CITY UNIVERSITY OF HONG KONG

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TRANSMISSION STRATEGIES AND RESOURCE ALLOCATION FOR WIRELESS COOPERATIVE NETWORKS

無線協作網絡傳輸策略和資源分配

Submitted to Department of Electronic Engineering

電子工程學系

In Partial Fulfillment of the Requirements for the Degree of Master of Philosophy

哲學碩士學位

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August 2010

二零一零年八月

Abstract

In a wireless ad hoc network, a wireless node not only acts as a source or a destination, but also works as a relay to help forward messages for other source-destination pairs. In general, cooperative transmission methods can be classified as transmitter cooperation and receiver cooperation, depending on whether cooperation is among transmitters or among receivers. One of the most fundamental concerns in cooperative communication is to comprehend the performance limits in the networks with cooperation. That leads to a growing demand on the area of network information theory and especially the topic of relay networks. Based on the considerations above, we analyze two kinds of networks respectively. One is wireless networks with receiver cooperation, and the other one is wireless networks with full cooperation in which both transmitter cooperation and receiver cooperation exist. In order to demonstrate the problem in a simple and direct way, we assume that there are two source-destination pairs in both networks we concern, and that the channel state is fixed and perfectly known at all nodes.

In the wireless network with receiver cooperation, we assume that there is a direct link between the source and the destination of a pair. Besides there is also a cross link between a non-paired source node and a destination node. Furthermore, the two destination nodes have cooperative links between them for the cooperation. For the frequency-flat model, a cut-set outer bound and a cooperative coding strategy are derived. We use Matlab to see the performance of the proposed strategy, and compare it with the outer bound and two other strategies in the scenario of high signal to noise ratio (SNR) and low SNR, respectively. Moreover, we found that our proposed strategy achieves the outer bound in a special case. Then, we extend the model to a frequency-selective one, in which each node can take several subcarriers to transmit messages. We develop two resource allocation methods to maximize the sum rate, and compare them with two counterparts in the regimes of high SNR and low SNR. We also compare them in terms of computational complexity, and realize the tradeoff between the sum rate and computational complexity.

In order to present the problem in a more general way, we add cooperative links between the two source nodes in the model of wireless networks with full cooperation. In this model, each source node can also work as a relay to help forward messages of the other source-destination pair. Therefore, there exist three relay paths for either source-destination pair. The first one is a two-hop path by the other destination node as relay. The second one is a two-hop path by the other source node as relay. The last one is a three-hop path by the other two nodes as relay. Likewise, an outer bound in the scenario of frequency-flat channel is given for comparison and a forwarding strategy is proposed. We evaluate the performance of the strategy under different channel conditions. It is shown that there is a gap between the proposed strategy and the outer bound in every case we have for full cooperation. Besides, its performance in high SNR regime and low SNR regime are also studied. For the scenario of frequency-selective channel, we utilize similar resource allocation methods used in the networks with receiver cooperation, and compare them with two other schemes in terms of sum rate and computational complexity.

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Nomenclature

$\bar{\tau}^{(i)}$ The fraction of time that subcarrier i is used in phase 2, page 29

η_A The sharing factor of node A's power for frequency band 1, page 20

η_B The sharing factor of node B's power for frequency band 2, page 20

$\Gamma_{kl}^{(i)}$ The power to noise ratio at the link from node k to node l, $\Gamma_{kl}^{(i)} \triangleq P_k \cdot (g_{kl}^{(i)})^2$, page 27

$\mathcal{S}_1$ The set involving subcarriers in the first group, page 18

$\mathcal{S}_2$ The set involving subcarriers in the second group, page 18

$\mathcal{S}_3$ The set involving subcarriers in the third group, page 43

$\mathcal{S}_4$ The set involving subcarriers in the fourth group, page 43

$\omega_k^{(i)}$ The fraction of the transmission power of node k allocated to subcarrier i, page 27

$\tau^{(i)}$ The fraction of time that subcarrier i is used in phase 1, page 29

$\tau_n^{(i)}$ The fraction of time used in phase n at subcarrier i, page 55

$\varepsilon_{kl}^{(i)}$ The fraction of node k's power allocated to the link from node k to node l at subcarrier i, page 29

ϑ_n The frequency sharing factor of phase n, page 20

$C(x)$ Shannon's capacity formula: $C(x) \triangleq 0.5 \log_2(1+x)$, page 19

$D_B(P, h_1, h_2, h_3, n_0, B)$ The capacity region of the three-user BC with the link gains from the base station to users h_1, h_2 and h_3, with the common receiver noise power spectral density $n_0/2$, and with the bandwidth B. , page 8

$D_C(P_1, P_2, P_3, n_0, B)$ The capacity region of three-user MAC with common information shared by user 1 and user 3, page 9

$D_M(P_1, P_2, P_3, n_0, B)$ The capacity region of the three-user Gaussian MAC with users' power P_1, P_2 and P_3, and bandwidth B, page 5

$g_{kl}^{(i)}$ The link gain from node k to node l at subcarrier i, page 18

n_0 The real Gaussian noise power, page 5

N_1 The number of elements in $\mathcal{S}_1$, page 35

N_2 The number of elements in $\mathcal{S}_2$, page 35

P_l The power of node l, page 19

R_1 The total data rate between node A and node 1, page 22

R_2 The total data rate through node B and node 2, page 22

r_{k1} The aggregate rate from node k to node l summed over all subcarriers in the corresponding group, page 26

$r_{k1}^{(i)}$ The rate from node k to node l at subcarrier i, page 26

R_{Kd} Source K's data rate through the direct path, page 22

R_{Kr} Source K's data rate through the relay path, page 22

$V_{BC}(P, g_a, g_b, g_c, \tau, n_0, B)$ The set consisting of rate triple (r_a, r_b, r_c) that satisfies $(R_1, R_2, r_c) \in \tau \cdot D_B(P/\tau, g_a, g_b, g_c, n_0, B)$., page 54

$V_{MAC}(\Gamma_a, \Gamma_b, \Gamma_c, \tau, n_0, B)$ The set consisting of rate triple (r_a, r_b, r_c) that satisfies $(r_a, r_b, r_c) \in \tau \cdot D_M(\Gamma_a/\tau, \Gamma_b/\tau, \Gamma_c/\tau, n_0, B)$., page 28

W The bandwidth of each subcarrier, page 18

W' The whole bandwidth, page 19