AI Basis Massive MIMO Performance Optimization

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Summary

Massive MMO has become a key technology component in 5G networks for improving spectral efficiency, data rates and network coverage. Massive MIMO brings also new challenges and requires a set of new solutions for the mass market. This thesis illustrates Artificial Intelligence basis Massive MIMO beamforming optimization process and performance results. Improved spectral efficiency characteristics of the proposed method in comparison with the conventional methods are demonstrated through computer simulations to support the proposed method.

Ⅰ. Introduction

Over the recent years, the advances in theoretical Artificial Intelligence and Machine Learning (AI/ML) have been extraordinary. These advances have been driven by the computational capacity, open-source research, accessible publications, free development software with state-of-the-art libraries and the era of big data. While traditional AI research has primarily targeted domains such as natural language processing and computer vision, it can be very useful in other domains. It is a powerful tool in solving complex optimization problems with multiple input and output variables, "finding better solutions faster". This paper shows the proposed solutions to search for customized beam sets that can optimize the overall RF spectral efficiency of the cell or the group of cells with mMIMO.

Ⅱ. The proposed Method

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Over the next few years, we expect AL/ML to be applied to 5G systems in at least three different ways. First, they have the potential to replace some of the model-based Layer 1 and Layer 2 algorithms [1] such as channel estimation, preamble detection, equalization and user scheduling, either because they perform better or are less complex. Second, they are likely to be applied extensively in deployment optimization, for example for configuring an optimal subset of beams with which to illuminate the coverage area, taking cell traffic patterns into account. Given the complexity of 5G systems in terms of the sheer number of parameters to be configured at the time of deployment, AI/ML techniques will play an important role in the vision of zero human touch network optimization [2]. The challenge for mMIMO optimization would be compute complexity in proportional to large number of antenna/beams/layers [3]. We propose dynamic programming problem formulation and DQN as bellows

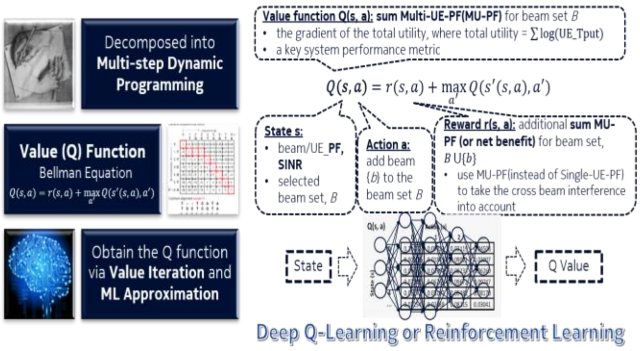

Fig.1: The proposed DQN method

Fig.2 shows that the best ML scheduler can achieve close to theoretical maxⅢ. Conclusion and the reduced complexity ML scheduler can achieve good performance gains: 17% in geomean (GM) user throughput and 31% in cell edge (CE) user throughput comparing to product and 6% GM, 16% CE comparing to best heuristic possible. The latest 2 s-DQN scheme reduces the compute complexity of the DQN-based scheme via various means including the size the NN, the activation function, the safety net, etc.

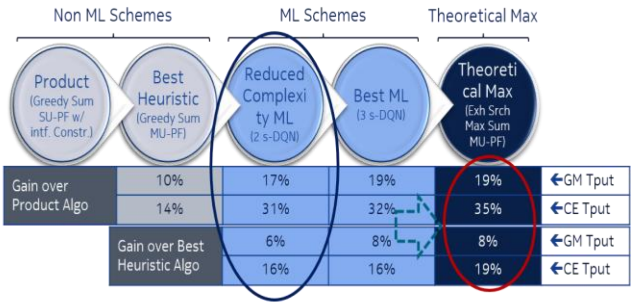

Fig.2: Performance comparison

In addition to simulating beam selection performance, we compare 3 schemes as follows

1. Manual beam selection to cover entire cell area

2. Greedy beam selection irrespective of other beams picked

3. DQN based beam selection capability

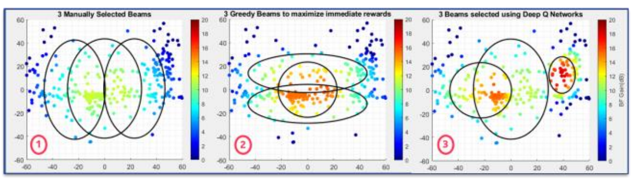

Fig.3: 3 beams from a dictionary of 120 beams

The simulation shows that Manual beam selection to cover entire cell area. In this scheme, generally broader beams used to cover the entire cell area. This doesn't take into account the UE density.

The scheme 2 shows that the beams are selected without considering what other beams are already selected. Hence, many beams provide overlapping coverage to the same high traffic-density region.

The scheme 3 show that Beam selection using ML Deep Q Networks. Here the group of beams are selected so that the overall beamforming gain is maximized. Hence, high traffic-density regions are served by narrow beams, while low traffic-density regions are served by wider beams.

We could see performance of the proposed method has the best beamforming gain for all three beams case.

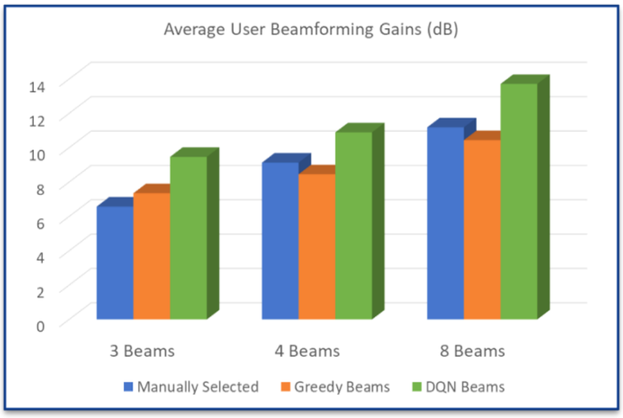

Fig.4: Average beamforming gain

Ⅲ. Conclusion

In this paper, we investigate DQN method provides good gain over naïve ways of picking beams for 5G mMIMO with 25~30% improvement.

References

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