MODULATION DESIGN IN AMPLIFY-AND-FORWARD TWO-WAY RELAY HARQ CHANNEL

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ABSTRACT

As a practical transmission enhancement technique for relay and HARQ system, Modulation Diversity (MoDiv) uses distinct mappings to the same constellation for different (re)transmissions. In this work, we study the MoDiv optimization in a Amplify-and-Forward (AF) Two-Way Relay Channel (TWRC). The design of MoDivto minimize the bit-error rate (BER) is formulated into a successive Koopmans-Beckmann Quadratic Assignment Problem (QAP), which is solved sequatially with a robust taboo search method. The performance gain of our MoDiv scheme over retransmission without remapping and a heuristic MoDiv scheme is demonstrated with numerical ressults.

Index Terms— Modulation diversity, two-way relay, amplify-and-forward, HARQ, QAP

1. INTRODUCTION

As an advanced technique to improve the robustness of high-rate wireless transmissions against poor channel conditions, Hybrid Automatic Repeat reQuest (HARQ) has found its application in various communication systems [1]. HARQ works on both PHY layer and MAC sublayer to mitigate packet loss due to channel fading and link-adaptation accuracy. Recently, substantial research interest has been drawn to HARQ in Two-Way Relay Channel (TWRC) [2-4]. In [2], the average throughput of naive Type-I HARQ policy for both Amplify and Forward (AF) and Decode and Forward (RF) TWRC schemes have been analyzed. The energy-delay tradeoff, and the diversity-multiplexing tradeoff of type-II HARQ policy, also known as full Incremental Redundancy (IR), for AF TWRC scheme have been studied in [3] and [4], respectively. Related works about TWRC with ARQ for different relay schemes and retransmission policies can also be found in [5, 6, 7] and the references therein.

Apart from the naive Type-I HARQ and HARQ-IR, Type-I HARQ with maximal ratio combining (MRC), also known as HARQ-Chase Combining (HARQ-CC) [8], is another simple and practical HARQ scheme supported by such standands as HSPA [9], LTE [10] and so forth. As practical transmissions often admit linear modulations of finite-alphabet constellation (e.g. Q-ary QAM), the performance of HARQ-CC can be improved with Modulation Diversity (MoDiv) [11], in which a same group of $\log_2 Q$ bits are mapped to different symbols in a same constellation in different round of (re)transmissions. MoDiv has been studied for HARQ [12], relay networks [13, 14] and relay-HARQ systems [15, 16].

In this paper, we study the MoDiv design for the TWRC under a simple AF scheme and HARQ-CC protocol. We first derive an upper bound for the uncoded bit-error rate (BER) of TWRC-AF channel under the Rayleigh fading condition, given M different mapping schemes corresponding to each (re)transmission. Based on this upper bound, we formulate a successive BER minimization MoDiv design into a series of Quadratic Assignment Problem (QAP) in Koopmans-Beckmann (KB) form [17]. Although QAP is NP-hard, efficient numerical algorithms have been extensively researched [18], some of which have shown extremely high performance over QAPLIB [19]. We adopt a taboo search algorithm [20] to solve each QAP in our formulation. Moreover, the coefficients of QAP problem can be also be computed efficiently in a successive manner based on the solution to the preceding QAP problem. Our numerical results demonstrate significant BER reduction over both non-MoDiv and a simple heuristic MoDiv retransmission scheme for 16-QAM, 32-QAM and 64-QAM constellation, even under mismatching design parameters.

The paper is organized as follows. Section 2 introduces the TWRC-AF model and the HARQ protocol we are using. Section 3 presents the successive BER minimization MoDiv design problem. In Section 4, we present the numerical results to show the performance gain of our MoDiv scheme. Finally, Section 5 concludes the paper.

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2. SYSTEM MODEL

3. SUCCESSIVE CONSTELLATION MAPPING DESIGN FOR MODULATION DIVERSITY

3.1. A BER upperbound

3.2. The Successive Quadratic Assignment Problem

4. NUMERICAL RESULTS

5. CONCLUSION

6. REFERENCES

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