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# Review on Optimized Schemes For Wireless Communication Using NOMA

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***Abstract*— In this paper a brief survey is carried out on NOMA for wireless schemes, where in Buffer aided Non-orthogonal multiple access relaying system in Rayleigh fading channel is discussed on context of outage probability reduction and increasing transmission rate. NOMA for multiple antenna relaying networks briefs about usage in cellular communication adopting transmit antenna selection at base station and maximal ratio combining (MRC) a mobile users. NOMA in coordinated Direct and relay transmission focuses on performance gain.**

***Index Terms*— Non-Orthogonal multiple access, outage probability, multiple antenna relaying networks, coordinated direct and relay transmission.**

## I. INTRODUCTION

Orthogonal Multiple Access OMA [1]-[10] is a technique where signals are orthogonal from a source which carries differing signals to multiple destinations where spectrum utilization is not effective. In Buffer aided Non Orthogonal Multiple Access (NOMA) relaying system [11] facilitates the users to share all communication resources such as time, frequency and code by transmitting superposition of multiple signals to multiple receivers to achieve higher transmission rates than OMA. By enabling the usage of buffer aided relaying system the throughput of system can be enhanced even in the presence of outages. NOMA for multiple relaying networks [12] without buffers is facilitated using multiple antenna source node transmitting information to multiple access point through relay where relay is limited to single antenna. Outage performance depends on relay i.e. when relay location is close to base station performance of NOMA is greater than OMA. When relay location is close to mobile users conventional OMA achieves better performances NOMA in Coordinated and the Direct Relay Transmission [13] (CDRT), here interference cancellation is achieved by receiver which obtains side information such as other UE's data. Performance gain is better in CDRT than nCDRT.

## II. METHODOLOGY

### *A. Buffer –Aided Noma Relaying Systems In Rayleigh Fading Channel*

The network operates in the time-division duplex (TDD) mode where time duration is partitioned into slots

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with equal length of T.The channels are assumed to be flat Rayleigh block fading channels which remain constant during one time slot and change randomly from one time slot to another.

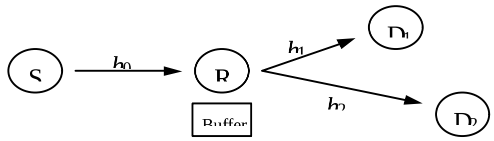



Fig.1. System Model Of A Buffer Aided NOMA Relaying System.S-Source,R-Relay,D1,D2-Two Destinations[11]

*Outage Probabilities when relay knows Channel State Information [CSI].*

The outage probability of source-to-relay link is

$$P_{0=}1\text{-exp }(-(2^{2r0}-1)/\beta|{h_0}^2|) \quad (1)$$

where, Ps is transmit power, $r_0$ is target transmission rate from relay to each destination ($r_0$>0), $h_0$ is channel response from source to destination.

The relay transmits superimposed information symbols in a time slot given by

$$x = \sqrt{x_1}\alpha + \sqrt{(1-\propto x_2)} \quad (2)$$

Where $x_1$ and $x_2$ are information symbols of destination 1 and destination 2 respectively. $\propto$is power allocation coefficient. The received signal at destination is

$$y_i = h_i\sqrt{\propto}\, p_r x_1 + h_i\sqrt{1-\propto p_r x_2} + n_i, \quad (3)$$

Where $p_r$ is transmit power of relay,$n_i$ is additive Gaussian noise at destination .Applying Signal to interference Cancellation[SIC] destination 1 is able to remove the detected information symbol $x_2$ from its received signal.

The probability that |h1|≥|h2| and outage will not occur is

$$P_1 = \frac{1}{\Omega 1}\exp\left(-\frac{\zeta\Omega 1 + b\zeta\Omega 2}{\Omega_1\Omega_2}\right)\int_{\zeta}^{\infty}\exp\left(-\frac{x}{\Omega_1}-\frac{b\zeta^2}{\Omega_2 x}\right)dx - \frac{\Omega_2}{\Omega_1+\Omega_2}\exp\left(-\frac{\zeta(\Omega_1+\Omega_2)(b+1)}{\Omega_1\Omega_2}\right) \quad (4)$$

The probability that $|h_2| \geq |h_1|$ and outage will not occur is

$$p_2 = \frac{1}{\Omega 1}\exp\left(-\frac{\zeta\Omega 2 + b\zeta\Omega 1}{\Omega_1\Omega_2}\right)\int_{\zeta}^{\infty}\exp\left(-\frac{x}{\Omega_2}-\frac{b\zeta^2}{\Omega_1 x}\right)d - \frac{\Omega_1}{\Omega_1+\Omega_2}\exp\left(-\frac{\zeta(\Omega_1+\Omega_2)(b+1)}{\Omega_1\Omega_2}\right) \quad (5)$$

The outage probability of relay-to-destinations links is

$$p_3 = 1 - p_1 - p_2 \quad (6)$$

*Outage probability of links when the relay doesn't know $h_1$ and $h_2$*

The probability that $|h_1| \geq |h_2|$ and outage will not occur is

$$\overline{p}_1 = \exp\left(-\frac{\zeta}{(1-b\alpha)\Omega_2}-\frac{\zeta}{\alpha\Omega_1}\right) - \frac{\Omega_1}{\Omega_1+\Omega_2}\exp\left(-\frac{\zeta\Omega_1+\zeta\Omega_2}{\alpha\Omega_1\Omega_2}\right) \quad (7)$$

The probability that $|h_2| \geq |h_1|$ and outage will not occur is

$$\overline{p}_2 = \exp\left(-\frac{\zeta}{(1-b\alpha)\Omega_1}-\frac{\zeta}{\alpha\Omega_2}\right) - \frac{\Omega_1}{\Omega_1+\Omega_2}\exp\left(-\frac{\zeta\Omega_1+\zeta\Omega_2}{\alpha\Omega_1\Omega_2}\right) \quad (8)$$

TABLE 1.RELAY DECISION SCHEME

| Case | SR | RD | L | Decision | Probability |
|---|---|---|---|---|---|
| Case1 | Out | Out | | S | $P_{SR}P_{RD}$ |
| Case2 | Out | | $l = 0$ | S | $P_{SR}$ |
| Case3 | | Out | | S | $P_{RD}$ |
| Case4 | Suc | Out | $l = 0$ | R | $P_{SR}P_{RD}$ |
| Case5 | Out | Suc | $l < L$ | T | $P_{SR}P_{RD}$ |
| Case6 | Suc | Suc | $l \geq 2$ | T | $P_{SR}P_{RD}$ |
| Case7 | Suc | Suc | $l \leq l$ | R | $P_{SR}P_{RD}$ |

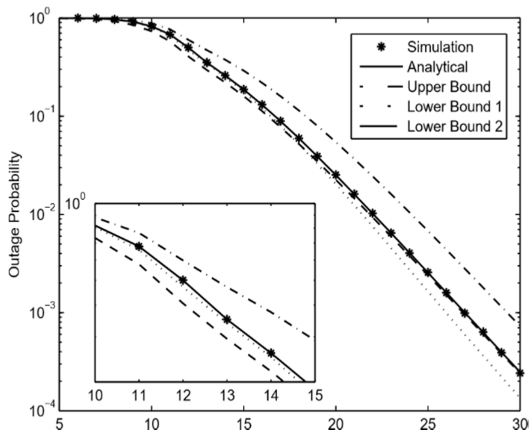
In TABLE 1 the relay decision scheme proves how to reduce average packet delay and improve reliability of the system, where SR denotes source to relay link, Relay to destination link-RD, OUT denotes occurrence of outage, SUC denotes outage does not occur, R-Relay receives a packet, T-Relay transmits 2 packets simultaneously-relay neither transmits nor receives, $P_{SR}$-outage probability of source to relay link, $P_{RD}$ -outage probability of relay to destination link. $P_{SR}=p_0$.when relay knows channel responses, $P_{RD}=p_3$and $P_{RD}=\bar{p}_3$.Case 6 and case 7 leads to tradeoff between outage probability minimization and average packet delay minimization.

Diversity order of Buffer aided NOMA is same as given below whether relay knows or doesn't know the channel responses.

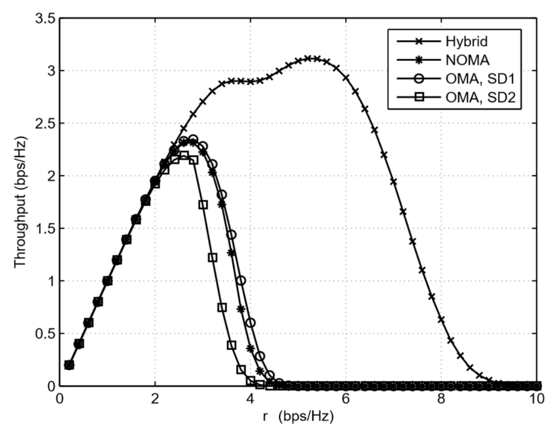
TABLE 2. DIVERSITY ORDER OF NOMA

| L-Storage units having stored information | Diversity order |
|---|---|
| L=2 | 1 |
| L≥3 | 2 |

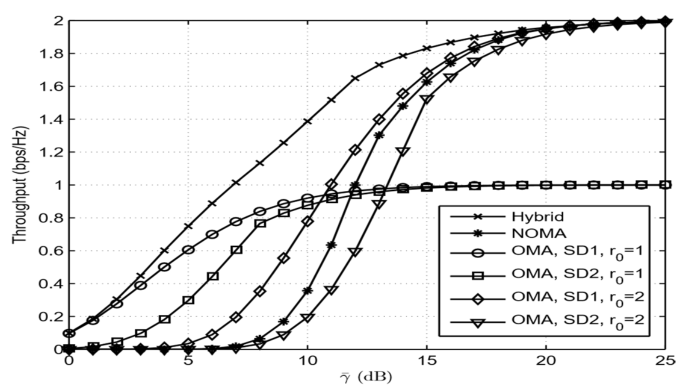
*Performance of proposed relay decision scheme whether elayknows$h_1$ and $h_2$:* Fig.2, infers that at low SNR "lower bound1" is closer to analytical and simulation result whereas at high SNR "lower bound 2" is closer. Fig .3,infers that highest throughput obtained by hybrid NOMA and OMA relying system is about 3.1 bps/Hz. Whereas that obtained by conventional OMA is lower than 2.4 bps/Hz.




Signal To Noise Ratio [SNR] Fig.2.Outage Probability Versus SNR [11]




Target Transmission Rate
Fig.3.Throughput Versus Target Transmission Rate [11]




Snrfig. 4. Throughput Versus SNR, $\bar{\Gamma}$;

In Fig.4. Target transmission rates for source to destination, $r_0$, of 1 bps/Hz and 2 bps/Hz are considered for the OMA relaying system. For hybrid NOMA and OMA relaying system, we mean that the relaying system is able to switch between NOMA and OMA relaying modes, i.e., if one of the destinations in our proposed NOMA relaying system is able to detect its corresponding information symbols and the other is not, the relaying system switches to the OMA relaying mode. From Fig. 9, it is observed that the hybrid NOMA and OMA relaying system outperforms any OMA relaying system.

*B. Non-Orthogonal Multiple Acess for multiple antenna relaying networks*

Consider a base station S which transmit information to M mobile users through the AF relay R. $N_S$and $N_D$ are the number of antennas at S and M. At first S selects single antenna from $N_S$ antennas and transmit $x_S$ to R. The transmit antennas which maximizes instantaneous signal to noise ratio at the base station is selected for transmission at the relay where excess is the coded modulation symbol of M users and is expressed as

$$x_S=\sum_{i=1}^{M}\sqrt{a_i P_S}\,x_i \quad (9)$$

where$a_i$ is power allocation coefficient of $i^{th}$ user $\sum_{i=1}^{M} a_i=1$.

The received signal at R is given by

$$y_R=h_{SR}^{\max}\sum_{i=1}^{M}\sqrt{a_i P_S}\,X_i+n_R \quad (10)$$

Secondly $y_R$ is multiplied with an amplifying gain G and then R broadcast it. The received signal at user M is expressed as

$$y_{RD_m}=G h_{RDm}\, h_{SR}^{\max}\sum_{i=1}^{M}\sqrt{a_i}\,P_S X_i+G h_{RD_m} n_R+n_{D_m} \quad (11)$$

Signal to Interference Cancellation will be carried out at the user.
The diversity order of $m^{th}$user is $G_d$=min ($N_s$, $Mn_D$).
*Performance of multiple antenna relaying network.*The Fig.5. infers the system outage performance can be improved significantly by increasing number of antennas at base station and mobile users even if relay has single antenna. In Fig.6. the optimal relay location for the user with better channel condition should be nearer to S in order to achieve high SNR at R. since NOMA allocate less transmit power to the users. When $d_{SR}$≈0.5 the outage performance of NOMA and OMA are same, when $d_{SR}$«0.5, NOMA can achieve better outage performance than OMA because of multiple user diversity as outage performance depends on relay to destination link, when $d_{SR}$ »0.5 OMA outperforms NOMA as outage performance depends on source to relay link.

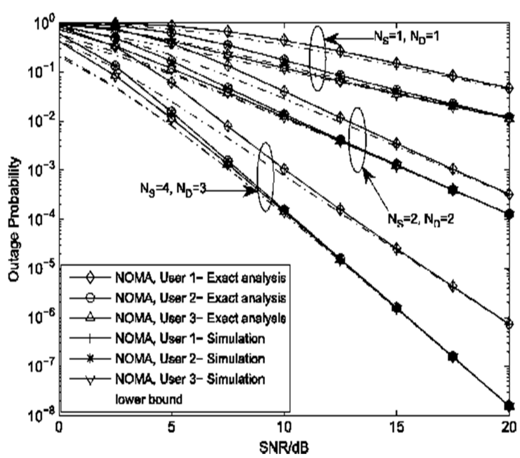



Fig.5.Outage probability vs SNR

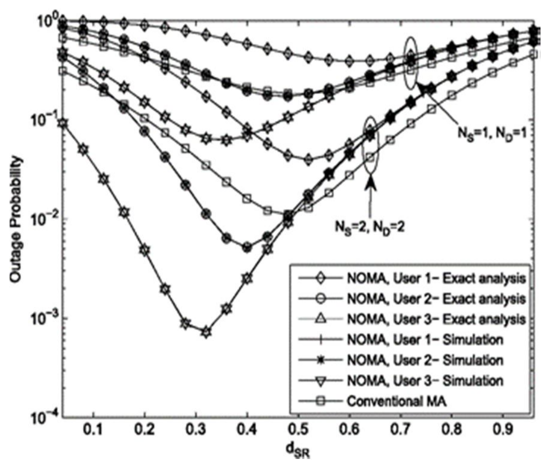



Fig.6.Outage probability vs $d_{SR}$
[Distance between S and R]

### *C. Non-orthogonal Multiple Access in Coordinated Direct and Relaying networks*

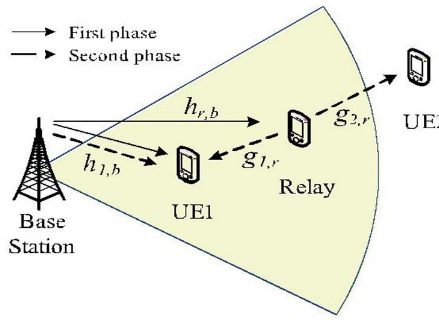



Fig. 7. System Model [13]

Consider a system model where user equipment 1 (UE1) directly communicates with base station while user equipment 2 (UE2) needs help of a relay.

In phase one the base station transmits

$$x_N(t_1)=\sqrt{P_b}\,a_1(t_1)x_1(t_1)+\sqrt{P_b}\,a_2(t_1)x_2(t_1) \quad (12)$$

Where $x_1(t_1)$ and $x_2(t1)$ are data symbols of UEI and UE2 and $a_1$ $(t_1)$ and$a_2$ $(t_1)$ are the power allocation coefficient. The received signals at UE1 and relay are given by

$$y_1(t_1)=h_{1,b}x_n(t_1)+n_1(t_1) \quad (13)$$

$$y_r(t_1)=h_{r,b}x_n(t_1)+n_r(t_1) \quad (14)$$

In second phase, the relay retransmits the decoded signal $x_2(t_1)$, simultaneously the base station transmits the new data symbol $x_1(t_2)$ UE1. The received signals at UE1 and UE2 are given by

$$y_1(t_2)=h_{1,b}\sqrt{p_b\,a_1(t_2)x_1(t_2)}+g_{1,r}\sqrt{p_r x_2(t_1)}+n_1(t_2) \quad (15)$$

$$y_2(t_2)=g_{2,r}\sqrt{p_r x_2(t_1)}+n_2(t_2) \quad (16)$$

UE1 can remove the interference signal in $y_1(t_2)$ using the side information $x_2(t_1)$. The achievable data rate of UE1 for the first phase is given by

$$c_1(t_1)=\frac{1}{2}\log_2(1+\gamma_1(t_1)) \quad (17)$$

The achievable data rate at UE2 is given by

$$c_2=\frac{1}{2}\log_2(1+\min(\gamma_{0,r},\gamma_2)). \quad (18)$$

NOMA in CDRT provides additional data rate compared to NOMA in nCDRT of

$$c1(t_1)=\frac{1}{2}\log_2(1+\gamma_1(t_2)) \quad (19)$$

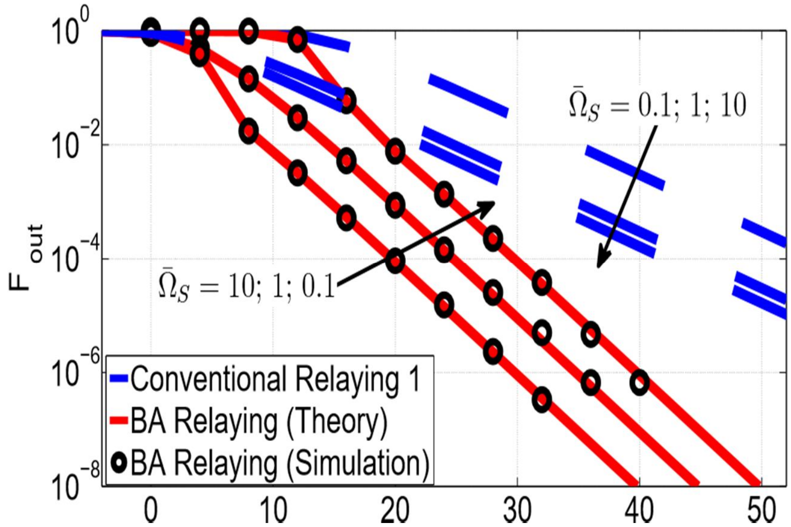
### *D.Buffer-Aided Relaying with Adaptive Link Selection — Fixed and Mixed Rate Transmission*

In this model, we consider the simple three-node relay network with a half-duplex decode-and-forward relay, which is equipped with a buffer, and assume that the direct source destination link is not available for transmission. We assume that both the source-relay and the relay-destination links are affected by fading.

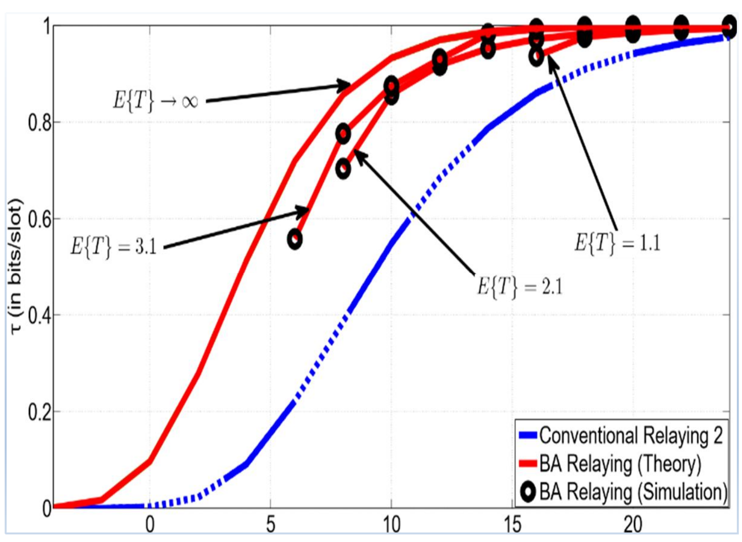

Fig 8.System Model For Three Node Relay Network Employing Half –Duplex

Depending on the availability of CSIT at the transmitting nodes (and their capability of using more than one modulation/coding scheme), we consider two different modes of transmission for the relay network: *Fixed rate transmission* and *mixed rate transmission*. In both modes of transmission, each code word spans one time slot . In fixed rate transmission, the node selected for transmission (source or relay) does not have CSIT and transmits with fixed rate. In contrast, in mixed rate transmission, the relay has CSIT knowledge and exploits it to transmit with variable rate so that outages are avoided. However, the source still transmits with fixed rate to avoid the need for CSIT acquisition.

*Performance of buffer-aided relay with adaptive selection.* Fig.9. infers for buffer-aided relaying with adaptive link selection, $F_{out}$ was obtained and confirmed by Monte Carlo simulations. For conventional relaying, $F_{out}$ was obtained. Buffer-aided relaying achieves a diversity gainoftwo, whereas conventional relaying achieves only a diversity gain of one,which underlines the superiority of buffer-aided relaying with adaptive link selection.




Transmit SNR Γ (In Db) Fig.9. Throughputs Of Buffer-Aided (BA) Relaying And Conventional Relaying 2 Vs




Transmit SNR [γ] (in dB) Fig.10. Outage probability of buffer-aided (BA) relaying and Conventional Relaying 1 vs. $\gamma$.

Fig.10 infersthe throughput for delay constrained transmission approaches the throughput for delay unconstrained transmission for sufficiently high SNR. Furthermore, the performance gain compared to Conventional Relaying 2 is substantial even for the comparatively small average delays $E\{T\}$.

II. COMPARISON TABLE.

| YEAR | TITLE | METHODOLOGY | ADVANTAGES | DISADVANTAGES | APPLICATIONS |
|---|---|---|---|---|---|
| 2017 | Buffer–Aided NOMA Relaying Systems | Outage probability and diversity order derived when relay knows CSI or not | Based on derived outage probability Relay operation is decided which increases the data rate and throughput. Compared to conventional OMA, Hybrid NOMA and OMA relaying a system out performs any OMA relying system. Achieves higher transmission rate. | If destination is not able to detect information symbols relaying system has to switch to OMA relaying mode. | Communication systems. |
| 2015 | Buffer-Aided Relaying with Adaptive Link Selection — Fixed and Mixed Rate Transmission | Link Adaptive Transmission Protocol | Protocols with adaptive link selection achieve large performance gains compared to conventional relaying. | Outages affect the achievable throughput negatively. | Communication systems. |
| 2015 | Non orthogonal multiple access for multiple antenna relaying networks | Adopts maximal ratio combining close to mobile user and antenna that maximizes SNR at relay is selected for transmission | Relay location has significant impact on outage performance. NOMA outperforms OMA when relay is close to base station and when close to mobile user OMA achieves better outage performance but NOMA can achieve better spectral efficiency and user fairness | Relay node is limited to single antenna device due to size and power constraint | Cellular communication systems or wireless sensors |

III. CONCLUSION

Using Buffer aided NOMA the throughput from relay to destination doubles compared to OMA, when channel conditions are good and diversity order of 2 can be achieved whether relay does or does not no channel state material. NOMA for multiple antenna relaying network focuses on outage probability of mobile users when relay location is close to the mobile user NOMA can outperform conventional OMA .When relay location close to mobile user conventional NOMA can achieve better outage performance .but NOMA can offer better spectral efficiency and user fairness. NOMA with CDRT can achieve higher spectral efficiency with low cost which is applicable to 5G networks. Buffer aided NOMA combined with CDRT can enhance throughput and spectral efficiency.

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