Optimal Mixture of Concurrent and Sequential Transmissions for Full-duplex Multihop Wireless Networks

1810411 KHUN Aung Thura Phyo

Full-duplex (FD) communication has been considered as the potential technology to provide the services for increasing the traffic in the future wireless networks. FD increases the data rate and the spectral efficiency to utilize the capacity of the network. FD performs as an attractive solution to cope with the ever-increasing capacity demand, with the double spectrum efficiency by simultaneous transmission and reception to remarkably enhance the throughput of the transmission than the Half-duplex (HD) communication systems.

One of the key elements of FD is to overcome interference occurred in simultaneous transmissions. Interference is a wireless signal that alters or disrupts the desired wireless signal from transmitting source to a receiver. Since the FD system can transmit and receive simultaneously over a single time/frequency channel, the self-interference (SI) is the main challenge to realize the FD transmission. However, the residual self-interference (SI) can be modelled as additive white Gaussian Noise (AWGN), in the other way, as noise through transmission, according to the existing proposed techniques for self-interference cancellation.

Recent developments towards SI cancellation techniques have allowed to realize the FD communications on low-power transceivers, such as small-cell (SC) base stations. However, with the potential research solution, although FD can be eliminated to Noise level, there is still the interference from other nodes in the network which is called co-channel interference (CCI). Theoretically, although FD brings the potential benefits of doubling capacity if SI can be eliminated, CCI still affects as the potential threat of performance degradation in the dense network. And, the reduction of interference issues in the previous works still need to focus on for advanced wireless communication. Therefore, this research completely takes into consideration the interference issues in transmission in FD networks.

The purposes of the research are to propose a cooperative medium access control (MAC) for high throughput performance in FD multihop wireless network and to propose an optimal transmission scheme for FD wireless network by increasing the achievable capacity while mitigating the interference occurred during simultaneous transmissions. With the motivation of lack complete research methodology to study the performance of simultaneous transmission in FD network, the system model and the complete methodology of the research is discussed as the first objective of the research. Then, to ensure high achievable capacity by using the mixture of concurrent and sequential transmissions scheme, the second objective is to minimize the interference level from the simultaneous transmissions with power control mechanisms. This research takes into consideration two types of transmission in FD network, i.e., bi-directional FD (BFD) and relay FD (RFD).

By taking advantage of an opportunistic MAC, i.e., spatial reuse in concurrent transmission (CT) for capacity gain and minimum interference in sequential transmission (ST), the mixture of concurrent and sequential transmissions (MCST) scheme is proposed to achieve a better achievable capacity of the transmissions in the FD wireless network. Besides that, to reduce the interference power while maximizing achievable capacity, the power control schemes, minimum transmit power control (MTPC) and minimum interference power control (MIPC), under the constraint of minimum transmit power and minimum interference power of the transmissions are investigated with MCST to manage the CCI.

Since device-to-device (D2D) communication can improve the capacity of the network when the users are close to each other, and FD communication gives an advantage in the small range network with low transmit power, this research focuses on the FD network in a dense environment. Three numerical studies have been done to evaluate the performance of the proposed novel transmission scheme. They are the basic 4-node network topology with fixed transmit power, the dense network topology with different node density, i.e., 20-100 nodes and the 20-node network topology with different transmit power.

According to the theoretical and numerical studies with the assumption of the system model, the achievable capacity of the network can be increased up to 2.5 times of the CT capacity and interference can be mitigated up to about 5% in the basic 4-node FD network with fixed topology. Besides that, the achievable capacity of FD network can be improved with the proposed transmissions scheme up to around 8 times of the achievable capacity with sequential transmissions when the number of wireless node is 100 with BFD transmissions. With RFD transmissions, the achievable capacity gain can be increased about 5 times of the capacity with sequential transmissions. The interference power can be reduced up to 4% for BFD transmissions whereas up to 17% for RFD transmissions when the number of nodes is 100 in the FD network.

For the mitigation of interference, this research shows that the interference can be mitigated up to 80% in the basic 4-node FD network by applying MCST scheme with MIPC approach power control mechanism. Regardless of the transmit power, the achievable capacity of FD network can be increased about 2.5 times.

Based on the system model and assumptions in this research, the thesis concludes that the MTPC mechanism provides better achievable capacity compared to MIPC algorithm while MIPC reduces more average total interference power than TPC mechanism. Finally, this research concludes that MCST is an optimal transmission scheme for future wireless communication since it always gives a better achievable capacity than the other two simultaneous transmissions, ST and CT.

Keywords: Full-duplex, Device-to-Device Communication, Co-channel interference, Achievable Capacity, Simultaneous transmissions, Transmit Power Control