An Extensive Review on Phase-Precoding Scheme for Cooperative Wireless Systems

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Abstract- In recent years mobile communications have known great technological developments that have had important social and economical impacts. This importance has resulted, among many other things, in an exponential growth of the number of wireless devices as well as in increasingly richer multimedia applications which have leading these devices to require higher and higher data rates. These trends, combined with the fact of a limited spectrum, point to the conclusion that interference between devices will be one of the dominant bottlenecks in wireless networking. Precoding, a key element of MIMO techniques, is one way to mitigate the interference between different data streams. It is a generalization of beamforming that can support transmission for multiple streams in multi-antenna communication systems. Beamforming is a powerful technique to increase the link signal-to-noise ratio (SNR) through focusing the energy into desired direction. It is achieved when the transmit antennas are appropriately weighted in gain and phase for each transmission stream. In the case of multiple data streams, precoding generally combines the streams in orthogonal directions using weighting matrices according to the channel distribution. With channel status fully known at the transmitter and receiver, interference between different data streams could be limited by using a suitable precoding algorithm, resulting in higher data throughput.

Keywords- Precoding, Frequency Selective Channel,Cooperative system, MIMO, Signal to Noise Ratio.

I. INTRODUCTION

Due to the broadcast nature of wireless transmission, signals dedicated to one user will be overheard by its neighbors. When users do not cooperate, as is usually the case in current systems, such overheard signals degrade the quality of the desired signal and therefore are treated as interference. Ever since the birth of wireless communication about one hundred years ago, numerous research efforts have been devoted to formulate a virtual point-to-point connection between source and destination nodes by suppressing the interference. As illustrated in Figure 1.1, interference signals originating from parallel transmission in the neighborhood can be deliberately suppressed by scheduling such parallel transmission at different time slots, frequency bands, spacial direction, or with different (preferably orthogonal) digital sequences. The spectrum and energy efficiency of such point-to-point wireless connection has been constantly improved via new innovations in antenna design, signal processing, and modulation and coding design. As the throughput of the point-to-point wireless connection is approaching its theoretical limit, it be- comes harder and harder to meet the ever growing data rate requirement by further improving the spectrum and energy efficiency.

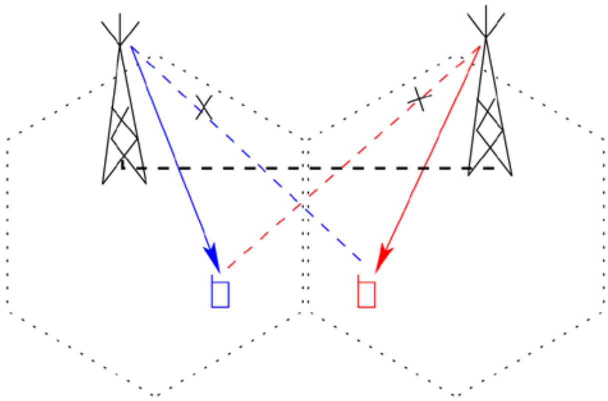

Figure 1.1 Conventional wireless communication system.

To overcome such difficulties, the broadcast nature of wireless transmission has to be taken into consideration during the design and innovation of wireless communication techniques. The overheard signal, although appears destructive to one user, might be helpful for another user nearby if the two users are allowed to co-operate. When users can cooperate, the destructive interference signal becomes a valuable resource and therefore can be utilized to assist the decoding of desired signals, leading to higher energy efficiency. Besides, cooperation allows parallel transmission over the same channel and hence has the potential to greatly increase the spectrum efficiency. Such communication scheme is named cooperative communication to differentiate from the traditional point-to-point communication scheme.

The cooperation can be carried out among source nodes, among destinations, and with aid from dedicated relay nodes, as illustrated in Figure 1.2. The cooperation among wireless access points (base stations) can be realized via the widely deployed backhaul connection, either fiber or microwave, and the cooperation among user terminals can be achieved via device-to-device communication channels. Although dedicated relay nodes, known as repeaters, have been introduced to assist long distance wireless transmission around one hundred years ago shortly after the invention of triode vacuum tube, relays with more advanced functionality were not considered for commercial deployment until several years ago.

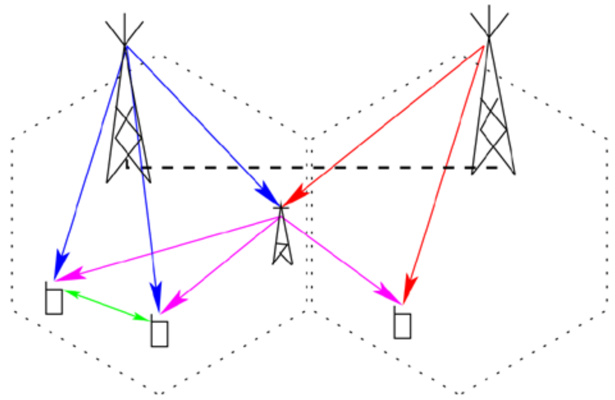

Figure 1.2dedicated relay node based cooperative communicationsystem

Dedicated relay nodes have been adopted in the next generation wireless communication systems, such as in the Long-Term Evolution Advanced (LTE-Advanced) standard, which are expected to come into commercial deployment within a few years. Relay nodes with advanced functionality will continue to play an important role in the future communication systems.

II. PRECODING SCHEME

For broadcast channels (BC) in FBWA, where a BS communicates with multiple users, OFDMA or single-carrier modulation may be combined with MIMO systems to combat inter-symbol interference and to provide high data rates as well as improved reliability. The absence of mobility in fixed wireless systems allows channels to be modeled as time-invariant over a long period. Channel estimation at the receivers and high-quality feedback of these estimates to the BS is therefore possible. This enables the implementation of various transmitter precoding techniques.

The main difficulty in MIMO channels is the separation of the data streams which are sent in parallel. In the context of the multiple access channels, this task is called multiuser detection.

Precoding or pre-equalization of the transmitted signals for MIMO systems. This type of processing at the transmitter requires the channel state information (CSI) at the transmitter. In order to be able to obtain CSI at the transmitter, the channel should be fixed (non-mobile) or approximately constant over a reasonably large time period. If CSI is available at the transmitter, the transmitted symbols, either for a single-user or for multiple users, can be partially separated by means of pre-equalization at the transmitter.

a. MIMO Single-user Systems

A MIMO channel can be described by a very basic model as $y = Hx + v$, where x, y are the transmit and receive signal vector respectively, v represents the receive noise, and H is the $r \times t$ MIMO channel. In a zero-forcing receiver, the transmit data signals are detected by multiplying the received signal vector by the pseudo inverse of the channel matrix.

For this, the number of receive antennas should be greater than or equal to the number of transmit antennas. It is well known that zero-forcing equalization suffers from noise enhancement. To overcome this deficiency, decision-feedback equalization (DFE) can be applied at the receiver. In DFE, the symbols are detected sequentially. After each symbol is detected, it is cancelled out before the next symbol is detected, therefore DFEsuffers from error propagation.

b. MIMO Multiuser Systems

A multiuser downlink channel can be also modelled as $y = Hx + v$, while H is the overall downlink channel matrix, and y includes the received signals for all users. However, since the receivers are not collaborating, joint processing of the vector y is not possible, and consequently the schemes proposed for single-user systems may not be applicable.precoding is generalized beamforming to support multiple streams transmission in a multi-antenna communication system through focusing the energy into desired direction. Its functionality is to mitigate the interference between different streams.Figure 2.1 shows the role of precoding in a 2X2 MIMO system.

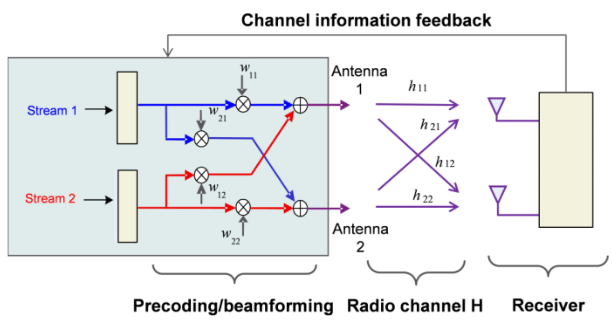

Figure 2.1 Precoding in 2X2 MIMO.

Assuming two independent data streams are sent from the transmitter, after precoding, the two streams are mixed to each other with precoding weights and then transmitted from different antennas. Hence, beamforming is formed. In the receiver, the received data streams are decoded by using decoding methods that corresponds to the transmitter and channel condition. In the meantime, the feedback from the receiver about channel information through channel estimation will be sent to the transmitter to select the suitable precoder.

III. RELATED WORK

SR. NO.	TITLE	AUTHORS	YEAR	APPROACHES
1	Relay-Assisted OFDM for Ultraviolet Communications: Performance Analysis and Optimization,	M. Haghighi Ardakani and M. Uysal,	2017	The powerful combination of relay-assisted transmission and multi-carrier architecture based on orthogonal frequency division multiplexing (OFDM).
2	Phase-precoding scheme for cooperative wireless systems over frequency-selective channels	M. Ayedi, N. Sellami and M. Siala,	2016	An efficient precoding technique for cooperative wireless systems has reported
3	Complex field network coding with OFDM in distributed wireless networks	R. Khan, G. K. Kurt and İ. Altunbaş,	2016	A thorough analysis of CFNC in distributed wireless networks, combined with OFDM. Different relaying schemes
4	Cooperative space-time block coded full-duplex relaying over frequency-selective channel	S. Jeon, J. S. Han, J. M. Choi and J. S. Seo	2015	Investigate a distributed time-reversal space-time block coded (D-TR-STBC) system with amplify-and-forward full duplex relaying (FDR)
5	A limited-feedback-based optimal precoding algorithm for OFDM multi-relay networks	D. Zhou and B. Hu	2014	In order to reduce the feedback load of OFDM-based wireless systems, a practical limited bits feedback precoding algorithm is proposed
6	SLNC for Multi-Source Multi-Relay BICM-OFDM Systems	T. Islam, R. Schober, R. K. Mallik and V. Bhargava	2014	A mapping based symbol level network coding (SLNC) scheme for a cooperative diversity system comprising multiple sources, multiple relays, and one common destination.
7	Simple wireless cooperative system to enhance the channel capacity in microcell scenarios	I. Sousa, M. P. Queluz and A. Rodrigues	2013	The use of a simple wireless cooperative system based on Multiple-Input Multiple-Output (MIMO) spatial multiplexing

M. Haghighi Ardakani and M. Uysal,[1] Ultraviolet (UV) communication enables non-line-of-sight (NLOS) outdoor wireless connectivity and is particularly desirable to relax or eliminate pointing and tracking requirements of infrared links. In comparison to infrared counterparts, UV links are subject to relatively higher path loss as well as intersymbol interference resulting from frequency selective nature of the channel. In this work, reported the powerful combination of relay-assisted transmission and multi-carrier architecture based on orthogonal frequency division multiplexing (OFDM). Specifically, it considers a cooperative diversity system with orthogonal cooperation protocol and use DC-biased optical OFDM as the underlying physical layer. Consider both amplify-and-forward (AF) and detect-and-forward (DF) relaying. Investigate the error rate performance of the proposed relay-assisted OFDM UV system under consideration and demonstrate performance gains over point-to-point OFDM UV systems. Further determine optimal power allocation schemes to improve the performance. Alsoreported a variable-rate UV OFDM system and improve system throughput via bit loading.

M. Ayedi, N. Sellami and M. Siala, [2] In this work, reported an efficient precoding technique for cooperative wireless systems. The technique aims to reduce the effect of Inter-Symbol Interference (ISI) in cooperative transmissions over frequency-selective channels between two sources nodes, one relay node and one destination node. At each source node, a phase-precoding scheme that changes the phases of the transmitted symbols is applied. At the relay node, received sources sequences are detected, precoded and combined using the Digital Network Coding (DNC) scheme. The destination node uses both direct received signals and relayed signals to estimate the source sequences. For the detecting scheme at the relay and the destination nodes, to use a linear filtering equalization based on Minimum Mean-Square Error (MMSE) criterion has reported. Simulation results show that the proposed precoding technique enhances the Bit Error Rate (BER) performance compared to the non-precoded system.

R. Khan, G. K. Kurt and İ. Altunbaş,[3]Cooperative diversity method is a major way to significantly increase the capacity of multi-source distributed wireless networks with improved coverage. On the other hand, complex field network coding (CFNC) helps mitigate the spectral efficiency loss incurred by traditional relaying schemes in larger networks. Considering the frequency selective fading nature of wireless channels, it would be a practical approach to combine orthogonal frequency division multiplexing (OFDM) with CFNC in wireless relay networks. Therefore, in this exploration, make a thorough analysis of CFNC in distributed wireless networks, combined with OFDM. Different relaying schemes such as amplify and forward (AAF) and decode and forward (DAF) are used for evaluating the system performance. Moreover, it also consider relay selection technique with both AAF and DAF schemes. Simulation results are presented for uncoded and convolutionally coded relaying schemes for CFNC when OFDM is incorporated in the given setup.

S. Jeon, J. S. Han, J. M. Choi and J. S. Seo, [4]In this study, the investigate a distributed time-reversal space-time block coded (D-TR-STBC) system with amplify-and-forward full duplex relaying (FDR) over frequency-selective channel. In the first, they present an FDR to use in a cooperative D-STBC relaying in which a relay transmits the delayed signal as much as one frame in order to maintain the orthogonal property of STBC at the destination. Then, they briefly present the conventional full self-interference cancellation (SIC) which continuously removes the self-interference signal. As an alternative to the full SIC, they further introduce a partial SIC that periodically performs the SIC process. As a result, it can reduce cancellation processing by a half time compared to the full SIC. In the second, they propose the efficient and yet optimal destination structure consisting of the forward interference cancellation (IC), backward IC and joint equalisation and data combining in order to obtain a full coding gain. It is shown that the proposed D-TR-STBC-FDR system has ~3 dB signal-to-noise ratio gain compared to cooperative half-duplex relaying with D-TR-STBC while it has the same diversity order. In addition, they show that there are no performance losses between FDR with full SIC and FDR with partial SIC.

D. Zhou and B. Hu,[5]Based on amplify-and-forward cooperative relay under frequency selective fading channels, in order to reduce the feedback load of OFDM-based wireless systems, a practical limited bits feedback precoding algorithm is proposed. Using matrix decomposition method, precoding matrices are designed. The source node precoding need only one precoding matrix per OFDM frame. Source precoder and relay precoder are jointly optimized and quantified. The precoding matrix index is fed back for Clustered subcarrier of OFDM. The algorithm achieves precoding matrices at source and relay nodes with limited feedback. Simulations indicate that the proposed method can improve bit-error-rate performance. The bit error rates are also compared with different relay number.

T. Islam, R. Schober, R. K. Mallik and V. Bhargava,[6]In this exploration, study the application of bit-interleaved coded modulation (BICM) and orthogonal frequency division multiplexing (OFDM) to reap the benefits of wireless multiuser network coding in practical frequency-selective fading channels. A mapping based symbol level network coding (SLNC) scheme for a cooperative diversity system comprising multiple sources, multiple relays, and one common destination has reported. A simple cooperative maximum-ratio combining scheme is used at the destination and is shown to successfully exploit both the full spatial and the full frequency diversity offered by the channel for arbitrary numbers of sources, arbitrary numbers of relays, and arbitrary linear modulation schemes. To gain analytical insight for system design, derive a closed-form upper bound for the asymptotic worst-case pairwise error probability (PEP) and obtain the diversity gain of the considered SLNC scheme for BICM-OFDM systems. These analytical results reveal the influence of the various system parameters, such as the number of sources, the free distance of the code, and the frequency diversity of the involved links, on performance. Furthermore, reported two different relay selection schemes for the considered system: a) bulk selection, i.e., a single best relay is selected to transmit on all sub-carriers, and b) per-subcarrier selection, where a best relay is selected on each sub-carrier. Last but not least, exploit the derived PEP expression for selecting a subset of sources from the set of active sources when the number of active sources is larger than the number of available orthogonal relay channels. Study the achievable diversity gain for the proposed relay and source subset selection schemes. Numerical results corroborate the derived diversity gain expressions and confirm the performance gains.

I. Sousa, M. P. Queluz and A. Rodrigues,[7]In this exploration discuss the use of a simple wireless cooperative system based on Multiple-Input Multiple-Output (MIMO) spatial multiplexing, in order to enhance the channel capacity of single antenna and multiple antenna terminals in microcellular systems. The proposed cooperative system is envisioned for technology that is already available on the market, it can be implemented in a transparent manner to the cellular network and it can be used both in the downlink and in the uplink. Also a simple, fast and distributed scheme to select a good relay within the cooperative system has reported. The study is performed using a simulator that generates realistic frequency-selective channel realizations for a microcell environment. The simulation results show that the proposed cooperative system plus the relay selection scheme accomplish the goal of enhancing the channel capacity for all the considered situations.

IV. PROBLEM STATEMENT

Currently there are a number of research achievements in precoding algorithm studies. However, most of these are based on the flat-fading assumption, i.e., similar fading characteristic for different frequency components of the signal. As a wideband transmission signal likely suffers a frequency-selective channel that gives different characteristics among frequency signal components, the methods mentioned above are inapplicable in WCDMA. Some other researchers stated methods that can solve the frequency-selective problem. Nevertheless, those methods are usually too complex to be implemented in practical system.

Another problem is the additional overhead caused by extra information feedback in a real MIMO system. In wireless communications, channel state information (CSI) refers to channel properties of a communication link that represents the combined effect of scattering, fading, power decay with the distance, etc. in a channel.

V. CONCLUSION

This brief presents an extensive survey of literature onphase-precoding scheme for cooperative wireless systems.Currently, with a rapidly increasing trend of video on demand traffic like YouTube, on-line games like Minecraft and streaming video/audio like Netflix and Spotify, there is a need for smart and efficient communication systems in terms of power and spectrum. Since spectrum is expensive and limited, it is essential to use spectrum more efficiently. There are a variety of methods to increase spectral efficiency, for example, using a higher order modulation scheme. Multiple antenna is an alternative technique.Relaying-based cooperative communication techniques have the potential to boost both the communication range and data rate. In this exploration recent work on cooperative communication system and precoding scheme has reported and analyzed.

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