Evolving Cellular Communications towards Mobile over Fiber Networks

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Background

Driven by an explosion of personal computers, tablets and smart phones, the demand of data traffic has increased by a hundred times in the past decade and an accelerating trend is expected beyond 2020. New applications such as virtual reality (VR), augmented reality (AR), and immersive gaming are expected to consume even more bandwidth with Gbps connections. The number of devices to be supported could also reach tens or even hundreds of billions, due to many new applications on automotive, transport, security and healthcare. In this background, it is crucial for researchers to develop innovative communication technologies to meet these intense demands.

Motivations

Under this context, a Mobile over Fiber (MOF) network has been proposed by CSIRO to provide very high speed wireless connections to mobile devices through low cost remote access units (RAUs) installed in homes by users, and powerful mobile processing units in the optical office. The air-interface: from RAUs to mobile users, is essential for the proposed MoF architecture. Information theory has revealed that the capacity of a multiple-input and multiple-output (MIMO) channel can increase linearly with the number of antennas in a rich scattering environment. However, many challenges have to be tacked to develop practical MIMO technologies for MoF air-interface.

Outcomes

In our study, advanced MIMO technologies are studied to exploit the degree of freedom gain under a variety of proposals for future wireless networks.

First, a new linear vector physical-layer network coding scheme is proposed for a MIMO two-way relay channel where the channel state information is unavailable at transmitters. We present an explicit network coding method that minimizes the error probability at high signal-to-noise ratios (SNRs). We propose a novel typical error event analysis and show that the proposed scheme achieves the optimal error rate performance at high SNRs. Numerical results show that the proposed scheme significantly outperforms existing schemes.

Second, a new caching scheme is proposed for a random wireless device to-device (D2D) network, where each node is equipped with a local cache and intends to download files from a prefixed library via D2D links. The distributed MIMO technology is employed between source nodes and neighbours of the destination node for cache deliveries. The induced multiplexing gain and diversity gain increase the number of simultaneous transmissions, improving the network throughput. The average aggregate throughput scales almost linearly with the number of nodes, with a vanishing outage probability, and outperforms existing ones when the cache size is limited.

Third, a hybrid D2D-cellular scheme is proposed to make use of the standby users who possess D2D communication capabilities in close proximity to each other, and to improve the rate performance for cellular users. Through D2D links, a virtual antenna array is formed by sharing antennas across different terminals to realize the diversity gain of MIMO channels. We then design an orthogonal D2D multiple access protocol and formulate the optimization problem of joint cellular and D2D resource allocation. Extensive system-level simulations demonstrate that the cellular rate performance is significantly improved.