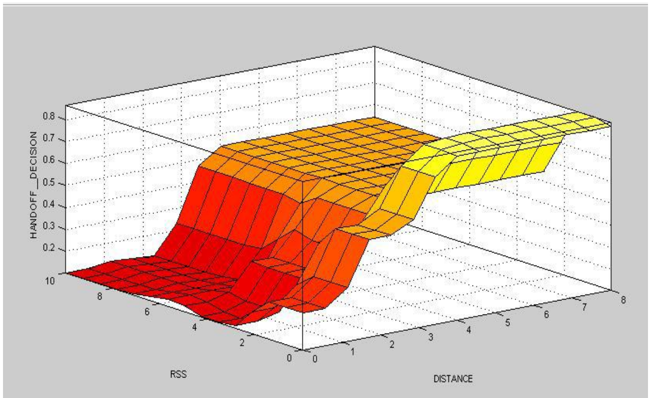

Figure 7. Surface curves between Distances, RSS & Handoff

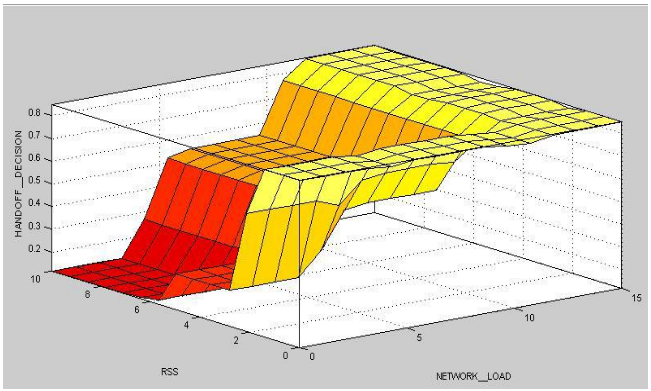

Figure 8. Surface curves between Network load, RSS & Handoff

The figure 7 shows the three-dimensional surface curve between Distance, RSS and Handoff decision. Similarly figure 8 surface curves between Network Load, RSS and Handoff Decision.

The figure 9 shows the relation between distance (between BS & MS) and handoff decision at different network load conditions and at fix received signal strength. The graph shows how handoff factor increases as distance of MS from current BS increases. It is also clear that if network load (i.e. number of users in the cell) increases the handoff factor also increases accordingly.

The figure 5.4 shows the relation between network load and handoff decision. The graph shows that as the network load increases the handoff factor also increases. As the distance of mobile station from base station increases the handoff factor also increases. For example at network load=10 and RSS=5 mW, the handoff factor for a mobile station at 4 Km from current base station is 0.4 whereas it is 0.6 when distance is 4 Km.

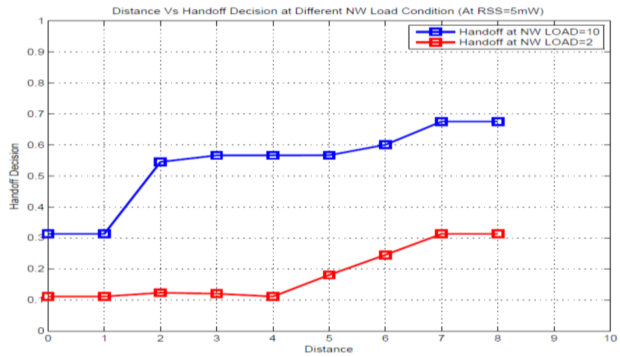

Figure 9. Distance Vs Handoff decision at different network load conditions

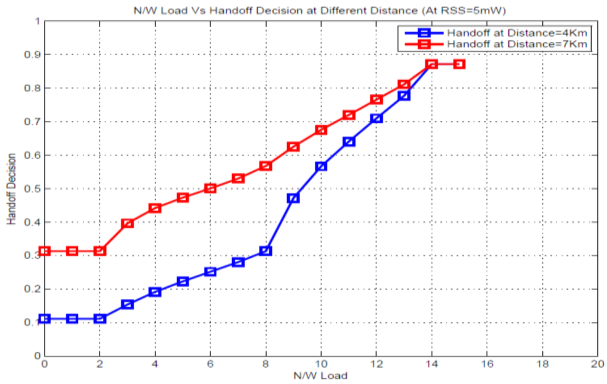

Figure 10. Network Load Vs Handoff decision at different Distance

V. CONCLUSION

In this paper a Fuzzy logic based approach for handoff decisions is presented. The proposed algorithm provides an intelligent handoff decision, in which three input parameters: Distance between BS and MS, Received signal strength from BS and network load on the cell are evaluated and feed to the fuzzy inference system. The output of the fuzzy inference system is handoff decision .The handoff factor for the current base station and target base station may be computed and compared. The results show that the handoff factor increases as the mobile station moves away from current base station. The handoff factor also increases as the network load (number of users) in the current cell increases.

REFERENCES

[1] Leonard Barolli, Fatos Xhafa, Arjan Durresi, Akio Koyama, "A Fuzzy-based Handover System for Avoiding Ping-Pong Effect in Wireless Cellular Networks" International Conference on Parallel Processing, 1530-2016/08 $25.00 © 2008 IEEE

[2] Mamun Bin Ibne Reaz and Md. Saiur Rahman, "FPGA Realization of Fuzzy Based Subway Train Braking System" ICECE 2002, 26-28 December 2002

[3] Nasıf Ekiz, Tara Salih, Sibel Kuçukoner, and Kemal Fidanboylu, "An Overview of Handoff Techniques in Cellular Networks.", World Academy of Science, Engineering and Technology- 6, 2005.

[4] Ahmad. M Ibrahim., "Introduction to Applied Fuzzy Electronics", PHI, 2004.

[5] George Edwards and Ravi Shankar, "Handoff using Fuzzy Logic", 0-7803-2509-5/95 IEEE Proceeding, 1995.

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