Selective Decode-Forward Cooperative Communication over Nakagami-m Fading Channel with Channel Estimation Error

Vikash Sachan, Ravi Shankar, Ritesh Kumar Mishra
ECE Department, NIT Patna, Patna 80005, India.
vikash_ietk@rediffmail.com

Abstract—**In this paper, we analyzed the symbol error rate (SER) performance of a selective decode-forward (DF) relaying based on multiple-input-multiple-output (MIMO) orthogonal space-time block coded (OSTBC) cooperation network, considering the channel estimation error. First, the symbol error rate performance of 3 nodes, 2 phase selective DF relaying based MIMO-STBC cooperation network over Nakagami-m fading channels with consideration of channel estimation error has been analyzed. Secondly, equal power allocation and optimal power allocation scenario have been considered and the SER performance has been analyzed. Thirdly, we derive the upper bound and asymptotic expressions of SER. We have achieved the full diversity by using the MIMO with orthogonal space-time block coded selective decode-forward system.**

Index Terms—**Optimal Power Allocation; SER; Equal Power Allocation; Multiple Input Multiple Output; Decode-Forward; Space-Time Block Code.**

I. INTRODUCTION

In the cooperative communication [1-3], a scenario is when we apply one or multiple relays to reduce the symbol error rate and increase the quality of the signal at the destination. These wireless networks have shown a substantial increase in diversity gain because they form a virtual MIMO [4] system due to the cooperation between the source to destination and the relay to the destination network. In cooperative communication [5], there are two popular protocols. One is amplified and forward (AF) and the other is decode and forward (DF). These protocols are simple in nature and provide robust performance. In the AF cooperation scenario, in the first phase, the signal is received at all relays and destination from the source and in the second phase, amplification is performed at the relay and then relay retransmits to the destination. In the case of selective DF relay-based system, relay retransmits the decoded signal to the destination only when it decodes correctly; otherwise, it will remain idle. We can also apply multiple input multiple output technique at every given node to further improve the performance of the system. This improvement arises because of spatial multiplexing and diversity gain provided by this system. This MIMO-based wireless system results in an increase in channel capacity of DF based MIMO cooperative communication. Further, we can improve our diversity by applying an orthogonal space-time block code with MIMO technique and this will further improve the performance of SER because space-time block code provides diversity gain. OSTBC provides spatial diversity as well as cooperative diversity. For maximal ratio combining based system, we require the channel state information. We should know the complete channel matrix, i.e. we should know the channel link of source relay and source destination. This further increases the system complexity of the system. OSTBC based wireless transmission does not require the prior knowledge of channel state information and it also produces full diversity gain; hence it nullifies the disadvantage of beam forming based on MIMO cooperative scheme. However, in most of the system, Rayleigh fading channel is used. In paper [6], an analysis of the DF cooperative system is available over the Nakagami-m fading channel considering the channel estimation error. Further, in literature Survey, it has been given that SER performance is optimal in the cooperation scenario when the relay to destination link is weaker than the source to relay. When these links become equal, then we get an equal power allocation, which does not surely belong to the optimal power allocation. In order to overcome the disadvantages of Single Input Single Output based system, we have used the MIMO-STBC [7] based on selective decode-forward three node cooperation wireless networks over Nakagami-m fading including the channel estimation error effect.

II. THREE NODES COOPERATION MODEL

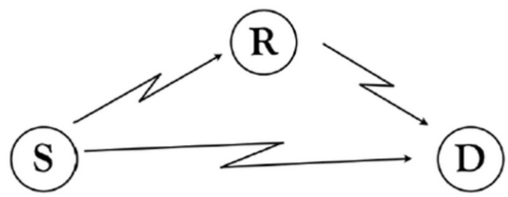

Figure 1: Three Nodes Two Phase Cooperation Model

With reference to the 3 nodes, 2 phase cooperation model, the DF cooperation scenario has two phases: In the first phase, the signal is received at all relays and destination from the source, and in the second phase, retransmission of the decoded signal to the destination is performed at relay only when it decodes correctly; otherwise, it will remain idle. System equations are given as:

$$Y_{SD}(1) = \sqrt{P_s} h_{SD}(1) X + \sqrt{(\delta P_S + N_0)} \eta_{SD}(1) \qquad (1)$$

$$Y_{SD}(2) = \sqrt{P_s} h_{SD}(2) X + \sqrt{(\delta P_S + N_0)} \eta_{SD}(2) \quad (2)$$

$$Y_{SR}(1) = \sqrt{P_s} h_{SR}(1) X + \sqrt{(\delta P_S + N_0)} \eta_{SR}(1) \quad (3)$$

$$Y_{SR}(2) = \sqrt{P_s} h_{SR}(2) X + \sqrt{(\delta P_S + N_0)} \eta_{SR}(2) \quad (4)$$

$$Y_{RD}(1) = \sqrt{P_R} h_{RD}(1) X + \sqrt{(\delta P_R + N_0)} \eta_{RD}(1) \quad (5)$$

$$Y_{RD}(2) = \sqrt{P_R} h_{RD}(2) X + \sqrt{(\delta P_R + N_0)} \eta_{RD}(2) \quad (6)$$

Here, Y_{SD}, Y_{SR} and Y_{RD} are the signal transmitted from the source to destination, from the source to relay and from the relay to destination respectively. Here, δ is the channel estimation error. Here, we have considered the Nakagami-m fading channel and the PDF is given as:

$$f(x, m, \Omega) = \frac{2m^m x^{2m-1}}{\Omega^m \lceil m} \exp(-\frac{mx^2}{\Omega}) \quad (7)$$

Here m is shaping the parameter of the Nakagami-m fading probability distribution and Ω=E[|x|[2]] is the channel variance, and m varies from 0.50 to infinity. The distribution of instantaneous SNR is Gamma distributed and is given as:

$$P_\gamma^\gamma = \frac{m^m \gamma^{m-1}}{\overline{\gamma}^m \lceil m} \exp(-\frac{m\gamma}{\overline{\gamma}}) \qquad \gamma \geq 0 \quad (8)$$

$$\overline{\gamma} = \frac{\Omega E_S}{N_0} \quad (9)$$

III. SER Analysis over Nakagami-m fading channel

SNR (instantaneous) of the Maximal Ratio Combining is:

$$\gamma_{MRC}^D = \sum_{l=1}^{l=2} \frac{P_S |h_{SD}(l)|^2}{(\delta P_S + N_0)} + \sum_{l=1}^{l=2} \frac{P_R |h_{RD}(l)|^2}{(\delta P_R + N_0)} \quad (10)$$

As we have taken MIMO-STBC DF system, hence the Power Ps is one half as in the case of Alamouti scheme. Therefore, the instantaneous SNR is given as:

$$\gamma_{MRC}^D = \sum_{l=1}^{l=2} \frac{P_S |h_{SD}(l)|^2}{2(\delta P_S + N_0)} + \sum_{l=1}^{l=2} \frac{P_R |h_{RD}(l)|^2}{2(\delta P_R + N_0)} \quad (11)$$

The SER (conditional) is given in equation below:

$$P_{E,PSK}(E/\gamma^D) = \frac{1}{\Pi} \int_0^{\frac{(M-1)\Pi}{M}} \exp(-(\sum_{l=1}^{l=2} \frac{P_S |h_{SD}(l)|^2}{2(\delta P_S + N_0)} + \sum_{l=1}^{l=2} \frac{P_R |h_{RD}(l)|^2}{2(\delta P_R + N_0)}) \frac{b_{PSK}}{\sin^2 \theta}) d\theta \quad (12)$$

Here:

$$b_{PSK} = \sin^2(\Pi / M) \quad (13)$$

The SER (conditional) for Decode and forward Cooperation can be formulated in the Equation (14):

$$\begin{aligned} &P_{E,PSK}(E/\gamma^D, \gamma_{SR}) \\ &= P_{E,PSK}(E/\gamma^D) \big| P_R = 0 * P_{E,PSK}(E/\gamma_{SR}) \\ &+ P_{E,PSK}(E/\gamma^D) \big| P_R = P_R * (1 - P_{E,PSK}(E/\gamma_{SR}) \end{aligned} \quad (14)$$

Here, $\gamma_{SR} = \sum_{l=1}^{l=2} \frac{P_S |h_{SR}(l)|^2}{2(\delta P_S + N_0)}$ is the instantaneous signal to noise ratio at relay node. In Equation (14), the first term indicates the SER is at the destination, considering the incorrect decoding at the relay and the second term indicates the conditional SER when the relay decodes correctly. The average SER is given as:

$$P_{E,PSK}(E) = \int_0^\infty P_{E,PSK}(E/\gamma) f_y(\gamma) d\gamma \quad (15)$$

The average probability over the Nakagami-m fading channel is given as:

$$P_{E,PSK}(E) = \left(1/\Pi\right) * \int_0^{\frac{(M-1)\Pi}{M}} (1 + \frac{b_{PSK} m^{-1} \overline{\gamma}}{\sin^2 \theta}) d\theta \quad (16)$$

The expected SER is given as:

$$P_{PSK} = E[P_{E,PSK}(E/\gamma^D, \gamma_{SR})] \quad (17)$$

$$\begin{aligned} P_{E,PSK} = {} & F_1(1 + \frac{b_{PSK} P_S \Omega_{SD} m_{SD}^{-1}}{2\sin^2 \theta (\delta P_S + N_0)})^{-2m_{SD}} \\ & * F_1(1 + \frac{b_{PSK} P_S \Omega_{SR} m_{SR}^{-1}}{2\sin^2 \theta (\delta P_S + N_0)})^{-2m_{SR}} \\ & + F_1((1 + \frac{b_{PSK} P_S \Omega_{SD} m_{SD}^{-1}}{2\sin^2 \theta (\delta P_S + N_0)})^{-2m_{SD}} \\ & * (1 + \frac{b_{PSK} P_R \Omega_{RD} m_{RD}^{-1}}{2\sin^2 \theta (\delta P_R + N_0)})^{-2m_{RD}})) \end{aligned} \quad (18)$$

Here:

$$F_1(x(\tau)) = \frac{1}{\Pi} \int_0^{\frac{(M-1)\Pi}{M}} x(\tau) d\tau \quad (19)$$

Upper bound symbol error rate is given in the equation below:

$$\begin{aligned} &P_{PSK,UPPER} \leq \\ &\frac{(M-1)^2}{M^2} (1 + \frac{b_{PSK} P_S \Omega_{SD} m_{SD}^{-1}}{2(\delta P_S + N_0)})^{-2m_{SD}}) * (1 + \frac{b_{PSK} P_S \Omega_{SR} m_{SR}^{-1}}{2(\delta P_S + N_0)})^{-2m_{SR}} \\ &+ (\frac{M-1}{M})(1 + \frac{b_{PSK} P_S \Omega_{SD} m_{SD}^{-1}}{2(\delta P_S + N_0)})^{-2m_{SD}} * (1 + \frac{b_{PSK} P_R \Omega_{RD} m_{RD}^{-1}}{2(\delta P_R + N_0)})^{-2m_{RD}}) \end{aligned} \quad (20)$$

Taking high signal noise ratio approximation, the asymptotic expression is given in the equation below:

$$\begin{aligned} P_{E,PSK} \quad & \left(\frac{2(N_0 + \delta P_S) m_{SD}}{P_S \Omega_{SD} b_{PSK}} \right)^{2m_{SD}} \left(\frac{2(N_0 + \delta P_S) m_{SR}}{P_S \Omega_{SR} b_{PSK}} \right)^{2m_{SR}} A_{SD} A_{SR} \\ & + \left(\frac{2(N_0 + \delta P_S) m_{SD}}{P_S \Omega_{SD} b_{PSK}} \right)^{2m_{SD}} \left(\frac{2(N_0 + \delta P_S) m_{RD}}{P_S \Omega_{RD} b_{PSK}} \right)^{2m_{RD}} A_{SD-RD} \end{aligned} \quad (21)$$

$$A_{SD} = \left(\tfrac{1}{\Pi}\right) \int_0^{(M-1)\Pi/M} \sin^{4m_{SD}} \theta d\theta$$
$$A_{SD-RD} = \left(\tfrac{1}{\Pi}\right) \int_0^{(M-1)\Pi/M} \sin^{4(m_{SD}+m_{RD})} \theta d\theta \quad (22)$$

IV. SER Analysis In Correlated Nakagami-m Fading Channel

The channel coefficient between source-relay and relay-destination link correlates with each other. Let ρ be the channel correlation coefficient and the case, $m_{SD}=m_{RD}=m_{C.}$ MGF (Moment Generating Function) is:

$$M(S;\gamma_{SD},\gamma_{RD};m_C;\rho) = (1 - \frac{(\gamma_{SD}+\gamma_{RD})}{2m_C}S + \frac{(1-\rho)\gamma_{SD}\gamma_{RD}}{4m_C{}^2}S^2)^{-2m_C} \quad (23)$$

The average symbol error rate over Nakagami-m fading channel is given in Equation (24). Asymptotic expression over the correlated case is given in Equation (25).

$$\begin{aligned} P^C_{E,PSK} &= F_{PSK}((1+\frac{P_S\Omega_{SD}b_{PSK}}{2(N_0+\delta P_S)m_C\sin^2(\theta)})^{-2m_C}) \\ &* F_{PSK}((1+\frac{P_S\Omega_{SD}b_{PSK}}{2(N_0+\delta P_S)m_C\sin^2(\theta)})^{-2m_C}) \\ &+ F_{PSK}((1+\frac{(P_S\Omega_{SD}+P_R\Omega_{RD})b_{PSK}}{2(N_0+\delta P_S)m_C\sin^2(\theta)} + \frac{(1-\rho)P_SP_R\Omega_{SD}\Omega_{RD}b^2{}_{PSK}}{4(N_0+\delta P_S)^2m_C^2\sin^4(\theta)})^{-2m_C}) \\ &* (1-F_{PSK}((1+\frac{P_S\Omega_{SR}b_{PSK}}{2(N_0+\delta P_S)m_{SR}\sin^2(\theta)})^{-2m_{SR}}) \end{aligned} \quad (24)$$

$$\begin{aligned} P^C{}_{E,PSK} & \left(\frac{2(N_0+\delta P_S)m_C}{P_S\Omega_{SD}b_{PSK}}\right)^{2m_C}\left(\frac{2(N_0+\delta P_S)m_{SR}}{P_1\Omega_{SR}b_{PSK}}\right)^{2m_{SR}} A_C A_{SR} \\ & +(\frac{4(N_0+\delta P_S)m_C^2\sin^4\theta}{(1-\rho)P_SP_R\Omega_{SD}\Omega_{RD}b^2{}_{PSK}})^{2m_C} A_{2C} \end{aligned} \quad (25)$$

$$\begin{aligned} A_C &= \left(\tfrac{1}{\Pi}\right)\int_0^{(M-1)\Pi/M} \sin^{4m_C}\theta d\theta, \\ A_{SR} &= \left(\tfrac{1}{\Pi}\right)\int_0^{(M-1)\Pi/M} \sin^{4m_{SR}}\theta d\theta, \\ A_{2C} &= \left(\tfrac{1}{\Pi}\right)\int_0^{(M-1)\Pi/M} \sin^{8m_C}\theta d\theta \end{aligned} \quad (26)$$

V. Optimal Power Allocation Over Uncorrelated and Correlated Nakagami-m Fading Channel

If the channel state information is not available at the transmitting side, then we get an equal power allocation case, but it will surely not optimal. Further, we have used MIMO-STBC based system; hence, there is no need of channel state information. When the difference between the channel coefficients is larger than the equal power allocation, it is definitely not the best option. In this section, the optimal power allocation case, and the equal power allocation case are analyzed. We only need partial channel state information for an optimal power allocation case. The power constraint is given as:

$$P_S + P_R = P; 0 < P_S < P \quad (27)$$

The close form of expression of the asymptotic symbol error rate for uncorrelated case can be written as:

$$P_{E,PSK}(P_S) \quad \frac{C_1}{P_S^{2(m_{SD}+m_{SR})}} + \frac{C_2}{P_S^{2m_{SD}}(P-P_S)^{2m_{RD}}} \quad (28)$$

For correlated case, it can be written as:

$$P^C{}_{E,PSK}(P_S) \quad \frac{C_1}{P_S^{2(m_{SD}+m_{SR})}} + \frac{C_2}{P_S^{m_{SD}}(P-P_S)^{2m_{RD}}} \quad (29)$$

Here, C_1, C_2, C_3 and C_4 contain the essential remaining terms and $C_1 \geq 0$, $C_2 \geq 0$, $C_3 \geq 0$ and $C_4 \geq 0$. At this condition, we find the second derivative and it turns to be positive. We have applied the convex optimization [8-9] for solving this optimal power allocation scenario.

VI. Simulation Result

Simulations were performed to confirm the accuracy of the theoretical results for MIMO-STBC selective decode-forward based on cooperative wireless network. Here, we used Nakagami-m fading channel considering the effect of channel estimation error, and we presume that the relay can confirm the correctness of the decoding result. To analyze the rightness of the analysis for M-PSK signals, we applied M=4 to look into the M-PSK signal results.

A. SER Performance Of MIMO-STBC Selective DF Cooperative Wireless Communication System Over Nakagami-m Fading Channel Considering the Effect of a Channel Estimation Error

In this section, initially we check the performance of MIMO–STBC selective DF cooperative wireless communication network over Nakagami-m fading channel, considering the effect of channel estimation error. In this section, we tally the cooperative wireless system performance over correlated Nakagami-m fading channel considering the effect of channel estimation error. Figure 2 presents the symbol error rate for PSK signals for various values of Signal to Noise Ratio in dB.

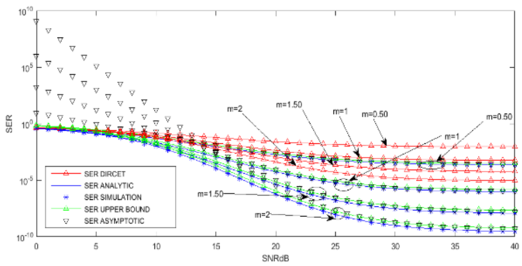

Figure 2: SER performance of MIMO-STBC selective DF over Nakagami-m fading channels, $m_{sd} = m_{sr} = m_{rd} = m$, $\Omega_{sd} = \Omega_{sr} = \Omega_{rd} = 1$ for 4PSK with channel estimation error δ=0.001.

In Figure 2, we fixed $m_{SD} = m_{SR} = m_{RD} = m$, $\Omega_{SD} = \Omega_{SR} = \Omega_{RD} = 1$ and δ=0.001. We have taken direct communication between the source to destination also i.e. no cooperation. We can easily show from our results of the analytic SER matches with simulated SER. In addition, the SER tight approximation is asymptotically tight at high SNR values. This indicates the rightness of our theoretical results given in the equations (18, 20, 21). We can show that from the medium to high value of Signal to noise ratio, the Decode and Forward cooperation improves the Symbol Error Performance, as compared to direct communication i.e. no cooperation. We have simulated various values of m and from the simulation results, we can easily show that increasing the values of m improves the Symbol Error Rate performance. In Figure 3, we have fixed m_{SR} = m_{RD} = m, m_{SD} = Ω_{SD} = 1 for distinct Ω_{RD} and Ω_{SR} for 4PSK signal considering estimation error δ=0.010. With dissimilar Ω_{SR} and Ω_{RD}, it can be seen that instead of increasing Ω_{SR} and Ω_{RD} , increasing the value of m is more significant, leading to symbol error rate improvement. Also, the relay with Ω_{SR} =1 and Ω_{RD} = 10 gives rise to a little Symbol Error Rate performance of cooperative wireless communication network than when Ω_{SR} =10 and Ω_{RD} =1. It signifies that a large Ω_{sr} is less significant than a large Ω_{RD} for Cooperation wireless network Symbol Error Rate performance.

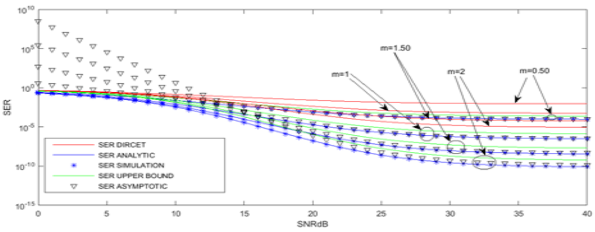

Figure 3: SER performance of MIMO-STBC selective DF over Nakagami-m fading channels m_{sd} = Ω_{sd} = 1 and m_{sr} = m_{rd} = m for different Ω_{sr} and Ω_{rd} for 4PSK signal considering estimation error δ=0.001.

In Figure 4, we fixed m_{SD} = m_{SR} = m_{RD} = 0.50, Ω_{SD} = Ω_{SR} = Ω_{RD} = 1 and δ=0.001,0.020 for 4PSK signal, considering estimation error. From the results, we can see that Upper Bound expression of Symbol Error Rate is asymptotically parallel with the Exact Analytic SER expression, which signifies that they have the same DO (Diversity Order). Symbol Error rate performance degrades with an increase in value of the channel estimation Error δ. For improvement in Symbol Error Rate, increasing the value of Ω_{SR} or Ω_{RD} is less important as compared to increasing the value of m. Increasing Ω_{SR} is less important as compared to increasing Ω_{RD}.

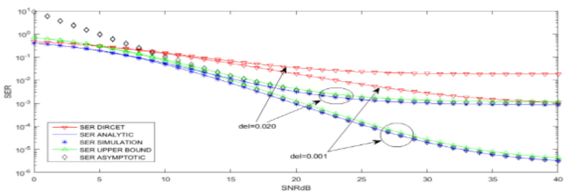

Figure 4: SER performance of MIMO-STBC selective DF over Nakagami-m fading m_{SD} = m_{SR} = m_{RD} = 0.50, Ω_{SD} = Ω_{SR} = Ω_{RD} = 1 and δ=0.001,0.020 for 4PSK signal considering estimation error. δ=0.001,0.020

In Figure 5, we fixed Ω_{SD} = Ω_{SR} = Ω_{RD} = 1,m_{SD} = 1 with dissimilar m_{RD} and m_{SR} for 4PSK signal, considering the effect of estimation error. By changing m_{SR} and m_{RD}, we can view the improvement in SER performace with inceasing m_{SR} or m_{RD}. Also increasing m_{SR} for SER improvement is least significant than increasing m_{RD}.

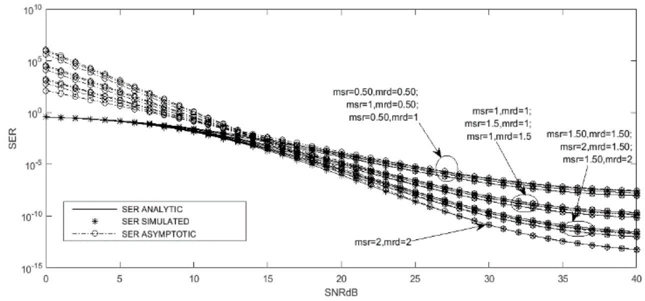

Figure 5: SER performance of MIMO – STBC selective DF cooperation over Nakagami-m fading channels m_{sd} = 0.1, Ω_{sd} = Ω_{sr} = Ω_{rd} = 1 with different m_{sr} and m_{rd} and modulation is 4PSK.

B. SER performance of MIMO-STBC selective DF Cooperative Wireless Communication system over Correlated Nakagami-m Fading Channel considering the effect of Channel Estimation Error

In Figure 6, we have fixed δ=0.001, Ω_{SD} = Ω_{SR} = Ω_{RD} = 1 and m_{SD} = m_{SR} = m_{RD} = m_c and ρ = (0.90,0) for 4PSK signals over correlated Nakagami-m fading channel. Again in case of correlated case, the theoretical results are the same as the simulation results. As the correlation between the source destination and relay destination increases, the SER performance decreases. We can observe that as the value of m increases, performance debasement becomes more illustrious. However, with ρ = 0.90, the SER performance improvement for the DF cooperation is even visible when likened with the SER performance of no cooperation. Thus, cooperation is working, and there is no issue whether a similarity exists between the relay to the destination and the source to destination channel coefficients.

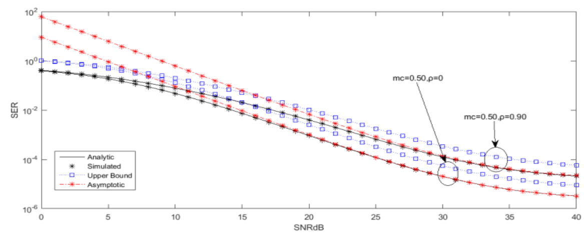

Figure 6: SER performance of MIMO-STBC selective DF over Nakagami-m fading channel with consideration channel estimation m_{sd} = m_{sr} = m_{rd} = 0.50, Ω_{sd} = Ω_{sr} = Ω_{rd} = 1 and error δ=0.001,0.020 for 4PSK signal considering estimation error.

In Figure 7, we set Ω_{SD} = 1 and m_{SD} = m_{SR} =1 for curves with different Ω_{SR} and Ω_{RD}. We also get the same results from the simulations, and we can easily verify the theoretical results. Similarly, Figure 8 represents the Symbol Error Rate for 4PSK signals for various combinations of m, h_{SD} and h_{RD}.

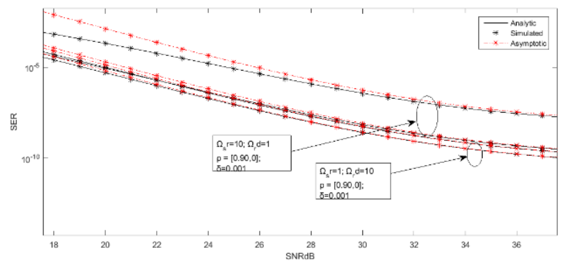

Figure 7: SER performance of MIMO – STBC selective DF cooperation over correlated Nakagami-m fading channels (for curve with different Ω_{sr} and Ω_{rd}, m_{sd} = m_{sr} = 1and Ω_{sd} = 1; for curve with different Ω_{sr} and Ω_{rd}, m_{sd} = m_{sr} = 1and Ω_{sd} = 1) for 4PSK signals.

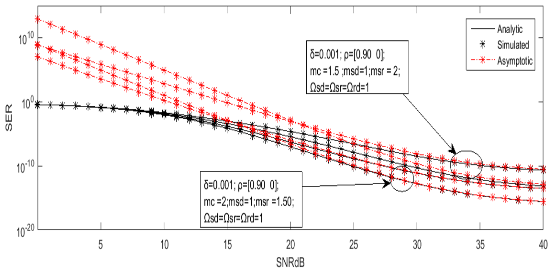

Figure 8: SER performance of MIMO – STBC selective DF cooperation over correlated Nakagami-m fading channels (for curve with different $\Omega_{SD} = \Omega_{SR} = 1$, mc = 1.50 and $\Omega_{RD}=1$, $m_{sd} = 1$, $m_{sr}=2$; and for curve with different $\Omega_{SD} = \Omega_{sr} = 1$ and $\Omega_{rd} = 1$, mc = 2, $m_{sd} = 1.50$, $m_{sr} = 1.50$) for 4PSK signals.

C. SER Performance at Optimal Power Allocation

Lastly, the projected optimal power allocation strategy results for the DF cooperation over the correlated and uncorrelated Nakagami-m fading channels with the effect of channel estimation error have been proved in Figure 9 and 10. In Figure 9, considering 4PSK signals with estimation error consideration, we have fixed $\Omega_{SD} = \Omega_{SR} = 1$, δ=0.010, m_{SD}=m, $m_{SR} = m_{RD}$ =m, , Ω_{RD} =10. In Fig. 10 we have fixed ρ = 0.70 , $\Omega_{SD} = \Omega_{SR}$ =1, $m_{SD} = m_c$ =m, δ=0.010, Ω_{RD} =10 for 4PSK signals with estimation error. It can be seen from the two figures that an optimum power case does not result in good SER performance when m is low. As the value of m increases, the optimal power allocation results in better SER performance. Uncorrelated channel gives a better SER performance as compared to the correlated case in the case of optimal power allocation case.

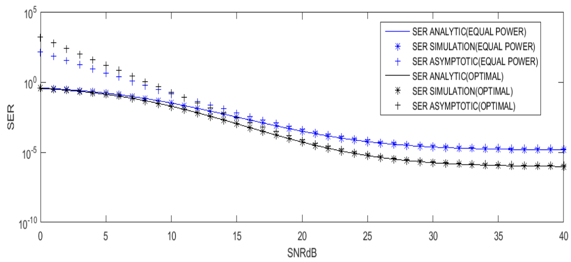

Figure 9: SER performance of MIMO – STBC selective DF cooperation over correlated Nakagami-m fading channels (for curve with different Ωsr and Ωrd, msd = msr = 1 and Ωsd = 1; for curve with different Ωsr and Ωrd, msd = msr =1 and Ωsd = 1) for 4PSK signals.

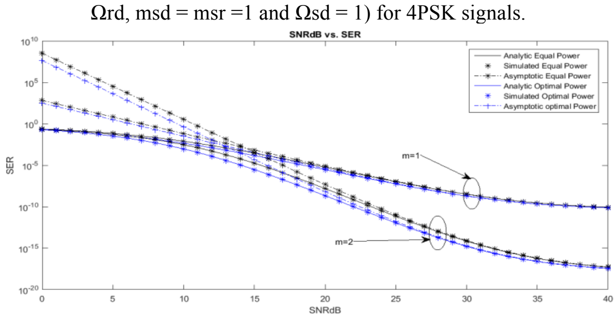

Figure 10: SER performance of MIMO–STBC selective DF cooperation over correlated Nakagami-m fading channels, ρ = 0.70, $m_{SD} = m_c$ = m, $\Omega_{SD} = \Omega_{SR} = 1$, Ω_{RD} =10, δ=0.010 for 4PSK signals with estimation error

In Table 1, it can be seen that the difference between P_S/P and P_R/P becomes high in most of the scenarios when the conflict between m_{RD} and m_{SR} increases. We can say that more power will be allotted to the source. The Symbol Error Rate diminution with the optimum power allocation is to a greater extent suitable for Nakagami-m shape parameter, m and for $\Omega_{SD} = \Omega_{SR}$ and Ω_{RD}. In Table 2, we have given the optimal power allocation with different values of m_c and Ω_{RD} for correlated channel conditions. We can see from Table 2 that SER reduces when the correlation factor increases.

Table 1
Optimum power allocation considering different m_{RD} and m_{SR} for $\Omega_{SD} = \Omega_{SR} = \Omega_{RD} = 1$, m_{SD}=1

m_{SD}	m_{SR}	m_{RD}	P_S/P	P_R/P
1	0.50	0.50	0.7215	0.2785
1	0.50	1	0.50795	0.49205
1	1	1	0.5910	0.4090
2	2	2	0.5505	0.4500
2	2	1.50	0.73021	0.2697
2	2	1	0.89932	0.1000
2	1.50	1.50	0.6096	0.3904

Table 2
Optimal power allocation with different values of m_c and Ω_{RD} for correlated channel conditions

m_C	Ω_{RD}	ρ=0 P_S/P	ρ=0 P_R/P	ρ=0.70 P_S/P	ρ=0.70 P_R/P	ρ=0.90 P_S/P	ρ=0.90 P_R/P
	1	0.59	0.41	0.51	0.49	0.50	0.50
1	10	0.83	0.17	0.71	0.29	0.59	0.41
	100	0.96	0.04	0.91	0.09	0.83	0.17
	1	0.57	0.43	0.51	0.49	0.50	0.50
1.5	10	0.85	0.15	0.71	0.29	0.57	0.43
	100	0.97	0.03	0.93	0.07	0.85	0.15
	1	0.56	0.44	0.50	0.50	0.50	0.50
2	10	0.86	0.14	0.72	0.28	0.56	0.44
	100	0.97	0.03	0.94	0.06	0.86	0.14

VII. CONCLUSION

Cooperative communication acts as a virtual MIMO wireless system, as diversity can be attained with the help of another node or user terminals called the relay node. In this paper, we have considered MIMO-STBC selective Decode and Forward cooperation wireless communication network over Nakagami-m fading channels, considering channel estimation error. The symbol error rate (SER) performance analysis has been for various decode-forward cooperation. Specifically, we found that m is an important parameter and we found that the system should have the largest possible value of m. We also examine that Ω_{RD} is more important than Ω_{SR}. We can show that the equal power allocation case outperformed by the optimal power allocation when the value of the shape parameter has high value. We can also see that with an increase in channel estimation error, SER performance is degraded. As we increase the value of m, SER performance improves. It is to be noted that increasing the value of ρ causes a degradation in SER performance.

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