Literature survey for Decoder Performance Analysis of Relay Based Decode-and-Forward Cooperative Diversity Network

R.V.Anusha
PG Scholar,Department of ECE
PET engineering college
Tirunelveli,India

K.Madhan Kumar
Associate Professor,Department of ECE
PET engineering college
Tirunelveli,India

Abstract---Performance degradation is an major problem in a relay based Decode-and-Forward (DF) receiving cooperative system. In the DF protocol , existing decoder performances have high decoding complexity, because destination require exact knowledge of the source-relay link along with the channel coefficient of source-destination and relay –destination links. In the proposed method, degradation can be avoided by using Maximum-likelihood(ML) decoder at destination, assuming that average probability of error of source-relay link known to destination. Since average probability of error is a function of the average SNR, the proposed ML decoder avoids the need of exact knowledge of the channel coefficient of the source- relay link in the destination node. PL decoder is also used which performance is similar to ML decoder with low decoding complexity. This literature survey discuss about DF protocol based relay strategies and their performance.

Keywords-Decode-and-Forward protocol, Cooperative diversity, ML decoding.

I-INTRODUCTION

In Maximum-likelihood (ML) decoder is used at destination to avoid performance degradation in a decode-and-forward (DF) cooperative system, is proposed for BPSK constellation [6]. This ML decoder maximizes the conditional p.d.f of the received data at the destination terminal for given average probability of error in the source-relay link and results into low decoding complexity. The work in [2]-[3] presents a similar treatment referred to as user cooperative diversity. It also highlights a practical implementation of the cooperative scheme in the frame work of CDMA system. In [8] Laneman and Wornell discuss a cooperative protocol for combating multiple fading. This protocol exploits the spatial diversity available among a collection of distributed terminals that assist one another. In the decoding schemes [10], [6] the destination requires to possess exact knowledge of the channel coefficient of the source-relay link along with the channel coefficient of the source-destination and relay destination links. Therefore the existing decoder [10], [6] results into very high decoding complexity. Relay nodes have some possibilities of making decoding errors, the selection relaying (SR) protocol was proposed to reduce error propagation at the relay nodes [12]. The threshold-based maximal ratio combining(MRC)[5] and threshold based selection combining(SC) of multiple antenna signals are analyzed. It is found that end-to-end error performance of a network which has few relay with many antennas is not significantly worse than that which has many relay each with a fewer antennas. The multiple antennas at relay are configured in SC fashion is not significantly worse than that in which MRC is used.

II.LITERATURE SURVEY

A.ML Performance Analysis of the decode-and-forward Protocol

MinChulJu and Il-Min Kim[6] analyze the ML performance of the decode-and-forward protocol in cooperative diversity networks for M-PAM and M-QAM. Consider a cooperative diversity network which consist of source, a relay and a destination with a direct path signal from the source to the destination, but which is not equipped with CRC codes, and the destination has instantaneous channel state information (CSI) from the source to relay. In this system, due to a symbol error at the relay, the ML receiver at destination must consider all the possible symbol detection scenarios not only at the destination but also at relay. This makes ML performance analysis very difficult. In order to facilitate the derivation of decision regions, simplify the ML detection rule into two dimensional real space. Also found this simulation could be applicable to one-dimensional based modulations such as M-PAM and rectangular M-QAM. However, this simplification was not applicable to M-PSK and M-FSK expect binary constellation. Since the metric value is given by linear combination of exponential function, one cannot utilize the classical minimum Euclidean distance rule and the BER analysis is extremely difficult. Max-log approximation is widely used because of its simplicity and accuracy.To apply max-log approximation, we take natural logarithm for the metric $\sum_{\hat{x}} \varphi_{X,Y}(x,\hat{x})$. Since the natural logarithm function is monotonically increasing can replace $\sum_{\hat{x}} \varphi_{X,Y}(x,\hat{x})$ in with ln $\sum_{\hat{x}} \varphi_{X,Y}(x,\hat{x})$. And further simplify the ML detection rule such that two metric values of two adjacent constellation points are sequentially compared. Then obtain the decision region in a simplified form without union and intersection. Then based on the decision regions, derived a closed-form BER approximation for M-PAM and M-QAM. Table 1 shows the BER approximation for the BPSK,QPSK,16-QAM,64-QAM. The SNR values increases, the BER value decreases, and gives better performance for BPSK compared to another schemes shown in the Table 1. As the SNR value increases, the BER performance is reduced is shown in Table I. The closed form BER approximation for M-PAM is given in probability form as,

$$p_M = \frac{1}{\log_2 M} \sum_{k=1}^{\log_2 M} p_M(k) \qquad (1)$$

The closed form BER approximation for M-QAM is given in probability form as,

$$p_M = \frac{1}{\log_2 (I.J)} \left(\sum_{k_1=1}^{\log_2 I} p_I(k_1) + \sum_{k_2=1}^{\log_2 J} p_J(k_2) \right) \qquad (2)$$

TABLE 1

Approximation for BPSK using eq (1), for QPSK eq (2), for eq 16-QAM (2), for 64-QAM eq (2)

γ (db)	BER			
	BPSK	QPSK	16-QAM	64-QAM
0	10^{-1}	$1.8*10^{-1}$	$3*10^{-1}$	$4*10^{-1}$
5	$2.5*10^{-2}$	$6*10^{-2}$	$1.8*10^{-1}$	$3.8*10^{-1}$
10	$3.5*10^{-3}$	$1.2*10^{-2}$	$8*10^{-2}$	$1.8*10^{-1}$
15	$4*10^{-4}$	$1.7*10^{-3}$	$1.8*10^{-2}$	$8*10^{-2}$
20	$4.5*10^{-5}$	$1.8*10^{-4}$	$3*10^{-3}$	$2*10^{-2}$

B.High Performance Cooperative demodulation with DF relay

T.Wang, A. Cano,G.B. Giannakis and J.N. Laneman[10]. This paper is to exploit the knowledge of the instantaneous BEP of the source-relay link at the destination, and derive a novel combiner capable of collecting full diversity with DF for any coherent modulation and in any general relay links. Such a combiner called as Cooperative-Maximum-ratio-Combining (C-MRC). The weight are selected adaptively to account for the quality of both source-relay-destination and source-destination links. Unlike the ML and PL demodulator, C-MRC offers a high performance demodulator with low complexity, regardless of the underlying constellation. The implementation of higher order constellations becomes prohibitively complex. Moreover, analysis of this equation is very complicated, which prevents one from assessing ML performance. Assuming that the average SNR of the S-R link is available at the destination, the PL-ML approximation was advocated to overcome this problem. As the destination requires exact channel knowledge of the source-relay link along with the channel coefficient of source-destination and relay-destination links.

Flow Chart

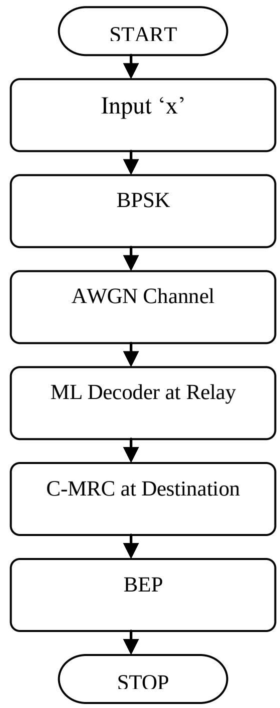

Fig.1 Flow Chart for high performance Cooperative demodulation with DF protocol

The Fig.1 shows the simulation process of the high performance cooperative demodulation with DF protocol. The source broadcast input symbol ‘x’ to relay and destination. Relay decode and forward the incoming symbol by using ML demodulator, which minimize the error at the relay. At the destination the two orthogonal phase symbol are combined by using Cooperative-MRC. Then the bit error probability(BEP) of DF protocol is estimated by using BPSK.

For multibranch multihop cooperation, they validate full-diversity claims for an arbitrary number of branches and relaying nodes per branch. Diversity claims are simulated when considering multi hops per path. A fair comparison require hops $R_1, R_2 \dots R_N$ to be equally spaced between Source and destination , which may be realistic when destination is far from source. Assuming path-loss exponent equal to 3, the average output SNR per hop is $\hat{\gamma_n} = \hat{\gamma_{SD}} \left({d_0}/{d_{n,n-1}} \right)^3$, where d_0 stands for the distance between source and destination, and $d_{n,n-1}$ denotes the distance between nodes R_n $and R_{n-1}$. More cooperating nodes pe branch improve performance in parallel BEP shift, which is the well-known coverage enhancement effect achieved by multihop transmission.

Single relay cooperation, consider representative attenuation levels that correspond to those in which R is located either close to the source, close to the destination or equidistant from both. The ,corresponding average output SNRs($\gamma\hat{}_{\downarrow}SR, \gamma\hat{}_{\downarrow}RD, \gamma\hat{}_{\downarrow}SD$) in logarithmic-scale are $\bar{\gamma}$ +30db,$\overline{\gamma, \bar{\gamma}}$), ($\bar{\gamma}, \bar{\gamma}$ +30db,$\bar{\gamma}$) and ($\bar{\gamma}, \bar{\gamma}, \bar{\gamma}$) respectively. Performance is seen to be virtually identical, which implies that the bounds derived are tight. The SNR setup of $\bar{\gamma}$ +30db,$\overline{\gamma, \bar{\gamma}}$) performance better than ($\bar{\gamma}, \bar{\gamma}$ +30db,$\bar{\gamma}$) because with the S-R link having SNR, error propagation to D is mitigated. When it comes to regenerative protocol, the proposed DF decoder outperforms SR, and comes very close to AF. One considers that although both DF based on C-MRC and SR are adaptive protocols achieving full diversity, the SR one is based on hard decision at the relay, while DF with C-MRC exploit soft reliability of the S-R-D link.

C.Differential Modulation for DF Multiple relay system

Yonglan Zhu, Pooi-Yuen Kam and Yan Xin[12] ,Proposed receiver designs and analyzed the error probability of decode-and-forward (DF) protocol and the selection relaying (SR) multiple relay systems with DBPSK modulation. For the DF protocol , derive the nonlinear ML detector and propose the PL detector that has similar performance to the nonlinear ML detector. Both the ML and PL detector take the average BEPs of all the source-relay transmission into the account, and the received signals at the destination from the source and all the relays are combined with different weights, because the transmission links in the relaying system have different statistics. Since the BEP analysis for the nonlinear ML detector appears intractable, derive the BEP of the PL detector.

For the DF protocol, the destination needs to know the average BEP for all the relay nodes. However, for the SR protocol, the destination only needs to know the decoding set D for each frame. The SR protocol shows that, the ML receiver at the destination is an MRC receiver. Compared to ML and PL receivers for the DF protocol, the MRC receiver for the SR protocol is relatively simple, because some computational is shifted from the destination to the relay nodes, which need to compute their instantaneous BEPs and make decisions on whether to transmit or remain silent for the SR protocol. For a DF single relay system, obtain the exact BEP and its high signal-to-noise ratio (SNR) approximation. The BEP approximation at high SNR shows explicitly the diversity order and the different roles of the source-relay link and the relay-destination link in determining the end-to-end performance. Moreover, a chernoff upper bound on the BEP and a high SNR approximation for the BEP are obtained for a DF multiple relay system. The ML and PL detector in the DF relay system cannot achieve full diversity when the number of relay is greater than one. Table II shows the performance of average BEP of the DF and SR relay systems. As the value of SNR increases, the BER performance decreases, Table II shows that SR relay based MRC decoder at L=2 gives better performance compared to DF relay based ML and PL decoder.

For the SR protocol, each relay computes the instantaneous BEPs of the source-relay transmission to perform selection and uses the instantaneous BEPs to decide whether to transmit or remain silent. When the instantaneous BEPs at the relay satisfy certain criteria, the relay belongs to the decoding set which is a randomly selected subset of the set containing all the potential relays. In this case, the ML receiver at the destination is a MRC receiver. Analyze the error performance of the multiple relay system operating with the SR protocol at high SNR, and show from an error probability prospective that the SR protocol offers full space diversity. More specifically, the SR protocol offers a space diversity order equal to the number of all potential cooperating nodes, not just the number of nodes that are transmitting to the destination

TABLE.II
Average BEP for Relay systems with DF and SR protocol

SNR (db)	BEP			
	DF relay based ML & PL decoder		SR relay based MRC decoder	
	L=1	L=2	L=1	L=2
0	$2.5*10^{-1}$	$3*10^{-1}$	10^{-1}	$9*10^{-2}$
5	$8*10^{-2}$	$8*10^{-2}$	$2.5*10^{-2}$	$1.8*10^{-2}$
10	10^{-2}	$7*10^{-3}$	$4.5*10^{-3}$	$2.5*10^{-3}$
15	$2*10^{-3}$	$3*10^{-4}$	$6.5*10^{-4}$	$2.5*10^{-4}$
20	$2*10^{-4}$	$5.5*10^{-6}$	$7*10^{-5}$	$3.5*10^{-5}$

D.Cooperative Relaying in Multi-Antenna Fixed Relay

A.Adinoyi and HalimYanikomeroglu[5] this paper investigates distributed decode-and-forward fixed relays which are engaged in cooperation in a two-hop wireless network as a means of removing the burden of multiple antennas on wireless terminal. In contrast to mobile terminal, the deployment of a small number of antennas on infrastructure-based fixed relays is feasible, thus the paper examine the impact of multiple antennas on the performance of the distributed cooperative fixed relay. For the given performance requirement, the multiple antennas at relays can tremendously reduce the number of relays required in a network area, thereby, reducing system deployment cost. The conventional fixed protocol decode-and-forward relay network, where the destination relies only on the signal from the relay. The two-hop system architecture consists of N_R threshold decode-and-forward based fixed relays each carrying L diversity antennas. The scenario referred to as symmetric network, as opposed to the asymmetric one, is considered. The symmetric networks assume that all links experience independent but statistical identical channels with the same mean path loss.

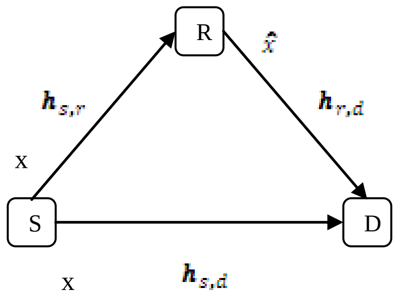

Fig 2. Block model for a single-relay Cooperative System

The protocol operates as follows, in the first time slot, the source broadcasts a signal that is received by relays and destination. The destination stores this signal for future processing. The received L signal at each relay are processed using either SC or MRC diversity technique, depending on the processing complexity that the relays possess. Whether SC or MRC is used the relay checks the SNR of the received signal against a preset threshold. The relay decodes and forwards only when this SNR is greater than this threshold. In the second slot the relay either does or does not forward a new signal to destination. If atleast one relay forwards, the destination MRC combines the delayed buffered signal received in the first slot with the new versions from the relays. It is assumed that only one antenna is utilized at each relay for forwarding.

Threshold selection combining at the relays represents an excellent compromise between performance and complexity. It is found that a minimum of two antennas are required at the relay to yield an end-to-end diversity order equal to the number of relays plus one. Furthermore, it is observed that threshold decoding is not required when there are few relays and these relay have large number of antennas. The aim in threshold decoding is to ensure that signal forwarded by the relay is reliable since the number of times, reliably detected signal is relayed to the destination has an impact on the cooperation benefit. Therefore, the decode-and-forward probability of relays is an important system performance criterion. However, for a small number of antennas the choice of threshold is important. It is found that the end-to-end error performance of a network which has few relays with many antenna is not significantly worse than that which has many relays each with fever antennas. It is also observed that error-to-error performance of a network in which the multiple antennas at relays are configured in SC fashion is not significant worse than that in which MRC is used. Here for this analysis Nakagami fading channel is used.

E.ML Decoder for Decode-and-Forward protocol

M.R.Bhatnagar and Are Hjorungnes[3] this paper derive a Maximum-likelihood(ML) decoder for the Decode-and-Forward(DF) protocol using arbitrary complex value constellation. The source transmit signal to relay and destination. Then the relay performs ML decoding and forward the decoded signal to destination, and it might have the error in the decoding the data. The ML decoder at the destination is obtained by maximizing the probability density function (p.d.f) of the data received towards two orthogonal transmission at the destination, under the assumption that the average probability of error of the source-relay link is known to the destination. Since the average probability of error is a function of the average SNR[11], so the proposed ML decoder avoids the need of exact knowledge of the channel coefficient of the source-relay link in the destination node compare to the existing decoders. Therefore, the proposed ML decoder is simpler for practical implementation as compared to the existing decoders. Then PL decoder is used, performances is similar to the ML decoder. And low decoding complexity compare to the ML decoder. Proposed PL decoder derives an approximate symbol error rate (SER) expression for the M-PSK constellation.

The data received at the relay in the first phase can be written as

$$y_{s,r} = \boldsymbol{h}_{s,r} x + e_{s,r} \qquad (1)$$

Where $\boldsymbol{h}_{s,r}$ is the channel gain between the source and the relay and $e_{s,r}$ is the zero mean complex additive white Gaussian noise(AWGN) with variance $N_{s,r}$. Then the data received at destination in the first phase is given as

$$y_{s,d} = \boldsymbol{h}_{s,d} x + e_{s,d} \qquad (2)$$

Where $\boldsymbol{h}_{s,d}$ is the channel gain between the source and the destination and $e_{s,d}$ is the zero mean complex additive white Gaussian noise(AWGN) with variance $N_{s,d}$.

Let source transmit the symbol x to the relay and destination. Decoding of x at relay is difficult, so relay needs to find out log-likelihood-ratio (LLR). The LLR expression is given as

$$\Lambda^{r}_{p,q} = \frac{|h_{(s,r)}|^2}{N_{s,r}}\left(|x_q|^2 - |x_p|^2\right) + 2Re\left\{y_{s,r}\frac{h^{*}_{s,r}}{N_{s,r}}\left((x_p - x_q)\right)^{*}\right\} \quad (3)$$

For M-PSK constellation $|x_q|^2 = |x_p|^2 = C$, where C is a constant, hence it is simplified as

$$\Lambda^{r}_{p,q} = Re\left\{ y_{s,r} \frac{h^{*}_{s,r}}{N_{s,r}((x_p - x_q))^{*}} \right\} \qquad (4)$$

The ML decoding rule based on the LLR at destination is given as,

$$\Lambda^{r}_{p,q} = \frac{|h_{(s,d)}|^2}{N_{s,d}}\left(|x_q|^2 - |x_p|^2\right) + 2Re\left\{ y_{s,d} \frac{h^{*}_{s,d}}{N_{s,d}((x_p - x_q))^{*}} \right\} + \ln$$

$$\left(\left(\epsilon/(M-1) \sum_{i=1, i \neq p}^{M} e^{(-1/N_{(r,d)}) \left(|h_1(r,d)|^2 |x_i|^2 - 2Re(y_1(r,d)\, h_1(r,d)^{*} x_i^{*})\right)} \right) + (1-\epsilon) e^{(-1/N \ldots}\right.$$

where p,q denote the pair of any two different symbol belonging to an M-point constellation.. ϵ is the average probability of error at the relay terminal in decoding x_p as x_i, where i=1,2….M, $i \neq p$, is $\epsilon / M - 1$. Which are the some parameter used in cooperative system for ML decoder receiver side.

The PL based approximation decoder is given as,

$$\Lambda^{d}_{p,q} = t_0 + f_{PL}(t_1) \qquad (5)$$

The approximate average SER for M-PSK can be obtained by solving the following integral,

$$E_{\gamma_{s,d},\gamma_{r,d}}[P_e(\gamma_{s,d},\gamma_{r,d})] = \iint_0^{\infty} P_e(\mathbf{h}_{s,d}, \mathbf{h}_{r,d}) p_{\gamma_{s,d}}(\gamma_{s,d}) X p_{\gamma_{r,d}}(\gamma_{r,d}) d\gamma_{s,d} d\gamma_{r,d}$$

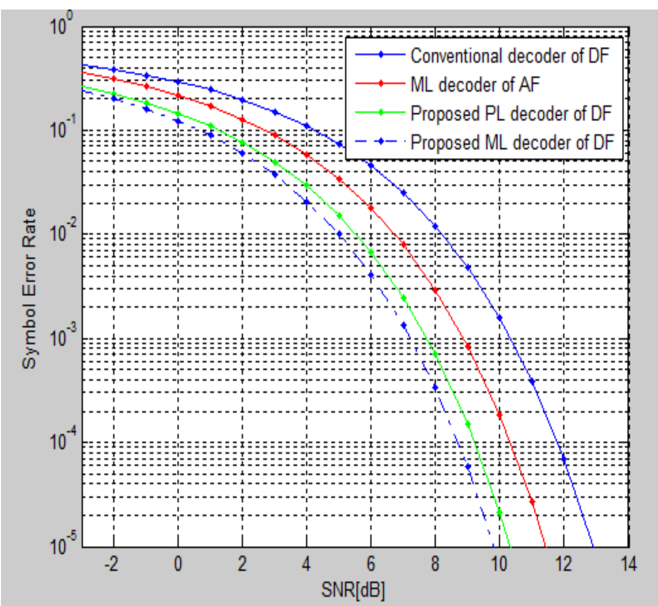

Fig.3 SER performance of proposed ML and PL decoders with the existing schemes for 8-PSK constellation

Fig.3 shows that SER performance of proposed ML and PL decoder with the existing ML decoder for Amplify-and-Forward(AF) and Conventional decoder of DF. As the SNR value increases, the SER value decreases. Here the proposed ML and PL decoder outperforms the existing decoder schemes. Because decoding process of proposed ML and PL decoder is less complex compare to existing decoder as explained earlier.

IV.RESULT AND DISCUSSION

Table I shows the closed–form Bit error Rate(BER) approximation for the M-PAM and M-QAM based on decision region. From the table closed-form BER approximation for BPSK gives better performance. Table II shows the average BER of the relay systems with DF and SR protocol. From the table observe that for the single relay system, both the DF and SR protocol achieve the same diversity order. Fig 1, shows the simulation process for high performance cooperative demodulation in DF protocol. The Bit error Probability(BEP) of DF protocol is estimated by using BPSK. Fig 3, shows the SER performance of proposed ML and PL decoder with the existing ML decoder for Amplify-and-Forward(AF) and Conventional decoder of DF. As the SNR value increases, the SER value decreases. Here the proposed ML and PL decoder outperforms the existing decoder schemes.

V.CONCLUSION

In this paper, a brief literature survey for decoder performance of DF protocol relay based strategies is discussed and their performance were analyzed. From this analysis, the proposed ML and PL decoder for relay based DF protocol gives better performance and also low decoding complexity compared to the existing decoder performance.

ACKNOWLEDGEMENT

I have taken efforts in this paper. However, it would not have been possible without the kind support and help of many individuals. I would like to extend my sincere thanks to all of them. I am highly indebted to Mr.K.Madhan Kumar for their guidance and constant supervision as well as for providing necessary information regarding the project and also for their support in completing the paper. I owe a sincere prayer to the LORD ALMIGHTY for his kind blessings and giving me full support to do this work, without which would have not been possible. My thanks and appreciations also go to my colleague in developing the paper and people who have willingly helped me out with their abilities.

REFERENCES

[1] Andrew Sendonaris, Erkip.E, and Aazhang.B,(2003) “User cooperation diversity-part I: system description,” IEEE Trans. Commun., vol. 51, no. 11, pp. 1927-1938.

[2] Andrew Sendonaris, E.Erkip, and B.Aazhang,(2003) “User cooperation diversity-Part II: Implementation aspects and performance analysis,” IEEE Trans. Commun., vol. 51, no. 11, pp. 1939-1948.

[3] M.R.Bhatnagar and Are Hjorungnes(2011), “ML Decoder for Decode-and-Forward Based Cooperative Communicetion systems” IEEE Trans, WirelessCommun.. vol. 10, no.12, pp. 4080-4090.

[4] Deqiang Chen and Laneman.J.N,(2006) “Modulation and demodulation for cooperative diversity in wireless systems,” IEEE Trans. Wireless Commun., vol. 5, pp.1785-1794.

[5] HalimYanikomeroglu and Abdulkareem Adinoyi,(2007) “Cooperative Relaying in Multiantenna fixed Relay Network” IEEE Trans. Wireless Commun., vol. 6, no. 2, pp. 533-544.

[6] M.Ju and I1.Min Kim,(2009) “ML performance analysis of the decode-and-forward protocol in cooperative in diversity neyworks,” IEEE Trans. Wireless Commun., vol. 8, no. 7, pp. 3855-3867.

[7] J.N.Laneman and G.W.Wornell,(2000) “ Energy-effective antenna sharing and relaying for wireless networks,” in Proc. IEEE Wireless Communications and Networking Conference, pp. 7-12.

[8] J.N.Laneman, D.N.C.Tse, and G.W.Wornell,(2004) “Cooperative diversity in wireless networks: efficient protocol and outage behavior, ” IEEE Trans. Inf. Theory, vol. 50, no. 50, pp. 389-400.

[9] J.G.Proakis, Digital Communications, 4th edition. McGraw-Hill, 2001.

[10] T.Wang, A.Cano, G.B.Giannakis, and J.N.Laneman,(2007) “High performance cooperative demodulation with decode-and-forward relays,” IEEE Trans. Commun., vol.55, pp. 1427-1438.

[11] M.K.Simon and M.-s Alouini Digitsl Communication over fading channels. John Wiley & sons, Inc., 20

[12] Yonglan Zhu, Pooi-Yuen Kam and Yan Xin,(2010) “Differential modulation for Decode-and- Forward multiple Relay systems” IEEE Trans. Commun, vol. 58, no. 1, pp 189-199.