COMPARISON OF HANDOVER DECISION PROCEDURES FOR MOBILE TELEPHONE SYSTEMS BETWEEN CONVENTIONAL AND FUZZY LOGIC ALGORITHM

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Abstract

This paper proposes an efficient handover decision based on fuzzy logic principle in order to decrease unnecessary handover but still properly keeps an appropriate number of lost calls by only changing software used for control at Base Station Controller (BSC), thus this method can utilize the same hardware of mobile telephone systems that have already been installed. The proposed method is compared with conventional algorithm. The system model is based on the GSM system. The result shows that by using the proposed method, handover number was reduced with a proper lost calls number, compared to the conventional (1-3) algorithm.

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I. Introduction

At present, the size of cells used in Cellular Mobile Telephone Systems tends to be smaller in order to increase traffic channels for more users in that area, especially in the city area. Because of the small size, handovers occur more frequently. Moreover, there are many buildings built in various shapes and various location arrangements in the city area that affect the signal strength level, mobile telephones (MS) receive, by increasing fading which causes more number of handovers.

In conventional algorithm (3-5), signal strength level mobile telephone received from service cell and adjacent cells are used to compare with thresholds for handover decision by using handover margin to decrease unnecessary handovers. The number of handovers are still high, especially in high fading areas.

There are some researchers who use fuzzy logic in handover process such as Y. Kinoshita, Y. Omata (4-5) but they emphasizc the stability of handover in indoor areas. Their method still uses handover margin to reduce the number of handovers by adapting from conventional algorithm with created fuzzy inference for learning cell boundary (4), and incresing inference rules for softer decision (5).

II. Handover decision procedure using fuzzy logic

There are 3 important sub- procedures in proposed handover decision algorithm : Fuzzification, Fuzzy Inference and Defuzzification (6). Observed parameters are signal strength level mobile telephone received from service cell and adjacent cells, distance between mobile and service cell and target cell.

A. Fuzzification

Changing parameter values to fuzzy values (linguistic values) with defined membership function (example in Fig. 1,2) will be processed in this step

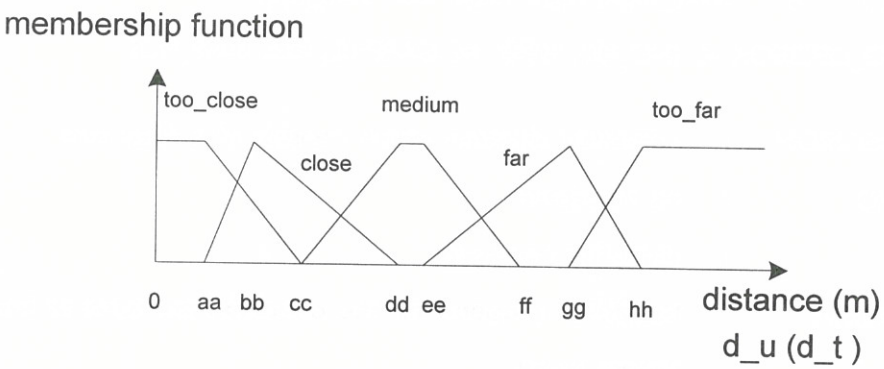

Fig. 1 membership function of distance

(d_u : distance between MS and used-base station, d_t : distance between MS and target-base station)

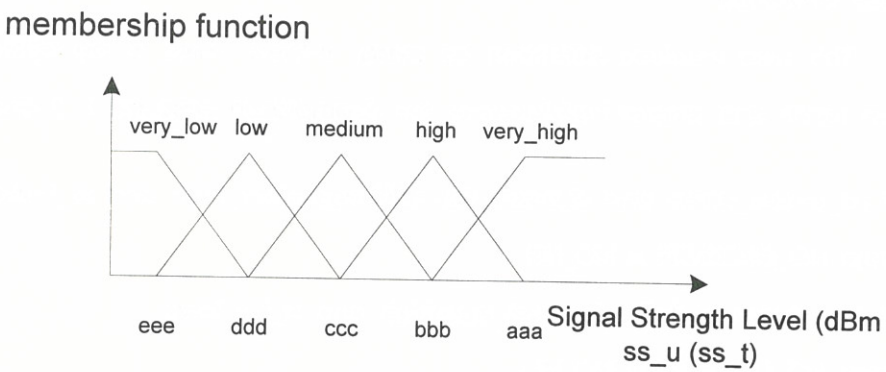

Fig. 2 membership function of signal strength

(ss_u : signal strength level MS receives from used-base station, ss_t : signal strength level MS receives from target-base station)

Linguisitic varables Fuzzy sets

1. d_u ∈ {too_close, close, medium, far, too_far}
2. d_t ∈ {too_close, close, medium, far, too_far}
3. ss_u ∈ {very_high, high, med, low, very_low}
4. ss_t ∈ {very_high, high, med, low, very_low}
5. HO_DECISION ∈ {NO_HO, WAIT, BE CAREFUL, HO, SURE_HO}

HO_DECISION : handover decision which consists of 5 fuzzy sets

NO_HO : no handover

WAIT : delay for handover

BECAREFUL : handover (depend on the condition because of low signal stregth level)

HO : handover

HO_SURE : handover (high signal stregth level MS receives from target-based station)

B. Fuzzy Inference

This step involves definition by using "if-then" rules to be relevant to human sense and proper handover as the examples in case no 1, 2 and 3.

1. If (d_u=too_close and d_t=too_far and ss_u=very_high and ss_t=very_low) then HO_DECISION = NO_HO
2. If (d_u=close and d_t=far and ss_u=high and ss_t = low) then HO_DECISION = NO_HO
3. If (d_u=medium and d_t=too_far and ss_u=very_high and ss_t= very_low) then HO_DECISION = NO_HO

Assignment of conditions in proposed method can be changed in any case depending on the designer, so that there is no need for hysteresis area (handover margin) to reduce the number of handover because many conditions can be defined for this purpose.

Aggregation : consider "if-then" conditions for each case of all inference rules such as

let (d_u = too_close) : A

(d_t = too_far) : B

(ss_u = very_high) : C

(ss_t = very_low) : D

(HO_DECISION = NO_HO) : Q

μ : membership function

then μ_Q = min (μ_A, μ_B, μ_C, μ_D) = membership function of NO_HO equals μ_Q

Composition : use the results from Aggregation step in order to compute the value of each case of HO_DECISION (handover decision)

Ex. Consider case 1, after Aggregation step, membership function of NO_HO equal μ_{Q1} so, case 2 : membership function = μ_{Q2}, case 3 : membership function = μ_{Q3} case i : membership function = μ_{Qi} then NO_HO = max (μ_{Q1}, μ_{Q2}, μ_{Q3}, ... μ_{Qi}) For WAIT, BECAREFUL, HO and SURE_HO, use the same step like NO_OH.

C. Defuzzification

All of fuzzy values will be changed into real value. In this research, Mean of Maximum method is selected (6).

III. Simulation

System model is based on GSM mobile telephone system by using 2 cells under 1 BSC. 3 routes are selected for the mobility of mobile telephone. :

Route 1) Direct line from base station (BTS) 1 to BTS 2

Route 2) 45 degree straight line from cell 1 to cell 2 crossing center between 2 cells

Route 3) right angle with route 1. Between 2 cells

Mobile telephone will update signal strength level and other observed parameters every 480 ms (3) in order to be processed at BTS and BSC (window size = 10) (3) and then the result is used to decide handover. There are several parameters that are used to test with 3 routes. : Handover Margin, Handover Decision parameter, fading, velocity of mobile telephone, distance between BTS

IV. Simulation Results

In Fig. 3, demonstrate the reference coordinate pair of MS position, and Fig. 4 show the example of signal strength level MS receive from base stations.

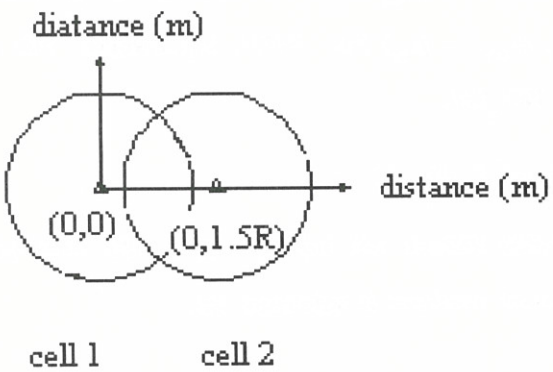

Fig. 3 The reference coordinate pair of MS position.

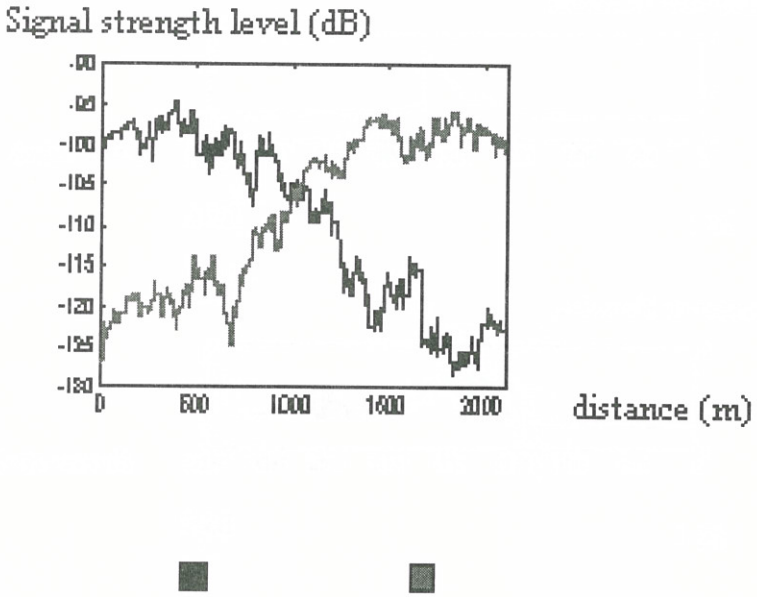

Fig. 4 The example of signal strength level MS received in case of route 2 when the distance between base station is 1.5 time of cell radius.

The Handover Decision can detected as shown in Fig. 5. Its value will be used for handover decision in algorithm that uses fuzzy logic. In little fading environment, the value is smooth so that it makes a low number of handover. While in high fading environment handover decision value can fluctuate, but only the value that is over the threshold will be triggered for the system to do the handover for MS.

Handover decision using fuzzy logic can reduce handover number with proper lost calls when compared with other methods as shown in Fig. 6 and Fig. 7 for examples :

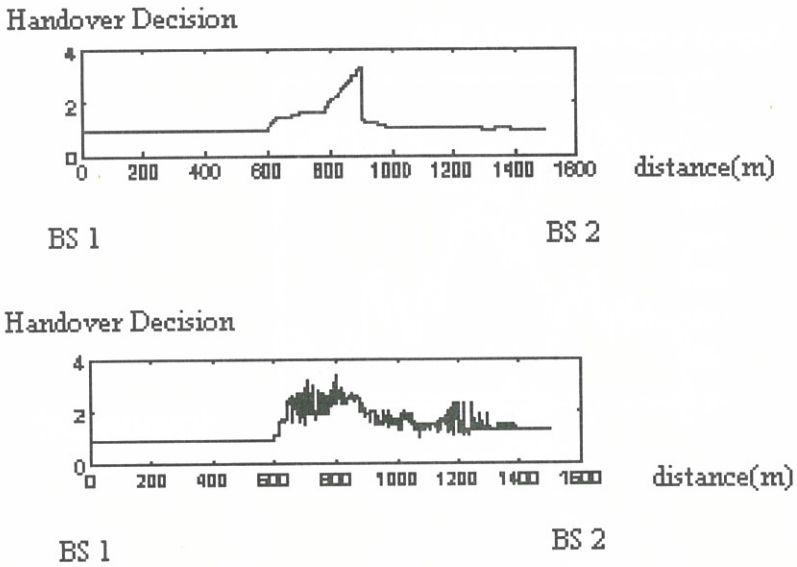

Fig. 5 The examples of Handover Decision depend on incresed fading (+/- 0 dB for above figure, +/- 6 dB for another one)

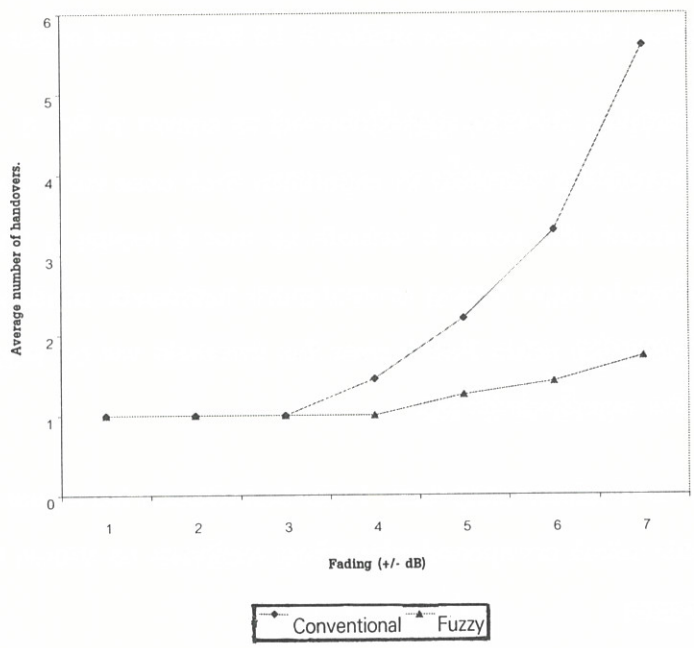

Fig. 6 Comparison of the average number of handover between two methods

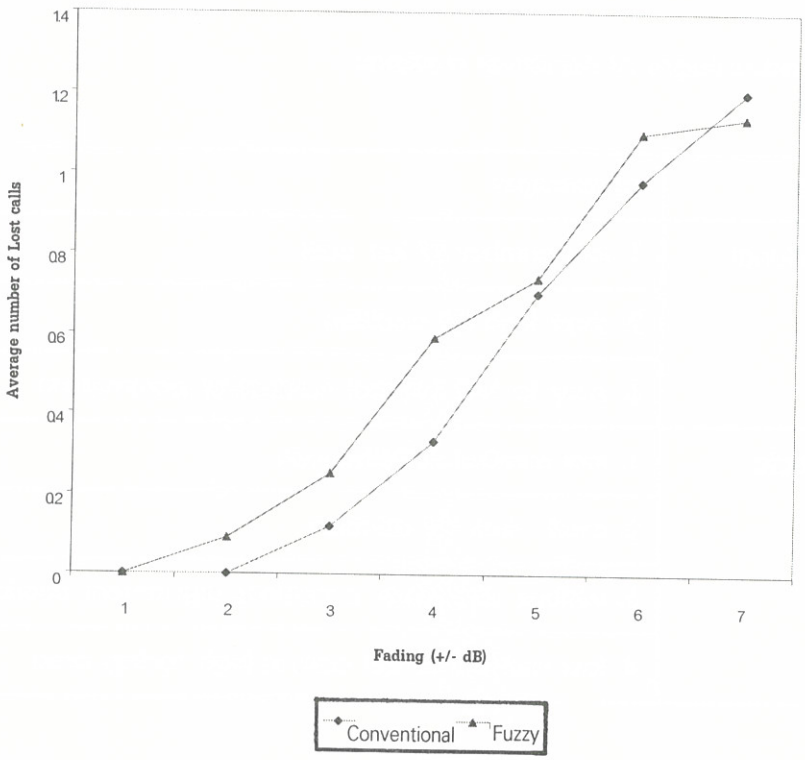

Fig. 7 Comparison of the average lost calls number between two methods

It can be seen from Fig. 6 and Fig. 7 that in case of high fading, conventional algorithm gives more number of handovers than the method that uses fuzzy logic. For lost calls number, the conventional method tends to change higher with more fading changing. Lost calls number of the proposed method also depends on the size of fading but gives more number than other methods in low fading area (only in case of route no.2). The number of lost calls of proposed method tends to be less than the conventional methods for high fading area for example at +/- 7 dB case in Fig. 7. However, the number of loss calls for each method is low and can be accepted for using.

V. Conclusion

Table 1. advantages of handover methods

Methods	advantages
Conventional	1. low number of lost calls
	2. short time for decision
	3. easy to test (several number of parameters)
Fuzzy Logic	1. low number of handovers
	2. short time for decision
	3. various handover conditions adjustment possible
	4. low number of lost calls in high fading area

Table 2. disadvantages of handover methods

Methods	disadvantages
Conventional	1. high number of handovers
	2. less handover control (small number of parameters)
Fuzzy Logic	1. high number of lost calls in low signal strength area
	2. long time for adjusting optimized parameters used in handover decision

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