

## **Link Allocation for Multiuser Systems With Hybrid RF/FSO Backhaul: Delay-Limited and Delay-Tolerant Designs**

In this paper, we consider a cascaded radio frequency (RF) and hybrid RF/free space optical (FSO) system where several mobile users transmit their data over an RF link to a decode-and-forward relay node (e.g., a small cell base station) and the relay forwards the information to a destination (e.g., a macro-cell base station) over a hybrid RF/FSO backhaul link. The relay and the destination employ multiple antennas for transmission and reception over the RF links while each mobile user has a single antenna. The RF links are orthogonal to the FSO link but half-duplex with respect to each other, i.e., either the user-relay RF link or the relay-destination RF link is active. For this communication setup, we derive the optimal fixed and adaptive link allocation policies for sharing the transmission time between the RF links based on the statistical and instantaneous channel state information (CSI) of the RF and FSO links, respectively. Thereby, we consider the following two scenarios depending on the delay requirements: 1) delay-limited transmission where the relay has to immediately forward the packets received from the users to the destination, and 2) delay-tolerant transmission where the relay is allowed to store the packets received from the users in its buffer and forward them to the destination when the quality of the relay-destination RF link is favorable. Our numerical results illustrate the effectiveness of the proposed communication architecture and link allocation policies, and their superiority compared to existing schemes, which employ only one type of backhaul link.