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An Extensive Review on Cooperative Wireless Mobile Networks

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Abstract- **Most of the present researches on cooperative network in which the user nodes are equipped with a single antenna or multiple, there have been some new results which exploit the benefits of multiple antenna deployment. Cooperative MIMO technology allows a wireless network system to attain better performance gains than provided by either usual MIMO or cooperative systems. It promised significant improvement in spectral efficiency and network coverage phenomena for different next generation wireless communication systems. In wireless communication, the path towards the various techniques that gives high service quality and data rate has been through the use of the cooperative network provided by the rich scattering wireless channels. Due to their great aspects, MIMO and cooperative systems have found their way into several standards for future wireless communication systems, especially in cellular networks and wireless local area networks (LAN) in this review article we are presenting the comparative analysis.**

Keywords-- **Cooperative Diversity, MIMO, WiMAX, SER, Complexity.**

I. INTRODUCTION

The wireless channel suffers from fading. The fading can cause a significant fluctuation in signal strength that increases bit error rate. Therefore, repetitive transmission of signal can effectively mitigate the effect of fading by generating diversity. Particularly spatial diversity is generated by transmitting signals from different locations, so allowing receiving independently faded versions of the transmitted signal at the receiver. Spatial diversity techniques are particularly attractive as they can be easily combined with other forms of diversity, for example time and frequency diversity. The MIMO system provides a number of advantages. Although MIMO systems have spatial diversity, they cannot be used to provide diversity when transmitter or receiver cannot support multiple antennas due to size, cost or hardware limitations. In this case, alternative techniques have to be exploited in order to guarantee capacity and diversity gains. To overcome size, cost and hardware limitations, another form of spatial diversity called cooperative diversity, has recently been proposed for mobile wireless communication.

In this approach, single-antenna mobiles in a multi-user environment share their antennas in order to generate virtual multiple antenna arrays that allows them to exploit spatial diversity [1]. Cooperative communication is built on the broadcast nature of wireless channel which suggests that the transmitted signal between source and destination can be overheard at neighboring nodes. Cooperation communication aims at processing and retransmitting of this overheard information towards destination to create spatial diversity, hence to obtain higher throughput or reliability.

The key advantage of cooperation is that it allows a network of relatively simple, low-cost, single antenna devices to achieve many of the distinguished advantages of physical antenna arrays. Additionally, cooperative diversity can be combined with other forms of diversity, such a temporal and frequency diversity, to further exploit the available degrees of freedom in the wireless propagation environment and improve overall network performance [2].

Phases of Cooperative Transmissions

Most cooperative communication schemes involve two transmission phases: *A coordination phase and a cooperation phase.*

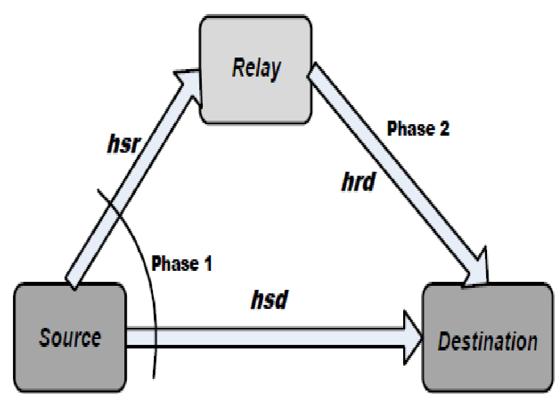

Figure 1.1.: A basic two user cooperative communication network

Coordination is especially required in cooperative systems since the antennas are distributed among different terminals, as opposed to that in centralized MIMO systems.

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Coordination can be achieved either by direct inter-user communication or by the use of feedback from the destination. In cooperation phase (phase 2), the users cooperatively retransmit their messages to the destination. A essential cooperation system consists of two users transmitting to a common destination. One user acts as the source while the other user serves as the relay and the two users may interchange their roles as source and relay at different instants in time. A basic cooperation system is shown in Figure 1.1. In Phase I, the source user broadcasts its data to both the relay and the destination and in Phase II; the relay forwards the source's data either by itself or by cooperating with the source to enhance reception at the destination [3].

Information signals that were transmitted from source and relay are multiple accessed to destination, and then they are combined. Thus, cooperative communication enables single antenna mobiles to generate a virtual multiple antenna transmitter by exploiting relay. Thus, it can achieve spatial diversity. It is also very useful when channel environment of direct path is experiencing deep fading. Each node shares their antennas and other resources, and source acts as relay as well as information source. The two user cooperation described so far can be readily extended to a large network by having one user serve as the source and the remaining users serve as relays. It can also be extended to cooperative communication systems with multiple sources and/or multiple receivers.

Cooperative Communication Protocols

Cooperative transmission requires relaying strategies in relays and combining techniques at the destination. Relaying strategies are methods that define how data is processed at the relays before onward transmission to the destination. A number of cooperative relaying techniques can be used in the relay station namely, the amplify-and-Forward (AF), decode-and-forward (DF), detect-and-forward (DtF), selective detect-and-forward and compress-and-forward (CF). In this thesis, we use AF relaying strategy. The next section will provide more details on the above mentioned relay processing strategies.

II. System Model

The MIMO systems as given, where M no.of transmit and N no. of receive antennas are used. The antennas may be assumed to be omnidirectional or bidirectional, the antennas transmit and receive evenly well in all directions.

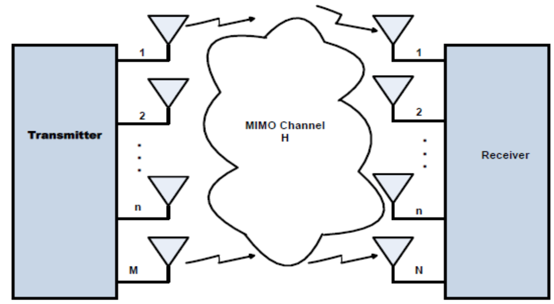

Fig 2.1.: Block diagram of a MIMO Structure.

In linear link model the transmitter and receiver antennas may be represented in the vector notation as:

$$Y = Hx + n \qquad 2.1$$

Where Y is the $N\times 1$ received data signal, x is the $M\times 1$ transmitted data signal vector, n is the $N\times 1$ complex Gaussian noise vector with zero mean and equal variance, which is equal to σ^2, and H is the $N\times M$ normalized channel matrix, which may be represented as

$$\begin{pmatrix} h11 & \cdots & hM1 \\ \vdots & \ddots & \vdots \\ h1N & \cdots & hMN \end{pmatrix} (2.2)$$

Every element hmn represents the complex gains between the m^{th} transmitter and n^{th} receiver antennas. The elements of the channel matrix H can be either deterministic or random. We will focus on Rayleigh distribution, as it is most representative for non-line-of-sight (NLOS) radio propagation.

MIMO Detection Techniques

As explained before, in MIMO multiple antennas are used to simultaneously transmit different streams of data on the different transmit antennas (at the same carrier frequency). Even though these parallel data streams are mixed in the air, when the MIMO channel is well conditioned they can be recovered at the receiver by using spatial sampling (i.e., multiple receive antennas) and corresponding signal processing algorithms. These techniques which are used to recover the original signal are referred to as MIMO detection techniques. MIMO detection techniques are categorized into two main categories; linear and non linear. Linear signal detection methods treat all the transmitted signals as interference except for the desired stream from the target transmit antenna.

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Although linear detection schemes are easy to implement, they direct to high degradation in the achieved diversity order and error performance due to the linear filtering. Zero Forcing (ZF) and Minimum Mean Square Error (MMSE) are linear detection techniques.

On the other hand, non-linear detection techniques optimally take into account the properties of noise and interference. Maximum Likelihood (ML), Successive Interference Cancellation (SIC), Ordered Successive interference cancellation (OSIC) and Sphere Decoding Algorithms (SDAs) are examples of non-linear detection techniques.

III. Literature Review

The joint impact of cooperative diversity and antenna diversity, called cooperative MIMO system. A three-node network scenario consisting of one source, one destination and one relaying nodes is considered; the relaying node employs AF relaying technique. This is followed by complexity analysis of the system.

Kanghee Lee; Kwon, and H.M., Y investigated optimal amplify-and-forward (AF) relay scheme for a multiple-input-multiple-output (MIMO) system consisting of M-mobile destinations, M-mobile sources, and N-cooperative distributed mobile relay nodes. The wireless mobile relaying network with channel state information is presented. The received signals from the mobile sources are exchange between mobile relays to achieve optimal performance. Authors contributed in their research work, the derivation of mobile relaying amplifying matrices (MARMs) designed for cooperative MIMO networks based on the minimum mean square error (MMSE) condition. By adopting the new proposed MRAMs, the bite error rate (BER) performance of the system is evaluated using Monte-Carlo simulations [6].

Jamali-Rad, H. and Ramezani, extended one of recently proposed anchorless mobile network localization algorithms in their proposal a geometric missing link reconstruction algorithm for noisy scenarios and repeat the proposed algorithm in a local-to-global fashion to reconstruct a complete distance matrix. Results further illustrate that the proposed link reconstruction algorithm leads to the lowest reconstruction error as well as the most accurate network localization performance [7].

Yu-Chung Chen and Chun-Ting Chou presented the Wireless and mobile social networking service (SNS) which utilizes location information to enrich user experience.

A main challenge in location-aware SNS is its strict requirement in precision of user location, which normally cannot be met by the existing GPS or cellular networks. Authors proposed a user-level cooperative localization scheme that improves the precision of existing localization methods. Mathematical model is developed and in-depth simulation is conducted to evaluate the performance of the proposed scheme [8].

Changiz, R.; Halabian, H. and Yu, F.R. demonstrated the trust management method for wireless mobile networks with cooperative communications. Conventional Bayesian process is insufficient for the cooperative communication, as it is biased from the channel conditions and relay selection decision processes. Therefore, authors modify the conventional trust management method by incorporating not only the relay selection policy but also the dynamic wireless channel conditions among the source, relays and destination. Their results are presented to show the usefulness of the proposed method [9].

Singh, C.P. and Garg, P. cooperative communication system has been proposed that enables single-antenna mobiles in multi-user environment to share their antennas and form a virtual multiple-antenna transmitter that allow them to achieve transmit diversity. The proposed methods require distributed space-time coding algorithms which is very critical. Authors proposed a method that provides transmit diversity gain on the order of the number of relays in the network. The selection of best relay is not required any topology information and is based on local measurements of the instantaneous channel conditions [10].

IV. Proposed Methodology

The proposed method is to combine MIMO techniques with user cooperative diversity and investigate the application of the resulting system in WiMAX technology and also study its performance.

The wireless channel suffers from fading. The fading can cause a significant fluctuation in signal strength that increases bit error rate. Hence, repetitive transmission of signal can effectively mitigate the effect of fading by our methodology. Detection Technique can be enhanced be following methods

The wireless channel suffers from fading. The fading can cause a significant fluctuation in signal strength that increases bit error rate. Hence, repetitive transmission of signal can effectively mitigate the effect of fading by our methodology. Detection Technique can be enhanced be following methods:

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Detection Technique:

1. Linear Detection Technique.
   - MMSE & Zero Forcing
2. Non-Linear Detection Techniques.
   - ML and V-BLAST

Combining Techniques:

1. Maximum Ratio Combining. (MRC)
2. Selection Combining. (SC)
3. Equal Gain Combining. (EGC)

Modulation Technique:

1. 16/32/64 QAM will be used.

V. CONCLUSION

The performance of wireless networks highly depends on Multipath fading in terms of degradation. One of the most dominant methods the effect of fading is by using multiple antennas that provides high system stability. The combination of space diversity and spatial multiplexing is called Multiple-Input Multiple-Output (MIMO). Cooperative diversity, a substitute form of realizing MIMO, it has been newly proposed to recognize the diversity benefit in a distributed manner. Cooperative diversity method exploits the broadcast nature of wireless communication and creates a virtual antenna array system through cooperating nodes. Though, previous research in cooperative diversity considers users equipped with single antenna, in realistic scenarios users can be able to contain many antennas due to the new advances in semiconductor industry. Therefore, the main purpose of this review paper is to study and analysis the performance of the cooperative mobile network employing multi-antenna at cooperating nodes. The purpose is to simultaneously use the enhanced gain with low bit error rate offered by the cooperative diversity network. Cooperative MIMO systems may achieve considerably better performance in bit error rate (BER). The cooperative MIMO scheme may have effective throughput in low SNR regime when compared to the conventional point-to-point system.

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