Low Complex Spatial Diversity Detect and Forward Relaying Scheme with Efficient Combining for UWB Systems

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Abstract - A development of C-MRC for cooperative networks with dual hop communication has been reported in this work. The proposed approach contains the combining techniques employed at the receiver to combine various signals received from different cooperative channels like SD, SR and RD. The joint scheme referred here is Spatial-MRC and SC with four different relay modes and two cooperative modes AF (Amplify and Forward) and DF(Detect and Forward). The combined signals are followed by detection technique, Minimum Mean Square Error (MMSE) to reduce the bit error rate (BER) and found enhancement in the existing results.

Keywords - Low Complexity Spatial Diversity, DF, Spatial-MRC Combining, MMSE.

I. INTRODUCTION

Historically, the concept of UWB was developed in the early 1960s through research in time-domain electromagnetics where impulse measurement techniques were used to characterize the transient behavior of a certain class of microwave networks. In the late 1960s, the impulse measurement techniques were applied to the design of wideband antenna elements, leading to the development of short pulse radar and communications systems. In 1973, the first UWB communications patent was awarded for the short-pulse receiver. Through the late 1980s, UWB was referred to as baseband, carrier-free, or impulse technology. The term ultra-wideband was first coined in approximately 1989 by the US Department of Defense. By 1989, UWB theory, techniques and many implementation approaches had been developed for a wide range of applications such as radar, communications, automobile collision avoidance, positioning systems, liquid level sensing and altimetry. However, much of the early work in the UWB field occurred in the military or funded by the US Government under classified programs. In late 1990s, UWB technology became more commercialized and the development of UWB technology has greatly accelerated. For further interesting and informative review of UWB history. Ultra Wideband (UWB) systems are very different from conventional wireless systems as they transmit signals over much wider frequency spectrum and use pulses to transmit data as compared to narrowband radio links which use continuous-waves. Fig. 1.1 shows the comparison between ultra-wideband communication system and narrowband.

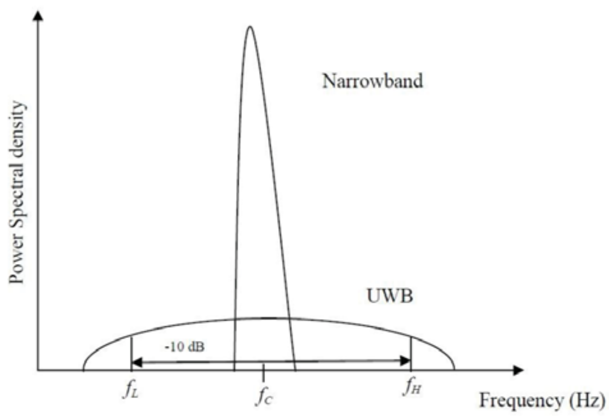

Fig. 1.1 Ultra wide band and narrowband communication.

There has been a lot of research done on UWB communication systems but comparatively very less on the cooperative UWB communication systems. Researchers have put effort in analyzing the ways to improve UWB communication systems but few have put some effort on cooperative UWB communication systems.

In multi-user systems the resources can be shared by different users to cooperate with each other. They can act as relay for other users as well as support each other to transmit information. Another revolutionary application is to exchange information between different users using the protocols of relays. The throughput of the system can be increased dramatically by manipulating the information of one's own transmitted signal. The cooperative and relay communications involves multi-layer design.

The relay channel model is an origin of cooperative communication but it differs significantly from relay model in different ways. The relay channel model only concentrates on investigating the AWGN channel capacity while cooperative communication technology helps to drop the multipath fading.

The purpose of this examination is to investigate and compare BER, System complexity and efficiency of proposed low complex spatial diversity detect and forward relaying scheme with efficient combining for UWB systems with respect to existing detect-and-forward relaying schemes for multiuser UWB MIMO systems model through simulation and formulation.

II. UWB SYSTEMS MODULATION SCHEMES

Modulation is a process of altering features such as amplitude, phase or frequency of a periodic waveform with another signal. Pulse amplitude modulation (PAM), On-Off Keying (OOK), Pulse position modulation (PPM) and binary phase shift keying (BPSK) are the most commonly used modulation schemes in UWB communication.

a. Pulse Amplitude Modulation (PAM)

In PAM, the pulses are transmitted in a time sequence by altering the amplitude of the pulses. “1” is represented by the pulse with higher amplitude and“0” is represented by lower amplitude pulse. The M-ary PAM signal is expressed as:

$$s(t) = \sum_{k=\infty}^{\infty} a_m(k)p(t-ktf) \dots\dots\dots\dots\dots\dots..(1)$$

b. Pulse Position Modulation (PPM)

In PPM, the position of the transmitted UWB pulse is controlled by the selected bit. PPM is related to the nominal pulse position, which translates that information encoding is done by two or more positions in time. “0” is represented if the pulse is transmitted at nominal position while “1” is represented by the pulse which is transmitted beyond the nominal position.

Number of bits per symbol can be increased by increasing the number of positions. The signal model for PPM can be mathematically defined as

$$s(t) = \sum_{k=0}^{+\infty} p\left(t-kT_f \pm T_{pk}\right) \dots\dots\dots\dots\dots\dots\dots.(2)$$

c. On-Off keying (OOK)

OOK is the modulation scheme used for binary level, which contains equally probable two symbols. “1” is represented when a pulse or signal is transmitted and “0” is represented by the absences of the signal. On-Off keying can be mathematically defined as:

$$s(t) = \sum_{k=\infty}^{\infty} m(k)p\left(t-kT_f\right) \dots\dots\dots\dots\dots\dots\dots\dots\dots(3)$$

d. Binary Phase Shift Keying (BPSK)

In the BPSK technique, data is transmitted in the polarity of the pulses. It is also known as bi-phase modulation scheme. “1” is represented by the positive polarity and “0” is represented by the negative polarity of the pulse. BPSK can be expressed as:

$$S(t) = \sum_{k=\infty}^{\infty} d(k)p(t-kT_f) \dots\dots\dots\dots\dots\dots\dots\dots\dots(4)$$

III. PROPOSED METHODOLOGY

A low complex spatial diversity detect and forward relaying scheme with efficient combining for UWB systems has been proposed to overcome bit error rate and to achieve effective wireless communication system. Fig 3.1 show the block representation of proposed work. UWB provides high data rates for wireless communication and sensor networks to fulfill demand of high speed communication system. In the proposed spatial diversity Detect and forward relaying scheme with efficient Combining for UWB Systems, all the nodes at both source and destination end are configured with only one antenna because of their small physical size. The MRC combiner measures the received signals regarding their SNR and is known to be of high performance. However, MRC receiver's complexity is straightforwardly corresponding to the quantity of diversity branches.

The fundamental concept of cooperative communication is that solitary antenna nodes can gain a portion of the advantages of MIMO systems by imparting their antennas to each other to make a virtual MIMO framework. In spite of the fact that cooperative communication has been intensively inspected for general wireless networks with different comprehensive works, it has been relatively unexplored for UWB.

The users relay messages to each other and spread repetitive signals over multiple ways in the network. This redundancy empowers the receiver to aggregate the channel variances because of fading, shadowing, and other interference. The partition between the spatially disseminated user terminals can enable us to make the signal independence. This signal autonomy is required to accomplish system diversity.

The process flow of proposed work in Matlab has shown in Fig . 3.2.

The cooperative strategy can be classified generally as either amplify and forward (AF) or decode-and-forward (DF) protocol, and it provides a good solution not only for overcoming the shortages of UWB systems.

a. Decode-and-Forward (DF)

The most favored strategy in relay nodes data handling is Decode and Forward (DF) on account of its straightforwardness and closeness to the traditional relay. In other words, we can say that it is the regenerative relaying digital signal processing scheme. In this technique, the data is decoded at the relay after being received from source node and then transmitted to the destination node.

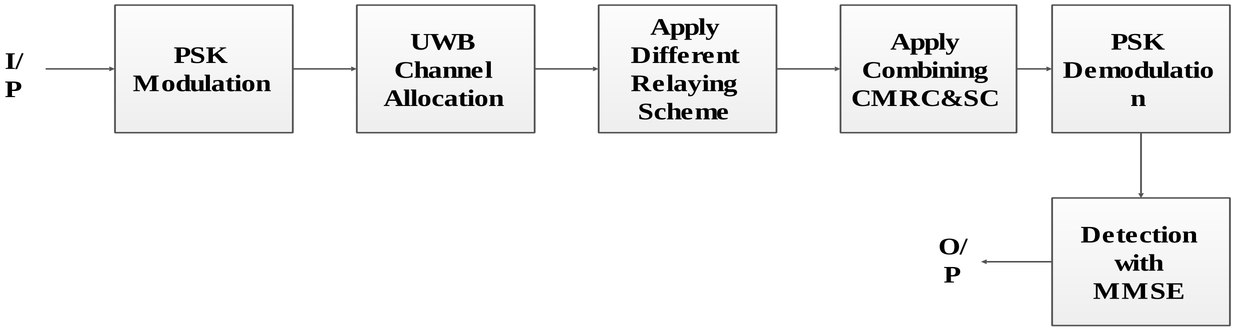

Fig. 3.1 Block Diagram of Proposed Methodology.

The channel performance of source-relay directly affects the signal processing in DF. The full diversity orders cannot be achieved without implementation of Cyclic Redundancy Check (CRC). During the signal decoding and demodulation, the errors introduced by the relay nodes will add up with the increase in number of hops, thus affecting the advantage of diversity and relay performance. It can be stated that one of major factors which can have major negative effect on the performance of DF relaying method is the transmission characteristics of source- relay channel.

b. Amplify-and-Forward (AF)

The Amplify and Forward technique can easily understood by its name as the name suggest in this system the received signal is first amplified by relay before sending it to the destination node. In amplify and-forward it is accepted that the base station knows the inter user channel coefficients to do ideal interpreting, so some system of exchanging or evaluating this data must be incorporated into any usage.

AF likewise DF is often called fixed cooperation modes, because without taking into consideration channel transmission characteristics, relay node always contributes in cooperative communication. Therefore, cooperative communication cannot be considered favorable for every scenario as it has its own drawbacks.

The implementation and simulation of proposed scheme has completed in Matlab Simulation environment. Steps and flow of implementation and simulation has given in Fig. 3.2.

Step-1: Start Simulation in Matlab Simulation environment.

Step-2: Crete simulation environment to initialize simulation parameters.

Step-3: Choose relaying scheme 1 to 4

Step-4: Allocate / Initialize UWB channel.

Step-5: Generate data for transmission over N/W.

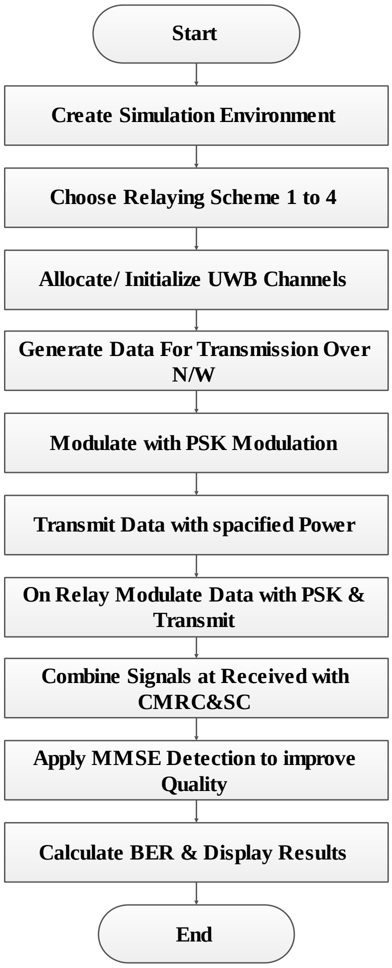

Fig. 3.2 Flow Chart of Proposed Methodology.

Step-6: Modulate with PSK modulation.

Step-7: Transmit data with specific modulation

Step-8: On relay modulate data with PSK & Transmit

Step-9: Combine signals at received end with CMRC & SC

Step-10: Apply MMSE detection to improve quality

Step-11: Calculate BER & Display results

IV. SIMULATION RESULTS

The simulation of proposed work has carried out in Matlab Simulation environment the results of the proposed system utilizing different cooperative modes (RD/SD/SR) and Various Relay Selection Modes and the optimum BER is achieved using minimum mean square error (MMSE) detection. The detected signals at the receiver side from various cooperative modes are than combined using efficient combining techniques (e.g. SC, C-MRC etc.) and outcomes are given in below figures.

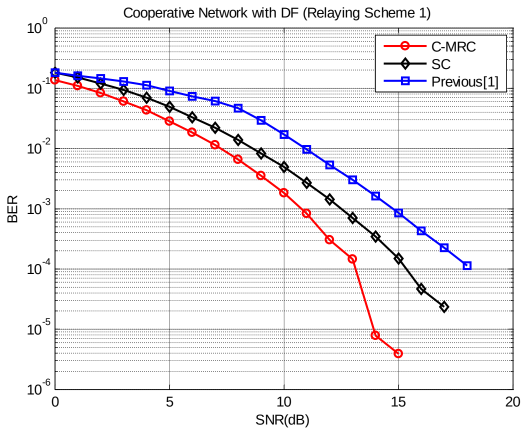

Fig. 4.1 BER Vs SNR Curves using No collaboration threshold Max (min (snr)) Scheme (1) Relay Selection with MMSE Detection, Different Combining Techniques and Cooperative Modes

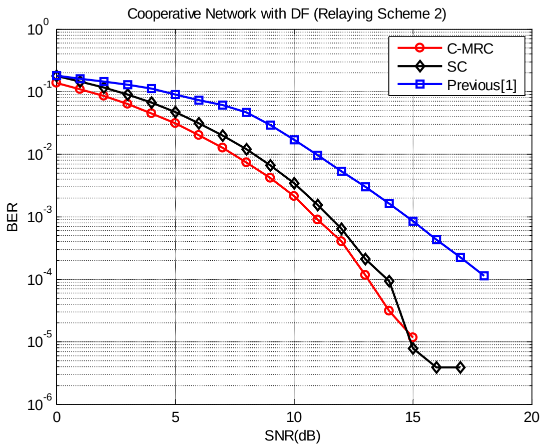

Fig. 4.2 BER Vs SNR Curves using No collaboration threshold Hamonic (snr) Scheme (2) Relay Selection with MMSE Detection, Different Combining Techniques and Cooperative Modes.

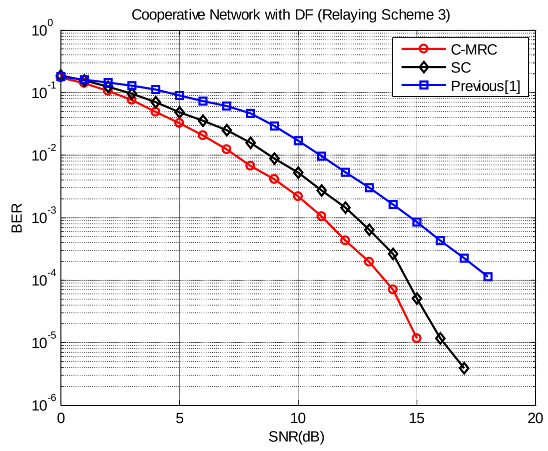

Fig. 4.3 BER Vs SNR Curves using Collaboration threshold Max (min (SNR)) Scheme(3) Relay Selection with MMSE Detection, Different Combining Techniques and Cooperative Modes

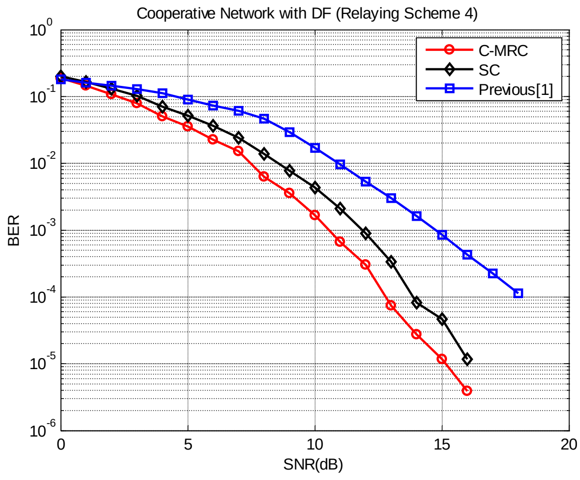

Fig. 4.4 BER Vs SNR Curves using Collaboration threshold Harmonic (SNR) Scheme (4) Relay Selection with MMSE Detection, Different Combining Techniques and Cooperative Modes

From the above simulation results of proposed system with C-MRC and SC with four different relay selection schemes and MMSE detection technique, and it can be seen that the cooperative relay communication system outperform with C-MRC with AF cooperative mode with No Collaboration Threshold Harmonic(SNR) and SC with DF cooperative mode with Collaboration threshold Max (min (SNR)) relay mode.

V. CONCLUSION AND FUTURE SCOPE

This work present implementation and simulation of a new algorithm for UWB Systems which offer low complex spatial diversity detect and forward relaying scheme with efficient combining. From the simulation and results analysis it can be concluded that the results of the proposed approach is better with the maximal ratio combining (C-MRC). From the results analysis it is found that the proposed work has better performance as compared to existing system. The comparative analysis of simulation results are carried out based on signal to noise ratio, SNR and Bit Error Rate BER

In future, proposed relaying scheme with efficient combining for UWB Systems can be implemented for cooperative UWB communication system and power consumption performance can be analyzed. The proposed work covers examination of the BER performance analysis of the proposed cooperative UWB Communication System.

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