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A New Environment Dependent Handoff Technique for Next Generation Mobile Systems

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Abstract

With the growth of mobile computing it has become extremely important to maintain continuous connectivity when a mobile host moves from one location to another. Thus call handoff has become an important factor. In this paper a fuzzy logic based call handoff technique is proposed and its performance is studied. The algorithm considers the distance from base, node velocity and path loss factor as determining parameters. The algorithm is simulated and found to give good results.

Keywords: *Mobile cellular communication, call handoff, fuzzy logic, membership function, path loss exponent.*

1 Introduction

In mobile cellular system, maintaining continuity of a call when a mobile host or node migrates from one cell to other is an important task. This is done by changing the controlling base station when the service by the serving base is no longer satisfactory. This dynamic support of terminal migration is called call handoff. In present generation mobile cellular systems, Mobile Station (MS) estimates the signal strengths from each base station and the value of the received signal level is generally affected by three parameters : path loss, shadow fading and small scale fading. Small scale fading has much shorter correlation distance compared to shadow fading and averaged out over the time scale under consideration [1] as well as antimultipath fading techniques are available now-a-days [2, 3]. Hence, in a system with antimultipath technique the effect of small scale fading has insignificant contribution and is not considered in the present work. So the distance from base station is considered as an input parameter here considering no fading effect and uniform signal strength degradation.

In practical situation the low velocity mobiles may stop or turn back after the handoff execution resulting unnecessary handoff and the high velocity mobiles may move into the next cell before the handoff execution resulting call termination. So a velocity dependent handoff algorithm is essential. It is known that the signal strength from base station decreases as exp $(-\gamma d)$ where d is the distance of the mobile station from base station and γ is the path loss exponent. In uniform propagation environment, γ can be taken as constant. But in real environment γ may have different values at different places. The value varies from 2 to 6. More the value of γ, more rapid is the signal strength degradation. So the path loss exponent should be considered also in designing the algorithm. In this work, the distance from base station, user velocity and path loss exponent are considered as input to the fuzzy based system. Fuzzy logic is used because it is a multi-valued logic and many parameters can be used for taking decision. The algorithm is discussed in the following section.

2 Proposed Algorithm

The signal strength degrades as mobile station moves from base station and it requires handoff to other base station when the signal strength becomes week. Moreover, handoff characteristics are user velocity dependent. The effect of mobile velocity on handoff performance has been studied [4, 5, 6]. It has been shown that probability of handoff, average number of handoff, call blocking probability and call completion probability change significantly as user velocity changes. So in the present work, along with distance from base station, user velocity is considered to take handoff decision.

The traffic density in an average urban area generally follows normal distribution [7]. In India, the average speed in four metro cities e.g, Delhi, Mumbai, Chennai and Kolkata are 30 Km/hr, 25 Km/hr, 25 Km/hr and 22 Km/hr respectively [8]. In Japan, the average national speed is 35 Km/hr [8]. In highways, an optimum speed is fixed, say 100 Km/hr before designing highway features. So normally traffic speed is considered to vary from 10 Km/hr to 100 Km/hr with a mean of 40 Km/hr and standard deviation 10 Km/hr as shown in Fig 1. The cumulative distribution of traffic is calculated and shown in Fig 2. The cell radius is chosen to be 500 meters which is practically used in many urban area and the distance between two base stations is 1 Km.

As discussed in the previous section the signals from serving and target base stations will differ more if the path loss exponent is large. Due to the sensitivity of handoff performance to path loss exponent, a variable hysteresis scheme is already in use [9] where the hysteresis margin is expressed as a function of path loss exponent. Path loss exponent is also considered to be a determining parameter in our work. Thus a scheme of fuzzy controlled system is proposed which takes care of path loss exponent along with distance from base station and mobile velocity.

In the fuzzy system, the linguistic variables for three input parameters distance, velocity and path loss exponent are assumed to be low, medium and high. The membership functions are then considered to be bell shaped and shown in Fig. 3, 4 and 5 respectively. Bell shaped functions are considered because with bell shaped function fluctuations are minimum and the rise time is also low. Mamdani rules are used here in implementing the algorithm and the model is shown in Fig 6. The fuzzy rules are also shown in Fig 7.

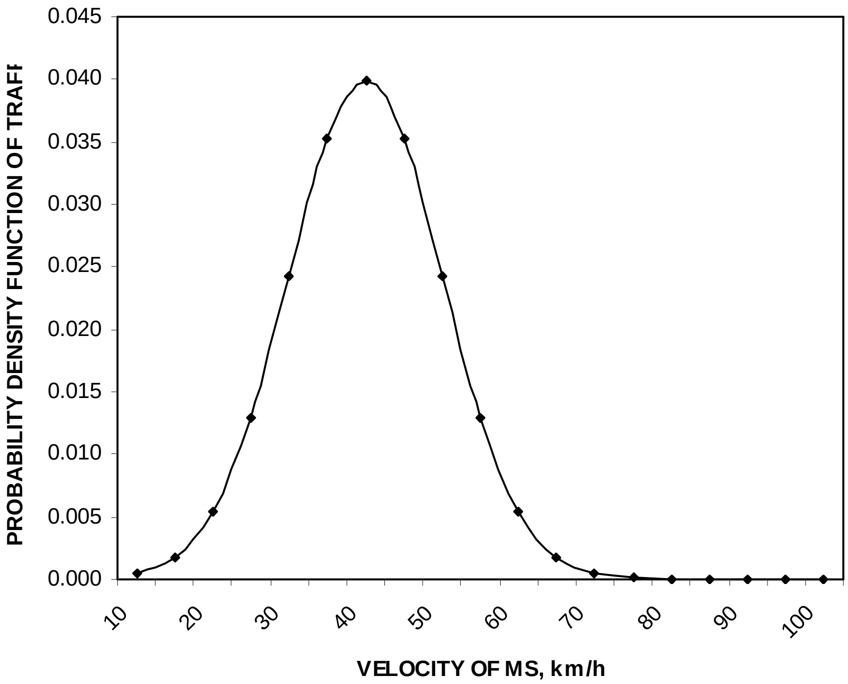

Fig 1. Probability density function of traffic

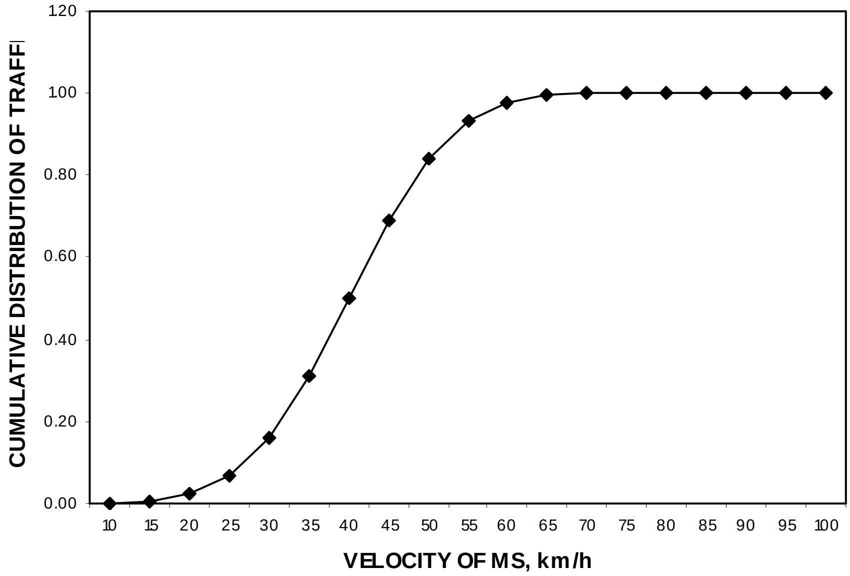

Fig 2. Cumulative probability density function of traffic

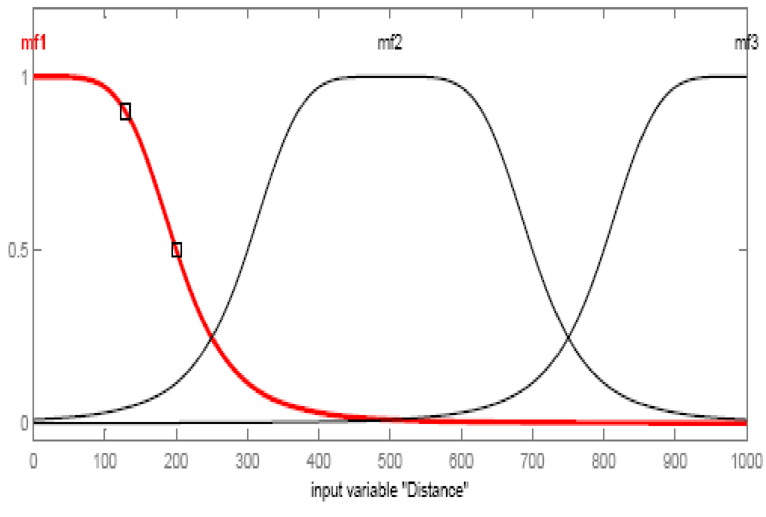

Fig 3. Membership function for distance from base station (meters)

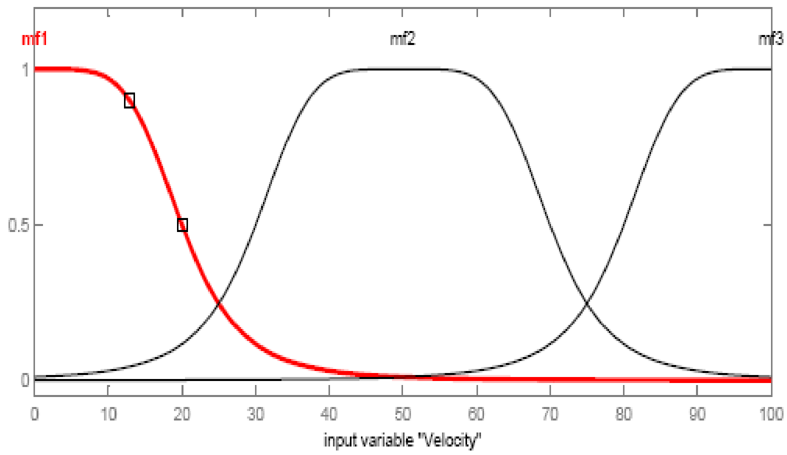

Fig 4. Membership function for velocity (Km/hr)

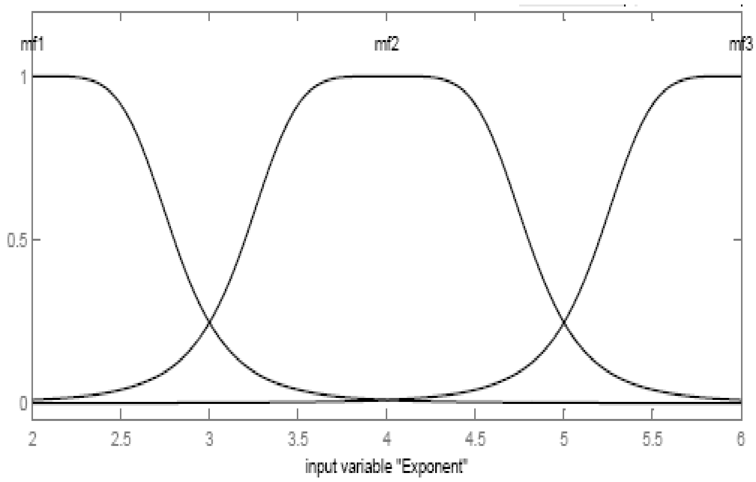

Fig 5. Membership function for path loss exponent

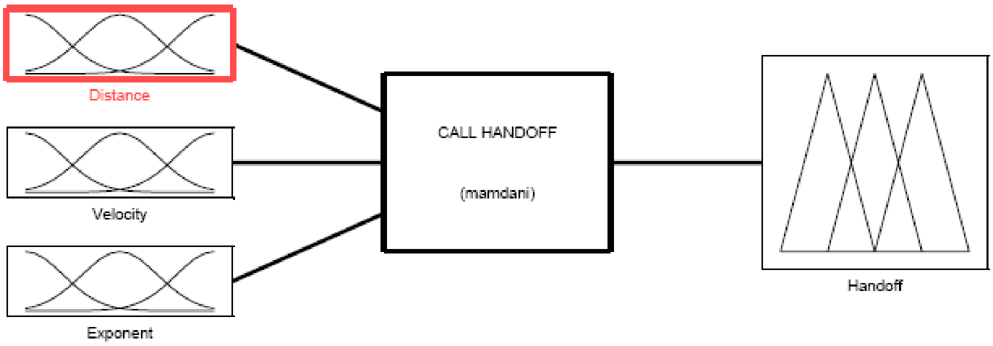

Fig 6. Model of the fuzzy based system

1. If (Distance is mf1) and (Velocity is mf1) and (Exponent is mf1) then (Handoff is mf1) (1)
2. If (Distance is mf1) and (Velocity is mf1) and (Exponent is mf2) then (Handoff is mf1) (1)
3. If (Distance is mf1) and (Velocity is mf1) and (Exponent is mf3) then (Handoff is mf1) (1)
4. If (Distance is mf1) and (Velocity is mf2) and (Exponent is mf1) then (Handoff is mf1) (1)
5. If (Distance is mf1) and (Velocity is mf2) and (Exponent is mf2) then (Handoff is mf1) (1)
6. If (Distance is mf1) and (Velocity is mf2) and (Exponent is mf3) then (Handoff is mf2) (1)
7. If (Distance is mf1) and (Velocity is mf3) and (Exponent is mf1) then (Handoff is mf2) (1)
8. If (Distance is mf1) and (Velocity is mf3) and (Exponent is mf2) then (Handoff is mf2) (1)
9. If (Distance is mf1) and (Velocity is mf3) and (Exponent is mf3) then (Handoff is mf2) (1)
10. If (Distance is mf2) and (Velocity is mf1) and (Exponent is mf1) then (Handoff is mf1) (1)
11. If (Distance is mf2) and (Velocity is mf1) and (Exponent is mf2) then (Handoff is mf2) (1)

18. If (Distance is mf2) and (Velocity is mf3) and (Exponent is mf3) then (Handoff is mf3) (1)
19. If (Distance is mf3) and (Velocity is mf1) and (Exponent is mf1) then (Handoff is mf3) (1)
20. If (Distance is mf3) and (Velocity is mf1) and (Exponent is mf2) then (Handoff is mf3) (1)
21. If (Distance is mf3) and (Velocity is mf1) and (Exponent is mf3) then (Handoff is mf3) (1)
22. If (Distance is mf3) and (Velocity is mf2) and (Exponent is mf1) then (Handoff is mf3) (1)
23. If (Distance is mf3) and (Velocity is mf2) and (Exponent is mf2) then (Handoff is mf3) (1)
24. If (Distance is mf3) and (Velocity is mf2) and (Exponent is mf3) then (Handoff is mf3) (1)
25. If (Distance is mf3) and (Velocity is mf3) and (Exponent is mf1) then (Handoff is mf3) (1)
26. If (Distance is mf3) and (Velocity is mf3) and (Exponent is mf2) then (Handoff is mf3) (1)
27. If (Distance is mf3) and (Velocity is mf3) and (Exponent is mf3) then (Handoff is mf3) (1)

Fig 7. Fuzzy rules

Simulation is carried out using Matlab 7.0 and the results obtained are discussed in the next section.

3 Results and discussion

Simulation results are shown in Fig 8, Fig 9 and Fig 10. It may be seen from the figures that the possibility of handoff increases as mobile station moves away from the base station. A value of 1 may be considered for handoff request and a value close to 0.5 as be-careful condition. The handoff decision is taken much earlier as user velocity increases (Fig 8). So probability of call termination may be avoided for fast moving users and unnecessary handoff may be avoided for slow moving users. From Fig 9 it is seen that the handoff decision is taken much earlier for large path loss exponent which is also desirable because in case of large path loss exponent the signal strength degrades rapidly and there is more chance of call quality degradation or call termination. Fig 10 also indicates the similar finding but in all the cases handoff decision is not taken for a distance which is near to serving base.

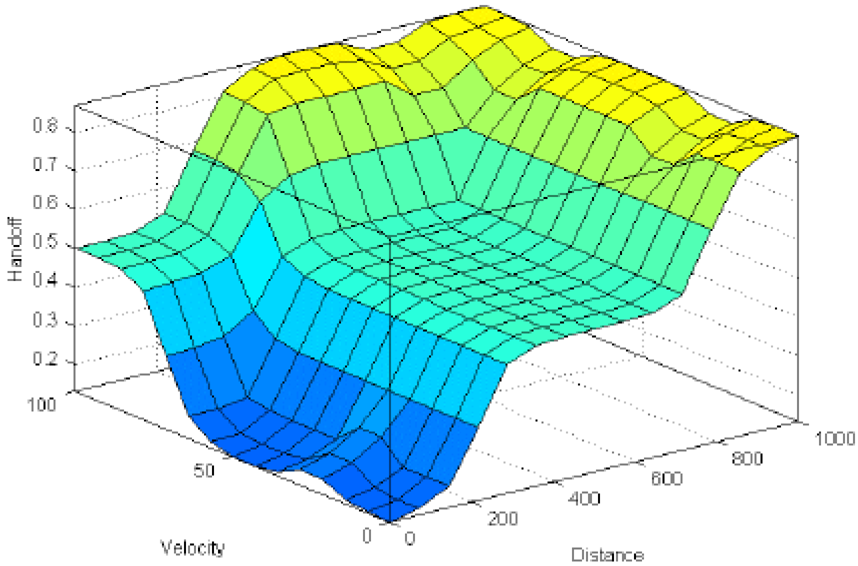

Fig 8. Possibility of handoff vs. distance from base station (m) and user velocity (Km/hr)

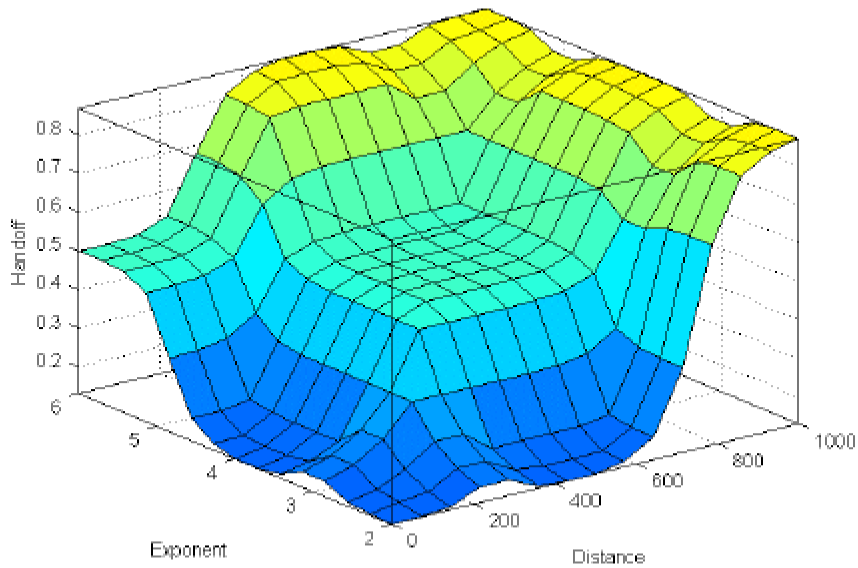

Fig 9. Possibility of handoff vs. distance from base station (m) and path loss exponent

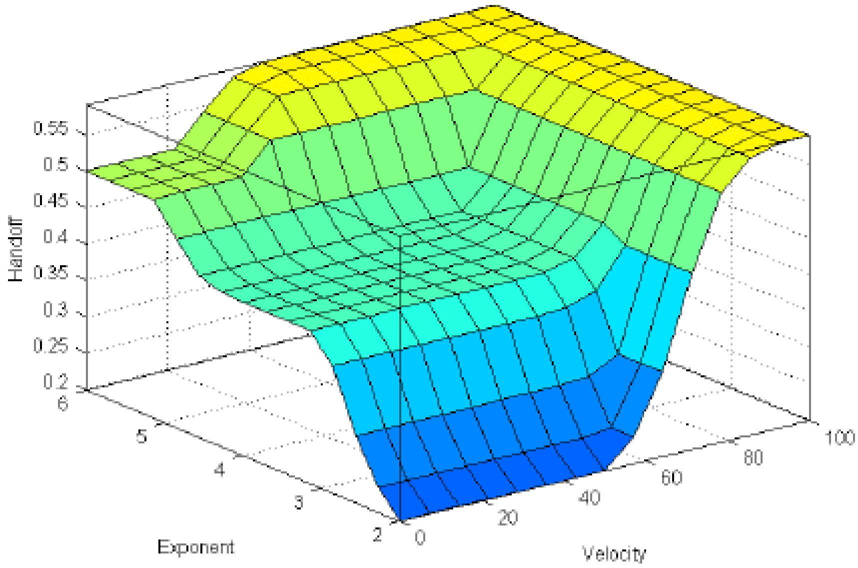

Fig 10. Possibility of handoff vs. velocity (Km/hr) and path loss exponent at a distance of 250 meters

4 Conclusion

The present handoff technique avoids both call termination and unnecessary handoff for high and low velocity mobiles and thus efficiently utilizes radio channels. It also takes handoff decision depending on the environment and path loss exponent. Since the algorithm avoids early and unnecessary handoff, it will also reduce the Base Station Controller (BSC) and Mobile Switching Center (MSC) processor loading. The mobile station may estimate its velocity using the available standard techniques such as level crossing rate, zero crossing rate etc. [10]. Then using the algorithm the position of handoff request may be decided so that it avoids call termination and early handoff.

5 Open Problem

The author suggests that the future workers embed the algorithm to implement it in real systems.

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