An Extensive Review on Relaying Schemes for Multiuser Cooperative Systems

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Abstract- High data rates and quality of service are the demands of the explosive market of the future wireless communication. The multiple input multiple output (MIMO) technique is an emerging technology that dramatically increases the spectral efficiency and capacity of wire- less systems. This system utilizes arrays of antenna components at both the transmitting and reception terminal. The cooperative UWB is receiving prevalence in wireless communication systems because of its advantages of higher data rates utilizing the concept of virtual MIMO. However, it is extremely bulky to design the receiver because of the tremendous data transfer limit of UWB systems. The significant issue that emerges in designing the receiver is the conversion of analog signal to digital over the entire data transmission. Finding a strategy for cooperative UWB communication framework that gives better execution as well as BER, system complexity and power utilization is a challenging task. In this work an extensive survey of literature on multiuser UWB MIMO systems has given in this brief.

Keywords- MIMO, Relaying Schemes, UWB, Wireless Communication.

I. INTRODUCTION

The conventional cellular architecture appears incapable of delivering the ubiquitous high data-rate coverage expected of the future generation of wireless systems. The intended cover- age, quality of service and transmission rates of these systems is order of magnitude higher than that supported by the present generation systems. Therefore, there are excessive expectations put on certain communication resources such as scarce radio spectrum and the link budget. Even the recent advances in antenna technologies (such as smart antennas and MIMO systems) and signal processing techniques (such as advanced channel coding methods) alone do not seem sufficient to alleviate the potential stress that is caused to the link budget

Numerous modern technological applications are now substantially reliant on wireless communication systems which will soon become a commodity similar to the electricity. The application scenarios require various advances in wireless systems such as higher data rates, larger coverage areas, more reliable communication, smaller latency, and less complex designs with lower power and processing requirements. In particular for mobile technology, it is predicted that the number of mobile devices will exceed the world population over the next few years [1]. This is already one of the primary contributors of global wireless traffic growth. Traffic will further increase as future mobile devices will possess more sophisticated features compared to early generation devices. These challenges are tackled, e.g. by reducing cell size, which allows reusing the limited frequency spectrum in a more efficient manner. The ultimate goal of this is to bring the wireless devices as close as possible to infrastructure.

Telecommunication plays a very vital role by bridging gap between people hence turning the world into global village. The tremendous growth in wireless communication has changed the lifestyle of people by making it an essential part of everyday life. As the wireless technology grows, the need of higher capacity, faster and more secure service grows day by day. To fulfill the requirements different technologies are being introduced every now and then. One of those technologies is UWB that fulfills most of these demands by using a large amount of channel bandwidth i.e. 500 MHz to transmit and receive data. On the other hand cooperative communication is a term, used for different techniques which are being employed for achieving transmit diversity for a single antenna mobile user in a multiuser environment i.e. creating virtual MIMO. When UWB combines with cooperative communication, it increases the data rate without compromising any of the above mentioned features. However, many technical challenges still remain in designing robust wireless systems that deliver the performance necessary to support emerging applications.

The inadequacy of the conventional cellular architecture requires a fundamental change in the way systems are designed and deployed as well as novel signal processing techniques. One of the promising strategies is the incorporation of multihop capability in the current wireless networks. This is believed to be the most feasible architectural upgrade towards delivering almost ubiquitous high data rate coverage. Due to the cost-effectiveness of this approach.

A new wireless technology that is able to support multiple high data rate streams, consume very low power, and maintain low implementation cost. Ultra-wideband (UWB) is one of the emerging technologies that can fulfill these requirements. The enormous bandwidths available, the potential for the data rate, and the potential for very low cost operation makes UWB technology a viable candidate for current and future wireless applications. Nevertheless, to fulfill these expectations, UWB re- search and development has to cope with several design challenges that limit the performance and coverage range of UWB systems.

Conveying information with ultra-short duration waveforms, UWB signals have low susceptibility to multipath interference. Multipath interference occurs when a modulated signal arrives at a receiver from different paths. The combining of signals at the receiver can result in the distortion of the received signal. The ultra-short duration of UWB waveforms gives rise to a fine resolution of reflected pulses at the receiver. As a result, UWB transmissions can resolve many paths, and are thus rich in multipath diversity.

The low complexity and low cost of UWB systems arises from the carrier-free nature of the signal transmission. Specifically, due to its ultra wide bandwidth, the UWB signal may span frequency commonly used as carrier frequency. This eliminates the needs for an additional radio frequency (RF) mixing stage as required in conventional radio technology.

In conventional RF technology, MIMO has been well known for its effectiveness of improving system performance in fading environments. Space-time (ST) coded MIMO systems.

The main concept is the joint processing in time as well as in space via the use of multiple transmits and receives antennas, so as to achieve both spatial and temporal diversity. When the fading channel is frequency-selective, space-frequency (SF) coded MIMO-OFDM systems have been shown to be an efficient approach to make benefits of spatial and frequency diversity.

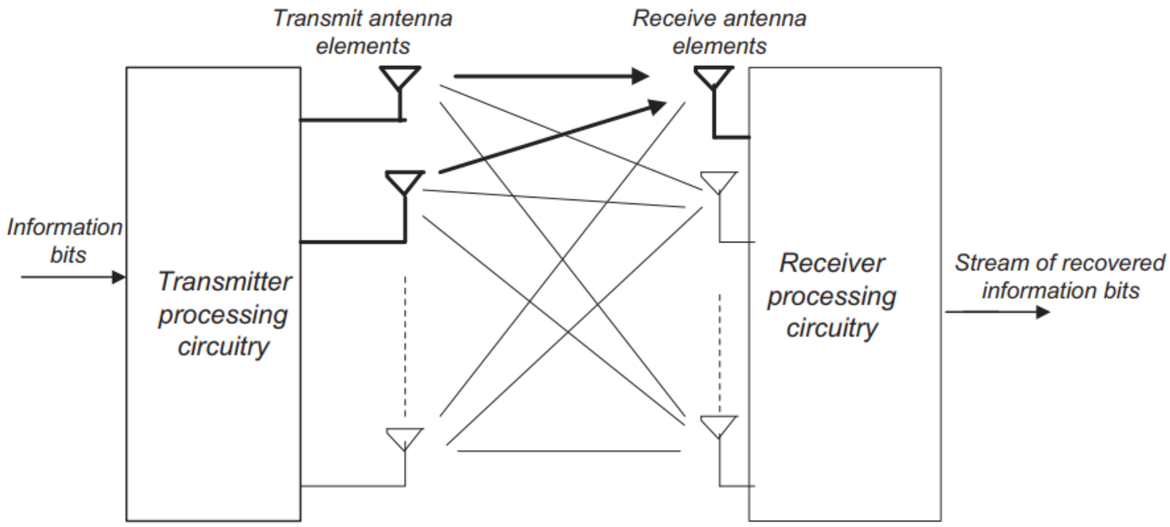

Figure 1.1 A MIMO communication systems.

In a point-to-point MIMO system, multiple antennas are deployed at both transmitter and receiver, as shown in Fig. 1.1. These symbol streams are modulated with a pulse shaping function, translated to the passband via parallel RF chains, and then simultaneously transmitted over all transmit antennas. After down conversion, matched-filtering and demodulation processes, the receiver jointly decodes the received signals across all receive antennas.

II. COOPERATIVE WIRELESS NETWORK

In Cooperative communication, introduction of relay channel generates few more independent paths between source and destination along with the direct link. The total communication process occurs in two stages namely broadcasting stage and cooperating stage.

In broadcasting stage, Source sends its information to destination via a transmission medium. But due to openness of wireless network, relay and eavesdropper overhears the source information.

In cooperating stage, Relay processes the received source signal, using one of the cooperating relaying schemes and it sends the processed signal to its legitimate receiver. At the same time jammer generates the artificial noise to reduce the channel capacity of source to eavesdropper link.

The main aspect of this cooperative communication is processing of the received source signal done by the relay. These different processing schemes at relay, leads to different cooperative relaying protocols.

Cooperative communication schemes are generally categorized into two types:

- Fixed relaying scheme.
- Adaptive relaying scheme.

In Fixed relaying scheme, all the resources of channel are shared between source and relay in a fixed manner. Processing at the relay differs for each protocol. In fixed amplify and forward (AF) relaying, relay simply forwards the received source signal to destination where as in fixed decode and forward (DF) relaying, relay decodes the arrived information signal, re-encode it and sends to legitimate receiver. Implementation of fixed relaying schemes is easier but the efficiency of bandwidth is low because of sharing, half of resources of channel to relay. If the source-legitimate receiver link is more, sharing half of resources to relay becomes useless since the source can send its information signal to destination directly.

After receiving the information signal from the source, relay uses cooperating relaying schemes to process the signal. Elemental cooperating relaying schemes to transmit the information signal to the destination are Decode and Forward (DF) and Amplify and Forward (AF). In addition to these two relaying schemes, Cooperative jamming is used by the relay, to produce artificial interference to confound the eavesdropper.

a. Decode and Forward (DF)

In decode and Forward (DF) relaying scheme, relay first decodes the received source signal, then re- encode it and forwards to the destination. When the signal to noise ratio of the received source signal exceeds a certain threshold value, relay can perfectly decode the signal.

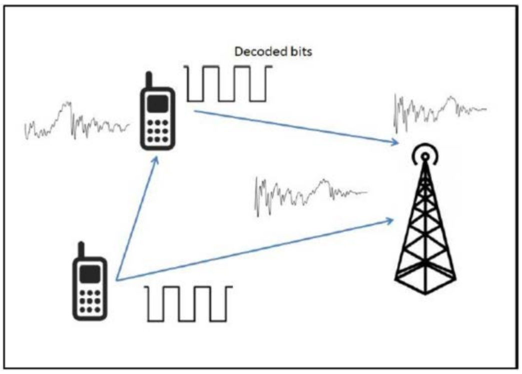

Figure 2.1 Decode and Forward (DF) Relaying Scheme.

b. Amplify and Forward (AF)

In Amplify and Forward (AF) relaying protocol, relay first amplifies the received information signal and then forwards to the destination. But the disadvantage with AF relaying is, it also amplifies the noise signal along with the information signal.

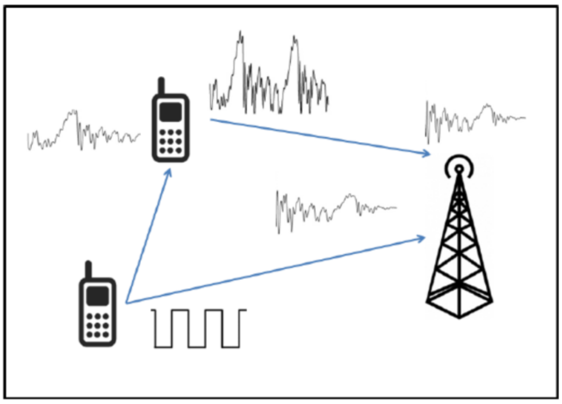

Figure 2.2 Amplify and forward relaying Scheme.

III. LITERATURE REVIEW

SR. NO.	TITLE	AUTHOR	YEAR	APPROACH
1	Code-Multiplexing-Based One-Way Detect-and-Forward Relaying Schemes for Multiuser UWB MIMO Systems	A. A. D'Amico,	2017	Decode-and-forward (DF) one-way relaying schemes utilized for multiuser impulse-radio ultrawideband (UWB) communications
2	UWB MIMO array design for medical applications,	D. Ziani, S. M. Meriah and L. Merad,	2016	A MIMO array design with a reduced number of antennas of a 2×5 combination with 2 transmitting antennas and 5 receiving antennas
3	A novel CPW fed UWB-MIMO antenna with modified ground structure,	P. Sharma, K. Vyas and R. P. Yadav,	2016	Two planar UWB MIMO antenna arrays designed from a compact novel CPW fed UWB antenna
4	Detect and forward based two-way relay systems with maximum-ratio transceivers,	Y. Şahin, E. Erdoğan and T. Güçlüoğlu,	2015	A two-way communication system that uses maximum ratio transceivers proposed to provide reliable and low complexity communication
5	Performance analysis of Amplify Quantize and Forward Relaying in Network Coded based system at various relay locations,	S. Saleem, A. Rahman, I. Khan, S. Jan and T. Muhammad	2015	Examines the performance of Network Coded (NC) based cooperative network for different relays location over Rayleigh fading channels
6	Spectral and Energy Spectral Efficiency Optimization of Joint Transmit and Receive Beamforming Based Multi-Relay MIMO-OFDMA Cellular Networks	K. T. K. Cheung, S. Yang and L. Hanzo,	2014	For the sake of improving the SE/ESE performance attained, the SMCs are grouped using a pair of proposed grouping algorithms
7	Generalized Code-Multiplexing for UWB Communications	Q. Zhou, X. Ma and V. Lottici,	2013	A generalized code-multiplexing (GCM) system based on the formulation of a constrained mixed-integer optimization problem

A. A. D'Amico,[1] In this work consider decode-and-forward (DF) one-way relaying schemes for multiuser impulse-radio ultrawideband (UWB) communications. assume low-complexity terminals with limited processing capabilities and a central transceiver unit (i.e., the relay) with a higher computational capacity. All nodes have a single antenna differently from the relay in which multiple antennas may be installed. In order to keep the complexity as low as possible, the work concentrate on noncoherent transceiver architectures based on multiuser code-multiplexing transmitted-reference schemes. Propose various relaying systems with different computational complexity and different levels of required channel knowledge. The proposed schemes largely outperform systems without relay in terms of both bit error rate (BER) performance and coverage.

D. Ziani, S. M. Meriah and L. Merad, [2] this work presents a MIMO array design with a reduced number of antennas of a 2×5 combination with 2 transmitting antennas and 5 receiving antennas. The system is designed to have a compact size for UWB microwave imaging in medical application. A suitable compact UWB antenna is designed with a fractional bandwidth of more than 128%, which achieves good UWB performances. The mutual coupling within the array is investigated and the numerical results show the accuracy of the designed system for the medical applications.

P. Sharma, K. Vyas and R. P. Yadav,[3] This investigation presents two planar UWB MIMO antenna arrays designed from a compact novel CPW fed UWB antenna. The first MIMO antenna is made with lateral placement of the two proposed UWB antennas and second MIMO antenna is made with orthogonal placement of two UWB antennas and both MIMO antennas covers the entire UWB frequency band. The first MIMO antenna with lateral placement operates in frequency range from 2.7 GHz to 12.5 GHz and second MIMO antenna with orthogonal placement of antennas operates in 2.8 GHz to 13.1 GHz band. The designed MIMO antennas have volume of 54 × 30 × 1.6 mm3 for lateral placement and 61 × 30 × 1.6 mm3 for orthogonal placement. Both antennas have satisfactory performance in terms gain, radiation pattern, return loss, voltage standing wave ratio, envelope correlation coefficient and diversity gain for UWB MIMO application.

Y. Şahin, E. Erdoğan and T. Güçlüoğlu,[4] In this exploration, a two-way communication system that uses maximum ratio transceivers proposed to provide reliable and low complexity communication, and its symbol error rate over Nakagami-m fading channels is studied. Detect and forward technique is used at the relay which transmits re-modulated combined source signals to receivers having multiple antennas.

S. Saleem, A. Rahman, I. Khan, S. Jan and T. Muhammad,[5] This work examines the performance of Network Coded (NC) based cooperative network for different relays location over Rayleigh fading channels. The comparisons of Amplify Quantize and Forward (AQF), Amplify and Forward (AF), Decode and forward (DCF) and Detect and Forward (DTF) protocols for the proposed system are explained. The relays performance in AQF, AF, DCF and DTF is studied in terms of Bit Error Rate (BER) vs Signal to Noise Ratio (SNR). Matlab software is used to build Monte-Carlo link level simulation. The effect of relays at different position in Rayleigh flat fading channel along with Additive White Gaussian noise is studied. BPSK modulation scheme is used for the transferring information.

K. T. K. Cheung, S. Yang and L. Hanzo,[6] In this work first conceive a novel transmission protocol for a multi-relay multiple-input-multiple-output orthogonal frequency-division multiple-access (MIMO-OFDMA) cellular network based on joint transmit and receive beamforming. Then address the associated network-wide spectral efficiency (SE) and energy spectral efficiency (ESE) optimization problems. More specifically, the network's MIMO channels are mathematically decomposed into several effective multiple-input-single-output (MISO) channels, which are essentially spatially multiplexed for transmission. Hence, these effective MISO channels are referred to as spatial multiplexing components (SMCs). For the sake of improving the SE/ESE performance attained, the SMCs are grouped using a pair of proposed grouping algorithms. The first is optimal in the sense that it exhaustively evaluates all the possible combinations of SMCs satisfying both the semi-orthogonality criterion and other relevant system constraints, whereas the second is a lower-complexity alternative. Corresponding to each of the two grouping algorithms, the pair of SE and ESE maximization problems are formulated, thus the optimal SMC groups and optimal power control variables can be obtained for each subcarrier block. These optimization problems are proven to be concave, and the dual decomposition approach is employed for obtaining their solutions. Relying on these optimization solutions, the impact of various system parameters on both the attainable SE and ESE is characterized. In particular, demonstrate that under certain conditions the lower-complexity SMC grouping algorithm achieves 90% of the SE/ESE attained by the exhaustive-search based optimal grouping algorithm, while imposing as little as 3.5% of the latter scheme's computational complexity.

Q. Zhou, X. Ma and V. Lottici, [7] Code-multiplexed transmitted reference (CM-TR) and code-shifted reference (CSR) have recently drawn attention in the field of ultra-wideband communications mainly because they enable noncoherent detection without requiring either a delay component, as in transmitted reference, or an analog carrier, as in frequency-shifted reference, to separate the reference and data-modulated signals at the receiver. In this exploration, reported a generalized code-multiplexing (GCM) system based on the formulation of a constrained mixed-integer optimization problem. The GCM extends the concept of CM-TR and CSR while retaining their simple receiver structure, even offering better bit-error-rate performance and a higher data rate in the sense that more data symbols can be embedded in each transmitted block. The GCM framework is further extended to the cases when peak power constraint is considered and when inter-frame interference exists, as typically occurs in high data-rate transmissions. Numerical simulations performed over demanding wireless environments corroborate the effectiveness of the proposed approach.

IV. PROBLEM IDENTIFICATION

Multiple antennas at the transmitter and/or at the receiver can be effectively used in UWB systems [1] to overcome the difficulties due to the strict limitations on the average power spectral density (PSD) of the transmitted signals imposed by regulatory authorities. Relay communications can be used in conjunction with MIMO technology to improve the reliability and coverage of wireless systems. The information received at the relay is then forwarded to the terminals (which act like destination nodes) in the second phase. Since all the terminals know their own transmitted data, they can remove the self-interference from the received signal provided that the required channel state information is available. The proposed schemes in [1] are not intended to be used in a system with a high number of users. This means that even the optimal detectors can be implemented with reasonable complexity (in particular OD- PCK). On the other hand, when the number of antennas increases the performance of the low-complexity schemes (in particular DMD-CEK) approaches that of the optimal detector. This means that, with a high number of antennas, DMD- CEK provides a good trade-off between performance and complexity, if the length of the code sequences is sufficiently high to limit the multi-user interference.

V. CONCLUSION

An extensive survey of literature on UWB MIMO system has been presented in this work. Multi-antenna techniques are well-known for improving the performance of wireless systems usually without an increase in bandwidth and excellent power savings. Space, cost, and signal processing constraints, among others, prevent the use of a large number of antennas at wireless terminals. In conventional communication system, data transmission between source and destination node is done without any assistance by different users operating in the same wireless communication network. However, these neighboring nodes could be of great use as they can enhance the performance of the wireless system by assisting each other. In the past, the relays have been used to extend the range of wireless networks but recently different novel applications of relay communication have been emerged. The recent revolutionary application is to assist the neighboring node available in the wireless network by using different cooperative protocols.

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