A review paper on the various communication strategies used in wireless networks

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Abstract: Wireless communication technologies have become an indispensable part of our everyday life. The need for seamless communication over heterogeneous wireless networks quantifies the technical challenges associated with it. One such challenge is the design of efficient communication protocols in order to combat fading due to multipath propagation and prolong the network lifetime. Nanotechnology has led to the development of tiny computing devices which can be used as wearable objects or can be implanted inside a human body. Such networks are known as wireless body area networks (WBAN). This paper focuses on how different communication protocols and space time coding schemes along with evolutionary algorithms helps provide a reliable communication link thereby providing efficient communication between end users of the system.

Keywords: Diversity, Cooperative communication, Cooperative diversity, Relay selection, STBC, PSO.

I. INTRODUCTION

Wireless is a broad term and encompasses all sorts of technologies that transmit data over air than over wires. WBAN is a term developed over the past 15 years and can be used for remote monitoring of vital signs of patients suffering from chronic diseases such as asthma, heart attack and diabetes. WBAN’s may also be utilized in sports, military and security applications. It supports both medical and non medical applications with diverse application requirements. The development of WBAN brings a number of research challenges such as interoperability, scalability, reliability, QoS and energy efficiency for the design of communication protocols. This paper describes the various communication protocols and strategies used to maximize the network lifetime in order to ensure reliable end to end communication.

II. DIVERSITY

Diversity is a technique used to compensate for fading channel impairments. It is achieved by using the information on different branches available to the receiver in order to increase the signal to noise ratio (SNR) at the decoding stage. These techniques can be employed at the base station and mobile receivers. The fundamental idea of diversity technique is to transmit multiple independent replicas of the same information bearing symbols to the receiver. This reduces the probability of all replicas suffering severe fading simultaneously. Spatial diversity is the most commonly used diversity technique. It is also known as antenna diversity which aims at improving the reliability of the system by sending replicas of the same transmitted signal across different antennas of the receiver. The antennas need to be spaced sufficiently apart. Usually a separation of few wavelengths is required between two antenna elements in order to ensure that the symbols fade independently. However in some scenarios due to strict size and complexity limitations it may not be practical to implement multiple antennas and space them sufficiently apart due to which a new diversity scheme called cooperative diversity has been introduced.
III. COOPERATIVE DIVERSITY

Cooperative diversity exploits the broadcast nature and inherent spatial diversity of wireless channels. It is a technique which is obtained when relay nodes are used for transmitting data signals. Specifically a source several relays and a destination form a cooperative network where the relays help the source transmit the information bearing symbols to the destination. The same information bearing symbols are transmitted over several independent channels including the direct channel from source to destination and the indirect channels from the source through the relays to the destination. This redundancy allows the receivers to essentially average channel variations resulting from fading, shadowing and other forms of interference. Depending on how the relays process the signals and relay it to destination is known as protocol.

IV. RELAYING PROTOCOLS

The following are the basic protocols used while relaying the information from source to destination:

- **Amplify and Forward**: In this protocol the relay simply amplifies the signal received in the previous phase and forwards it to destination. Based on the principle of amplifying repeaters, amplify and forward protocol was formally introduced by Lane man et al.

- **Decode and Forward**: In this technique relay first decodes the information received from the source node, encodes it and then forwards it to the destination node. Thomas M. Cover and Abbas A. El Gamal are considered as its pioneer and later the idea was further explored by many authors.

- **Compress and Forward**: In this technique the relay first decodes the information at the transmitter and the relay then transmits the compressed version to the destination.

Among these three strategies, the AF protocol is of practical interest as it requires lower implementation and computational complexity, it carries less delay at the relay terminal and it is transparent to the modulation/ coding used by the source nodes. Decode and forward works best
when relay is close to the source whereas compress and forward works best when relay is close to the destination.

Figure 3. The wireless relay channel

V. SPACE TIME BLOCK CODING

Space time coding refers to channel coding techniques for transmission with multiple transmit and receive antennas. To take advantage of spatial diversity provided by multiple antennas, diversity combining methods of which the most successful is the space time coding is used which achieves a PEP \( \frac{1}{\text{SNR}^{MN}} \) where M is the number of transmit antennas and N is the number of receive antennas. When STBC is applied to a cooperative network, it is called distributed STBC (D-STBC). However perfect synchronization is required in these systems, otherwise it may cause degradation in system performance. Cooperative mechanism in D-STBC is done in two transmission phases:

- **Phase 1 - Broadcasting phase:** Source transmits original data to all the relay nodes and also to the destination node.
- **Phase 2 - Relaying phase:** Relays which have received the data will form the STBC version of the data and then transmit it to destination.

The two phases are done through either TDMA or FDMA. The space time coding achieves maximum diversity, maximum coding gain and maximum possible throughput. Space time block coding uses both spatial and temporal diversity, thus enabling significant gains to be achieved.

VI. ALAMOUTI SPACE TIME BLOCK CODE

The Alamouti STBC also known as orthogonal STBC (O-STBC) is the first space time block code to provide full transmit diversity for systems with two transmit antennas. In the Alamouti space time encoder, each group of m information bits is first modulated where \( m = \log_2 M \). This scheme does not need CSI or knowledge of channel coefficients at the transmitter and hence it is very useful from a practical perspective. The Alamouti code achieves half the SNR as compared with the MRC scheme so the price that we are paying for not having CSI at the transmitter is that the SNR in an Alamouti scheme is \(-3\)dB lower than transmit beamforming scheme or MRC scheme. The diversity order in the Alamouti scheme is preserved which means that it yields the same diversity order as that of MRC. Thus Alamouti is a very important transmission scheme and it’s a key milestone in the development of wireless system because the decoding at the receiver is simple due to orthogonal structure of Alamouti.
VII. PRECODING AND IT’S BENEFITS

The major drawback in MIMO channels is separation of data streams which are sent in parallel. Precoding is also known as optimum linear transformation which is done to minimize the problem of decoding error. It is a technique which exploits transmit diversity by weighing the information stream. This type of processing at the transmitter requires the CSI at the transmitter. If CSI is available at the transmitter, the transmitted symbols either for a single user or for multi users can be partially separated by means of pre-equalization at the transmitter. Precoding matrices are used to optimize capacity and to increase system performance. Precoding is a kind of digital beamforming which is conducted in the baseband by tuning the phases and amplitudes of transmit signals across all antennas. With beamforming also known as analog beamforming the number of simultaneous users is typically limited by the number of deployed RF chains and requires calibration where calibration complexity may grow with the number of antennas. On the other hand precoding is less limited by hardware and does not require array calibration.

VIII. PARTICLE SWARM OPTIMIZATION [PSO]

Particle swarm optimization is a stochastic optimization technique. It is an evolutionary algorithm by Dr. Eberhart and Dr. Kennedy in 1995. It begins by creating the initial particles and assigning them initial velocities. It evaluates the objective function at each particle location and determines the best function value and best location. It chooses new velocities based on current velocity, the particles individual best locations and the best locations of their neighbors. It then iteratively updates the particle locations, velocities and neighbors. Iterations proceed until the algorithm reaches a stopping criterion.

IX. ADVANTAGES AND DISADVANTAGES OF PSO

- Advantages:
  1. The calculation in PSO is comparatively simple compared with other developing calculations, it occupies bigger optimization ability and it can be completed easily.
  2. PSO have no overlapping and mutation calculation.
  3. It adopts to the real number code and is decided directly by the solution.
• **Disadvantages:**
  1. It is easy to fall into local optimum in high dimensional space and has a low convergence rate in iterative process.
  2. The method cannot work out the problems of scattering and optimization.
  3. It cannot work out the problems of non coordinate system.

**X. CONCLUSION**

In the above paper various strategies that can be applied to a wireless communication system for improving system performance have been discussed. Also discussed is PSO evolutionary algorithm which when applied to a wireless communication system provides the best possible output across a given condition.

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