Simultaneous Routing and Resource Allocation via Dual Decomposition

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In wireless data networks the optimal routing of data depends on the link capacities which, in turn, are determined by the allocation of communications resources (such as powers and bandwidths) to the links. Adjusting the resource allocation changes the capacities of individual links, influences the optimal routing of data flows, and alters the total utility of the network. The optimal performance of the network can only be achieved by simultaneous optimization of routing and resource allocation. In this paper, we study the simultaneous routing and resource allocation problem and exploit problem structure to derive efficient solution methods. We use a capacitated multicommodity flow model for the data flows in the network. We assume that the capacity of a wireless link is a concave and increasing function of the communications resources allocated to the link, and the communications resources for groups of links are limited. These assumptions allow us to formulate the simultaneous routing and resource allocation problem as a convex optimization problem over the network flow variables and the communications variables. These two sets of variables are coupled only through the link capacity constraints. We exploit this separable structure by dual decomposition. The resulting solution method attains the optimal coordination of data routing in the network layer and resource allocation in the radio control layer via pricing on the link capacities.