Volume 5, Issue 3
June 2016

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

Performance Analysis of WiMAX LDPC Based Cooperative Communication Using Oppertunistic Relay

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ABSTRACT

This paper investigates and analyses the outage performance when multiple terminal users want to communicate using the shared relay this is known as two way relay communication. In previous years, low density parity codes (LDPC) have proved to be more efficient error correcting codes in wireless communication networks. This paper examines and analyzes bit interleaved coded modulation with iterative decoding using LDPC codes by using bidirectional relay. In Two-way relay network (TWRN) two terminals users shares a common relay for sending and receiving data and by this maximum transmission has been achieved utilizing less number of time slots. The system performance is analyzed taking Bit error rate (BER) curves against signal to noise ratio (SNR) with the combination of serial LDPC by using different Phase Shift Keying (MPSK) modulation schemes. Simulated results show that proposed scheme achieves better link reliability, achieves greater range and low complexity with consuming lower transmit power.

Keywords: WiMAX LDPC Codes; MPSK; Two way relay network; Analog network coding; Cooperative communication

1. INTRODUCTION

Wireless communication is becoming challenging day by day due to demanding issues like link reliability, efficiency, real time communication and power handling issues. Cooperative communication comes up as promising candidate for solving challenging issues in today's communication [1]. Cooperative communication uses relay nodes for increasing diversity instead of using multiple antennas. It has replaced the previously used Multiple Inputs, Multiple Outputs (MIMO) technology where we have to use number of antennas. Although cooperative communication use distributed MIMO by employing different relay nodes. In Bit Interleaved Coded Modulation (BICM), bit inter-leaver is used instead of symbol inter-leaver to improve diversity as well as removes burst errors.

In [2], authors proposed new scheme, which is bit interleaved coded modulation, and this proved to be very efficient modulation scheme for removing burst errors removal. In traditional BICM scheme, the coder sequence first is interleaved and after that bit mapper is used for removing burst error where data is demapped, de-interleaved at the receiver side and given to the LDPC decoder. In BICM we used bit wise interleaver which is efficient for removing burst errors instead of using symbol interleaver. In this case, the receiver acknowledges the interleaving in data, however, due to random modulation scheme Euclidian distance also reduced and it also reduces system efficiency i.e. data rates. In [3], the authors have proposed a solution for overcoming degradation in data rates that by giving soft feedback from decoder to demapper and this is called iterative decoding and as iteration increases we will get improve data rates. In the last decade, a new coding scheme called LDPC became hot topic of the research community [4]. LDPC are class of error correction codes (ECC) and by using LDPC codes we can get transmission rate even close to Shannon limits.

Due to their practical application, LDPC codes have practical applications as efficient codes in IEEE WiMAX 802.16e standard .In LDPC-BICM-ID system the information fed from LDPC decoder to the demapper which makes iterative decoding and as the no of iteration increases it gives almost 2dB of gain if we use system without iterative decoding. It also improves data rates at low SNR values making out transmission more efficient.

Opportunistic relay is an effective tool in two way relay network for improving the overall network performance. In this work, we want to put this whole LDPC-BICM-ID scenario using TWRN. Recently two-way relaying network [5] has attracted attention of the researchers for achieving spectral diversity via bidirectional communication. The attractive feature of TWRN is that it can remove the inefficiency of one-way relaying communication in which senders don't have direct access to the receivers except the relay node for improving spectral efficiency. TWRN has the advantage of bi-directional access for sender as well as to the receiver in single phase. We can use many coding schemes like amplify and forward & decode and forward analog network coding along with various diversity combining techniques at the relay node itself. However, TWRN is bandwidth efficient technique which uses available resources in lesser time slots; it is fast, has better synchronization properties and efficiency. Authors in [6] have proposed a new scheme called Analog Network Coding (ANC) for two-way relay transmission.

Cooperative communication using relay nodes already contributed a lot in 4G and LTE networks. It also uses massive MIMO techniques in 5G communications it uses different mobile relay nodes for Device to Device D2D communication in 5G communication system which shows bidirectional communication [7]. Cooperative communication can be used in improving geographic network coverage, it also improves enhance power of the system and spectrum efficiency.

Volume 5, Issue 3
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2. ONE WAY/TWO WAY RELAY NETWORK

In one way relay communication sender first sends data to the relay for improving diversity and then in the second phase relay sends data to the receiver and vice versa this is kind of one way relay communication because communication occurs in different no of phases as shown from figure 1.

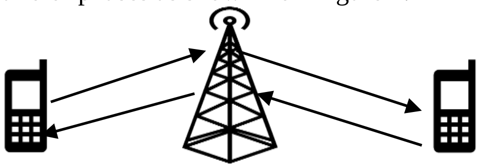

Figure.1 one way relay communication

In two way relay system communication occurs in full duplex as shown in figure2 i.e. both terminals can access the relay in single phase and similarly relay can send data in another phase to both terminals. In two way relay network we access the relay in single phase for improving diversity gain many operation can be done on relay node itself. TWRN is fast reliable and saving bandwidth by reducing time slots.

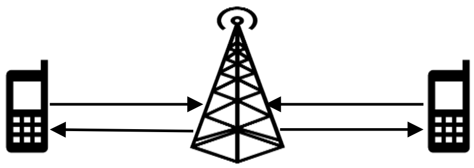

Figure.2 two way relay communication

2. SYSTEM MODEL

We propose a synchronized wireless communication link having two terminals source transmitter 'Y' which is combined of LDPC encoder, bit wise inter-leaver and a bit mapper as shown in Figure.3

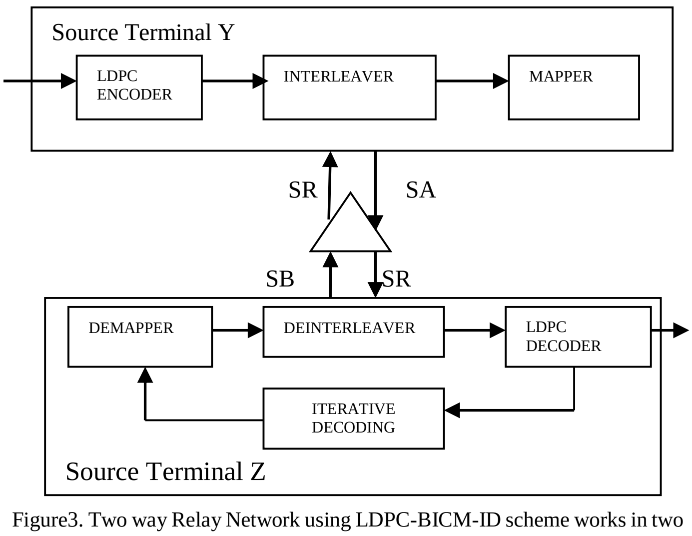

Figure3. Two way Relay Network using LDPC-BICM-ID scheme works in two phases one is Multiple Access phase (MAC) source to Relay, second is broadcast phase (BCP) Relay to Source

Terminal Z combined of De-mapper, de-interleaver and a LDPC decoder uses the two way relay for sending and receiving data in the Mac and Broadcast phases. We can apply different relay strategies and combining schemes at the relay node and further take output from the shared relay. However, this increases system complexity. Two terminal sources are able to use Channel State Information (CSI) by training signals. As depicted in Figure.3, both the terminals access the shared relay in access phase and can send their data in the next broadcast phase. The relay accesses both the sources and destination during the broadcast phase which leads to data corruption by random Gaussian noise. The superposition of two signals at the relay node can be described by the following equation.[8]

$$Y_R = \sqrt{p}\, h_{YR\,SY} + \sqrt{P}\, h_{ZR\,SZ} + {}_{WR} \qquad (1)$$

Where $_{SY}$ and $_{SZ}$ show transmitted signals from terminal Y and terminal Z respectively, $_{WR}$ shows additive Gaussian noise at the relay node and h_{YR} (h_{ZR}) is the path gain of these two signals from terminal Y and Z to the relays. Here, relay index in equation (1) is neglected. The selected opportunistic best relay performs analog network coding in the broadcast (BRC) phase and at the output we get mixture of these two terminal signals in compressed form as shown in equation [9]:

$$SR = \frac{\sqrt{P}hYRSY + \sqrt{P}hZRSZ + WR}{\sqrt{P\,|hYR|2 + P\,|hZR|2 + \sigma 2}} \qquad (2)$$

Here, terminal Y gets the Gaussian noise corrupted signal and fading distorted signal (√P $h_{RYSR+WY}$) and terminal Z gets (√P $h_{RZSR+WZ}$) where h_{RY}(h_{RZ}) shows path gain from relay to terminals Y and Z. $_{WA\,(WB)}$ shows the additive Gaussian noise at terminal Y (Z). Here we proposed that the links are reciprocal, i.e., $h_{YR} = h_{RY}$, $h_{ZR} = h_{RZ}$ and quasi-static, ideally, path gain is constant between two phases. Here in this system model both terminals have known their transmitted signals so they uses successive interference cancelation in order to remove Gaussian noise caused by transmission medium can be described by the following equations.

$$Y_A = \frac{\sqrt{P}hYR\boldsymbol{h}ZRSZ + \sqrt{P}hYRWR}{\sqrt{P\,|hYR|2 + P\,|hZR|2 + \sigma 2}} + \mathrm{WA} \qquad (3)$$

$$Y_B = \frac{\sqrt{\mathrm{P}}\mathrm{hYRhZRSA} + \sqrt{\mathrm{P}}h_{ZRWR}}{\sqrt{\mathrm{P\,|hYR|2 + P\,|hZR|2 + \sigma 2}}} + WB \qquad (4)$$

Here in this work we have used Maximal ratio combining scheme at the relay node we can also use amplify forward and decode and forward scheme at the relay node. Analog network coding is therefore efficient scheme for bidirectional communication and we have done some basic mathematical calculation using ANC. Here in this work using MRC at relay node which will combine data from terminal Y and terminal Z and will increase the diversity of signals from these two terminals. Applying combining and amplifying techniques at the relay node also increase complexity because other challenges have to face like source allocation, synchronization etc. the information shares from two terminals in two time slots are given by the following equations. The mutual information exchange between two terminals in two time slots are respectively depicted as [9]-[10]:

$$I_A = \frac{1}{2} LOG2(1 + \frac{\rho^2 |hYR|2|hZR|2}{2\rho|hYR|2+\rho|hZR|2+1} \quad (5)$$

$$I_B = \frac{1}{2} LOG2(1 + \frac{\rho^2 |hYR|2|hZR|2}{\rho|hYR|2+2\rho|hZR|2+1} \quad (6)$$

Where ρ= (P)/σ^2 denotes the SNR. Here bandwidth is normalized and measured in bit/s Hz Without loss of generality, we also assume that h_{YR} and h_{ZR} are independent complex Gaussian random variables which are denoted by $h_{YR} \sim CN$ (0, g1) and $h_{ZR} \sim CN$ (0, g2), respectively.

3. FADING CHANNELS

When we make transmission from transmission medium or free space it gets faded due to certain reason, to overcome these random noises is original task for quality transmission. Here we consider three wireless fading channels between sharing times using shared relay. Cooperative system using Rician-k, Rayleigh, and Nakagami-m fading channels have been analyzed in the proposed system model. Channel state information CSI is assumed to be present along with perfect synchronization at receiver.

RAYLEIGH DISTRIBUTION

In Rayleigh fading channel the signal amplitude varies according to the Rayleigh distribution also it has zero mean. In Rayleigh fading we have no line of sight signals simply follows Rayleigh distribution else if we have strong LOS line of sight than this said to be Rician channel. Rayleigh probability density function can be described by Ω = E (r^2) and mathematically can be written as (7)

$$p_{R(r)} = \frac{2r}{E(R^2)} e^{-r^2/E(R^2)} \quad (7)$$

RICIAN DISTRIBUTION

In Rician fading channel we have strong line of sight communication and due to this property of Rician fading channel many of the interfered signals super imposed on this strong line of sight communication. Rican fading is more application in LOS communication. Rician distribution can be mathematically described by the following equation

$$P(r) = \frac{r}{\sigma^2} e^{-\frac{(r^2+A^2)}{2\sigma^2}} I(\frac{Ar}{\sigma^2}) \quad (8)$$

NAKAGAMI DISTRIBUTION

When we talk about transmission through wireless medium we get replicas like original signals and can't get original signal in ideal. When signals travel through fading environments it gets faded by Gaussian random noise by time varying characteristics of the channel. The PDF of Nakagami fading has recommended for mobile and indoor communication because Nakagami has variety in its distributions values and flexible. Nakagami also have range in the shape factor values by changing the magnitude of the signals. Nakagami distribution can be described by the following equations as by his name Nakagami distribution is proposed by Nakagami by the following equations.

$$p_\alpha(\alpha) = \frac{2m^m \alpha^{2m-1}}{\Omega^m \Gamma(m)} \exp(-\frac{m\alpha^2}{\Omega}) \quad (9)$$

Gamma distribution scattered values of SNR given as:

$$p_\gamma(\gamma) = \frac{m^m \gamma^{m-1}}{\bar{\gamma}\Gamma(m)} \exp\left(-\frac{m\gamma}{\bar{\gamma}}\right) \quad (10)$$

Where m is shaping factor and has fluctuation in values of m due this variety in values Nakagami-m distribution has the property to have both distribution of Rayleigh and Rician fading channel. This feature of Nakagami makes it appropriate for indoor and mobile communication

4. SIMULATED RESULTS

In this section we have analyzed different parameters using WiMAX LDPC codes over the opportunistic relay called two way relay network. Here we considered three different fading channels and MPSK schemes. BICM-ID using LDPC codes also introduced as efficient coded modulation scheme for proposed cooperative communication scenario. Detail parameters are given in the following table no 1.

S. No	**Simulation Parameters**	
1	Sharing Method	TDMA
2	Codes Rate	1/2,2/3,5/6
3	Modulation Scheme	MPSK
4	Frame length	2304,512,1204
5	Relay	Shared Relay
6	Channels	Rician, Rayleigh, Nakagami
7	Relaying Mode	AF/DF
8	Channel coding	WiMAX LDPC
9	Method of Access	TDMA
10	Signal Combining	MRC
11	SNR	0 to 6 dB

Table: 1 Simulation Parameter for BER vs. SNR analysis over two way relay network.

RESULT 1: PERFORMANCE ANALYSIS OF BICM-ID BASED COOPERATIVE SHCEME USING CONVOLUATIONAL AND LDPC CODES

ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

In this scenario, we compared the performance of bit interleaved coded modulation with iterative decoding using convolutional codes and LDPC codes, results shows that using LDPC codes gives us more diversity at lower SNR looking at Figure.4, we can see that BICM-ID using LDPC codes gives almost 2dB gain at lower SNR values as compared to the convolutional codes.

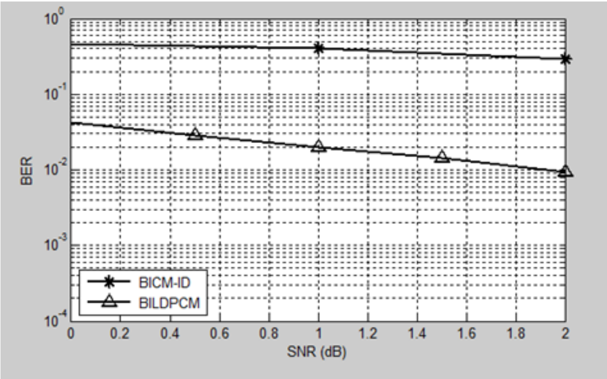

Figure.4 Simulated BER for BICM-ID using different codes

RESULT 2: PERFORMANCE ANALYSIS OF LDPC-BICM-ID SCHEME USING TWRN OVER RICIAN-K FADING CHANNEL.

Here we considered three different values of Rician-K fading channel i.e. K= 1, 5 and 10 it is shown from simulation analysis that when values of k increases we get improvement in the transmission. Analysis shows that increasing values of K factor from k=1 to k=5, BER are reduced at lower SNR; K factor is actually a ratio between the power in the direct path and in the scattered, paths. From figure5 it is also noticed that when we set k=5 the simulated results with the values of BER of 10^{-3} is achieved at very low SNR of 1dB thus increasing k factor values gives efficient transmission rate.

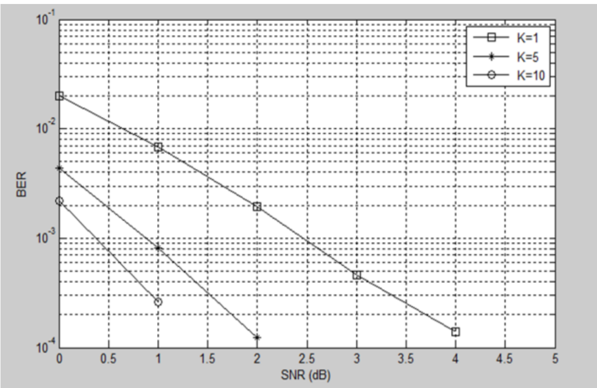

Figure5 Simulated BER over Rician fading channel

RESULT 3: PERFORMANCE ANALYSIS OF LDPC-BICM-ID SCHEME USING TWRN BY USING DIFFERENT CODE RATES;

In Figure.6, simulated results are taken using shared relay but with different coding rates. Here in this scenario the frame size is same i.e. 2304 for all coding rates but 1/2 ,5/6 ,3/2 coding rates are used from figure 4 it is clear that using coding rate 1/2 gives lower BER at lower SNR then other two coding rates. Results show that value BER of $10^{-1.5}$ is achieved at a very low SNR of 1.5dB, which is more reliable.

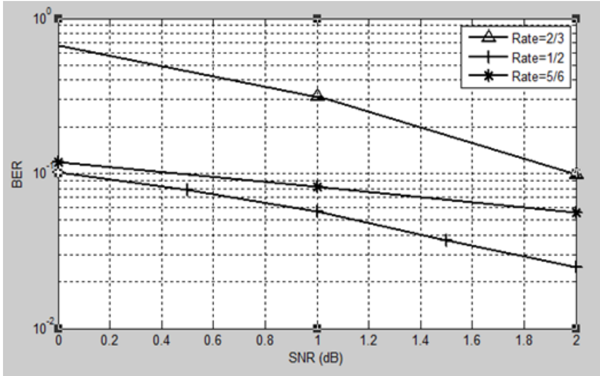

Figure.6 simulated BER for different coding rates

RESULT 4: SIMULATED BER OF LDPC-BICM-ID SCHEME USING TWRN OVER NAKAGAMI-M FADING CHANNEL

In this scenario, we have considered there different values of Nakagami-m fading channels i.e. from m= 1, 5 and 10 by increasing the values of m=1 to m=10 it is shown from the figure.7 that when we used m=10 we get improvements in BER at lower SNR the performance get better by large value of m here m factor in Nakagami fading channel is simply a shape parameter for probability distribution its neither a scale parameter it just effect the shape of signal distribution rather than to shifting it. In this simulation results Nakagami-m=5 distribution with shared Relay is able to achieve the BER of 10^{-3} at a very low SNR of 1dB while compare with low values of m.

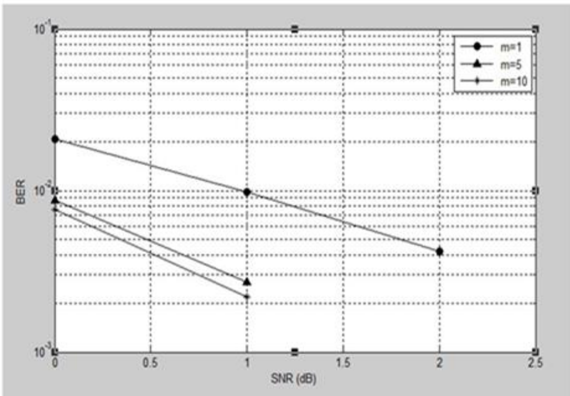

Figure7 simulated BER for Nakagami m fading channel

RESULT 5: SIMULATED BER OF LDPC-BICM-ID OVER RAYLEIGH FADING CHANNEL FOR 5 ITERATIONS

In this scenario, we have taken our results over Rayleigh fading channels the output is taken using single shared relay. Here, we noticed that increasing no of iteration gives reduced BER at

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Information Technology & Electrical Engineering

ISSN: - 2306-708X

lower SNR value. It is also clear from the figure that we have much more improvement in BER as we increase from iteration 1 to iteration 5 and the simulated results satisfied the scheme of BICM using with iterative decoding.

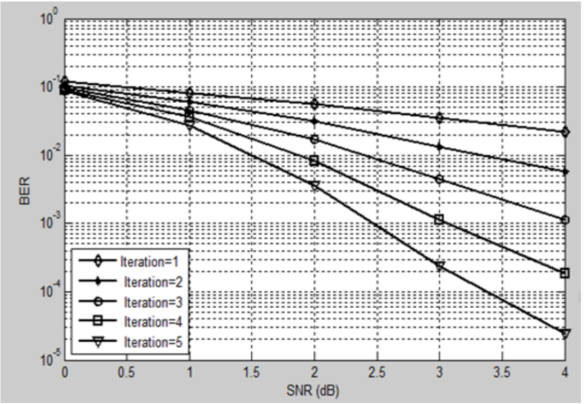

Figure8 simulated BER results over Rician fading channel For 5 iterations

5. CONCLUSION

Here in this research work, two way relay communication is analyzed using analog network coding. Cooperative communication system using shared relay is analyzed over different fading channels with Amplify and forward mode. TDMA access method has been investigated with LDPC-BICM-ID scheme. The use of opportunistic relay significantly improves diversity gain, achieves high efficiency and synchronization. The simulated results validated the accuracy of our proposed scheme. Cooperative communication originally works as distributed MIMO which will act in the form of Mobile relaying in 5G network but still many issues still to be addressed [11]. Future works includes Mobile relaying which will act as distributed MIMO even for device to device communication and this is main goal of future enhancement in wireless communication and cellular networks. There are many issues still facing challenges for future network in Mobile user relays like routing, radio resource management, and interference management are still to be addressed. In LTE/5G networks Device to device (D2D) communication is a step toward Mobile Relaying. Synchronization is key thing to handle when we talk about mobile relaying or vehicular communication in large mobile network setup. Also source allocation at the relay node for multiple users is also a challenging goal.

REFERENCES

[1] A. Nosratinia, T. E. Hunter, and A. Hedayat, "Cooperative Communication in Wireless Networks," in IEEE Commun. Mag, pp. 74-80, 2004.

[2] Ephraim Zehavi. Eight PSK trellis codes for a Rayleigh channel [J]. IEEE Trans. Commun., 1992, 40(5): 873-884.

[3] Li Xiaodong, Chindapol A, Ritcey, J.A. Bit-interleaved coded modulation with iterative decoding and 8-PSK signaling [J]. IEEE Trans.on Commun, 2002, 50(8):1250-1257

[4] S. A. K. Tanoli, I. Khan and N. Rajatheva, "Performance analysis of BICM-ID and BILDPCM-ID based cooperative communication," in Proc. 4-th Int. Conf. on Commun. and Net. in China (ChinaCom'09), Aug. 2009. Intl. J. of Sig. Proc., IJSP, Vol. 3, No. 4, pp 281-288, 2006.

[5] P. Razaghi, M. Aleksic, and W. Yu, "Bit-Interleaved Coded Modulation for the Relay Channel Using Bilayer LDPC Codes," 10th Canadian Workshop on Information Theory, 2007.

[6] X. Ji, B. Zheng, L. Wang, and X. Gao, "Opportunistic relaying for two-way relay transmission with analog network coding," in 2011 International Conference on Wireless Communications and Signal Processing (WCSP), 2011, pp. 1–5

[7] A. Gupta and R. K. Jha, "A Survey of 5G Network: Architecture and Emerging Technologies," IEEE Access, vol. 3, pp. 1206–1232, 2015.

[8] Z. Ding, K. K. Leung, D. L. Goeckel, and D. Towsley, " On the study of network coding with diversity," IEEE Trans. Wirel. Commun, vol. 8, no. 3, pp. 1247-1259, 2009

[9] R. Louie, Y. Li, and B. Vucetic,"Practical physical layer network coding for two-way relay channels: performance analysis and comparison," IEEE Trans. Wirel. Commun, vol. 9, no. 2, pp. 764-777, 2010

[10] J. Zhang, B. Bai, and Y. Li," Outage-optimal opportunistic relaying for two-way amplify and forward relay channel," Electron. Lett. vol. 46, no. 8, pp. 595-597, 2010

[11] S. Chu, X. Wang, and Y. Yang, "Exploiting Cooperative Relay for High Performance Communications in MIMO Ad Hoc Networks," IEEE Trans. Comput., vol. 62, no. 4, pp. 716–729, Apr. 20131.

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ITEE Journal
Information Technology & Electrical Engineering

ISSN: - 2306-708X

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