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Performance Enhancement of Decode and Forward Relaying Network in a Log- normal Fading Channel using Diversity Technique

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ABSTRACT

The demand for wireless communication services is increasing daily due to several emerging applications of wireless communication system. However, the services provided by wireless communication is affected by obstruction along the path of propagation resulting in scattering of signal at the receiver. Decode and Forward (DF) relaying network used in addressing the problem also suffer from signal outage at the destination due to inability of relay to decode the transmitted signal at the relay node. Hence, in this paper, performance enhancement of DF relaying network is proposed using Time Diversity (TD) at the source with hybrid Threshold Combiner and Equal Gain Combiner (TC-EGC) at the destination. The various copies of the transmitted signal are received at the DF relay node to carry out relay selection by selecting relay with signal strength greater than the set threshold of 3 dB. The selected relays decode and re-encode the received signal before been propagated to the destination. The various copies of the signal received at the destination with varying paths 'L' (2, 3 and 4) are combined using TC-EGC. Mathematical expressions of Outage Probability (OP) and Bit Error Rate (BER) for the proposed technique are derived using Probability Density Function (PDF) of the signal received. The proposed DF technique is simulated using MATLAB R2018a and validated using OP and BER by comparing with the conventional DF cooperative relaying network. The proposed technique improved the performance of conventional DF cooperative relaying network with reduced BER and OP.

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1. INTRODUCTION

Wireless Communication systems (WCs) involves the transfer of information between two or more locations through space. WCs is of great important in telecommunication infrastructure that has been gaining much attention in the area of technology due to the fact that it is not limited by the distance. The immense applications of wireless communication in various economic sectors such as Banking, Marketing and Security making the demand of its services to increase exponentially. However, the performance of WCs is limited by channel impairment which is described as a factor that degrades or distorts signals as its propagating through the space from transmitter (source) to receiver (destination). Multipath Fading (MF), Path Loss (PL) and Shadowing (SH) are the major channel impairment in WCs [1, 2, 3]. MF result from multipath propagation of the transmitting signal due to obstruction along the propagation path leading to variability in the received signal. PL describe the reduction in signal strength as it traverses from source to destination and, thus, becomes weaker as propagation distance increases. The total blockage due to obstruction along the propagation path is describe as shadowing and causes signal outage. The detrimental effects of channel impairment resulting in variation in the amplitude of the received signal know as signal fading and or attenuation. In this paper, fading and attenuation will be used interchangeably since the effect of each phenomenon is the variation in the power of the received signal at the destination [4, 5].

The problem of fading in wireless communication has induced considerable research for possible solutions to enhance performance of wireless communication system. Cooperative Diversity (CD) in which source propagating signal to destination via multiple relays is one of the techniques recently proposed to combat the effect of fading in WCs. The basic idea of CD is to enhanced the reliability and efficiency of communication system by positioning relay nodes between the transmitter (source) and receiver (destination). In CD technique, the transmitted signal is received at the destination with various copies that are usually independently affected by different fading. Cooperative network includes Amplify and Forward (AF) and Decode and Forward (DF) [5, 6, 7]. In DF, the transmitted is decoded at the relay nodes and retransmits the decoded signal via multiple or single antenna to the destination. In the other hand, decoding of signal is not required in AF, relay only amplifies the signal received and retransmits the amplified version of the signal to destination [8]. According to [5], AF relaying protocol showed a poor performance when compared to DF due to signal amplification that amplifies noise and thereby reduced the efficiency of the signal at destination [8, 9]. However, DF suffers from inability of relay to decode the signal if the channel is corrupted as a result of fading effect, thereby resulting in signal outage at the receiver (destination) [10, 11]. The effect of fading in the channel between source and destination that resulted in signal outage can be combated using Time Diversity (TD) in which various copies of the same information bearing signal is radiated at distinct time slot. TD is working on the principle that different channel will experiencing different fading. Therefore, the same information bearing signal transmits at distinct time slot will experience different fading events and thereby providing the receiver with various copies of faded signal [12].

In this paper, DF relay protocol is considered due to its ability to remove the noise from transmitted signal before forwarded to the destination. Also, TD is used at the source to combat the effect of fading in the relay node. Multiple relay system is adopted to decode the signal and to forward the decoded signal to destination. When multiple relays are being used for second hop transmission, it is required to combine the various copies of the transmitted signal at the receiver (destination) to maximize the positive effect of diversity between relay and the destination. The independent faded signals at destination are combined using Diversity Combining Technique (DCT) in which various number of independent copies of the same information bearing signal is processed and summed up [13]. According to [14] the four basic DCT are Equal Gain Combiner (EGC), Maximal Ratio Combiner (MRC), Selection Combiner (SC) and Threshold Combiner (TC). Others are modification of any of the four basic DCT or hybridization of any of two [15]. In this research, hybrid TC-EGC is adopted in this paper due to its reduced hardware complexity and achievements of higher diversity gain [1]. Several researches have been carried out on DF cooperative relaying network. In [16], symbol error rate expression for DF relay with generalized SC over Rayleigh fading channel was proposed. The problem of noise that resulted in poor reception of transmitted signal at the destination was addressed using decode and forward relaying protocol. Multiple relays were used to decode the transmitted signal and forwarded to the destination and combined using Selection Combiner (SC) to select the strongest path among the multiple copies of the signal forwarded to the destination. Also, in [17], DF cooperative protocol with interference cancellation was proposed to address the problem of variability of signal at the receiver using multiple decode and forward cooperative technique. Multiple relays were used and designed based on decode to cooperate. The decoding of signal at individual relay node was done using CSI between source (transmitter) and relay. The signals at the destination (receiver) were then combined using EGC. Two-way DF technique with space diversity is proposed in [10]. Incorporation of space diversity at the source was carried out to transmit copies of the same information bearing signal at the same carrier frequency using different antenna. The multiple copies of the signals are received at the relay node and relay decode the received signal based on set threshold. If the received signal has SNR is above the set threshold, the system decodes the signal and forwarded to the receiver (destination). The space diversity incorporated reduce the chances of signal outage at the receiver. However, the technique suffers from co-channel interference due to space diversity used. Also, the technique consumed a lot of bandwidth as the same information bearing signal is transmitted at the same time.

Furthermore, in [18], analysis of outage of SWIPT-based DF networks with partial relays selection was proposed to address the problem of variability of signal at the receiver. The signals received at the relay node were decoded using multiple relay before forwarded to the destination. SWIPT based relaying network where the power was scavenged from the radio frequency. The power scavenged was used to convey the information to the destination. optimal power splitting and Static power splitting were used to harvest power from the received signal at the relay node to check the performance of the two techniques on the decode and forward cooperative network. However, previous works on DF cooperative relaying network showed the technique has better performance when compared with AF relaying network and this is due to noise amplification that amplified noise. However, DF network suffers from signal outage at the destination resulting from inability of relay to decode the transmitted signal due to obstruction along the channel between source and relay. Therefore, in this paper, performance enhancement of DF relaying network is proposed using Time Diversity (TD) at the source and hybrid TC-EGC diversity combiner at the destination. The scattering effect of transmitting signal follows various distributions such as log-normal, Rican, and Rayleigh distribution. Many authors have worked on CD using Rician and Rayleigh, though they are good for terrestrial modeling. In this paper, log-normal fading distribution which is good in modelling both the indoor and outdoor environment is adopted. The contributions of this paper are:

(i) a new DF technique with low OP and BER than the conventional DF technique has been proposed,

(ii) mathematical expressions of outage probability and bit error rate for the proposed DF technique over log-normal fading channel has been derived.

The remaining sections are organized as follows; the proposed DF technique is discussed in section 2, with the mathematical expressions for OP and BER formulated to appraise the performance of the proposed DF technique. Section 3 depicts the results and discussion of the simulation for the proposed and conventional techniques with performance comparison, while, the conclusion of the paper is depicted in section 4.

2. PROPOSED DECODE AND FORWARD COOPERATIVE RELAYING NETWORK

Transmitting signals are generated randomly at the source using random integer generator which is available in the MATLAB software. Modulation using QAM is performed on the generated data for suitable transmission over log-normal fading channel. Different copies of the signal are transmitted from the source using Time Diversity (TD) over a log-normal fading channel. The transmitted signals are received at the relay node using multiple relays. The relays with SNR higher than threshold are selected and participate during second hop transmission. Threshold of 3 dB is used as a set threshold and if the SNR of the signal received is higher than threshold, such relay decodes the signal and participate in the second hop transmission. Otherwise, the relay will be on sleep mode until the SNR of the signal is greater than 3 dB. The decoded signal is re-encoding and forwarded to the destination in the second hop transmission as shown in Figure 1. The various copies of signal at the receiver (destination) are combined using hybrid Threshold Combiner and Equal Gain Combiner (TC-EGC). Hybrid TC- EGC select the signal that is higher than the threshold of 2dB and weighing the selected signals with equal weight. The weighted signals are then co-phase to avoid signal cancellation before summed up. In Figure 1, h_{SR} represents source to relay channel and h_{RD} represents relay -to- destination channel.

The instantaneous SNR of the signal received at individual relay is the product of gain of channel $'H'$ at a particular time and the constant $P_t/_N$. Therefore, the instantaneous SNR of received signal $'\gamma(i)'$ at individual relay node is given as

$$\gamma(i) = \frac{P_t H(i)}{N} \tag{1}$$

where: P_t is the transmit power at the transmitter (source)
$H(i)$ is the gain of channel across the source and relay at an instant
N is the noise at the relay

Equation (1) is used in obtaining the SNR of the signal at individual relay and relay selection is based on the SNR obtained when compared with a set threshold of 3 dB. The output SNR of EGC 'SNR_{EGC}' is given in [19] as

$$SNR_{EGC} = \frac{1}{NL}\left(\sum_{i=1}^{L} S(i)\right)^2 \tag{2}$$

where: $S(i)$ is the signal power on individual branch which is equal to output of TC in this paper
L is the number of paths which is equal to the number of TC

For hybrid TC-EGC, output of TC is the input to EGC and Output of TC '$S(i)$' is given as

$$S(i) = \gamma(i) > Th \tag{3}$$

where: Th is the set threshold at the destination which is equal to 2 dB in this paper
$\gamma(i)$ is the signal power on each branch received by TC

Therefore, by substituting Equation (3) into (2), the output SNR of the signal received for the proposed DF technique is obtained as

$$SNR_{TC-EGC} = \frac{1}{NL}\left(\sum_{i=1}^{TC} \gamma(i)\right)^2 \tag{4}$$

The PDF of the signal received across log-normal fading channel '$P(\gamma)$' is given in [20] as

$$P(\gamma) = \frac{10/_{ln10}}{r\sigma(2\pi)^{\frac{1}{2}}} exp\left(-\frac{(lnr-\mu)^2}{2\sigma^2}\right) \tag{5}$$

where: r is SNR of the signal received
μ is mean of lnr
σ is standard deviation of lnr

Therefore, by substituting Equation (4) into (5), the PDF for the proposed DF tecnique is obtained as

$$P(\gamma) = \frac{4.34}{\left(\frac{1}{NL}\left(\sum_{i=1}^{TC}\gamma(i)\right)^2\right)\sigma(2\pi)^{\frac{1}{2}}} exp\left(-\frac{\left(ln\left(\frac{1}{NL}\left(\sum_{i=1}^{TC}\gamma(i)\right)^2\right)-\mu\right)^2}{2\sigma^2}\right) \tag{6}$$

In this paper, in order to reduce the hardware complex, the number of TC is chosen to be equal to three, therefore, Equation (6) becomes

$$P(\gamma) = \frac{4.34}{\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)\sigma(2\pi)^{\frac{1}{2}}} exp\left(-\frac{\left(ln\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)-\mu\right)^2}{2\sigma^2}\right) \tag{7}$$

The PDF of the signal received for the proposed DF technique over log-normal fading channel is presented in Equation (7)

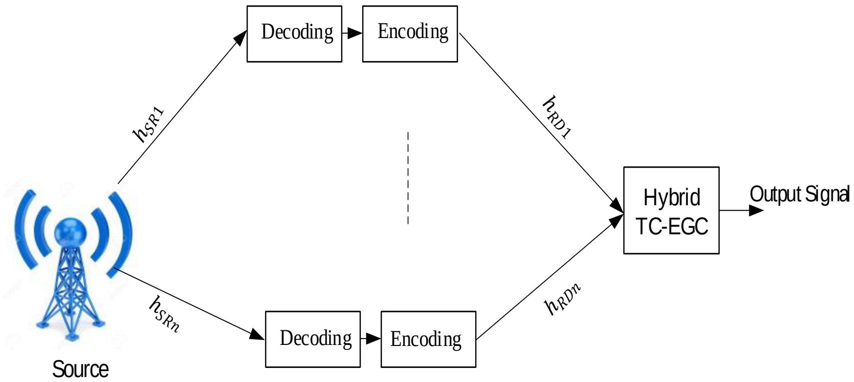

Figure 1. Block Diagram of the proposed DF Cooperative Relaying Network

2.1 Bit Error Rate to Validate the Proposed Technique

Bit Error Rate (BER) is one of the metrics used in validating the proposed DF cooperative relaying network and the expression for BER ($P_b(E)$) is given in [20, 21, 22] as

$$P_b(E) = \int_o^\infty P_b\left(E/_\gamma\right) P(\gamma) d\gamma \tag{8}$$

where: $P(\gamma)$ is the PDF of the signal received which is presented in Equation (7) for the proposed DF technique

Substituting Equation (7) into Equation (8) gives

$$P_b(E) = \int_o^\infty P_b\left(E/_\gamma\right) \times \frac{4.34}{\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)\sigma(2\pi)^{\frac{1}{2}}} exp\left(-\frac{\left(ln\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)-\mu\right)^2}{2\sigma^2}\right) d\gamma \tag{9}$$

But conditional error probability $P_b\left(E/_\gamma\right)$ is given in [23] as

$$P_b\left(E/_\gamma\right) = {}^1/_2 \exp\left(a\gamma\right) \tag{10}$$

where $a = {}^1/_2$ for the modulation that are not coherent

Therefore, for modulation that are not coherent, Equation (10) becomes

$$P_b\left({}^{E}/_{\gamma}\right) = 0.5\exp\left({}^{1}/_{2}\,\gamma\right) \tag{11}$$

Substituting equation (11) into (9) gives

$$P_b(E) = \int_o^{\infty} 0.5\exp\left({}^{1}/_{2}\,\gamma\right) \times \frac{4.34}{\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)\sigma(2\pi)^{\frac{1}{2}}} exp\left(-\frac{\left(ln\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)-\mu\right)^2}{2\sigma^2}\right)d\gamma \tag{12}$$

However, the SNR for the proposed DF technique is presented in Equation (4). Therefore, by substituting Equation (4) into (12), the expression of BER for the proposed DF cooperative Relaying Network is obtained as follow

$$P_b(E) = 0.5\int_o^{\infty} \exp\left(0.5\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)\right) \times \frac{4.34}{\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)\sigma(2\pi)^{\frac{1}{2}}} exp\left(-\frac{\left(ln\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)-\mu\right)^2}{2\sigma^2}\right)d\gamma \tag{13}$$

$$P_b(E) = 0.5\int_o^{\infty} \exp\left(0.17w\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right) \times \frac{4.34}{\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)\sigma(2\pi)^{\frac{1}{2}}} exp\left(-\frac{\left(ln\left(\frac{1}{3w}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)-\mu\right)^2}{2\sigma^2}\right)d\gamma \tag{14}$$

$$P_b(E) = 0.5\int_o^{\infty} \frac{4.34}{\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)\sigma(2\pi)^{\frac{1}{2}}} exp\left(\left(0.17N\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)-\frac{\left(ln\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)-\mu\right)^2}{2\sigma^2}\right)d\gamma \tag{15}$$

$$P_b(E) = \left(\left(\frac{2.17}{\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)\sigma(2\pi)^{\frac{1}{2}}}\right)-1\right) exp\left(\left(0.07w\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)-\frac{\left(0.5ln\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)-\mu\right)^2}{2\sigma^2}\right) \tag{16}$$

2.2. Outage Probability for the Validation of the Proposed Technique

Outage Probability (OP) describes the tendency that the strength of the signal received falls below a given threshold and the expression for OP is given in [1, 24, 25] as

$$OP = \int_o^{\gamma th} P(\gamma)d\gamma \tag{17}$$

where γth is the threshold which is 2 dB in this paper

Therefore, by substituting Equation (7) into Equation (17), the expression of OP for the proposed DF technique over log-normal fading channel is obtained as follow

$$OP = \int_o^{\gamma th} \frac{4.34}{\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)\sigma(2\pi)^{\frac{1}{2}}} exp\left(-\frac{\left(ln\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)-\mu\right)^2}{2\sigma^2}\right)d\gamma \tag{18}$$

$$OP = \int_o^{2} \frac{4.34}{\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)\sigma(2\pi)^{\frac{1}{2}}} exp\left(-\frac{\left(ln\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)-\mu\right)^2}{2\sigma^2}\right)d\gamma \tag{19}$$

$$OP = \left(\left(\frac{4.34}{\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)\sigma(2\pi)^{\frac{1}{2}}}\right)-1\right) exp\left(-\frac{\left(ln\left(\frac{1}{3N}\left(\sum_{i=1}^{3}\gamma(i)\right)^2\right)-\mu\right)^2}{2\sigma^2}\right) \tag{20}$$

To evaluate the performance of the proposed technique by comparing with the work of [18], twenty thousand bits were randomly generated using random integer generator in the MATLAB R2021a. The data generated were processed and modulated with QAM before been propagated over the log-normal fading channel at different time slots using TD. The multiple copies of the transmitted signal were received at the relay node using multiple DF relay protocol. The selected relays based on the SNR of the received signal decoded and re-encoded the received signal before being forwarded to the destination in the second transmission hop. The multiple copies of the signal at the destination were combined using hybrid TC-EGC.

Output of hybrid TC-EGC was finally demodulated with QAM demodulator. The demodulated signal was compared with the transmitted signals and set threshold of 2 dB was used to compute BER and OP, respectively. The work of [18] was also simulated for better and proper comparison.

3. SIMULATION RESULTS AND DISCUSSION

The simulation is carried out using MATLAB R2021a at frequency of 2300 MHz and symbol length of twenty thousand. OP and BER are the metrics used in evaluating the performance of the proposed DF cooperative Relaying technique. The values of OP and BER are obtained at different number of propagation path (L) to check the effect of different values of number of paths on the proposed DF technique. OP measures the rate of signal outage at the destination, while BER measures the error present in the received signal. The OP and BER values at different number of propagation paths were obtained and compared with the work of authors in [18].

3.1. Outage Probability Obtained for the Proposed and Conventional DF Cooperative Relaying Network

The values of Outage Probability (OP) for the proposed and conventional DF with varying number of propagation paths are obtained at different values of SNR. The proposed DF technique is represented as enhanced DF and conventional DF represent the work of [18]. Figure 2 presents OP versus SNR for the enhanced and conventional DF at L = 2 over log-normal distribution. At SNR of 2 dB, OP values of 0.4592 and 0.6947 are obtained for the enhanced and conventional DF, respectively, while, 0.2534 and 0.3566 are the OP values obtained with SNR of 8 dB for the enhanced and conventional DF. The obtained results revealed that the enhanced DF gives better performance with low OP than conventional DF. This is due to time diversity; where signals are transmitted at the different time slot at the source thereby increase the ability of relay in decoding transmitted signal from transmitter (source) at the relay node. The increase in the ability of relay to decode the transmitted signal reduced the chance of signal outage at the receiver (destination). Figure 3 depicts the OP for conventional and enhanced DF at L = 3. 0.3125 and 0.5611 are the values of OP obtained at SNR of 2 dB for the enhanced and conventional DF, respectively, while 0.1166 and 0.2451 are the corresponding values of OP obtained at SNR of 8 dB for the enhanced and conventional DF. The values OP obtained at L = 4 for the two techniques across log-normal distribution is presented in Figure 4. The values of OP obtained with SNR of 2 dB are 0.3029 and 0.4836 for the enhanced and conventional DF, respectively, while the corresponding values of OP obtained with SNR of 8 dB are 0.0534 and 0.0992 for the enhanced and conventional DF. It is thus revealed that, for the two techniques, OP reduced as SNR increases. This is due to increase in the signal strength as SNR increases and the higher the signal strength, the lower the chances of signal outage at the destination. It can also be deduced from the results obtained that the different between the OP for the two techniques is very high at a low SNR, while as the SNR increases, the difference is reducing gradually. The effect of number of paths on the OP for the enhanced and conventional DF is also revealed from the results obtained and this is presented in Figure 5. The values of OP reduce as the number of propagation paths increase and this is as a result of increase in signal power as propagation paths increase. Though, in all the scenario considered, the enhanced DF gives better performance with low OP values than the conventional OP. This is due to time diversity used at the source that increase the ability of relay in decoding the signal transmitted. The increase in the ability of relay to decode the transmitted signal at the relay node reduced the chance of signal outage at the receiver (destination).

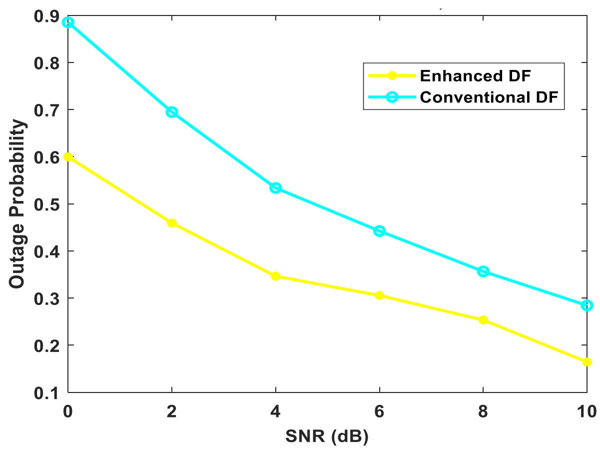

Figure 2. OP versus SNR for the enhanced and conventional DF Cooperative Relaying Network at L = 2 over log-normal fading channel

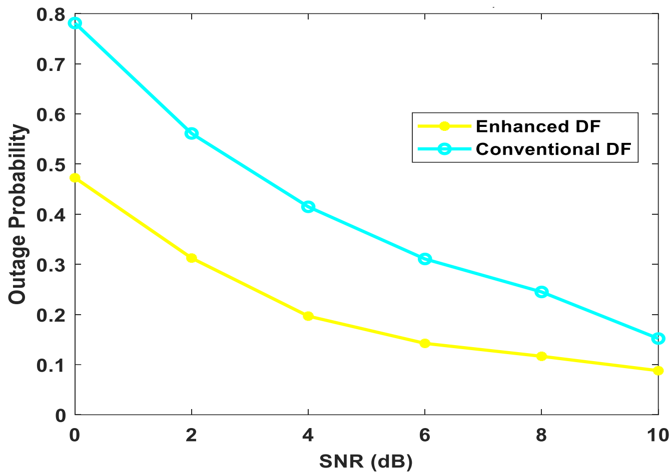

Figure 3. OP versus SNR for the enhanced and conventional DF Cooperative Relaying Network at L = 3 over log-normal fading channel

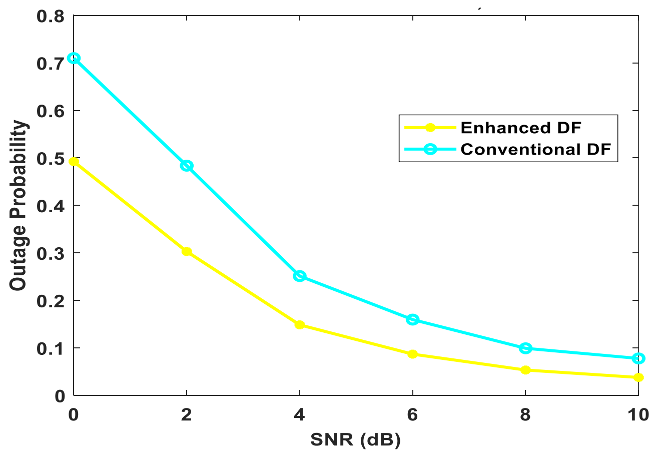

Figure 4. OP versus SNR for the enhanced and conventional DF Cooperative Relaying Network at L = 4 over log-normal fading channel

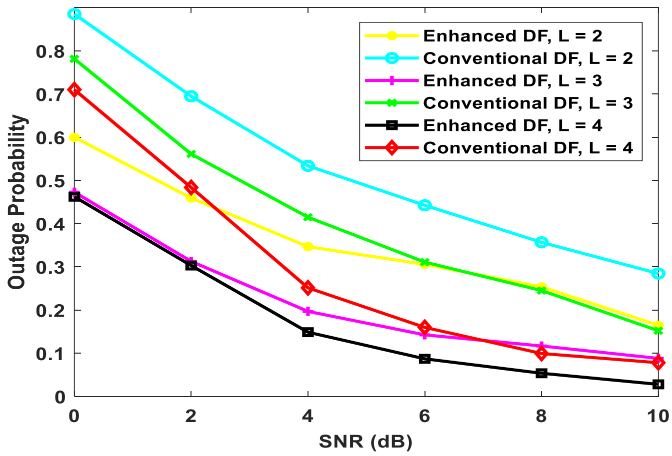

Figure 5. OP versus SNR for the enhanced and conventional DF at different number of paths over log-normal fading channel

3.2 Bit Error Rate obtained for the proposed and conventional DF cooperative Relaying Network

Bit Error Rate (BER) values are obtained at different propagation paths and SNR to validate the performance of the proposed DF technique. Figure 6 presents the BER against SNR for the enhanced and conventional DF at L = 2 over log-normal distribution. 1.91×10^{-7} and 6.03×10^{-6} are the values of BER obtained with SNR of 2 dB for the enhanced and conventional DF, respectively, while, with SNR of 8 dB,

2.15×10^{-9} and 6.79×10^{-8} are obtained for enhanced and conventional DF, respectively. From the results obtained, the enhanced DF technique gives better performance at all the SNR considered with low BER than the conventional DF technique. This is due to time diversity used at the source that increase the number of relays that participated in the second hob transmission, thereby reduced the error rate at the destination. The reduction in the BER of the enhanced technique is also due to hybrid TC-EGC used at the destination that increase signal strength.

Figure 7 depicts the BER against SNR for the enhanced and conventional DF at L = 3 over log-normal distribution. The BER values obtained with SNR of 2 dB are 4.27×10^{-8} and 1.35×10^{-6} for enhanced and conventional DF, respectively, while, for SNR of 8 dB, BER values of 4.81×10^{-10} and 1.52×10^{-8} are obtained for enhanced and conventional DF, respectively. Also, BER against SNR for the enhanced and conventional DF at L = 4 is depicted in Figure 8. At SNR of 2 dB, BER values of 9.55×10^{-9} and 3.15×10^{-7} are obtained for enhanced and conventional DF, respectively, while, with SNR of 8 dB, BER values of 1.08×10^{-10} and 3.40×10^{-9} are obtained for enhanced and conventional DF, respectively. The effect of number of paths on BER for the enhanced and conventional DF is also revealed from the results obtained and this is presented in Figure 9. The BER values reduces as number of paths increase and this is due to reduction in rate of error as signal power increases. Though, in all the scenario considered, enhanced DF gives better performance with lower rate of error than the conventional DF. This is due to reduction in error rate as the relays that participate in the second hop transmission increases. In the enhanced DF technique, time diversity used at the source increase the relays that decoded the received signal thereby increasing the number of relays that participated at the second hop transmission. The reduction in BER for the proposed DF technique is also due to hybrid TC-EGC diversity combiner used at the destination that increase signal strength thereby reducing error rate.

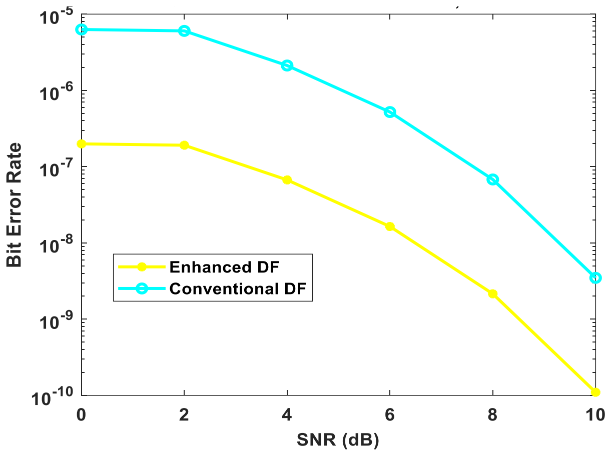

Figure 6. BER against SNR for the enhanced and conventional DF at L = 2 over log-normal fading channel

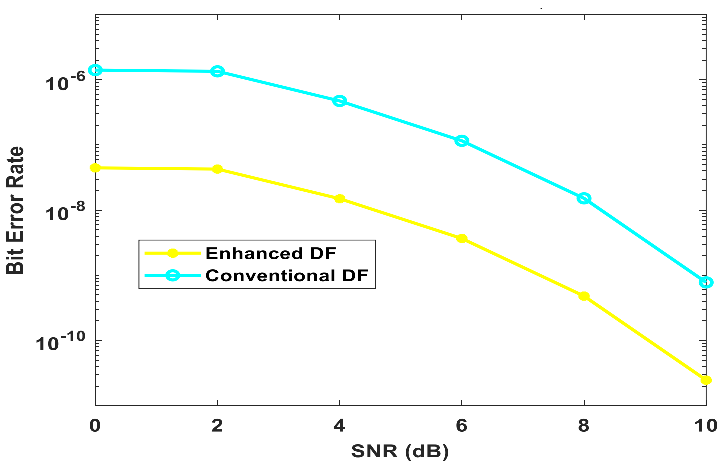

Figure 7. BER versus SNR for the enhanced and conventional DF at L = 3 over log-normal fading channel

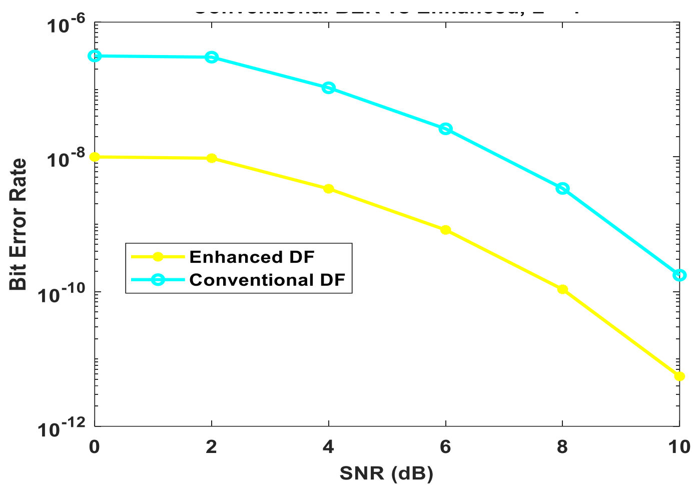

Figure 8. BER versus SNR for the enhanced and conventional DF at L = 4 over log-normal fading channel

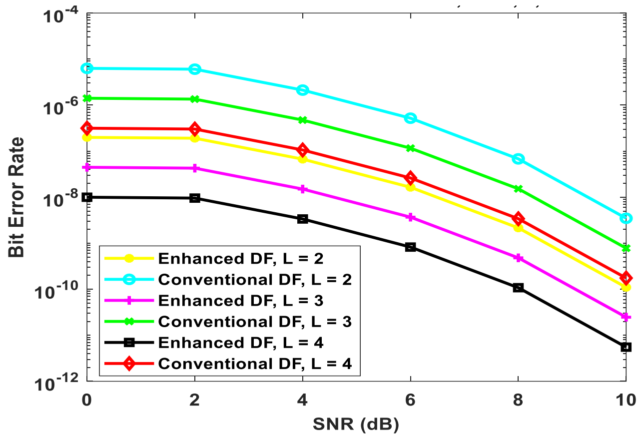

Figure 9. BER versus SNR for the enhanced and conventional DF at different number of paths over log-normal fading channel

4. CONCLUSION

This paper enhanced the performance of DF cooperative relay network over log-normal distribution. Time Diversity (DT) is adopted at the source to transmit various copies of the same information bearing signals with different time slot. The various signals received via multiple relay and relay selection is carried out to select the relay that participated at the second hop transmission using 3 dB as a threshold. The signals are propagated to the receiver (destination) through selected relays. The copies of signal at the receiver (destination) are combined using hybrid TC-EGC diversity combiner. Mathematical expressions of OP and BER for the proposed DF are obtained using PDF of the signal received for the proposed DF technique. The OP and BER obtained are used to validate the performance of the proposed DF technique by comparing with the convention DF technique. In the simulation process, the system model for the received signal at both the relay node and destination are modeled over log-normal fading channel, while the noise was modeled as AWGN. The coefficient of the fading envelop is multiplied with QAM signaling scheme with addition of AWGN at different trial. The multiple signals at the destination are received at a varying propagation paths ‘L’ (2, 3, 4) to investigate the effect of increasing the number of paths on the proposed DF technique. The OP and BER values for the proposed and conventional DF are obtained with different SNRs and different number of paths. The performance of the proposed and conventional DF technique has been validated at various propagation paths with different SNRs using OP and BER as performance metrics. The results obtained revealed that, the proposed DF technique showed a better performance with percentage reduction of 33.9% and 96% at 8 dB for OP and BER, respectively at all the scenario considered. This is due time diversity used at the source that increase the number of relays that participated in the second hop transmission thereby reducing the error rate and the probability of signal outage at the destination. Furthermore, the results obtained showed that for the two techniques, OP and BER reduces as number of propagation paths and SNRs increase. This is as a result of increase in signal power as SNR and number of propagation paths increases. Consequently, the proposed DF technique gives better performance at all the scenario considered than the conventional DF technique over log-normal fading channel with an improved signal strength at the destination.

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