

Chapter 8

Distributed Space–Time Block Coding for Amplify–and–Forward Cooperative Networks

Zhihang Yi

Queen's University, Canada

Il-Min Kim

Queen's University, Canada

ABSTRACT

This chapter focuses on distributed space-time codes (DSTCs) in cooperative networks. DSTCs can substantially improve the bandwidth efficiency of the cooperative network without requiring any feedback overheads from the destination to the relays. The first part of this chapter is dedicated to reviewing the existing works on DSTCs. In the second part of this chapter, distributed orthogonal space-time block codes (DOSTBCs) are presented in detail. It is shown that the DOSTBCs can achieve the single-symbol maximum likelihood decodability and full diversity order in an amplify-and-forward cooperative network. Then some special DOSTBCs, which generate uncorrelated noises at the destination, are introduced. Those codes are referred to as the row-monomial DOSTBCs. An upper bound of the data-rate of the row-monomial DOSTBC is derived and the codes achieving the upper bound are presented as well.

INTRODUCTION

A robust way to combat multipath fading phenomena in wireless communications is to implement diversity techniques. Diversity is achieved by providing the receivers multiple independent replicas of the same information-bearing symbols through space, time, or frequency. Recently, a new type of diversity, so-called cooperative diversity, has been proposed in order to provide diversity when the wireless terminals can not employ multiple antennas due to size or complexity constraints. The network that exploits the cooperative diversity is usually referred to as the cooperative network.

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Cooperative diversity is achieved by the cooperation of several single-antenna relays. Consequently, the coordination of the transmissions from the relays has a large impact on the performance and complexity of the network. The most well-known cooperative strategy is the repetition-based cooperative strategy, because it has very low complexity and achieves the full diversity order. However, researchers conclude that this strategy has very poor bandwidth efficiency. In order to improve the bandwidth efficiency of the cooperative networks, many other cooperative strategies have been proposed, including cooperative beamforming, relay selection scheme, and distributed space-time codes (DSTCs). Although the cooperative beamforming and relay selection scheme can improve the bandwidth efficiency, they are hard to implement because feedback overheads might be required from the destination to the relays.

This chapter will focus on the DSTCs, which can substantially improve the bandwidth efficiency without requiring any feedback overheads from the destination to the relays. The objective of this chapter is to provide the readers some insights into existing works of the DSTCs. Specifically, in the second Section of this chapter, we will review some of the most important works on DSTCs. It will be shown that, in the decode-and-forward (DF) cooperative networks, existing space-time codes (STCs), such as orthogonal STCs, quasi-orthogonal STCs and linear dispersion codes, can be used without any modification. This is because the use of cyclic redundancy check (CRC) at the relays makes the transmission from the relays to the destination essentially the same as that of a classic co-located multiple antenna system. On the other hand, the analysis and construction of the DSTCs in the amplify-and-forward (AF) cooperative networks is much harder. For example, the orthogonal space-time codes lose the single-symbol maximum likelihood (ML) decodability when they are used in the AF cooperative networks.

In the third Section of this chapter, we will discuss distributed orthogonal space-time block codes (DOSTBCs) in detail. The DOSTBCs are proposed by addressing the distributed nature of the cooperative networks. Due to this reason, those codes achieve the single-symbol ML decodability and the full diversity order in the AF cooperative networks. Then we will restrict our interests to some special DOSTBCs, which generate uncorrelated noises at the destination. Those codes are referred to as the row-monomial DOSTBCs. An upper bound of the data-rate of the row-monomial DOSTBC is derived and it shows that the codes achieve approximate twice higher bandwidth efficiency than the repetition-based cooperative strategy. Furthermore, we will also find the systematic construction methods that generate the row-monomial DOSTBCs achieving the upper bound. Numerical results demonstrate that the row-monomial DOSTBCs substantially outperform the repetition-based cooperative strategy when they have the same bandwidth efficiency.

BACKGROUND

In this section, we will first review some fundamental works on cooperative networks. After that, we will present the existing works on DSTCs.

Cooperative Networks

Multipath fading is one of the major impairments of wireless channels and it is seen as an obstacle to reliable data transmission. One effective method to mitigate fading is to implement *diversity* techniques in wireless communication systems. The fundamental idea of the diversity techniques is to transmit multiple independent replicas of the same information-bearing symbols to the receiver. By doing so,

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