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Empirical Mode Decomposition Based Two-Way Hybrid Decode Amplify and Forward Cooperative Relaying Protocol

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Abstract

In the recent year, wireless communication system has experienced a tremendous growth and happened to be one of the most active areas of technology that covers all aspects of everyday life. However, the system is characterized with multipath fading resulting in variability of the received signal that affect overall system performance. Existing Hybrid Decode Amplify and Forward (HDAF) cooperative relaying protocol used to address the problem suffers from signal outage and fluctuation in the amplitude of the received signal at the destination. Hence, in this study, two-way HDAF (2-HDAF) cooperative relaying protocol is proposed using Empirical Mode Decomposition (EMD) and angular beamforming technique. The multiple copies of the transmitted signals were decoded at the relay node by selecting signal that is greater than the set threshold of 2.5dB. The decoded signal was amplified by multiplying with the relay gain. However, if the channel between the source and relay is corrupted and relay cannot decode the received signal, the received signal was made to pass through EMD technique to attenuate the noise that might present before signal amplification. The amplified signal was beamformed using angular beamforming and propagated to the destination during second hop transmission. The proposed technique is evaluated using TP and BER by comparing with the existing HDAF technique. The proposed EMD-2HDAF gave better performance with 67.3% reduction in BER and 42.34% increase in TP. The proposed technique can be deployed to improve the performance of cooperative diversity in wireless communication system.

Keywords: 2-HDAF, Angular Beamforming, Cooperative Communication, Hybrid Decode Amplify and Forward and Empirical Mode Decomposition

1. Introduction

Wireless communication is characterized with multipath propagation due to obstruction in the medium of conveying signal from transmitter (source) to receiver (destination). The variability in the received signal's amplitude caused by multipath propagation is known as signal fading, which significantly degrades the performance of wireless communication systems. To counter this negative effect, Cooperative Diversity (CD) is a primary technique employed. CD works by having a source transmit its signal to the destination via multiple intermediate nodes (relays). The fundamental concept is to enhance the reliability and efficiency of the wireless link by strategically placing these relay nodes between the source and destination [1-4]. DF is cooperative technique in which relay decodes the received signal, re-encode and forward the coded signal to the destination during second hop transmission, while, in AF, decoding and encoding of the signal received at the relay node is not required, relay only amplifies the signal before forwarding to the destination Amplify and Forward (AF) cooperative relaying generally performs worse than Decode and Forward (DF). This is because the AF relay simply amplifies everything it receives, including the noise signal, before sending it to the destination. Decode and Forward (DF), conversely, is more selective. A DF relay will only transmit the signal if the quality of the received signal (often measured by the channel gain) is above a specific threshold. If the signal quality is too poor, the relay remains silent, which can unfortunately lead to a signal outage at the destination. In order to enhance the performance of the two basic cooperative relaying techniques, Hybrid Decode Amplify and Forward (HDAF) cooperative relaying protocol was proposed to utilize the merits of DF and AF relaying protocol [1], [5-8].

In HDAF cooperative relaying technique, relay decodes the received signal and amplifies the decoded signal before forwarded to the destination. The performance of existing cooperative relaying techniques can be significantly hampered if the wireless channel between the source and the relay is severely affected by fading. When this happens, the relay node cannot properly detect the received signal, leading to a signal outage at the destination. To overcome this issue and improve performance, this research focuses on developing the Two-way Hybrid Decode-Amplify-Forward (2HDAF) cooperative relaying technique, which is an enhancement of the existing Hybrid Decode-Amplify-Forward (HDAF) method. In 2HDAF cooperative relaying technique, relay decodes the received signal and amplifies the decoded signal before forwarded to the destination [9-10]. However, if the channel between the source and relay is corrupted due to fading effect and relay could not decode the received signal, relay only amplifies the signal before forwarded to the destination during second hop transmission. However, 2HDAF cooperative relaying technique will be characterized with poor performance due to noise amplification that occurs during signal amplification without decoding. Also, in 2HDAF technique, multipath fading that usually occurs in the channel between the relay and destination, resulting in variability of signal at the destination thereby affecting the overall system performance [2], [9], [10-11]. Beamforming technique in which transmitted signal is directed to focus a specific direction, rather than broadcasting in all directions has been proposed in the literature to overcome the detrimental effect of multipath fading in a short distance communication. The resulting effect of beamforming technique is faster and more reliable communication system than omnidirectional system of signal radiation. Antenna and angular beamforming are the two major beamforming techniques usually used in wireless communication system. Angular beamforming in which antennas array transmit signals in a specific direction rather than in all directions will be adopted in this research due to its better performance and simplicity. Angular beamforming will be used at the relay node to radiate the amplified signal and it will also be used at the destination to achieve spatial selectivity [12-16].

Several works have been done on hybrid decode amplify and forward. [17] worked on secrecy capacity of hybrid, outage-based power adaptive, cooperative relaying networks with imperfect channel state information to reduce the power consumption of hybrid decode amplify and forward technique. The results obtained revealed that the technique showed a reduction in power consumption due to adaptive relay gain that is based on channel state information. However, the technique suffers from signal outage when the channel between the source and relay is corrupted and relay could not decode the received signal at the relay node. The study in [18] focused on the performance analysis and optimization of a hybrid Time-Switching Relay (TSR) and Power-Splitting Relay (PSR) protocol. This was applied to three types of cooperative relaying: Amplify and Forward (AF), Decode and Forward (DF), and a hybrid AF–DF scheme, all operating under a Weibull fading environment. The main goal was to maximize the network's throughput by adjusting the Energy Harvesting (EH) fractions of the combined TSR–PSR protocol. The researchers derived complex integral-form expressions to calculate two key performance metrics for these protocols: Outage Probability and Throughput.

Previous researches showed that HDAF relaying protocol is characterized with high outage probability when the channel between the source and destination is corrupted. Also, in the existing HDAF technique, multipath fading usually occurs in the channel between the relay and destination, resulting in fluctuation in the amplitude of the received signal at the destination thereby affecting the overall system performance. Hence, this research developed an EMD based 2HDAF cooperative relaying protocol for wireless communication system using EMD technique at the relay node, angular beamforming at the relay node and destination. The major contribution of this paper is as follows:

1 establishment of a new HDAF cooperative relay technique with enhanced throughput and reduced error rate due to its dynamic nature and angular beamforming technique used at the relay node.
2. derivation of a closed form expression of throughput and bit error rate for the developed EMD-2HDAF technique over Kappa-mu shadowed fading channel.

2. Methods

Transmitting signal was propagated from the source over Kappa-mu shadowed fading channel. The multiple copies of the transmitted signal from the source was received at the relay node and decoded by selecting signal with SNR greater than the set threshold of 2 dB among the received signals. The SNR 'γ_{Ri}' of the signals received at the relay node was obtained using

$$\gamma_R = \frac{P_{ts} H_{isr}}{N_{isr}} \tag{1}$$

where: P_{ts} is the transmitting signal power at the source
H_{isr} is the channel gain between the source and relay at an instance
N_{isr} is the noise present at an instance

The decoded signal was amplified by multiplying with the relay gain. However, if the SNR of the received signal at the relay node is less than 2dB, relay select any signal path without decoding. The signal was made to pass through Empirical Mode Decomposition (EMD) for signal denoising, that is to remove the noise that might present. The signal output of the EMD which is expected to be a clean signal was amplified by multiplying with the relay gain. Therefore, the signal output at the relay node 'δ' when the relay could not decode the received signal, is the product of EMD output signal and the relay gain, obtained as

$$\delta_j(n) = \breve{x}_j(n)\left(\frac{P_r}{P_r h_{sr}^2 + N_r}\right)^{\frac{1}{2}} \quad 2$$

where: P_r is the relay power

h_{sr}^2 is the source to relay channel power

N_r is the noise present at the relay node

Equation (2) is the amplified signal at the relay node when relay could not decode the received signal. However, if the SNR of the received signal at the relay node is greater than the set threshold, the amplify signal at the relay node is obtained as

$$\delta_j(n) = x_i(n)\left(\frac{P_r}{P_r h_{sr}^2 + N_r}\right)^{\frac{1}{2}} \quad 3$$

where $x_i(n)$ is the decoded signal

The amplified signal will be beamformed using angular beamforming before being forwarded to the destination during second hub transmission. The block diagram of the proposed technique is depicted in Fig. 1.

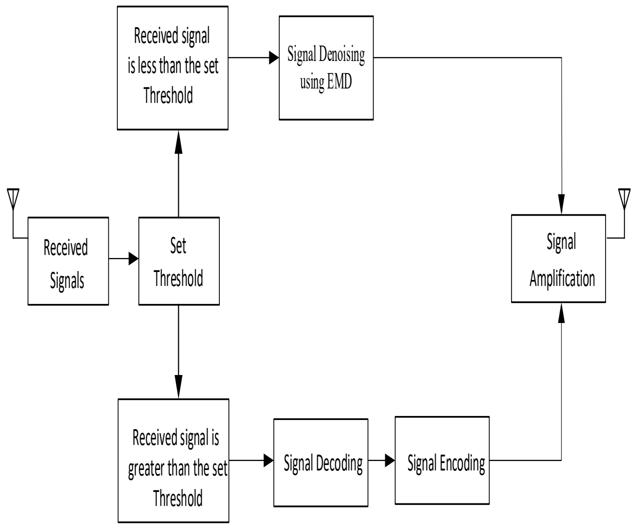

Fig. 1: Block Diagram of the developed EMD Based 2HDAF Cooperative Relaying Technique

Signals were randomly generated at the source and then transmitted over a wireless channel characterized by Kappa-mu shadowed fading. At the relay node, multiple copies of the signal arrived due to multipath propagation. These signals were processed using the novel Empirical Mode Decomposition (EMD) based Two-way Hybrid Decode-Amplify-Forward (2HDAF) cooperative relaying technique. In the second stage of transmission (the second hop), the processed signal was sent to the destination using an angular beamforming technique. The final beamformed signal received at the destination was then analyzed.

$$y = q_r\left(Hq_t\breve{x}_j(n)\left(\frac{P_r}{P_r h_{sr}^2 + N_r}\right)^{\frac{1}{2}}\emptyset + n\right) \quad 4$$

$$y = q_r\left(Hq_t x_i(n)\left(\frac{P_r}{P_r h_{sr}^2 + N_r}\right)^{\frac{1}{2}}\emptyset + n\right) \quad 5$$

where: y is the received signal

q_r is the received beamforming vector

q_t is the transmitting beamforming vector

x is the transmitting signal

H is the channel gain

$\emptyset$ is the beamforming angle

n is the noise present

Equations (4) and (5) are the received beamforming signals at the destination when the relay could not decode the signal and when relay decoded the signal, respectively. The multiple copies of the beamformed signal at the destination will be combined using Equal Gain Combiner (EGC). Therefore, by using EGC the SNR of the received signal for the proposed technique is obtained as

$$SNR_{EGCB} = \frac{1}{wL}\left(\sum_{i=1}^{L} q_r\left(Hq_t\breve{x}_j(n)\left(\frac{P_r}{P_r h_{sr}^2 + N_r}\right)^{\frac{1}{2}}\emptyset + n\right)\right)^2 \quad 6$$

Using equation (6) and PDF of the received signal over Kappa-mu shadowed fading, the PDF of the received signal $PDF_{KMD}(r)$ for the proposed technique is obtained as

$$PDF_{KMD}(r) = \frac{1.733}{\sigma^3} exp - \left(\left(\frac{(ln(SNR_{EGCB})-\mu)^2+(SNR_{EGCB})^2+A^2}{2\sigma^2}\right) I_o\left(\frac{A(SNR_{EGCB})}{\sigma^2}\right)\right) \quad 7$$

2.1 Throughput (TP)

In this paper, Throughput (TP) is defined as the successful rate at which messages are delivered across the wireless channel, specifically one affected by Kappa-mu shadowed fading. The subsequent text will present the mathematical expression used to calculate this Throughput TP for the proposed technique.

$$TP = B \times log_2(1 + SNR)(1 - OP) \quad 8$$

Therefore, by using equation (6), the expression for the TP for the proposed technique is obtained as

$$TP = Blog_2\left(1 + \frac{1}{wL}\left(\sum_{i=1}^{L} q_r\left(Hq_t\breve{x}_j(n)\left(\frac{P_r}{P_r h_{sr}^2 + N_r}\right)^{\frac{1}{2}}\emptyset + n\right)\right)^2\right)(1 - OP) \quad 9$$

The Outage Probability (OP), as defined by Equation (9), is calculated by comparing the Signal-to-Noise Ratio (SNR) of the received signal to a pre-defined threshold of 2.5 dB. If the received SNR drops below 2.5 dB, a signal outage is recorded at the destination. Conversely, if the SNR is equal to or above the threshold, there is no outage. This outage condition (based on the 2.5 dB threshold) is determined for every generated bit. These results are then used to calculate the overall Outage Probability, which is subsequently substituted into Equation (9) to find the Throughput (TP) of the system.

2.2 Bit Error Rate (BER)

The expression for BER for the proposed technique is obtained as

$$P_b(E) = \int_o^\infty P_b\left(E/_\gamma\right) \times \frac{1}{wL}\left(\sum_{i=1}^{L} q_r \left(Hq_t \breve{x}_j(n)\left(\frac{P_r}{P_r h_{sr}^2+N_r}\right)^{\frac{1}{2}} \emptyset + n\right)\right)^2 d\gamma \quad 10$$

According to Adeyemo *et al*. (2020), conditional error probability $P_b\left(E/_\gamma\right)$ is given as

$$P_b\left(E/_\gamma\right) = {}^1/_2 \exp(0.5\gamma) \quad 11$$

Using equations (10) and (11), the expression of BER for the proposed technique is obtained as

$$P_b(E) = \int_o^\infty {}^1/_2 \exp(0.5\gamma) \times \frac{1}{wL}\left(\sum_{i=1}^{L} q_r \left(Hq_t \breve{x}_j(n)\left(\frac{P_r}{P_r h_{sr}^2+N_r}\right)^{\frac{1}{2}} \emptyset + n\right)\right)^2 d\gamma \quad 12$$

$$P_b(E) = 0.5\int_o^\infty \exp(0.5\gamma) \times \frac{1}{wL}\left(\sum_{i=1}^{L} q_r \left(Hq_t \breve{x}_j(n)\left(\frac{P_r}{P_r h_{sr}^2+N_r}\right)^{\frac{1}{2}} \emptyset + n\right)\right)^2 d\gamma \quad 13$$

$$P_b(E) = \frac{0.5\left(\sum_{i=1}^{L} q_r \left(Hq_t \breve{x}_j(n)\left(\frac{P_r}{P_r h_{sr}^2+N_r}\right)^{\frac{1}{2}} \emptyset + n\right)\right)^2}{wL} \int_o^\infty \exp(0.5\gamma)\, d\gamma \quad 14$$

$$P_b(E) = \frac{0.5\left(\sum_{i=1}^{L} q_r \left(Hq_t \breve{x}_j(n)\left(\frac{P_r}{P_r h_{sr}^2+N_r}\right)^{\frac{1}{2}} \emptyset + n\right)\right)^2}{wL} \times 0.5 \quad 15$$

$$P_b(E) = \frac{\left(\sum_{i=1}^{L} q_r \left(Hq_t \breve{x}_j(n)\left(\frac{P_r}{P_r h_{sr}^2+N_r}\right)^{\frac{1}{2}} \emptyset + n\right)\right)^2}{wL} \quad 16$$

3. Results and Discussion

Throughput (TP) is one of the metrics used to evaluate the performance of the proposed Empirical Mode Decomposition (EMD) based Two-Way Hybrid Decode Amplify and Forward (2-HDAF) cooperative relaying protocol for wireless communication system over kappa-mu shadowed fading distribution. The TP values at different number of propagation paths with different angle of beamforming were obtained and compared with the work in [18]. In this work, existing HDAF technique represent the work in [18]. Fig. 2 presents the TP against SNR for the proposed EMD based 2HDAF (EMD-2HDAF) technique at L = 2 and beamforming angle of 30^0 over kappa-mu shadowed fading distribution. At SNR of 4 dB, TP values of 20.0121 and 14.5730 bit/sec were obtained for the proposed EMD-2HDAF and existing HDAF techniques, respectively, while the corresponding TP values obtained at SNR of 8 dB were 20.9631 and 14.9910 bit/sec. The TP values obtained for the proposed EMD-2HDAF technique using beamforming angle of 60^0 were 16.9578 and 17.5764 at SNR of 4 dB and 8 dB, respectively. The results obtained showed that at all the beamforming angle considered, the proposed EMD-2HDAF gave better performance with higher value of TP than the existing HDAF. This is due to dynamism of the proposed technique that allowed the relay to amplify and forward the received signal when relay cannot decode the transmitted signal from the source. The ability of the proposed technique to transmit signal at the relay node at all the time irrespective of nature of channel reduces the chances of signal outage at the destination. The reduction in signal outage enhances the rate at which messages were delivered successfully at the destination and thereby increased the value of TP.

The superior performance of the new EMD-2HDAF technique is also credited to two signal processing methods used in the network, that is Angular Beamforming at the relay node and EGC at the destination. Beamforming at the relay, help focuses the electromagnetic energy into a concentrated beam, thereby increasing the strength of the signal sent toward the destination. EGC at the destination efficiently combines the multiple copies of the received signal to maximize its quality. The TP values obtained at L = 4 using beamforming angles of 30^0 and 60^0over kappa-mu shadowed fading distribution for the proposed EMD-2HDAF and existing HDAF techniques were presented in Fig. 3. The TP values obtained at SNR of 4 dB using beamforming angle of 30^0 were 25.7595 and 17.5150 bit/sec for the proposed EMD-2HDAF and existing HDAF techniques, respectively, while the corresponding TP values obtained at SNR of 8 dB were 28.8740 and 18.6886 bit/sec. Also, at SNR of 4 dB, the TP values obtained for the proposed EMD-2HDAF technique were 25.7595 and 20.8742 using beamforming angles of 30^0 and 60^0, respectively. The effect of number of propagation path with different angle of beamforming is presented in Fig. 4. It can be deduced from the graph, as the number of propagation path increases, the performance of the proposed technique also increases and this is due to increase in signal strength as number of propagation paths increases.

However, as the beamforming angle increases, the performance of the developed technique decreases with lower TP values and this is because at lower beamforming angle, the transmitting signals are more focus on a certain direction than at higher beamforming angle thereby forming a focused beam of electromagnetic energy that enhances signal strength at the destination. The results obtained also revealed that, for both the developed and existing techniques, TP values increase as the number of propagation paths and SNRs increases and this is due to increase in the strength of transmitting signal as the SNR and number of propagation paths increases. The increase in the strength of transmitting signal enhances the rate at which messages were delivered successfully at the destination and thereby increased the value of TP. However, in all the cases considered, the developed EMD-2HDAF gave better performance with high value of TP than the existing HDAF. This is due to dynamism of the developed technique that allowed the relay to amplify and forward the received signal when relay cannot decode the transmitted signal from the source.

The better performance is also due to EMD used that denoise the noise that mighty present during signal amplification. The better performance of the proposed EMD-2HDAF with high value of TP is also attributed to angular beamforming technique and EGC used at the relay node and destination, respectively. These increases the strength of the received signal by forming a focused beam of electromagnetic energy and combined the multiple copies of the received signal at the destination. Considering all the cases considered, the developed EMD-2HDAF gave best performance with highest value of TP at number of propagation path of 4, SNR of 10 dB and beamforming angle of 30^0.

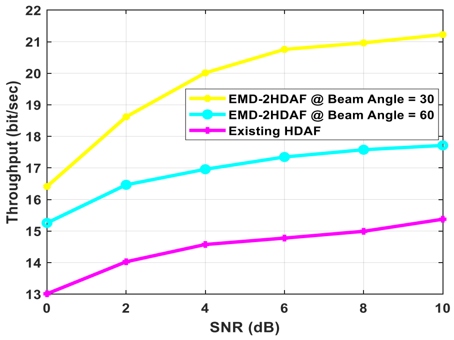

Fig. 2: TP against SNR for the proposed EMD-2HDAF and existing HDAF at L of 2 with different beamforming angles over kappa-mu shadowed fading distribution

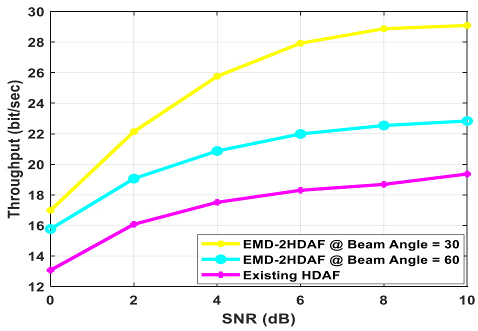

Fig. 3: TP against SNR for the developed EMD-2HDAF and existing HDAF at L of 4 with different beamforming angles over kappa-mu shadowed fading distribution

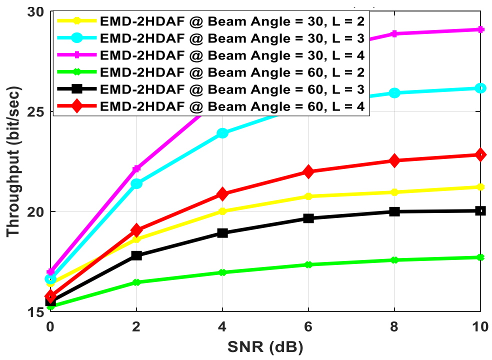

Fig. 4: TP against SNR for the developed EMD-2HDAF at different number of propagation path and different beamforming angles over kappa-mu shadowed fading distribution

Bit Error Rate (BER) values were also obtained at different propagation paths, SNR and angle of beamforming to evaluate the performance of the proposed EMD-2HDAF technique over kappa-mu shadowed fading distribution. Fig. 5 presents BER versus SNR for the proposed EMD-2HDAF and conventional HDAF techniques at L = 2 using beamforming angles of 30^0 and 60^0over kappa-mu shadowed fading distribution. At SNR of 4 dB, with 30^0 beamforming angle, $6.89 \times 10^{-8}$and 2.00×10^{-3} were the BER values obtained for the developed EMD-2HDAF and existing HDAF techniques, respectively, while the corresponding BER values obtained at SNR of 8 dB were 1.00×10^{-8} and 140×10^{-5}. The BER values obtained for the proposed EMD-2HDAF technique using beamforming angles of 60^0 were 1.68×10^{-7} and 3.00×10^{-8} at SNR of 4 dB and 8 dB, respectively. The results obtained revealed that, the proposed EMD-2HDAF technique gave best performance with lower value of BER than the existing HDAF which justify lower error rate in the developed technique at the destination. The better performance of the developed technique is due to angular beamforming technique used at the relay node that focused the beam of electromagnetic energy at a particular direction and thereby enhanced signal strength and reduce the number of erroneous bits at the destination. The better performance of the developed technique is also attributed to EGC used at the destination that combined the multiple copies of the received signal thereby improving the strength of the signal. The increase in the strength of the received signal reduces the number of erroneous bits and thereby reduces BER values at the destination.

The BER values obtained at different SNRs with L = 4 using 30^0 and 60^0 beamforming angles for the proposed EMD-2HDAF and existing HDAF is presented in Fig. 6. The BER values obtained at SNR of 4 dB using 30^0 beamforming angle were 1.08×10^{-7} and 7.06×10^{-4} for the proposed and existing techniques, respectively. Also, the BER values obtained for the proposed EMD-2HDAF using 60^0 beamforming angle were 2.46×10^{-7} and 2.05×10^{-9} at SNR of 4 and 8 dB, respectively. The results obtained revealed that for the two techniques, BER values reduces as the number of paths increases. This is due to reduction in error rate as the signal strength increases. The effect of angle of beamforming and number of propagation path on the performance of the developed EMD-2HDAF technique is depicted in Fig. 7. The results obtained revealed that, the proposed technique gave better performance with lower BER values at beamforming angle of 30^0 when compare with beamforming angle of 60^0 and this is due to lower angle of broadcasting that makes the signal to be more focus in a certain direction thereby forming a focused beam of electromagnetic energy that enhances signal strength and reduces erroneous bit at the receiving end. The results of the study show a clear trend: for both beamforming angles tested, the Bit Error Rate (BER) values decrease as the number of signal paths increases. This improvement is attributed to the increased signal strength that comes with having more propagation paths (multipath diversity). Crucially, in every scenario considered, the proposed EMD-2HDAF technique consistently delivered superior performance by achieving a lower BER compared to the existing HDAF technique. The better performance of the proposed technique is due to angular beamforming technique used at the relay node that focused the beam of electromagnetic energy at a particular direction and thereby enhanced signal strength. The results obtained revealed that, the performance of the proposed and existing techniques increases as the value of SNR increases and this is due to reduction in erroneous bit as the strength of the signal increases. Also, the performance of the developed technique increases with lower values of BER as beamforming angle decreases. The improved performance of the proposed technique is due to lower beamforming angle which focuses the transmitted signal more sharply in a specific direction. This creates a concentrated beam of electromagnetic energy, which enhances the signal strength and reduces the number of errors (erroneous bits) at the destination. The use of EGC at the destination is also key, as it efficiently combines the multiple copies of the received signal. This combination further increases the received signal strength. Ultimately, the stronger received signal resulting from both the focused beam and the combining technique reduces the number of erroneous bits, which leads to lower BER values at the destination.

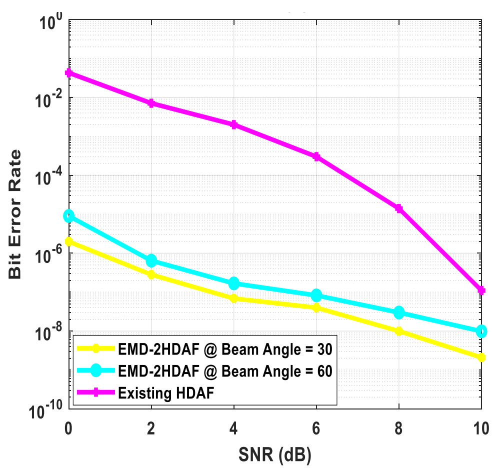

Fig. 5: BER against SNR for the developed EMD-2HDAF and existing HDAF at L of 2 with different beamforming angles over kappa-mu shadowed fading distribution.

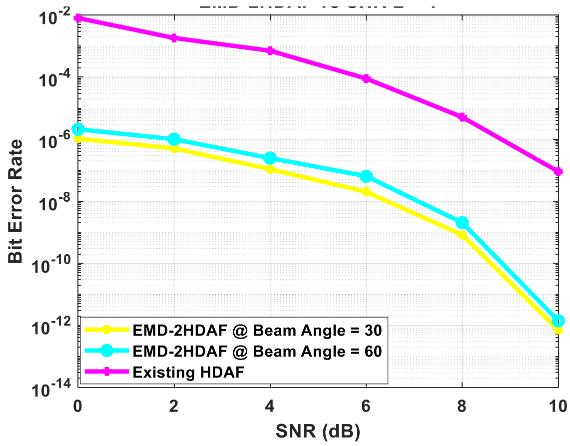

Fig. 6: BER against SNR for the developed EMD-2HDAF and existing HDAF at L of 4 with different beamforming angles over kappa-mu shadowed fading distribution

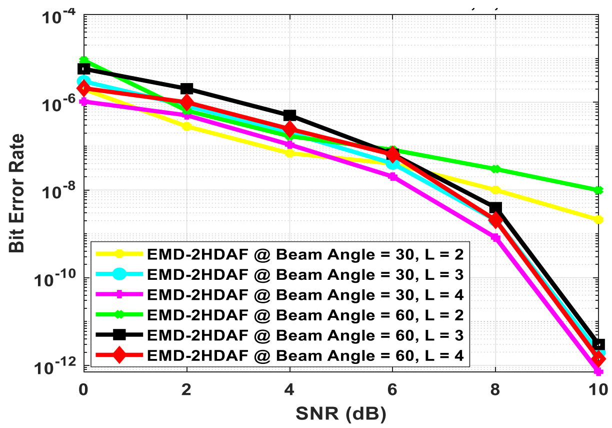

Fig. 7: BER against SNR for the proposed EMD-2HDAF at different number of propagation path and different beamforming angles over kappa-mu shadowed fading distribution.

4. Conclusion

This work proposed an EMD based 2HDAF (EMD-2HDAF) cooperative relaying technique for wireless communication system over kappa-mu shadowed fading distribution. The proposed technique was made to be dynamic in nature, that is, it has the ability to decode and forward the decoded signal to the destination during second hub transmission. However, if the technique could not decode the transmitted signal from the source as a result of deep fading between the source and relay, the technique only amplified the received signal and make it to pass through EMD before second hub transmission. The dynamic nature of the proposed technique reduces signal outage at the destination which in turn enhanced throughput at the destination. This study evaluated the performance of the proposed EMD-2HDAF technique against the existing HDAF method by measuring Bit Error Rate (BER) and Throughput (TP) across various

Signal-to-Noise Ratios (SNRs) and number of propagation paths (L). The results consistently showed that the proposed EMD-2HDAF technique performed better, achieving lower BER and higher TP. This superior performance is primarily attributed to the EMD-2HDAF's dynamic operation, which allows the relay to decode and forward the signal when possible and amplify and forward the received signal when it fails to decode it. This dual-mode capability ensures the relay transmits signal at all times, regardless of the channel quality, which significantly reduces the chance of a signal outage at the destination. Fewer outages mean a higher rate of successful message delivery, thereby increasing the TP value. An additional factor contributing to the EMD-2HDAF's better performance is the use of angular beamforming, which focuses the signal in a specific direction. This focused beam of electromagnetic energy enhances the signal strength at the destination. Finally, the results confirmed a general trend for both techniques: BER decreases and TP increases as both the SNR and the number of paths increase. This is because higher SNR and more paths both lead to an increase in signal strength.

Also, the proposed technique gave better performance at beamforming angle of 30^0 with lower BER and higher TP than beamforming angle of 60^0 and this is due to lower angle of broadcasting when using 30^0 making the signal to be more focus on a certain direction thereby forming a focused beam of electromagnetic energy that enhances signal strength. Conclusively, in all the cases considered, the proposed technique has better performance with higher TP and lower BER at L of 4, SNR of 10 dB and beamforming angle of 30^0.

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