
AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Computer Engineering and Systems

# MAC Layer Optimization for Millimeter-Wave Wireless Networks

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

Master of Science in Electrical Engineering

(Computer Engineering and Systems )

By

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(Electronics Engineering and Electrical Communications )

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# Statement

This thesis is submitted as a partial fulfilment of Choose an item. in Choose an item., Faculty of Engineering, Ain shams University. The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Muhammad

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# Researcher Data

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# Abstract

The unlicensed 7 GHz frequency band centered at 60 GHz, commonly known as the millimeter wave (mmW) band, caught the research and industry attention as a possible candidate to extend the usable spectrum especially after the recent success in fabricating cheap mmW transceivers. The purpose of this study is to enhance the throughput of Multi-hop wireless networks with directional links that operates in mm-Wave range. Mm-W has different propagation characteristics than waves in lower frequency bands, like: Blockage and Deafness. Researcher believes that these different characteristics require a change for MAC layer protocols to be able to deliver a sub-optimal data transfer throughput. Basically this research targets the scheduling algorithm of the MAC layer.

Scheduling for simultaneous directional transmissions has been studied in the literature in many works. One of the main proposed algorithms is Greedy Maximal Scheduling (GMS). But some researchers followed a different approach as they tried to reach a TDM- like performance, completely avoided the collisions and also assured that the transmitter and receiver aligned their beams towards each other via a distributed trial and error algorithm called memory-guided directional MAC (MDMAC)

The overhead of sending a packet in MDMAC is very expensive; it takes around 45% of the total packet time, as each packet needs beamforming, Short Interframe Space (SIFS) interval and acknowledgement packet. To avoid such big overhead we are trying to make use of packet aggregation high throughput gain to achieve a higher utilization for the network. This is done by trying to make the slots allocation as contiguous as possible. In other words, scheduling will not only target slot organization to avoid collisions

and achieve fairness but will also try to make the best of the air via reserving the same amount of slots for the nodes as contiguously as possible to be able to use packet aggregation and hence, be able to send groups of packets with one beamforming, SIFS and also get one acknowledgement on them in a bitmap-like fashion instead of getting an acknowledgement packet for each sent packet. We propose a scheduling algorithm to achieve that and show that the resulting net throughput under the saturated network model is higher than the schemes that do not take that property into consideration like GMS or MDMAC by **71%** on average. Researcher shows that the protocol processing overhead is insignificant. Although our suggested algorithm can be applied in many network topologies but here we are interested in mesh networking because the directional property is very promising in this particular case.

Researcher also tries to further improve the overall network throughput via increasing the number of reserved slots using a simple protocol. The previous block acknowledgement technique was concerned in first place to make the slot contiguous as much as possible to be able to make a use of the block acknowledgement concept here researcher tries to schedule much links concurrently but with fair scheduling and to make the schedule fast adaptive for the traffic changes. It depends on iterations fist it reaches any feasible schedule then tries to reach gradually to better schedules .Researcher showed that that technique can enhance the overall throughput by **6%.** It is worth saying that Block acknowledgment technique can enhance the throughput when operates in environments with low level signal to noise ratio. But this iterative method is not affected.

# Summary

The unlicensed 7 GHz frequency band centered at 60 GHz, commonly known as the millimeter wave (mmW) band, caught the research and industry attention as a possible candidate to extend the usable spectrum especially after the recent success in fabricating cheap mmW transceivers. The purpose of this study is to enhance the throughput of Multi-hop wireless networks with directional links that operates in mm-Wave range. Mm-W has different propagation characteristics than waves in lower frequency bands, like: Blockage and Deafness. Researcher believes that these different characteristics require a change for MAC layer protocols to be able to deliver a sub-optimal data transfer throughput. Basically this research targets the scheduling algorithm of the MAC layer. Researcher suggests two scheduling techniques. The First scheduling technique is inspired by block acknowledgments concept introduced early in WIFI. Simulation shows throughput gain of 70%. Such technique is valid for high signal to noise environments. But For low signal to noise ration environment the second scheduling technique will be more convenient as it depends on iterative method to reach better schedule in step by step manner. It starts with random schedule then make many enhancements for it to reach sub optimal schedule.

Chapter 1

This chapter presents an overview of Mm wave specialty. Motivation and research contribution are mentioned too in this chapter.

Chapter 2

Chapter 2 presents the challenges of the MAC layer due to Mm Waves characteristics. The wave in the band of mmW has different characteristics than waves at lower frequencies. The main concern of the researcher is characteristics that have effect on wireless communication application, such as, Deafness and blockage.

Chapter 3

Researcher introduces in this chapter a revision for the literate of MAC scheduling algorithms then focuses on algorithm that targets directional transmission. Researcher focuses on Memory guided MAC algorithm as it is already tailored for mmW networks.

Chapter 4

Chapter 4 presents the first proposed idea to increase the throughput of the mm wave networks range by trying to make contiguous slot allocation to be able to use block acknowledgement technique so reducing the packet sending overhead time.

Chapter 5

For low signal to noise ratio channels BLKACK will get low throughput so researcher suggests the second proposed algorithm to increase the throughput of the mm wave networks by increasing air utilization. Researcher developed iterative technique to get better schedule in step by step manner.

Chapter 6

Finally, Chapter 6 includes conclusion and future results.

**Keywords** -- mmWave; distributed; mesh networks; scheduling; throughput; MAC; block acknowledgment.

# Acknowledgment

Thanks god for all the blessings in my life.

Thanks Mom and Dad, I want to be successful just to make you happy.

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I hope the best for my country.

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# Table of Contents