



AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electronics Engineering and Electrical Communications

“Performance of Large Scale Antennas for 5G Cellular Systems”

A thesis submitted in partial fulfilment of the requirements of the degree of

Master of Science in Electrical Engineering

(Electronics Engineering and Electrical Communications)

by

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Cairo - (2019)



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Statement

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Electrical Engineering (Electronics and Communications Engineering).

The work included in this thesis was carried out by the author at the Electronics and Communications Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

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SUMMARY

The fifth generation of mobile wireless communication systems (5G) is a promising source for magnificent levels of connectivity and Quality of Services (QoS) to satisfy the growth of the number of users in a certain area and the growth of the data demanded. Massive Multiple Input Multiple Output (M-MIMO) technology is one of the key technologies that enables the 5G to satisfy its goals, such as enhancing the achievable data rate, minimizing the latency, enhancing the traffic capacity and improving the mobility. The collocated M-MIMO system is the system where the BS is mounted by a massive number of antennas (much larger than the number of active users). M-MIMO provides higher spectral and energy efficiency and reduces the inter-cell interference (ICI) to a certain level. However, the ICI remains a limiting factor in M-MIMO with its cellular distribution model.

Cell-Free (CF) M-MIMO is a new, practical and scalable concept in 5G wireless technology which has been introduced to serve the huge demand of wireless communications in the future. This can be done by distributing a large number of low-cost single antenna Access Points (APs) over a specific area. The APs are connected to a Network Controller (NC). The APs serve all the existing users simultaneously with no cell boundaries. This distributed model is more efficient due to space diversity and can provide much higher coverage at the cost of higher backhaul requirements.

In CF M-MIMO system, the selected pre-coders and Power Allocation (PA) algorithms in the APs are very important parameters, which influence the system performance. It was found in previous works that linear pre-coders – such as Conjugate Beamforming (CB) and Zero Forcing (ZF) – have simple implementation and good performance. Hence, CB and ZF pre-coders are used

in pre-coding in this thesis. Furthermore, power control is one of the main topics in the CF M-MIMO review. Many previous works used convex optimization programming tools in their proposed PA algorithms, however it does not consider the actual traffic pattern, plus it is more complex to be implemented. Hence, more simplified PA algorithms are needed to balance the fairness, to maintain good performance and to keep the distributed implementation.

Accordingly, this thesis proposes two PA algorithms for the most popular pre-coders – Conjugate Beamforming (CB) and Zero-Forcing (ZF) – in downlink scenario. They are based on quantizing the transmitted powers of APs according to the channel strength received at the user end. The performance of the proposed algorithms is evaluated under the most common practical scenarios such as channel errors, pilot contamination and correlated shadowing channel model.

The results show that ZF pre-coder significantly outperforms CB pre-coder in all the scenarios. Furthermore, it is observed that CB pre-coder is more robust in correlated shadowing condition than the ZF pre-coder, while ZF pre-coder is more robust to the pilot contamination effect than the CB pre-coder. CB pre-coder performs better than ZF pre-coder when the number of APs is small relatively to M-MIMO systems. The downlink rate per user was evaluated with the change in number of APs. Furthermore, it was evaluated with the change of the correlation domination factor in both algorithms. The sum spectral efficiencies in both algorithms were evaluated with the change of the pilot power and the number of existing users in all the practical scenarios. Furthermore, the total computational times of both algorithms were evaluated and compared with the variation of the number of the existing users in the CF M-MIMO System.

ACKNOWLEDGEMENT

All praise is due to Allah, Most Merciful, the Lord of the Worlds, who taught man what he knew not. I would like to thank God Almighty for granting me the chance, strength and ability to complete this work.

My sincere gratitude goes to my mother, father and family. This work would not have been possible without their continuous encouragement, patience, support and assistance. Very special thanks go to my husband Engineer Youssef Mounir, for his continuous, unconditional love, moral, financial support and encouragement. This work would not have been finished without his brilliant suggestions and solutions.

My words cannot express my gratitude to my advisor Prof. Dr. Salwa El-Ramly, who put me at the first step of M-MIMO world and guided me through my research. Her valuable notes, support, guidance, encouragement and confidence in me has made this work out to the light. Furthermore, very special thanks go to my advisor Dr. Bassant Abdelhamid. Her open mind gave me great space to discuss ideas that are more challenging. Her flexibility to work with me online during my stay in KSA gave this work a big push to be finished. Both of them treated me not just as their student but as their daughter and friend too.

Special thanks go to my friends Doha Akl, Maha Samir and Basma Hamdy, for their support so that this work can be finished.

Basant Amin

Cairo, Egypt

25 March, 2019

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