Abstract

Fifth-generation (5G) mobile communication system has been commercialized worldwide. Now, academia and industrial research organizations are moving forward to investigate the next mobile communication system, i.e., beyond 5G or six-generation (6G). Besides, 6G is also expected to play a central role in the Internet society changing from an Information Society 4.0 to a Super-smart Society 5.0. The progress of technology and the development of society in the communication environment is bringing the explosive growth of mobile devices and traffic connections. As a result, the capacity demand becomes a potential problem for efficient and effective communication in the future wireless network due to the limited wireless spectrum resources. To meet these requirements, the 6G is expected to support massive connectivity with extremely high data rate/capacity low latency, and high reliability. 3GPP Release 18 also investigates the possibility of performing uplink and downlink transmission simultaneously within the available TDD band in order to use the flexible spectrum. As one of the potential research interests in 6G, the full-duplex (FD) system with the characteristics of simultaneous data transmission and reception over a single channel has gained attention because of its ability to efficiently utilize the spectrum. This dissertation investigates the potential benefit of the FD system in providing efficient and effective communication through multihop wireless transmission and addressing the capacity demand of the future wireless network.

In this dissertation, the target problem of capacity demand for efficient and effective communication is approached by focusing on the three key issues of inefficient network capacity, ineffective transmit power control and inefficacious resource allocation in the multihop wireless network environment. Extensive research has been done in FD systems with or without the relaying strategy, focusing on simultaneous transmission to increase transmission capacity. However, more research work is still required consideration to truly achieve the potential benefit of the FD system. This dissertation investigates different approaches to the FD system to achieve efficient data communication for future wireless networks. The efficient and effective communication in this dissertation refers to communication with optimum transmission capacity, low interference, and high resource utilization, even in a dense network environment.

This dissertation develops a cooperative relaying medium access control (coreMAC) framework for the FD wireless networks. The coreMAC framework is conceptualized from the cooperative communication strategies, i.e., transmission strategy, relaying strategy, and allocation strategy. The proposed framework provides efficient communication through three schemes: a mixture of concurrent and sequential transmission (MCST) scheme, optimal achievable transmission capacity (OATC) scheme, and channel interference balancing allocation (CIBA) scheme.

The MCST scheme is designed for transmission capacity optimization in multihop wireless networks. MCST is the first transmission scheme to support the combination of both sequential and concurrent transmissions in a single timeslot in terms of spatial reuse mechanism. MCST scheme is proposed as the capacity management module to address the issue of inefficient network capacity management in the wireless network. Besides, an FD medium access control (MAC) protocol is proposed as FD-MCST to assist the MCST scheme.

As the second scheme, the OATC scheme is proposed to extend the MCST scheme to minimize interference and optimize transmission capacity. The OATC scheme is conceptualized by considering the temporal reuse mechanism with the MCST scheme and the spatial reuse mechanism with the TPC technique. The proposed OATC scheme acts as a power management module to address the second issue of ineffective transmit power control for effective communication.

Then, the CIBA scheme is designed to investigate the FD transmission capacity through interference mitigation via channel allocation in the multi-channel multihop wireless networks. The CIBA scheme reduces the interference by allocating nearby transmissions into different sub-channels and optimizes the transmission capacity. In this way, CIBA works as the resource management module and represents the possible solution to the inefficacious resource allocation management of future wireless networks.

The performance of the proposed three schemes of the coreMAC framework is evaluated through numerical simulations written in MATLAB programming with different simulation scenarios. The performance evaluation is mainly compared in terms of the achievable network capacity, throughput, transmission overhead, and total interference power of existing MAC protocols. The numerical simulation results can be summarized

as follows:

- The FD-MCST achieves 1.7 times and nearly two times improvement in achievable network capacity and achievable throughput, respectively, compared to existing MAC protocols in FD wireless networks.
- The OATC scheme shows a higher achievable network capacity with minimum interference power and around 56% improvement in achievable throughput.
- The multi-channel allocation scheme reduces the total interference power and optimizes the achievable network capacity compared to the single-channel allocation scheme in the FD wireless networks. Furthermore, in the multi-channel multihop wireless networks, the CIBA scheme accomplishes lower total interference power and higher achievable network capacity than the fixed multi-channel allocation schemes.

In this dissertation, the framework is proposed in the data link layer of the TCP/IP protocol. Through the three schemes, the proposed framework results in higher transmission capacity, higher achievable network capacity, higher achievable throughput, and lower achievable transmission latency and overhead. Furthermore, the proposed framework accomplishes lower transmission latency and higher achievable throughput that affect the transport layer protocol performance, which will benefit the quality of service for specified applications such as auto-driving cars and unmanned aerial vehicles.

Keywords: Capacity optimization, Interference mitigation, Interference-aware channel allocation, Cooperative communication strategies, Full-duplex system