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REVIEW OF COOPERATIVE SCHEMES BASED ON DISTRIBUTED CODING STRATEGY

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Abstract

In order to decrease fading and at the same time maintain an acceptable spectral efficiency, different cooperative schemes have been proposed for multi-source multi-relay networks. These schemes usually use the channel state information (CSI) at the transmitter side to do channel selection or relay selection to avoid deeply faded channels. A short note on the Distributed Coding Strategy, followed by an overview of different strategies for distributed coding in cooperative networks is analyzed.

Keywords- CSI, Cooperative Networks, distributed Channel Coding, Under Water Acoustic Channels

1. Introduction

The underwater acoustic (UWA) channel is a complex communication environment which is characterized by multipath propagation, low speed of sound, and frequency-dependent path loss. In order to combat fading and at the same time maintain an acceptable spectral efficiency, different cooperative schemes have been proposed for multi-source multi-relay networks.

The Cooperative schemes usually use the channel state information (CSI) at the transmitter side to do channel selection or relay selection to avoid deeply faded channels. However, in UWA communication systems, obtaining accurate CSI is difficult. This is due to the low speed of the acoustic wave in the water and hence CSI becomes outdated. To remedy this problem, distributed coding schemes that aim at achieving good diversity-multiplexing trade-off (DMT) for multiuser scenarios where CSI is not available for resource allocation.

2. Distributed coding structure

Distributed coding strategy, combines cooperative communications [1] and network coding [2].

The performance of relayed transmission can be further optimized if joint signal design and coding are performed at the source and relays. We refer to such a coding scheme as distributed coding.

In distributed coding different parts of the codeword are transmitted by different nodes through independent channels. Different strategies for distributed coding in cooperative networks have been proposed during the past decade

The major difference between distributed coding and conventional channel coding schemes is that in distributed coding, the overall codeword is constructed in a distributed manner. That is, different parts of the code word in distributed coding are transmitted by different nodes through independent wireless links. This creates additional degrees of freedom, but also poses challenges in code construction. Although we can directly apply the concepts of conventional channel coding to construct distributed coding in wireless relay networks

Some practical issues in designing these distributed coding schemes have to be taken into account, such as decoding errors at relays, channel variations in different parts of codeword, and rate and power allocations at the source and relays. In this section we present an overview of various distributed coding structures that have been successively developed over the past several years for wireless relay networks.

A major challenge in distributed cooperative transmissions is to find a way to coordinate the relay transmissions without requiring extra control information overhead

Different strategies of distributed coding in cooperative networks as follows[1]

- Distributed Space Time Code (DSTC)
- Distributed Space- Time block codes (DSTBC)
- Distributed Space -Time Trellis Codes(DSTTC)
- Distributed Low Density Parity Check (DLDPC) codes
- Distributed Turbo Codes (DTC)
- Random Distributed Space Time Code(RDSTC)

2.1 Distributed Space Time Coding

Let us consider a wireless relay network in which the source and relays cooperatively communicate with a common destination. This cooperative transmission among the source and relays forms a virtual antenna array. Therefore, conventional space-time coding schemes can be applied to relay networks for achieving the cooperative diversity and coding gain. Two types of distributed space -time coding (D-STC) schemes have been developed, including distributed space-time block codes (DSTBCs) and distributed space- time trellis codes (DSTTCs).

2.2 Distributed Low Density Parity Check Codes

In DSTTC the convolution codes are used as the constituent codes at the source and relay nodes. In order to further improve the system performance, some Distributed Low Density Parity Check (D-LDPC) coding schemes have been developed In D-LDPC the constituent codes at the source and relay are LDPC codes. An LDPC code with a predetermined code rate is first generated.

The whole codeword consists of three parts. The first one is transmitted by the source in the first time slot. The codeword is chosen from an LDPC codebook, CSR1. The other two parts are chosen from two other LDPC code-books, CRD2 and CSD2. They are transmitted by the relay and source in the second time slot. The bits chosen from CSR1 and CRD2 are transmitted by the source and relay to form another LDPC code, CSD1. As a result, the design of D-LDPC codes requires joint optimization of the code profiles of CSR1 and CSD1 [1]. The density evolution (DE) has been widely used for the optimization of LDPC codes. DE can accurately track the evolution of the probability densities in a belief propagation decoding algorithm. For the conventional LDPC codes, it has been shown that good check node distributions (CNDs) are concentrated. That is, all parity check nodes should have nearly equal degrees [1].

2.3Distributed Turbo Codes

Similarly, by following a turbo coding structure, another capacity approaching structure, referred to as distributed turbo coding (DTC). "The Figure 1" shows the block diagram of a DTC system. In a DTC scheme, the relay employs the Decode and Forward (DAF) protocol. The source broadcasts the coded signals to both the destination and relay. The relay decodes the received signals and interleaves them prior to re-encoding. The signals received at the destination consist of a coded signal transmitted from the source and coded interleaved information transmitted from the relay. These two signals form a distributed turbo code. It has been shown that such a coding strategy performs close to the theoretical outage probability bound of a relay channel. However, in such a coding scheme, it is usually assumed that the relay performs error-free decoding, which we refer to as the perfect DTC. Design of DTC schemes when imperfect decoding occurs at the relay has become a practical and important issue. Similar to the methods for overcoming error propagation in relay protocols, there are also two possible ways to design the DTC to avoid decoding errors at relay

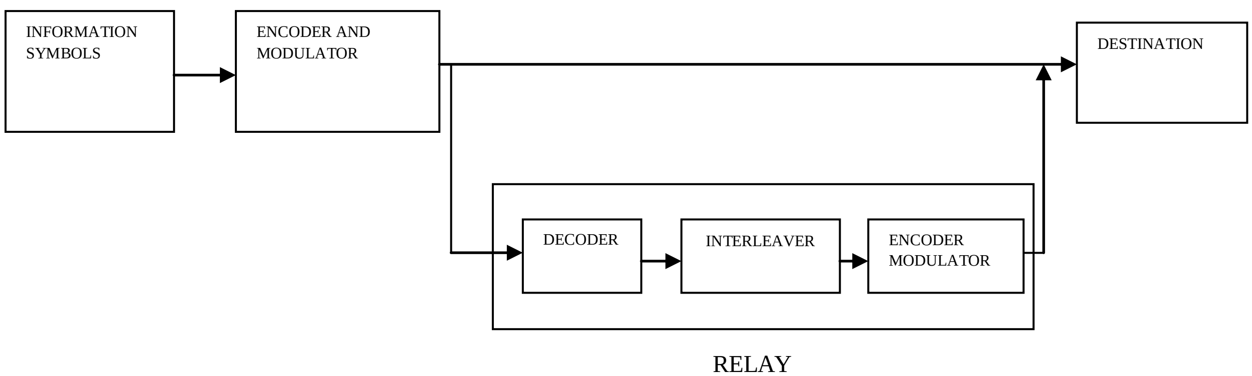

Figure 1.Distributed turbo coding (DTC) structure

The above mentioned distributed coding schemes have been developed for single-source cooperative networks.

Distributed coding schemes that aim at achieving good diversity-multiplexing tradeoff (DMT) without the need to have the CSI available for relay assignment

2.4 Relay protocols

Based on operations at the relays, there are several commonly used relay protocols

2.4.1 Amplify and Forward

Amplify and Forward (AAF) is one of the simplest relay protocols [4]. In AAF, upon receiving signals from the source, each relay just simply forwards to the destination a scaled version of the received signals, including both information and noise. By properly combining received signals from the source and relays, the destination node makes a final decision

2.4.2 Demodulation and Forward

To eliminate the effect of noise amplifications, several relay protocols have been proposed. Demodulation and Forward (DemAF) is one of the simple solutions among them. In DemAF the relay simply demodulates the received signals, with no decoding, and re-modulates to reconstruct the symbols transmitted by the source. This process can simply remove the noise components residing in the received signals at relay

2.4.3 Decode and Forward

Decode and Forward (DAF) is another commonly used protocol for eliminating the noise effect, especially for coded systems. The relay decodes the received signals and re-encodes them before forwarding to the destination. When the channel quality in the link between the source and relay is good, the process of decoding and re-encoding provides more powerful error correcting capabilities than DemAF. Thus, the method can considerably outperform both AAF and DemAF

2.4.4 Adaptive Relay Protocol

Adaptive Relay Protocol (ARP) has advantages of both AAF and DAF and minimizes their negative effects at the same time. In ARP, each relay adaptively selects the AAF or DAF protocol based on whether its decoding result is correct or not. All the relays that fail to decode correctly use the AAF protocol to amplify the received signals and forward them to the destination. On the other hand, all the relays that can successively decode the received signals use the DAF protocol

3. Types of Distributed Coding Techniques

The various distributed coding techniques based on cooperative networks are given below

A. Chakrabarti et al [1] proposed some simplified DE algorithms by using Gaussian approximation of the DE distribution and putting some constraints on the CNDs of CSR1 and CSD1 to reduce the search space. The search for good code profiles can be made using linear programming, and near optimum codes can be found by selecting the code with the optimum convergence threshold. It has been shown that through proper code design, an D-LDPC scheme over wireless relay channels can perform very close to the theoretical limit.

R. Koetter [2] proposed a polynomial-time soft decision algebraic list-decoding this property make RS codes a promising candidate for distributed code relaying

J Laneman et al [3] proposed distributed space- time block codes (DSTBCs) based on orthogonal STBCs. Since the design of orthogonal STBCs is not possible for every number of antennas and to overcome the difficulties imposed by large numbers of relays . The design of such a DSTBC becomes especially difficult for a large network with a large number of relays

Y. Li [4] proposed that ARP considerably outperforms the AAF scheme and simultaneously avoids error propagation due to the imperfect decoding at relays in a DAF protocol. Thus, it outperforms both AAF and DAF protocols. The performance gain grows as the number of relays increases, and it approaches the perfect DAF scheme at high SNRs.

Y.Li et al [5] proposed a probability inference method that traces the trellis of the code to calculate the probability of each symbol at time k based on the probabilities of all symbols at time k – 1. After obtaining the probabilities of the parity symbols of the interleaved information symbols, the corresponding soft estimates can then be calculated as the mean of modulated symbols

T. K. Moon [6] proposed that RS codes are non-binary cyclic codes where the input symbols and the generator matrix elements are selected from GF(q). The RS code is optimal in the sense that its minimum distance is the highest for a linear code of the same size this is known as the Singleton bound

J. Rebelatto [7] proposed propose and analyze a generalized construction of distributed network codes for a network consisting of users sending independent information to a common base station through independent block fading channels. The aim is to increase the diversity order of the system without reducing its throughput. The proposed scheme, called generalized dynamic-network codes (GDNC). The design of the network codes that maximize the diversity order is recognized as equivalent to the design of linear block codes over a non-binary finite field under the Hamming metric.

T. Wang et al [8] proposed the performance of DemAF by taking into account the detection errors at the relay, by introducing an equivalent one-hop link model to replace the two-hop source-relay-destination path. Its performance variation with respect to the relay position is similar to the AAF. When the relay is placed midway between the source and destination, the lowest outage probability is achieved

Yiu et al. [9] proposed a DSTBC which selects a subset of nodes for transmission. . It has been shown that by proper code design, DSTBC can achieve a diversity order equal to the number of active relay nodes This idea was also extended to distributed space-time trellis codes (DSTTCs).

J. Yuan [10] proposed distributed space-time trellis codes (DSTTCs) where a larger coding gain, compared to STBCs, is expected.

4. CONCLUSION

In this paper we have given an overview of the various distributed coding technology and relay protocols. Some efficient distributed coding schemes have been proposed in the past several years, through proper design, distributed coding can achieve both spatial diversity and a significant coding gain. For secure transmissions there are also some security issues which should be considered, like attacks from malicious relays, denial of service from selfish relays for the sake of saving its energy, etc.

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