

Chapter 17

Relay Selection in Distributed Transmission Based on the Golden Code Using ML and Sphere Decoding in Wireless Networks

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ABSTRACT

The implementation of cooperative diversity with relays has advantages over point-to-point multiple-input multiple-output (MIMO) systems, in particular, overcoming correlated paths due to small inter-element spacing. A simple transmitter with one antenna may exploit cooperative diversity or space time coding gain through distributed relays. In this paper, similar distributed transmission is considered with the golden code, and the authors propose a new strategy for relay selection, called the maximum-mean selection policy, for distributed transmission with the full maximum likelihood (ML) decoding and sphere decoding (SD) based on a wireless relay network. This strategy performs a channel strength tradeoff at every relay node to select the best two relays for transmission. It improves on the established one-sided selection strategy of maximum-minimum policy. Simulation results comparing the bit error rate (BER) based on different detectors and a scheme without relay selection, with the maximum-minimum and maximum-mean selection schemes confirm the performance advantage of relay selection. The proposed strategy yields the best performance of the three methods.

DOI: 10.4018/978-1-4666-2157-2.ch017

1. INTRODUCTION

In a wireless network, independent paths between the source and destination exist when multiple users act as relays for each other (Jing & Jafarkhani, 2006). Such cooperative diversity has been shown to be an effective technique to enable single-antenna users to share their antennas to create a virtual MIMO system (Li, 2009). Cooperative diversity has potential application in mobile wireless ad hoc networks. Better system performance gains can be achieved by exploiting relays due to pathloss gains as well as diversity and multiplexing gains. In traditional direct link communication systems, it is difficult to achieve high quality of service (QoS) for users, but with the exploitation of relays higher quality and cost-effective transmission can be obtained (Dohler & Li, 2010). In recent years there has been considerable effort in the development of cooperative diversity schemes. A variety of cooperative schemes has been proposed. Among these strategies, perhaps the most important are amplify-and-forward (AF) and decode-and-forward (DF) approaches. For AF schemes, every relay cooperates and just retransmits its received signal scaled by its own transmitted power. For most DF schemes, every relay decodes the transmitted information before retransmitting it using its transmit power (Jing & Jafarkhani, 2009). However, using all the relays may not obtain the optimal performance of the relay network, and present practical problems such as asynchronism (Li & Xia, 2007) between the relays. Improved performance can be potentially achieved by selecting the cooperating relays to employ. In particular, selection can aim to find the best relay for solving the problem of multiple relay transmissions by requesting only a single relay or a subset of relays forwards the information from the source (Uysal, 2010). Best relay selection must be repeated as the channel conditions can change for each symbol block.

On the other hand, space-time coding is also used to exploit spatial diversity in traditional point-to-point MIMO systems and in recent years such encoding has been adopted in distributed cooperative networks (Jafarkhani, 2005). While space-time codes for MIMO systems can achieve full spatial diversity, a new full-rate and full-diversity linear dispersion algebraic space time code based on the golden number was proposed in Belfiore, Rekaya, and Viterbo (2005). It is best matched to a 2×2 coherent MIMO system. The minimum determinant of the golden code matrix does not depend on the size of the signal constellation and it achieves the diversity-multiplexing tradeoff (DMT) (Yao & Wornell, 2003; Goldsmith, 2005), which for the single-antenna N -relay NAF channel can be characterized by Azarian, Gamal, and Schniter (2005).

$$d_{NAF}(r) = (1-r) + N(1-2r)^+ \quad (1)$$

where $(x)^+$ means the $\max\{x, 0\}$, r is the multiplexing gain and d is the diversity gain, which are given by

$$\lim_{SNR \rightarrow \infty} \frac{R(SNR)}{\log(SNR)} = r$$

and

$$\lim_{SNR \rightarrow \infty} \frac{\log P_e(SNR)}{\log(SNR)} = -d \quad (2)$$

where SNR is the signal-to-noise ratio, $R(SNR)$ is the data rate measured by bits per channel usage and $P_e(SNR)$ is the average error probability using the maximum likelihood (ML) decoder. The construction of the golden code allows application of spatial multiplexing so that it has higher bit rates. Meanwhile, the spatial diversity

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