An Extensive Review on Two-Way Cyclotomic Orthogonal Space-Time Transmission Scheme for Asynchronous Cooperative Systems

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Abstract - Multiple Input Multiple Output (MIMO) communication techniques have been an important area of focus for 4th generation wireless systems. This is mainly because of their potentials for high capacity, increased diversity, and interference suppression. The cooperative communication techniques can avoid the difficulties of implementing actual antenna arrays and convert the single-input single-output (SISO) system into a virtual MIMO system. In this scheme, the user explores its other neighbor users to act as relaying nodes and forming virtual MIMO system. Space-Time Block Coding (STBC) is used to improve the transmission reliably and spectral efficiency of MIMO systems. When STBC is applied to a cooperative diversity, the system termed as Distributed Space Time Block Code (D-STBC). Most of the existing research assumes perfect synchronization among cooperative users in DSTBC. This means that they have identical timing, carrier frequency, and propagation delay, which is almost impossible to be achieved. The lack of common timing reference can badly influence the performance of the D-STBC system. There are different research efforts to overcome this problem; most of which have high decoding complexity.

Keywords: asynchronous cooperative communication, two-way transmission, Cyclotomic orthogonal space-time block code (COSTBC)

1. INTRODUCTION

Wireless communications are one of the most attractive research areas which have seen enormous growth in the last several years. After the first appeared, in 1897 when Marconi succeeded to contact with ships sailing in the English canal by the radio, wireless communications has experienced many milestones, for example, the use of AM and FM communication systems for radios, and the development of the cellular phone system from its first generation in the 1970s to the fourth generation.

Wireless Communication has been one of the fastest growing technologies so there is a large amount of researches and investment about it, that's due to the emerging applications and services over it. Nowadays, wireless devices in anywhere around us: cell phone, PDA, wireless INTERNET, FM/AM radio, etc.

Figure 1.1: Wireless communication applications.

Instead of long training sequences sent at the beginning of each burst, inserting training symbols throughout the transmission constitutes a popular alternative that is known as pilot symbol-assisted modulation (PSAM) [5]. Acquiring the channel based on the periodically embedded pilots, PSAM is particularly suitable for transmissions over rapidly fading time selective environments. Being also known at the receiver end, pilot symbols are used not only for channel estimation, but also for timing- and frequency-offset synchronization. PSAM has also been suggested for decision-feedback (DF) equalization of block transmissions .The bit-error rate (BER) performance of PSAM with linear minimum mean-square error (LMMSE) estimation of time-selective channels was reported in [5]. Based on BER for BPSK, optimal pilots were designed for direct-sequence code-division multiple-access (DS-CDMA) systems in [19] and for systems with diversity in [20]. However, channel capacity issues with PSAM have not been fully addressed. Certainly, the insertion of pilot symbols reduces the information rate and, thus, reduces the utilization of the channel's capacity.

Distributed Space Time Block Coding:

Space Time Coding is a method employed time and space diversity to improve the reliability of data transmission in wireless communication systems. There are two main categories of space time coding: Space time trellis coding (STTC), and Space–time block codes (STBCs) where they differ in the way of coding process. Coherent and non-coherent are other categories due to another classification. In coherent STC, the receiver knows the channel model, but in non-coherent STC, the receiver does not know the model.

Cooperative Communication

The broadcast property entailed by wireless networks is an important characteristic affecting the optimal communication design for these networks. In a point-to-point communication model different messages received by single users are usually considered to be harmful and treated as interference. However, when multiple nodes re-transmit the same message, broadcasting may become beneficial for network throughput.

A common underlying assumption in earlier literature is the availability of perfect channel state information (CSI) at the relay/ destination receivers. In practical systems, CSI needs to be precisely estimated and can then be used in the detection process. The performance of cooperative communication systems in the presence of imperfect CSI has been recently investigated. These works build on the assumption of a quasi-static fading channel. Time-varying channels are considered only in some sporadic works [8]. In [8], Mheidat and Uysal have deployed pilot-assisted channel estimation and investigated the performance of amplify-and-forward (AF) relaying over time-varying Rayleigh fading channels through simulations and pairwise error probability derivation. In [9], Wu and Pätzold have derived an approximate expression for symbol error probability of AF relaying over time-varying fading channels through the moment generation function approach.

To the best of our knowledge, a detailed performance analysis of decode-and-forward (DF) relaying over time-selective channels has not yet been reported. In this paper, we consider DF relaying and derive a closed-form expression for the bit error rate (BER) over time varying Rayleigh fading channels. We assume the deployment of the pilot-symbol-assisted channel estimation technique. For the sake of presentation, the analysis here is carried for four-state phase-shift keying (4-PSK), but it can be extended to general M-ary quadrature amplitude modulation (M-QAM) with more cumbersome definitions and notations.

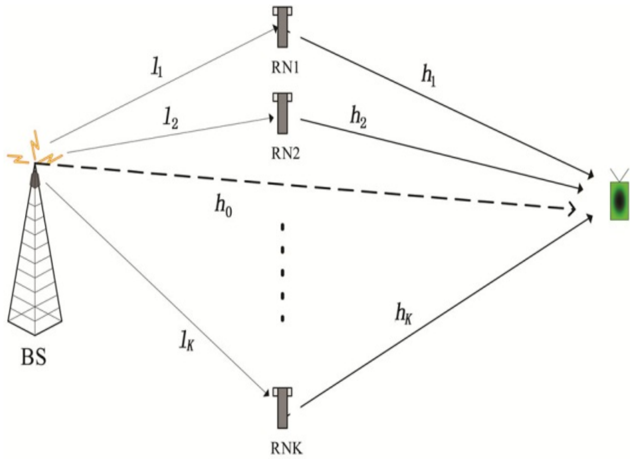

Figure 1.2: Multi-relay cooperative diversity network.

I. 2 LITERATURE REVIEW

Yudong Ma, H. Jiang and S. Du, [1] In this paper, a novel two-way cyclotomic orthogonal space-time transmission scheme (TCOSTS) is designed for asynchronous cooperative systems. In TCOSTS, the two terminals transmit signals to each other simultaneously to double the transmission rate. By exploiting cyclotomic orthogonal space-time block code (COSTBC); this scheme achieves full rate, full diversity and low decoding complexity. Also, higher diversity order is available by employing more relay nodes. Benefiting from OFDM asynchronous system architecture, operations implemented at relay nodes are very simple, and the scheme is tolerant of delays between relay nodes.

Y. Jing and H. Jafarkhani,[2] Distributed space-time coding was proposed to achieve cooperative diversity in wireless relay networks without channel information at the relays. Using this scheme, antennas of the distributive relays work as transmit antennas of the sender and generate a space-time code at the receiver. It achieves the maximal diversity when the transmit power is infinitely large. This paper is on the design of practical distributed space-time codes (DSTCs). We use orthogonal and quasi-orthogonal designs which are originally used in the design of space-time codes for multiple-antenna systems. It is well known that orthogonal space-time codes have full diversity and linear decoding complexity. They are particularly suitable for transmissions in the network setting using distributed space-time coding since their ldquoscale-freerdquo property leads to good performance. Our simulations show that they achieve lower error rates than the random code. We also compare distributed space-time coding to selection decode-and-forward using the

SR. NO.	TITLE	AUTHORS	YEAR	METHODOLOGY
1	Two-way cyclotomic orthogonal space-time transmission scheme for asynchronous cooperative systems	Yudong Ma, H. Jiang and S. Du,	2014	A novel two-way cyclotomic orthogonal space-time transmission scheme (TCOSTS) is designed for asynchronous cooperative systems.
2	Using Orthogonal and Quasi-Orthogonal Designs in Wireless Relay Networks	Y. Jing and H. Jafarkhani	Nov. 2007	Distributed space-time coding was proposed to achieve cooperative diversity in wireless relay networks without channel information at the relays.
3	A Distributed Differential Space-Time Coding Scheme With Analog Network Coding in Two-Way Relay Networks	Q. Huo, L. Song, Y. Li and B. Jiao,	Sept. 2012	Consider general two-way relay networks (TWRNs) with two source and N relay nodes. A distributed differential space time coding with analog network coding (DDSTC-ANC) scheme is proposed.
4	Improving Amplify-and-Forward Relay Networks: Optimal Power Allocation versus Selection	Y. Zhao, R. Adve and T. J. Lim	2006	Consider an amplify-and-forward (AF) cooperative diversity system where a source communicates with a destination with the help of multiple relay nodes.
5	Joint Relay Selection and Power Allocation for Two-Way Relay Networks	S. Talwar, Y. Jing and S. Shahbazpanahi	Feb. 2011	The authors present an optimal joint relay selection (RS) and power allocation scheme for two-way relay networks which aim to establish a communication link between two transceivers with the help of one relay.

Sameorthogonal designs. Simulations show that distributed space-time coding achieves higher diversity than selection decode-and-forward (DF) when there is more than one relay. We also generalize the distributed space-time coding scheme to wireless relay networks with channel information at the relays. Although our analysis and simulations show that there is no improvement in the diversity, in some networks, having channel information at the relays saves both the transmission power and the transmission time.

Q. Huo, L. Song, Y. Li and B. Jiao, [3] in this correspondence, we consider general two-way relay networks (TWRNs) with two source and N relay nodes. A distributed differential space time coding with analog network coding (DDSTC-ANC) scheme is proposed. A simple blind estimation and a differential signal detector are developed to recover the desired signal at each source. The pairwise error probability (PEP) and block error rate (BLER) of the DDSTC-ANC scheme are analyzed. Exact and simplified PEP expressions are derived. To improve the system performance, the optimum power allocation (OPA) between the source and relay nodes is determined based on the simplified PEP expression. The analytical results are verified through simulations.

Y. Zhao, R. Adve and T. J. Lim, [4] we consider an amplify-and-forward (AF) cooperative diversity system where a source communicates with a destination with the help of multiple relay nodes. The conventional system assumes all relay nodes participate, with the available channel and power resources equally distributed over all nodes. This approach being clearly sub-optimal, we first present an optimal power allocation scheme to minimize the outage probability for an AF system. Next, we propose a new selection scheme where only one, the "best" relay node is chosen to participate in the transmission. We show that at reasonable power levels the selection AF scheme maintains full diversity order, and has significantly better outage behavior and average throughput than the conventional scheme or that with optimal power allocation

S. Talwar, Y. Jing and S. Shahbazpanahi,[5] In this letter, the authors present an optimal joint relay selection (RS) and power allocation scheme for two-way relay networks which aim to establish a communication link between two transceivers with the help of one relay. Our approach is based on the maximization of the smaller of the received signal-to-noise-ratios (SNRs) of the two transceivers under a total transmit power budget. We show that this problem has a closed-form solution and requires only a single integer parameter (i.e, the index of the optimally selected relay) to be broadcasted to all relays. We also show that for large values of the total transmit power, the selection criterion can be approximated as the harmonic mean of the amplitudes of the relays' local channel coefficients. We evaluate the performance of our scheme numerically.

I. Maric and R. D. Yates, [6] Achievable rates with amplify-and-forward (AF) and decode-and-forward (DF) cooperative strategies are examined for relay networks. Motivated by sensor network applications, power-constrained networks with large bandwidth resources and a large number of nodes are considered. It is shown that AF strategies do not necessarily benefit from the available bandwidth. Rather, transmitting in the optimum AF bandwidth allows the network to operate in the linear regime where the achieved rate increases linearly with the available network power. The optimum power allocation among the AF relays, shown to be a form of maximal ratio combining, indicates the favorable relay positions. Orthogonal node transmissions are also examined. While the same optimum bandwidth result still holds, the relay power allocation in this case can be viewed as a form of water-filling. In contrast, the DF strategy will optimally operate in the wideband regime and is shown to require a different choice of relays. Thus, in a large scale network, the choice of a coding strategy goes beyond determining a coding scheme at a node; it also determines the operating bandwidth, as well as the set of relays and best distribution of the relay power.

3 PROBLEM IDENTIFICATION

Based on COSTBC for MIMO systems, we have designed a novel transmission scheme (TCOSTS) for asynchronous cooperative systems. In TCOSTS, transmission rate is doubled, and diversity order can be expanded according to the number of relay nodes employed. Due to the asynchronous OFDM architecture, delays shorter than l_{cp} will not damage TCOSTS’s reliability, and relay nodes only implement very simple operations on received signals. Simulation results demonstrate that BER performance of TCOSTS is close to the optimum level represented by DRQOSTBC for synchronous systems, and far better than clustered DAlamouti for asynchronous systems which only achieve diversity order 2.

4 CONCLUSION

Because of the growing demand for high data rates in wireless communication systems, array-based transceivers and space diversity methods have recently become an intensive area of research. It has been shown both analytically and using field tests that in rich scattering environments, multiple input multiple-output (MIMO) techniques can greatly increase the capacity of wireless systems. However, to use the advantages that MIMO systems can offer, accurate channel state information (CSI) is required at the transmitter and/or receiver. For example, the performance of transmit beam forming is entirely determined by the accuracy of the CSI at the transmitter. If space-time coding is used, then the availability of an accurate CSI at the receiver is crucial for the performance of space-time decoders. Therefore, accurate channel estimation plays a key role in MIMO communications.

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