Chapter 6

Conclusions and Future Work

Due to rapid development of smartphones, laptops, and tablets and their widespread integration in everyday life, the demand of high data traffic has been increased in wireless communications. This high data traffic can be mitigated by providing a larger signal bandwidth. It is available at the mmWave spectrum (30-300 GHz). However, the integration of mmWaves and MIMO has been studied to combat some technical challenges as discussed in Chapter 1. Thus, mmWave MU-MIMO accompanied with hybrid beamforming can be seen as one of the key technologies to increase transmission rate in the wireless systems. As discussed in Chapter 2, such systems exhibit inherent channel sparsity. To exploit this sparsity, the mmWave channel model is transformed form the spatial domain to the beamspace domain, known as mmWave beamspace MU-MIMO system.

Such systems suffer from radio frequency complexities. Beam selection algorithm play vital role in reducing the radio frequency complexity of the mmWave beamspace multiuser MIMO systems. Therefore, beam selection algorithms in mmWave beamspace MU-MIMO downlink systems are investigated and new low complexity beam selection algorithms are proposed in this work.

6.1 Conclusions

A mmWave beamspace MU-MIMO downlink system is considered to the following chapters in this thesis.

A "QR-based" beam selection algorithm to reduce the required number of beams associated with RF chains is discussed in Chapter 3. This algorithm maximizes the sum rate performance while pre-cancelling the interference at each user. In addition, an iterative precoding method is discussed which pre-cancels the interference for each user while performing "QR-based" beam selection. Simulation results demonstrate that the proposed "QR-based" beam selection algorithm outperforms the other existing beam selection algorithms [109, 110, 113]. Although complexity of the proposed "QR-based" beam selection algorithm is greater than [110], but it is less than [109, 113]. Further, low complexity algorithms, i.e., greedy and "MWM-based" beam selection algorithms are discussed while taking advantageous of the mmWave cellular system with regards to the availability of users and cell size. Simulation results demonstrate that the proposed greedy and "MWM-based" beam selection algorithms outperform the other existing beam selection algorithms "MC" [109], "M-SINR" [109], "MM" [113], "IA" [110], but those are inferior to the "QR-based" beam selection algorithm. But, both the proposed algorithms exhibit very less complexity than the "QR-based" beam selection algorithm.

In Chapter 4, the need for decentralized beam selection algorithm is discussed in details. First, this chapter discusses auction-based beam selection algorithm. Next, a variant of auction algorithm, i.e., distributed auction algorithm is discussed. Further, a distributed auction-based decentralized beam selection algorithm is discussed. Unlike the existing centralized beam selection algorithms "MC" [109], "M-SINR" [109], "MM" [113], "IA" [110], the decentralized beam selection algorithm distributes computations to each user who play an important role for selecting the beams. Thus, it reduces the computation burden of transmitter. After selecting the beams, one of the users nearer to transmitter feeds back the indices of beam to transmitter. Simulation results demonstrate that the proposed auction and distributed-auction based beam selection algorithms not only outperform the other existing beam selection algorithms [109, 110, 113], but also perform almost equal to "MWM-based" beam selection algorithm [117]. Complexity of the proposed decentralized beam selection algorithm is constant irrespective of changes in K, and approximates to "MWM-based" beam selection algorithm.

The need of NOMA in the power domain for such system is discussed in Chapter 5. Next, a beam selection algorithm accompanied with NOMA principle is discussed. After beam selection, a NOMA power allocation scheme is discussed to preform SIC successfully at user's end. Simulation results demonstrate that mmWave beamspace MU-MIMO-NOMA system achieves better performance (spectral and energy efficiency) with less number of RF chains than the mmWave beamspace MU-MIMO downlink system.

6.2 Future Work

In the context of beam selection, the thesis work has assumed a single cell mmWave beamspace MU-MIMO downlink systems. However, the issue can be extended into three other cases:

1. mmWave beamspace Massive MU-MIMO systems, in which the transmitters are equipped with a large number of beams and users are equipped with more than one receiving antenna. For such systems, selecting an optimal group of beams for transmission is considered a challenging task. This is because the search process is achieved on a large number of beams in order to select the desired subset among them. Hence, it is essential to find more practical algorithms of beam selection which can deal with such large number of beams with more flexibility and at the same time maintain rest other advantages of the systems.

2. Multi-cell mmWave beamspace MU-MIMO networks, by which network capacity can be maximized by using efficient methods of interference mitigation. In this case, nullifying inter-cell interference as well as intra-cell interference must be taken into consideration.

3. Another issue which should be considered in future mmWave beamspace MU-MIMO system is to obtain the perfect channel state information. By scaling up the number of users in the cell, the need of the perfect channel state information becomes more crucial in order to reduce the multi-user interference. Hence, investigating technologies of beam selection for mmWave beamspace MU-MIMO system with limited channel state information or imperfect channel state information is considered as a pioneering research work for mmWave beamspace MU-MIMO system.