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PERFORMANCE ANALYSIS OF TWO-WAY RELAY COMMUNICATION SYSTEMS

R. Lavanya
Assistant Professor,
Department of Information Technology
E.G.S Pillay Engineering College, Nagapattinam, India

Abstract: *This work focuses on two-way amplify-and-forward relaying system using non-coherent differential amplitude phase shift keying modulation. In this work we apply differential Amplitude phase shift keying modulation to Orthogonal frequency division multiplexing systems (OFDM) in two-way amplify-and-forward relay network using analog network coding at the relay to exchange information between the two sources. Our Simulation results demonstrate that the proposed DAPSK OFDM based differential detection in two-way relay network achieves significant improvement in BER performance compared to the coherent and non-coherent DPSK based scheme.*

Keyword: ***Amplify-and-forward (AF), cooperative diversity, differential amplitude and phase shift keying (DAPSK)***

I.INTRODUCTION

A relay assisted communication system produces the spatial diversity, also known as cooperative diversity. Cooperative diversity increases the transmission reliability and coverage, without expanding the expenditure of the scarce transmission resources (power and bandwidth).Cooperative diversity combined with differential detection has been attracting much attention particularly in the field of mobile radio where fast tracking and accurate carrier recovery is difficult to realize.

It also eliminates the need for pilot symbols for channel estimation, equalization which is particularly important in Relay aided cooperative system. Mobile radio systems require bandwidth-efficient modulation schemes, due to the limited resources of the available radio spectrum. An ideal modulation scheme for mobile radio systems and satellite transmission is APSK modulation scheme which gives better spectral efficiency (bits per symbol) than QPSK, and also more resistant to distortion than QAM [1]. This DAPSK based non coherent differential detection method is spectrally efficient and more robust to nonlinear distortion. DAPSK scheme can be employed in the second generation Terrestrial Digital Video Broadcasting (DVB-T2) systems to provide digital communication services with very high spectral efficiency, much improved BER and significantly reduced PAPR[2].Cooperative protocols for wireless networks such as Amplify-and-forward and decode-and-forward was studied actively in [3]. Differential encoding based on DPSK modulations have been studied for amplify-and-forward relays in [4]. The effect of nonlinearity caused mainly by High power amplifiers at the transmitter has been analyzed, estimated and presented in many papers [5, 6]. Low-Complexity Bit-Interleaved Coded DAPSK for Rayleigh-Fading Channels was proposed in [7]. Peak Power Efficient Cooperative Diversity using Star-QAM with Coherent and non-coherent Detection for differential AF cooperative networks was proposed in [8]. Soft-Decision Star-QAM Aided BICM-ID was proposed in [9]. A soft decision aided low

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Corresponding Author: **R. Lavanya** [lavanya.ngpt@gmail.com]

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Complexity DAPSK detector utilizing only a reduced subset of DAPSK constellation points was analyzed in [10]. The channel state information (CSI) estimation is more challenging in two-way relay network compared to direct communication between the source and the destination and the OWRN. Differential transmission schemes have been studied for TWRN in [11-13]. Optimum scheduling scheme to minimize sum bit error rate for TWRN is analysed in [14]. Differential transmission or non-coherent transmission for bidirectional relaying with analog network coding is studied extensively in [15]. 64 DAPSK modulations for multicarrier modulation is found in [16].Detailed performance analysis of coherent and non-coherent cooperative turbo transceivers for MIMO-OFDM is given in [17]. In this work we extend DAPSK modulation to two-way relay network and compare the performance with DPSK modulation based two-way relay network. To the best of our knowledge DAPSK OFDM based differential detection is not employed in TWRNs.

2. SYSTEM MODEL FOR TWO-WAY RELAY NETWORK

The general system model for the proposed TWRN with analog network coding is shown in Fig.1. Bits are encoded using a suitable forward error correction scheme before mapping into symbols. Here, convolutional encoder of rate (1/2) is adopted. The symbol undergoes Rayleigh fading and AWGN gets added. Multipath environment is considered. The information transmission takes place in two phases. During the first phase the two sources S1 and S2 transmit their differentially encoded symbols independently to the relay node. The relay linearly amplifies the signal from the two source nodes and broadcasts the information back to the two sources. At each source the self-interference is removed before differentially decoding the signals at the two sources.The amplitude information is recovered by performing differential amplitude detection to the received signal at the destination. After symbol detection, decoding is done using a Viterbi decoder. The decoded bit sequence is considered for evaluating the BER performance.

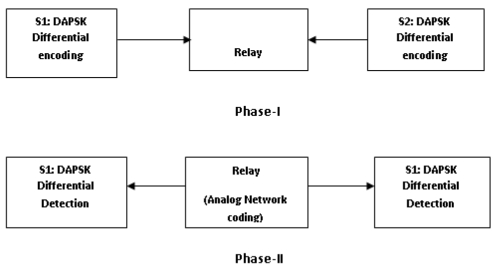

Fig. 1. System model of the proposed DAPSK Bidirectional relaying scheme with analog network coding

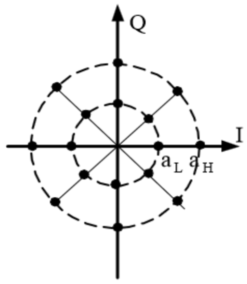

Fig. 2. DAPSK Constellation

The convolutionally encoded bit sequence is mapped into symbols. The bits are mapped

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into amplitude and phase information, they are differentially encoded and transmitted as DAPSK symbols. 16-DAPSK is the combination of 8-DPSK and 2-DASK modulation. The constellation diagram for 16-DAPSK modulation scheme is shown in Fig.2. Here M is the modulation order, 4 bit binary data is represented as C_k^0, C_k^1, C_k^2, C_k^3. In 16-DAPSK constellation, M-DAPSK (Ma, Mp) denotes that there are Ma = 2 amplitudes and Mp = 8 phases for each ring where M = Ma X Mp = 16. The modulated symbol is expressed as given in (1).

$$s(k)=\frac{a(k)}{a(k-1)}\exp(j\Delta\varphi_k) \quad (1)$$

$$s(k)=\rho(k)exp(j\Delta\varphi_k) \quad (2)$$

$$\rho(k)=\frac{a(k)}{a(k-1)} \quad (3)$$

$$\Delta\varphi_k=\varphi_k-\varphi_{k-1} \quad (4)$$

where a(k) in (1) and φ_k in(4) refer to the amplitude and the phase of the current symbol respectively and a(k-1) in (3) refers to the amplitude of the previous symbol. The parameters ρ(k) and $\Delta\varphi_k$in (2) represents amplitude transition factor and phase transition factor respectively.

3. SIMULATION RESULTS

The distance between source and destination is normalized to unity and denoted by d, $0 \leq d \leq 1$.The total signal transmission power in the network is E=Es+Er. Convolutional channel coding with rate ½ have been used. The ring ratio is taken to be 2 for DAPSK modulation. It can be inferred from Fig. 4 that for a BER of 10^{-3} approximately 2dB SNR gain is achieved for both the coherent and non-coherent DAPSK based differential detection scheme compared to the BER of the DPSK based coherent and non-coherent differential detection scheme for the TWRNs. For the OFDM two-way relay network, the data is grouped into 512 subcarriers. The cyclic prefix length used is 16.For Rayleigh-fading channel the BER curves of coherent DAPSK with and without OFDM are shown in Fig. 5.For a BER of 10^{-3}there is approximately 5 dB gain in the DAPSK modulated OFDM signal compared to DAPSK modulation without OFDM. BER values are compared for non-coherent 16 DAPSK modulated OFDM signal for two-way relay network and for 8 DPSK modulated OFDM signal and is shown in Fig. 3.

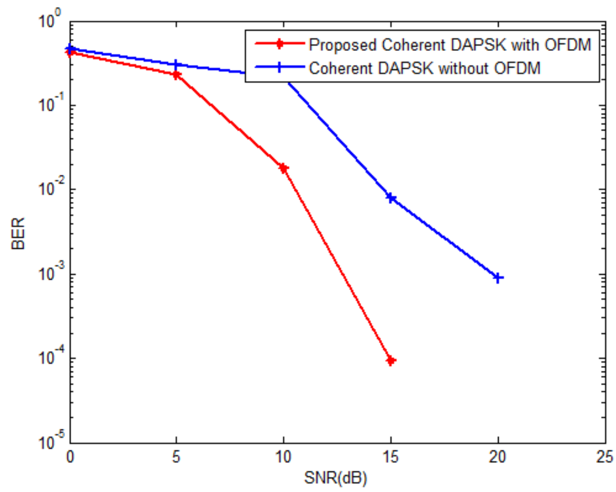

Fig.3. BER Performance of proposed coded coherent DAPSK modulated OFDM signals in two-way relay network .

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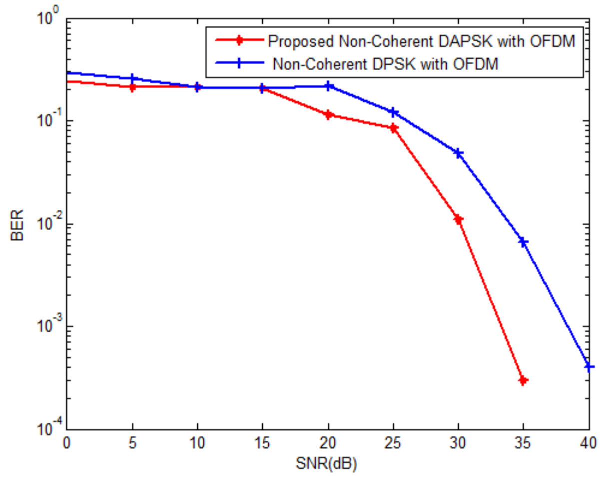

Fig.4 BER Performance of proposed uncoded non- coherent DAPSK modulated OFDM signals in two-way relay network.

4. CONCLUSION

Simulation results show that the proposed DAPSK differential detection performs better compared to DPSK based differential detection in TWRNs. Fig. 6 Shows that 8 DPSK modulated OFDM signal needs approximately 4.5 dB higher SNR than 16 DAPSK modulated OFDM signal at BER =0.006 for the non-coherent detection method. Since exact channel estimation and equalization is difficult to achieve in real OFDM receivers, DAPSK can be considered as a suitable method for reduced complexity and for high bit rate transmission system.

References

1. W. T. Webb, L. Hanzo, and R. Steele, “Bandwidth efficient QAM schemes for Rayleigh fading channels,” IEE Proc.-I, vol.138, no. 3 pp. 169–175, June 1991.
V. Engels and H. Rohling, “Multilevel differential modulation technique (64-DAPSK) for multicarrier transmission systems,” Eur. Trans.Telecommun., vol. 6, no. 6, pp. 633–640, Mar. 1995.

2.Q. Zhao and H. Li, “Differential modulation for cooperative Wireless Systems,” IEEE Trans. Signal Process., vol. 55, no. 5, pp. 2273–2283,May 2007.

3. T. Himsoon, W. Su, and K. J. R. Liu, “Differential transmission for amplify-and-forward cooperative communications,” IEEE Signal Process. Lett., vol. 12, no. 9, pp. 597–600, Sep. 2005.

4.Benedetto, S. et al.: “Modeling and Performance Evaluation of Nonlinear Satellite Links - A Volterra Series Approach”, IEEE Trans. on Aerospace and ElectronicSystems, vol. AES-15, No. 4, Jul. 1979

5.Silvano, P. et al.: Performance Analysis of Digital Radio Links with Nonlinear Transmit Amplifiers, IEEE Trans. on SAC,vol. SAC-5, Apr. 1987.

6.K. Ishibashi, H. Ochiai, and R. Kohno, “Low complexity bit- interleaved coded DAPSK for Rayleigh fading channels,” IEEE J. Sel. Areas Commun., vol. 23, no. 9,pp. 1728–1738, Sept. 2005.

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7.Koji Ishibashi, Won-Yong Shin, "A Peak Power Efficient cooperative Diversity using Star-QAM with Coherent Noncoherent Detection,"IEEE transactions on wireless communications, vol. 12, no. 5, pp2137-2147, May 2013.

8. D. Liang, S. Ng, and L. Hanzo, "Soft-decision star-QAM aided BICMID," IEEE Signal Process. Lett., vol.18, no. 3, pp. 169–172, Mar. 2011.

9. Chao Xu,Dandan Liang , "Reduced complexity Noncoherent Soft –Decision –Aided DAPSK Dispensing with channel estimation" IEEE Transactions on vehicular technology., vol. 62, no. 6, pp2633–2642, July 2013.

10.W. Guan and K. J. R. Liu, "Performance analysis of two-way relaying with non-coherent differential modulation," IEEE Trans. Wireless Commun., vol. 10, no. 6, pp. 2004– 2014, June 2011.

11.T. Cui, F. Gao, and C. Tellambura, "Differential modulation for two-way wireless communications: a perspective of differential network coding at the physical layer," IEEE Trans. Commun., vol. 57, no. 10, pp. 2977–2987, Oct. 2009.

12.W. Cho, R. Cao, and L. Yang, "Optimum resource allocation for amplifyand-forward relay networks with differential modulation," IEEE Trans.Sig. Proc., vol. 56, no. 11, pp. 5680–5691, Nov. 2008.

13.Zhaoxi Fang, Guosheng Li, and Jun Li, "Performance of Two- User Two-Way Amplify-and-Forward Relaying Systems with Scheduling " ETRI Journal, Volume 33, Number 5, October 2011.