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Fuzzy Logic- An Approach for BER Performance

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***Abstract*-In this paper, Bit Error Rate (BER) performance is observed over Nakagami fading channel for different values of threshold using fuzzy logic. Threshold based Generalized Selection Combining technique (T-GSC) is the method which combines only those branches at receiver whose energy levels are at above certain specified threshold.Selection of threshold value in T-GSCscheme affects the BER performance under fading channel condition. Simulations have been carried out with Binary Phase Shift Keying (BPSK) modulation scheme for Multiple co-channel interferers for Rayleigh and Nakagami fading channel with varying fading parameter. Bydefining appropriate rulesthreshold for best BER performance is shown by Fuzzy Logic window.**

***Index terms* - Combining techniques, fading channels, diversity, and fuzzy logic.**

I.INTRODUCTION

System designers have always faced the problem of fading channels, where amplitude and phase of signals can vary over time. Transmission quality of the signal degrades when the transmitter or receiver is in motion. Due to such scenarios many new challenges are posed to engineers involved with system design, one of which is that the integrity of data is maintained during transmission [1].

The demand for higher network capacity is on the rise. Diversity techniques can be used to meet the increasing demand for higher network capacity.These schemes are based on the fact that whenone copyof the signal may undergo deep fade,replica copies of same signal may have significant strength and can be used at the receiver. The BER performance using T-GSC technique was observed over a Nakagami fading environment, and compared with Maximal Ratio Combining technique [3, 4]. The T-GSC scheme combines all the strong diversity branches available at any time instant, discarding only the weak ones.BER performance is observed and analyzed using threshold value from T=0.6 to T=0.1 over Nakagami fading parameter [2]. From the observations made, best threshold value must be selected that gives lowest BER over Nakagami fading channel conditions. In this paper, best selected threshold value is shown by Fuzzy logic in Mamdani type Fuzzy Inference System (FIS).

Fuzzy Logic (FL) is a problem solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controller to large, networked, multi-channel Personal Computer or workstation based data acquisition and control systems [5]. It can be implemented in hardware, software, or a combination of both. It provides a simple conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information.

This paper is organised in IV sections. System model is presented in section II. BER is simulated and then rules are defined in fuzzy logic to analyze best BER performance in section III. Finally, the conclusion is presented in section IV.

II. SYSTEM MODEL

In this work, T-GSCdiversity technique has been used. This scheme is based on "Branch Relative Strength" (BRS)which is defined as the ratio of the SNR (Signal to Noise Ratio) of each branch to the SNR of the best branch at the same instant of time [3]:

$$BRSi=\frac{\gamma_i}{\gamma_{max}},\ i = 1, 2, \ldots, L, \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

Whereγ_{max} = max $\{\gamma_1, \gamma_2. . .\gamma_L\}$ is the maximum SNR received at each time instant, and γi is the SNR in the ith branch, i = 1, 2 . . . , L, where L is the number of branches. In the T-GSC scheme, if the BRSi is larger than or equal to a specified threshold T (where $0 \le T \le 1$), only then the branch is combined to get the total signal strength.

In the Fuzzy Logic approach, the BER performance for different threshold values over different fading parametersis observed andimplementedusing simple rules of the type"IF X AND Y THEN Z"in solving the problem rather than attempting to model the system mathematically [6].

Fuzzy control is one of the most important applications of fuzzy theory which uses fuzzy rules. The principle of knowledge-based (expert) control [7, 8] is to capture and implement experience and knowledge available from experts (e.g., process operators). Fuzzy logic can capture the continuous nature of human decision processes and provides improvement over methods based on binary logic (which are widely used in industrial controllers). Three steps taken to create a fuzzy controlled machine [9] are:Fuzzification (Using membership functions to graphically describe a situation), Rule evaluation (Application of fuzzy rules) and Defuzzification (Obtaining the crisp or actual results)as shown in Fig. 1.

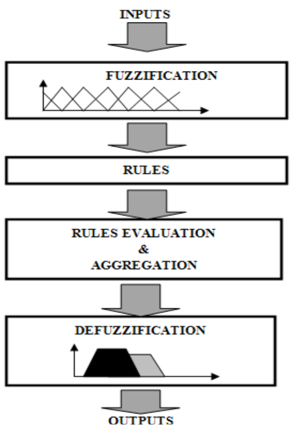

Fig. 1 Steps for fuzzy logic implementation

Different steps of fuzzy reasoning (inference operations upon fuzzy IF-THEN rules) are performed by Fuzzy Inference System to get best BER performance. Firstly the input variables arecompared with the membership functions in the antecedent part to obtain the membership values of each linguistic label. Then these membership values are combined in premise part to get firing strength of each rule.It is followed by generating the qualified consequents of each rule depending on the firing strength. These are then defuzzifiedto obtain the consequents in the form of crisp output.

III. SIMULATION AND RESULTS

The BER performance in T-GSC system is observed overNakagami-*m* channels for the Nakagami parameter *m* =1 (Rayleigh), *m*=2, and *m*=3 over different threshold value that are T= 0.1, 0.2, 0.4, and 0.6.From simulations, it is observed that for m=1, the best BER performance is for threshold T=0.1, for m=2, BER is less for T=0.1 and for m=3 as Nakagami fading parameter, BER performance is best for threshold T= 0.2. These BER performance curves are shown in figure2, 3 and 4 respectively [2].

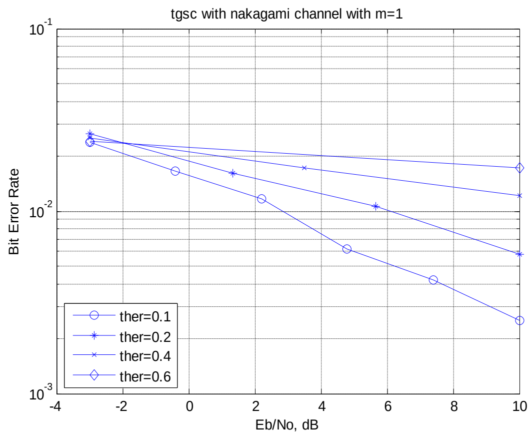

Fig.2 Comparison of BER performance of T-GSC with differentthreshold over Nakagami fading channel (m=1)

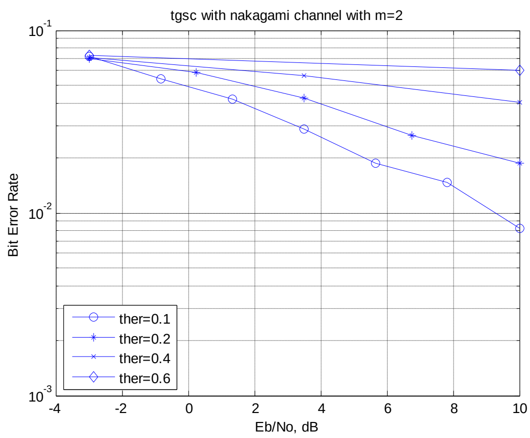

Fig.3 Comparison of BER performance of T-GSC with different threshold over Nakagami fading channel (m=2)

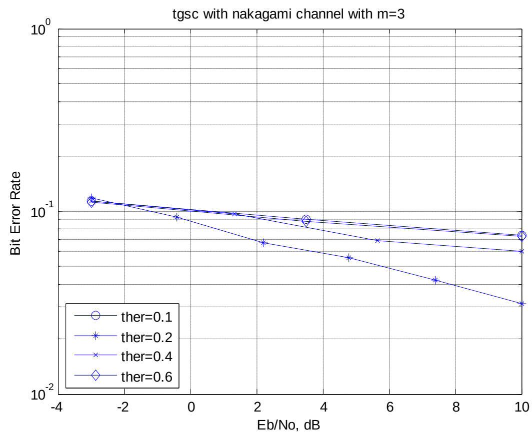

Fig.4 Comparison of BER performance of T-GSC with different threshold over Nakagami fading channel (m=3)

For implementation in Fuzzy logic, it is analyzed that there are two inputs, namely"Nakagami fading parameter (m)" and "threshold value (T)" and one output "select threshold (ST)". The output "ST"is to be obtained such that best BER performance is observed over Nakagami fading channel. So, m and T are chosen as the two linguistic variables to represent inputs and ST denotes the output linguistic variable. Thus, this is a 2-input, one- output fuzzy logic control system as shown in fig. 5.The associated fuzzy term sets for "m" are s(m1) for m=1, m(m2) for m=2 and l(m3) for m=3. For "T", the associated fuzzy term sets are Very Small (VS) for T=0.1, Small (S) for T=0.2, Medium (M) for T=0.4 and Large (L) for T=0.6.

Two input variables m and T and one output variable ST is defined in Mamdani type Fuzzy Inference System (FIS) as shown in Fig. 5

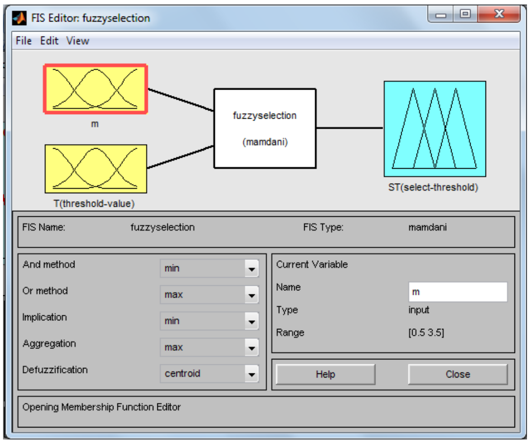

Fig. 5 FIS Editor for threshold selection

The Fig. 6shows three membership functions for the input variable 'm' that are s(m1), m(m2) and l(m3). Four membership function are defined for the input variable 'T' that are VS(T=0.1), S(T=0.2), M(T=0.4) and L(T=0.6) as shown in fig. 7. Four membership functions are also defined for output variable 'ST' that are VS(T=0.1), S(T=0.2), M(T=0.4) and L(T=0.6) as shown in Fig. 8.

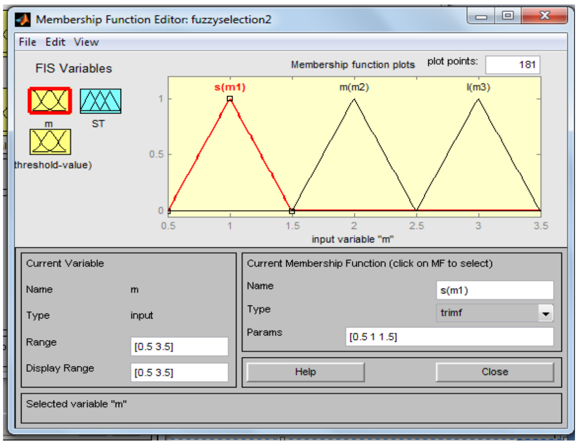

Fig.6 Membership function Editor for input 1(m)

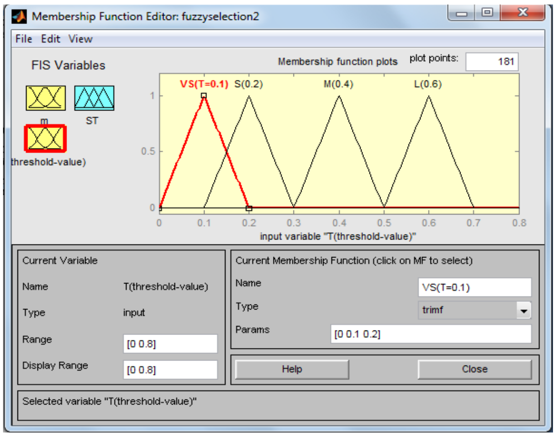

Fig.7 Membership function Editor for input 2(T)

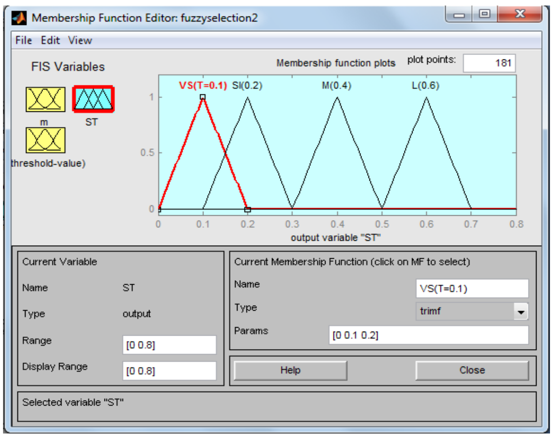

Fig.8 Membership function Editor for output (ST)

According to simulation of BER, the rules are framed and weighting factor is selected. Based on this observation and according to inputs and output 12 rules are made as shown in Table 1.

m \ T	s(m1)	m(m2)	l(m3)
VS(T=0.1)	ST (1)	ST (1)	ST (0.5)
S(0.2)	ST (0.75)	ST (0.75)	ST (1)
M(0.4)	ST (0.5)	ST (0.5)	ST (0.75)
L(0.6)	ST (0.25)	ST (0.25)	ST (0.5)

Table 1 Fuzzy results of select threshold

Different weight factor used are 1, 0.75, 0.5 and 0.25 which show the priority of the rules. The rule editor showing all the 12 rules for output ST are shown in Fig. 9. The rule having threshold with best BER performance for the particular Nakagami factor has the highest priority and the rule which gives poor BER performance is given the lowest priority.

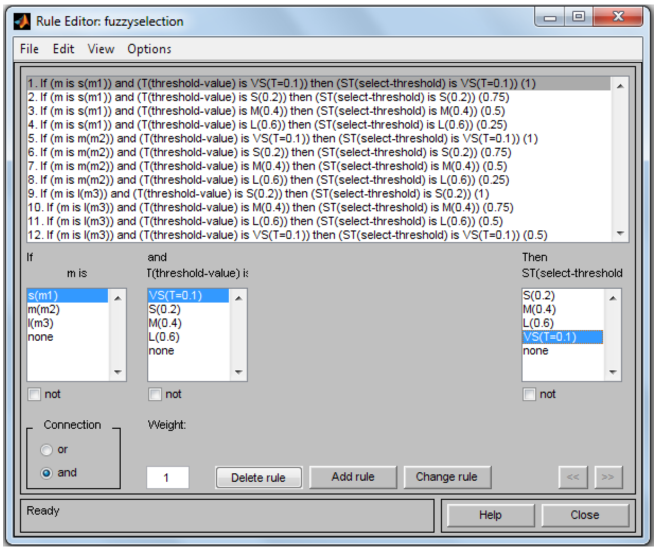

Fig.9 The Rule Editor showing the rules for ST

The inference process of above Fuzzy Inference System for T-GSC scheme is shown in rule view window of fuzzy logic toolbox.The rule view window for m=1 at ST=0.1, for m=2 at ST=0.1 and for m=3 at ST=0.2 as shown in Fig. 10, 11 and 12 respectively.

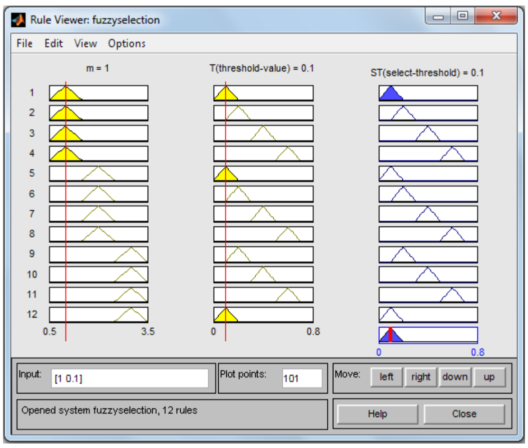

Fig. 10 The rule viewer for m=1

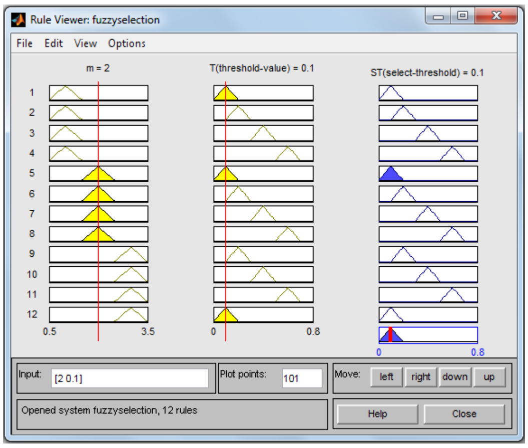

Fig. 11 The rule viewer for m=2

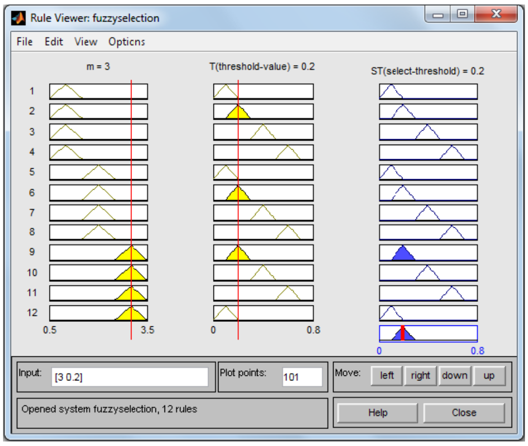

Fig. 12 The rule viewer for m=3

In rule view window we can analyse various values of output by sliding the cursor thereby varying the inputs. This fuzzy system can employ either clipping inference method or scaling inference method.

IV. CONCLUSION

In this paper, the BER performance of BPSK modulation scheme over Nakagami fading channel is compared for different threshold values and the threshold value which gives best BER performance is shown by Fuzzy logic. For this, Input 1 has three membership functionss(m1), m(m2) and l(m3). Input 2 has four membership functions and these are VS(T=0.1), S(0.2), M(0.4) and L(0.6). Also output has four membership functions and these are VS(T=0.1), S(0.2), M(0.4) and L(0.6). By using these input and output values 12 rules has been made. Threshold value for best BER performance over Nakagami fading channel is shown in rule viewer window.

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