A Novel Decoding Algorithm of Superposition Modulation for Cooperative IoT System

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***Abstract* – In this paper, we propose a novel decoding strategy for superposition modulation (SM) for cooperative IoT system. Unlike the conventional method where the SIC (successive interference cancellation) decoding is applied, whose performance degrades when the decoder fails to detect the main signal, we propose a novel decoding algorithm which derive the LLR (log likelihood ratio) directly from the received signal. The new decoding scheme performs well even when the main signal detection fails and outperforms conventional SIC based decoding method by more than 2 dB in the fading environment.**

1. INTRODUCTION

Recently, there has been a lot of research on improving the reliability of the IoT communication system. Since there exist power and cost limitations it is not easy to deploy multiple antennas in IoT devices to get the diversity gain. Therefore, cooperative communication technique obtaining a space diversity effect is a proper alternative [1]-[4]. Among several choices of relaying methods such as AF (amplify and forward), DF (decode and forward) and CF (compress and forward) we consider only DF in this paper.

To increase the data rate and save transmission powers, the authors in [5] and [6] proposed a cooperative transmission where the relay sends both the received packet from the source and its own transmission packet using the SM method. In the receiver, main signal is detected first and then the secondary superposed signal is decoded using the SIC algorithm.

The problem of this method is that the BER performance of the secondary signal degrades when there exists a detection error in the main signal. To mitigate the error propagation effects, we propose a novel decoding method where we extract the LLR information directly from the received signal without using the SIC.

1. SYSTEM MODEL

In this paper, we consider single hop relay network system. We denote *S*, *R* and *D* to denote the source, relay and destination nodes, respectively as shown in Fig. 1. We assume all nodes have a single transmission and receiver antenna. In transmission phase 1, the source node sends channel symbol to both the destination and receiver and the relay node send its symbol in the phase 2. When there exists the packet error in phase 1, the relay sends both the source and its own incremental channel symbol to the destination in transmission phase 2. In this paper we assume there exist no packet error between the source and the relay node assuming the distance between the source and relay is close.

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The received signal in each phase can be represented by

 (1)

and

 (2)

respectively, where and are channel gains modeled as complex Gaussian random variables with mean 0 and variance 1, and and are AWGN. is attenuation constant between the relay and destination node, and are source and incremental relay channel symbol. When there is no packet decoding error (so no feedback from the destination to the relay node) is set to 0 and only the incremental symbol is transmitted in phase 2.



Fig.1 System model of the cooperative IoT system.

1. PROPOSED DECODING ALGORITHM

Comparison of existing SM scheme and proposed algorithm is shown in Fig.2. For simplicity, channel coding is not considered with QPSK modulation in this explanation diagram but other channel coding strategies and different modulation can be applied. symbol of received packet denoted by , in phase 1 and phase 2.

Phase 1 : In both conventional and proposed methods, , referring to the index 2k & (2k+1) information bits of the source, are decoded to by deriving LLRs, .

Phase 2 : In the conventional method, the destination node derive , referring to LLRs of the index 2k & (2k+1) information bits for the relay, which can cause error propagation in case this step fails.

Fig.2 Conventional and Proposed Decoding Algorithm



Next, substrate , derive LLRs, denoted by , for the source and combine bit LLRs, resulting for .

In the proposed decoding algorithm, the destination node derives respective LLRs, & , for the source and the relay directly without SIC step by the adaptive power ratio mapping table. For example, the adaptive power ratio mapping table is used to derive bit LLRs, , since the bit index 4k & 4k+2 of refer to the information bits index 2k & (2k+1) of the source node in the case of QPSK modulation. It forwards to BLC step. In a parallel process, proposed scheme derive bit LLRs, , for the reason that refers to information bits index 2k & (2k+1) of the relay node. In summary, bit LLRs of & are derived directly without any propagation caused by SIC.

1. .SIMULATION RESULT

To evaluate the performance of the proposed system, we run Monte Carlo simulation. Though we described the algorithm assuming the un-coded case to ease the explanation, we included the rate 1/3 turbo code with block size of 780. QPSK modulation and Quasi-static Rayleigh fading channel is used in the simulation. The BER for the conventional and the proposed algorithm is measured in case of (SNR between R and D) 1 and 3.16, which is 0dB and 5dB in dB scale.

Since the performance of the decoding algorithm depends on the power ratio, of the main and superposed signal, we first evaluated the best of the conventional (0.7) and the proposed system (0.3). The proposed decoding algorithm gained 1.5dB and 2dB in respectively over the conventional SM decoding method at the BER and region as shown in Fig. 3. The performance gap increases as the operating SNR becomes higher.

1. CONCLUSIONS

In this paper, we propose a novel decoding method for superposition modulation for cooperative IoT system. We extract the LLR information directly from the received signal without regenerating the main signal to avoid the detection error propagation. The simulation results show that the proposed method outperforms the conventional method by more than 2 dB in the fading channel environment.



Fig.3 Comparison of BER performance curve of the proposed and conventional decoding methods

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