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Sparsity-Aware Multiple Relay Selection In Large Decode-and-Forward Relay Networks

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Abstract

Cooperative communication is a promising technology that has attracted significant attention recently thanks to its ability to achieve spatial diversity in wireless networks with only single-antenna nodes. The different nodes of a cooperative system can share their resources so that a virtual Multiple Input Multiple Output (MIMO) system is created which leads to spatial diversity gains. To exploit this diversity, a variety of cooperative protocols have been proposed in the literature under different design criteria and channel information availability assumptions. Among these protocols, two of the most-widely used are the amplify-and-forward (AF) and decode-and-forward (DF) protocols.
However, in large-scale relay networks, the relay selection process becomes highly complex. In fact, in many applications such as device-to-device (D2D) communication networks and wireless sensor networks, a large number of cooperating nodes are used, which leads to a dramatic increase in the complexity of the relay selection process. To solve this problem, the sparsity of the relay selection vector has been exploited to reduce the multiple relay selection complexity for large AF cooperative networks while also improving the bit error rate performance.
In this work, we extend the study from AF to large-scale decode-and-forward (DF) relay networks. Based on exploiting the sparsity of the relay selection vector, we propose and compare two different techniques (referred to as T1 and T2) that aim to improve the performance of multiple relay selection in large-scale decode-and-forward relay networks.
In fact, when only few relays are selected from a large number of relays, the relay selection vector becomes sparse. Hence, utilizing recent advances in sparse signal recovery theory, we propose to use different signal recovery algorithms such as the Orthogonal Matching Pursuit (OMP) to solve the relay selection problem.
Our theoretical and simulated results demonstrate that our two proposed sparsity-aware relay selection techniques are able to improve the outage performance and reduce the computation complexity at the same time compared with conventional exhaustive search (ES) technique. In fact, compared to ES technique, T1 reduces the selection complexity by O(K^2 N) (where N is the number of relays and K is the number of selected relays) while outperforming it in terms of outage probability irrespective of the relays' positions. Technique T2 provides higher outage probability compared to T1 but reduces the complexity making a compromise between complexity and outage performance. The best selection threshold for T2 is also theoretically calculated and validated by simulations which enabled T2 to also improve the outage probability compared with ES techniques.

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