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PERFORMANCE ANALYSIS OF COOPERATIVE COMMUNICATION FOR DUAL-HOPE RELAYING NETWORK WITH HARDWARE IMPAIRMENT OVER RAYLEIGH FADING CHANNEL

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ABSTRACT

The cooperative communication becomes an important topic in the field of wireless communication network to improve the reiliability and speed of communication over long distance and curvbed surface. As distance is increasing between transmitter and reciver, the transmitter RF power requirement goes up to maintain the required SNR. The cooperative communication is an alternative way to fulfill this requirement with the help of relaying technique . There are no. of research articles have been pulished in the area of cooperative communication. The major research works have been carried out with an assumption of ideal hardware used for communication.This paper explore the effect of hardware impairement on coopratíve communication. The AF and DF protocols has been used during simulation. The result of the outage probability with SNR has been shown in result section to identify the effect of hardware imapirement. The effect of noise added by hardware and the gain error is considard as a effect of hardware impairment.

KEYWORDS: Cooperative communication, Modulation technique, Rayleigh channel, etc.

INTRODUCTION

The wireless transmission signal quality suffers severe degradations due to effects like fading caused by multipath propagation. Reduce such effects; diversity can be used to transfer the various samples of the same signal over essentially independent channels. There are various approaches to implement diversity in a wireless transmission. The multiple antennas can be used to achieve space diversity. Although transmit diversity is clearly advantageous on a cellular base station (BS), but it may not be practical for certain other scenarios like wireless sensor networks (WSN), mobile ad-hoc networks and other. Specifically, due to size, cost, power or hardware limitations, a wireless agent may not be able to support multiple transmit and receive antennas

The cooperative communication technique exploits the spatial diversity gains inherent in multiuser wireless technique without the need of multiple antennas at every node. This is achieved through having the users relay each other's messages and, thus, forming multiple transmission paths to the destination. The cooperation in communication networks results when terminals use their time, power, and bandwidth resources to mutually improve their transmissions which results in increasing capacity and multiplexing gain and also helps to combat the effects of fading channel. Thus single antenna station or nodes can also reap the benefits of a MIMO scheme.

User cooperative communication is a form of communication network in which users work together to deliver their data. By relaying each other’s data, an multiple independent copies of the data are received at the destination. The processing of multiple independent copies of the signal reduces the probability of error. In the cooperative communication, diversity acquired at destination improves the channel reliability and saves resources. Diversity in Communication is an effective way to tackle fading and improve reliability. Diversity is obtained over time and frequency through means of coding and interleaving. It can also be obtained via repeated transmission. Cooperative transmission through relaying is also a way to achieve diversity. User cooperative transmission is a special case of cooperative communication transmission where users act as relays to help each other.

Consider the dual-hop relaying scenario in Fig. 1. Let the transmission parameters between the source and the relay have subscript 1 and between relay and destination have subscript 2. Using the generalized system model , the received signals at the relay and destination are

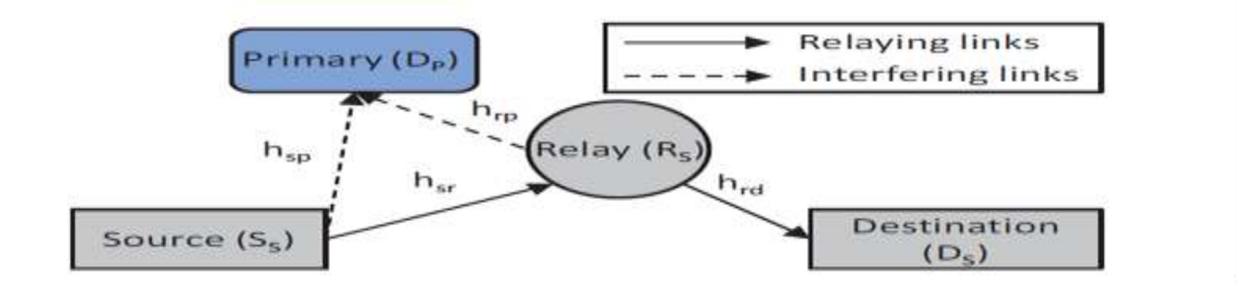

Fig. 1: dual hope relay for Cooperative communication system

the use of relay nodes for improving coverage reliability and quality-of-service in wireless systems has been a hot research topic over the past decade, both in academia and in industry This is due to the fact that, unlike macro base stations, relays are low-cost nodes that can be easily deployed and hence enhance the network agility . The vast majority of works in the context of relaying systems make the standard assumption of ideal transceiver hardware impairements of physical transceiver that create distortions which degrade the performance of communication system .this paper analeyzes the performance with different relay technique .the vast majority of technicals contribution in the area of relaying neglect hardware impairements and thus assumes idel hardware. such approximation sense in low rate system, but can lead to ver y misleading results when analyzing future high rate systems. This paper quantifies the impact of hardware impairments on dual-hop relaying, for both amplify - and - forward and decode - and - forward protocols. The outage probability (OP) in these practical scenarios is a function of the effective end- to- end signal - to – noise - and - distortion ratio. The effective end-to- signat to-noise and – distiortion ratio (SNDR) which i inversely proportional to the level of impairments . This paper derive new closed-form expressions for the output probability of AF and DF relaying network with hardware impairments are drived over Rayleigh fading channels,.Ops, accounting for hardware impairments at the source, relay, and destination, which provides the fast and efficient means to evaluate the impact hardware impairments on the system performance. We assume that both hops are subject to Independent but non-identically distributed Rayleigh fading. we provide fundamental design guidelines for selecting hardware that satisfies the requirements of a practical relaying system.

However,in practice,hardware suffers from several types of impairments for example, phase noise, I/Q imbalance, and high power amplifier (HPA) nonlinearities among others.The impact of hardware impairments on various types of single-hop systems was analyzed in. For instance, I/Q imbalance was considered in and it was shown to attenuate the amplitude and rotate the phase of the desired constellation

Despite the importance of transceiver hardware impairments, their impact on one-way relaying has only been partially investigated; bit error rate simulations were conducted for amplify-and-forward (AF) relaying, while derived expressions for the bit/symbol error rates considering only non-linearities or I/Q imbalance, respectively. Most recently, elaborated on the impact of I/Q imbalance on AF relaying and suggested novel digital baseband compensation algorithms.

SYSTEM MODEL

The simulation model consist dual hop relaying system in the relaying fading enviorment. The ideal hardware system has been used initially used for the simulation for the symbols more than 10^5. This paper consider a dual hope relaying cooperative communication network where a source node (S) communicate with a destination node (D) via an intermediate relay node (R) as illustrated fig:1.the direct link between S and D assumed to be absent due to strong propagaition attenuation and keeping mind that the transmitted power of the relay system.The figure below shows a schematic diagram of the dual hop transmission . The out can be modeled as

$$y = h(s + \eta) + \nu$$

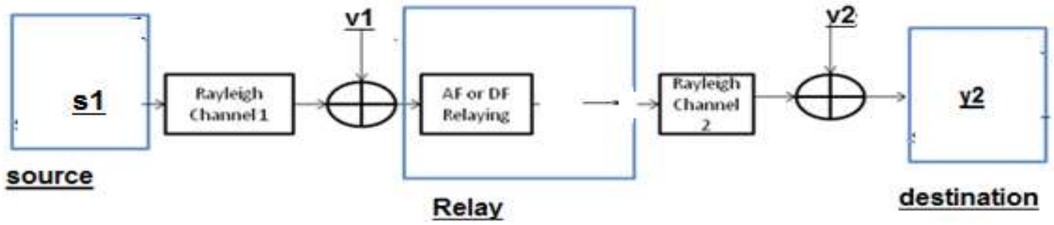

Fig:2 Dual-hop relaying scenario for ideal hardware case

There are no impurity in the signal introduced by source or by relay channel. There are different type of imperfectness has been observed in practice. This paper deals with the imperfectness at source side and relay side as shown in the figure below,the output can be obtained as

$$\begin{aligned} y_2 &= h_2\, G_{\mathrm{ni}} \Big(h_1\,(s_1 + \eta_1) + \nu_1 \Big) + h_2\,\eta_2 + \nu_2 \\ &= G_{\mathrm{ni}}\, h_1\, h_2\, s_1 + G_{\mathrm{ni}}\, h_1\, h_2\, \eta_1 + G_{\mathrm{ni}}\, h_2\, \nu_1 + h_2\, \eta_2 + \nu_2 \end{aligned}$$

Where S is the information signal , Y is the destination signal, V is the noise, H is the gain of the channels, G is the amplification factor of system and N is noise by hardware imapairements

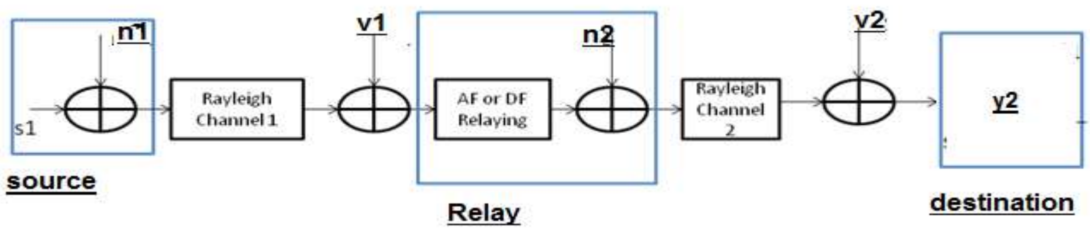

Fig:3 Dual-hop relaying scenario for non-ideal hardware case

The v1 and v2 are the noises added during the transmission. The distortion noise by hardware impairement is n1 and n2 is respectively transmitter and receiver ,hardware impairement distortion noise is independent of the fading distribution noise.The gain of the AF technique influence due to the noise variance and an addition gain error also introduce in the transmission from source and relay. The figure below shows the gain error .

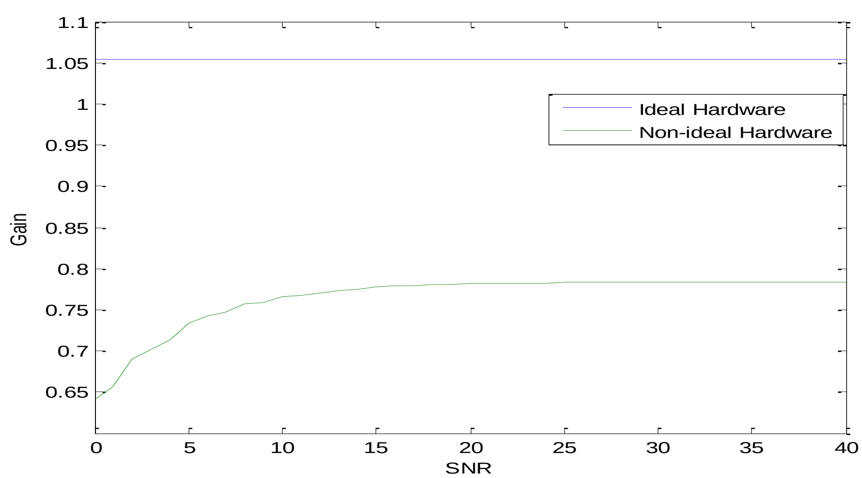

Figure :4 Imperfectness in the gain from relay

RAYLEIGH FADING CHANNEL

In wireless communication channel,the trsnmitted signal can travel from transmitter to receiver over multiple reflective paths this gives rise to multipath fading which cause fluctuations in amplitude,phase and angle of arrival the received signal. for example , the transmited signal from the BTS (base transceiver staion) may suffer multiple reflectionsfrom the buildings nearby, before reching the mobile station

Such multipath fading channels are often classified into slow fading / fading and frequency – selective/ flat fading channels

Rayleigh fading occurs when there are multiple indirect paths between the transmitter and the receiver and no direct non -fading or line- of sight path. It represents the worst case scenario for the transmission channel. Rayleigh fading channel assumes that a received multipath signal consists of a large number of reflected waves with independent distributed phase and amplitude. The envelope of the received carrier signal is Rayleigh distributed in wireless communications The Rayleigh distribution has a PDF given by

$$p(r) = \frac{r}{\sigma^2} e^{-\frac{r^2}{2\sigma^2}} \quad 0 \le r \le \infty$$

$$pr^2(r) = \frac{1}{2\sigma^2} e^{-\frac{r^2}{2\sigma^2}}$$

Where $\sigma^2 = E[r^2]/2$ is the total power in the received signal and I is the standard deviation.The cumulative distribution function (CDF) is given by

The multipath model is commonly modeled as a two-ray model for illustrating Rayleigh fading. The impulse response is given by

$$h(t) = \alpha_1 e^{j\theta 1(t)}\delta(t) + \alpha_2 e^{j\theta 2(t)}\delta(t-\tau)$$

α_1, α_2 are independent random variables with Rayleigh PDF. $\theta 1, \theta 2$,are independent random variables with uniform PDF and $\tau$is the time delay.

COOPERATIVE TRANSMISSION PROTOCOL

The cooperative transmission protocols used at the relay are amplify and forward (AF), and decode and forward (DF), compress and forward and coded cooperation. The most commonly used strategies are AF and DF.

Amplify and Forward

In this case the relay forwards the information received from the sender during broadcast phase and it amplifies and retransmit the signal to its destination during the cooperation phase. In doing so, noise also get amplified, which is the major drawback of this method. This method is used when the time delay caused by decoding and encoding is to be minimized.

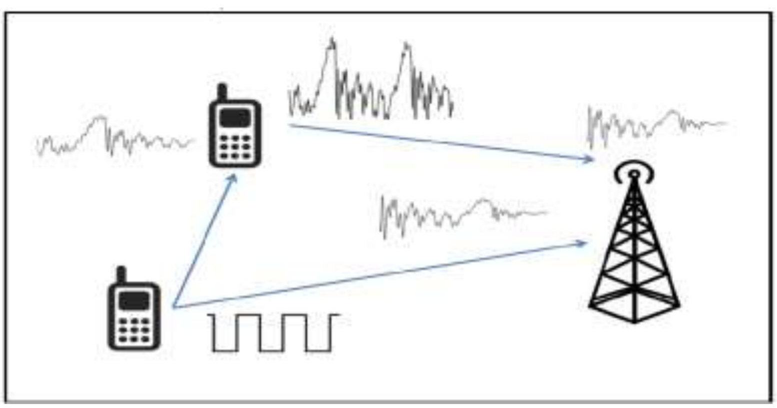

Fig: 5 Amplify and Forward

The relay has to send the signal at the same power level at which it received the signal; hence the relay has to use a gain of

$$\beta_r = \frac{\sqrt{P}}{\sqrt{P|h_{s,r}|\text{^}2+N_0}} + \eta_{s,r}$$

Thus signal received at the destination is

$$y_{r,d} = \frac{\sqrt{P}}{\sqrt{P|h_{s,r}|^2+N_0}} + h_{r,d}\, y_{s,r} + \eta_{s,r}$$

$$y_{r,d} = \frac{\sqrt{P}}{\sqrt{P|h_{s,r}|^2+N_0}} + h_{r,d}\sqrt{P}h_{s,r}x + \eta'_{r,d}$$

Where equivalent noise is given as:

$$\eta'_{r,d} = \frac{\sqrt{P}}{\sqrt{P|h_{s,r}|^2+N_0}} + h_{r,d}\,\eta'_{s,r} + \eta_{r,d}$$

Decode and Forward

In this scheme, the relay decodes the information received from the source during the broadcast phase before forwarding it to its destination. After successfully decoding the received signal, the relay re-encodes the signal an forwards it to the destination .So there is no amplified noise in the received signal. The received information at the receiver via relay can be expressed

$$y_{r,d} = x.h_{r,d} + \eta_{r,d}$$

The decode and forward method can be implemented in two ways. One is when the relay can completely decode the message, but this requires a lot of time. If there is an error correcting code in the source message, then the received bit errors can be corrected at the relay station.

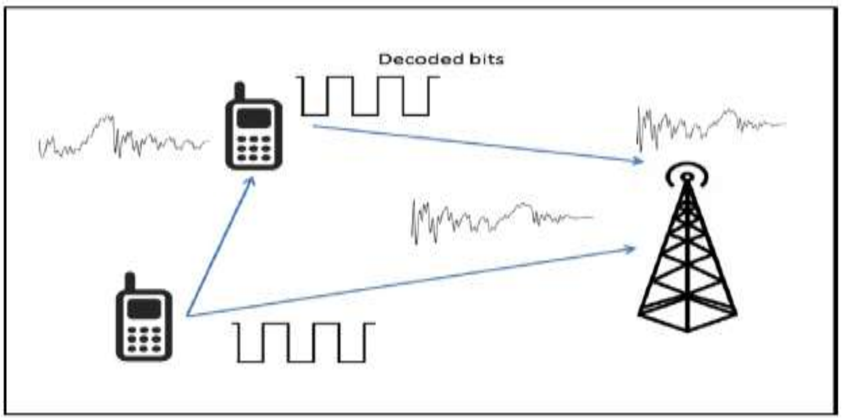

Fig: 6 Decode and Forward

is just decoded and re-encoded symbol by symbol. So no error correcting code can be applied. But it is not possible to always completely decode the source message, since this requires a lot of computing time and the additional delay caused might be unacceptable. In such a case, the source message

OUTAGE PROBABILITY

We first derive the analytical expression for outage probability based on the Lemma 1 as given below.

Lemma 1: Let m, n and k be strictly positive constants, ρ_1 and ρ_2 be a non-negative random variables, λ is the threshold of SNDR, $\Omega_1 = E\{\rho_1\}$ and $\Omega_2 = E\{\rho_2\}$ be average gain, the outage probability is comuted by

$$P_r\left(\frac{\rho_1\rho_2}{m\rho_1^2 + m\rho_1\rho_2 + n\rho_1 + k} \le \lambda\right) = 1 - \frac{2}{\Omega_1} e^{-\frac{n\lambda}{\Omega_2(1-\lambda m)}} \times \sqrt{\frac{k\lambda}{\Omega_2(1-\lambda m)}\left(\frac{1}{\Omega_2}\frac{\lambda m}{1-\lambda m} + \frac{1}{\Omega_1}\right)} \times K_1\left(2\sqrt{\frac{k\lambda}{\Omega_2(1-\lambda m)}\left(\frac{1}{\Omega_2}\frac{\lambda m}{1-\lambda m} + \frac{1}{\Omega_1}\right)}\right)$$

where $K_1(.)$ stands for the first-order modified Bessel function of the second kind. For Proof: See Appendix.

Without loss of generality, we assume that $P_A = P_B = P$ and derive the outage probability of these proposed protocols in general form as below

$$\gamma_x^* = \frac{\rho_1\rho_2}{m\rho_1^2 + m\rho_1\rho_2 + n\rho_1 + k}$$

where γ * A denotes the upper bound of SNDR, $\rho_j = |h_j|^2$ and hence using the results of Lemma 1,
we obtain the outage probability of received signal at each source node in the THRN which is defined as

$$P^A_{out} = \Pr(\gamma^*_A \leq x),$$

where x is the threshold of SNDR, if the SNDR threshold substituted as ($x = 2^{2R} - 1$), by changing the variables as below

$$m = \frac{\tau_R^2}{1-\beta}, n = \frac{\sigma^2}{(1-\beta)P}, k = \frac{\sigma^2(1+\tau_R^2)}{P(1-\beta)\eta\beta}, \text{ for PSIR.}$$

$$m = \frac{\tau_A^2}{1-\beta}, n = \frac{\sigma^2(1+\tau_A^2)}{(1-\beta)P}, k = \frac{\sigma^2}{\eta(1-\beta)P\beta}, \text{ for PSIS.}$$

The desigen parameter k1 and k2 (k1,k2 ≥ 0) characterize the level of impairments in the transmitter and receiver hardware, respectively.it is sufficient to characterize the aggregate level of impairments k = squre(k1^2+k2^2).when k =0 which represents ideal transmitter and receiver hardware since it is implies that k1 = k2 =0 .

RESULTS AND DISCUSSION

The performance of cooperative communication with hardware impairment over rayleigh fading channel has identified in this paper Two parameters BER and outage probability has been used in the paper. The BER is the ratio of no. of error bit with respect to total transmitted bit. The outage probability is described There are four different case has been considard in this paper and the outage probability is define as below

BER analysis with different modulation :l

Using MATLAB coding the performance curves are plotted in the terms of Pout versus the Signal to Noise ratio of the transmitted signal (Es /N0 dB) where Es is the transmit energy signal.

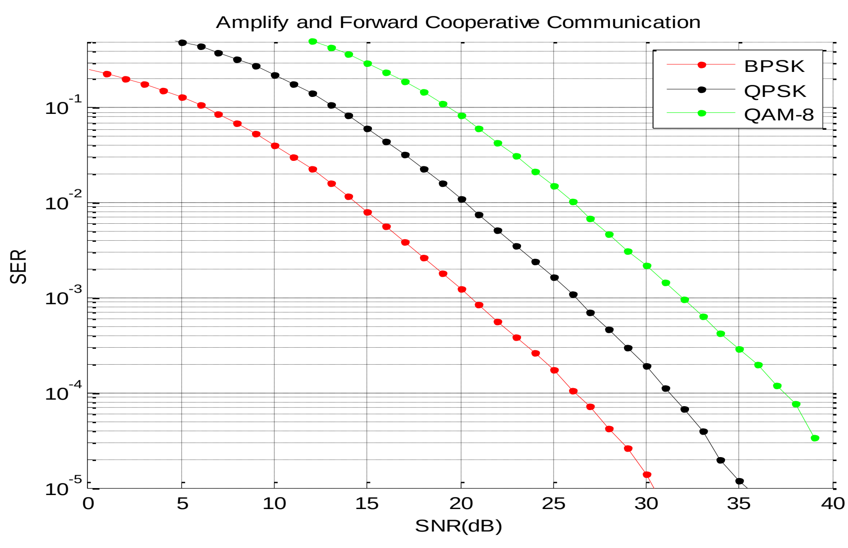

Fig: 7 Performance of SNR V

Fig.7 show in modulation technique with cooperative communication, Effect of modulation order on the BER of AF cooperative communication

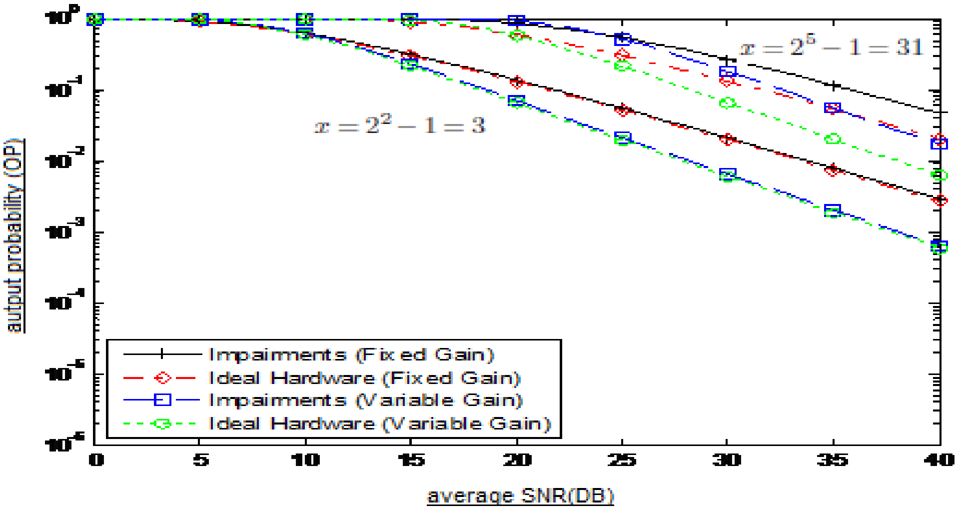

Fig:8 Poutage probability $P^{A}_{out\,(x)}$ ***for AF relaying with ideal hardware and with hardware impairments of k1=k2=0.15***

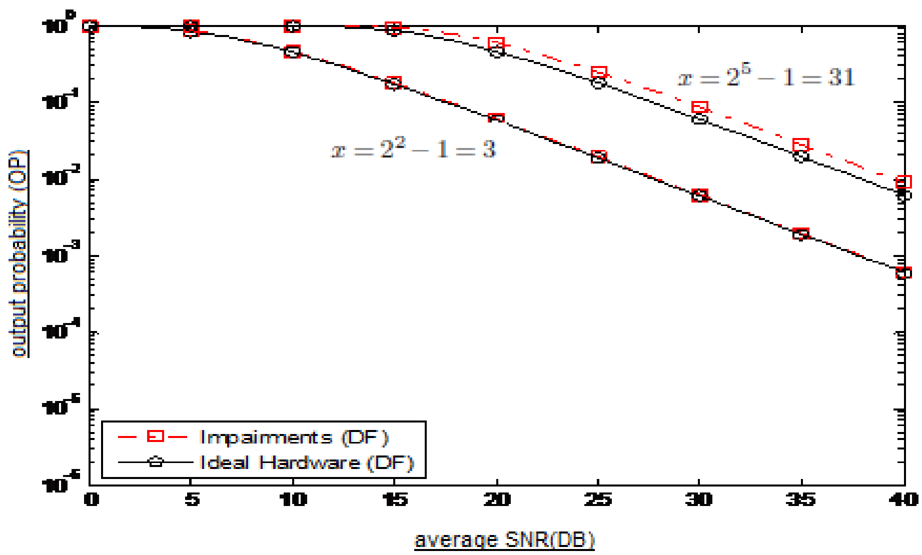

Fig: 9 outage probability $P^{A}_{out\,(x}$ ***for DF relaying with ideal hardware and with hardware impairments k1=k2=0.15***

fig: 8,9 shown first ,we consider the impact of hardware impairements on autput , $P^{A}_{out\,(x)}$ for two different thresholds: x =3 and x =31 *(* $x = 2^{2R} - 1$) .keep in mind that the relay communication accupies two time slote ,these correspond to rate of 1.2 and 2.5 bits/ channel use respectively. we consider a symmetric scenario with fixed levels impairements of k1=k2=0.15

A number of conclusions can be drawn frome corollary.first ,an SNDR ceiling effect appears in high –SNR regime ,which significantly limits the performance o f both AF and DF relaying systems. This means that for x smaller than the ceiling, $P^{A}_{out\,(x)}$ goes to zero with increasing SNR (at the same rate as with ideal hardware) while the OP always equals for x larger than the ceiling .this phenomenon is fundamentally different form ideal hardware case ,in which an increasing SNR makes the end-to –end SNDR grow without bound and $P^{A}_{out\,(x)}$ is zero for any x.note that this ceiling effect is independent of the fading distribution of the two hops relaying system

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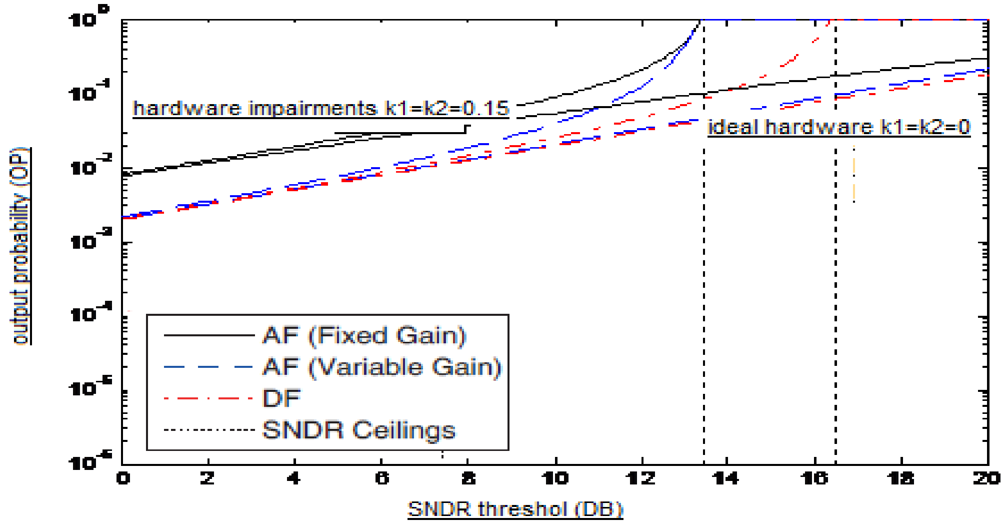

Fig: 9 outage probability $P^{A}_{out\,(x}$ ***for AF and DF relaying for different threshold there exist SNDR ceiling transceiver hardware impairements***

CONCLUSION

The cooperative communication becomes an important topic in the field of wireless communication network to improve the reiliability and speed of communication over long distance and curvbed surface.Our analytical and numerical results manifested that the performance of dual-hop relaying is notably affected by these hardware impairments, particularly when high achievable rates are required.The BER curve of the AF relaying for different modulation has ben studied. The error rate for dual hop relaying is increase with modulation.

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