CHAPTER-1: INTRODUCTION

1.1 Overview

802.11n WiFi standard which introduced new technologies brought massive speed improvement over legacy 802.11a and g wireless LANs. 802.11ac is essentially an updated version of 802.11n. Majority of changes are in the PHY layer with higher modulation and encoding schemes, better transmit beam forming and enhanced MIMO techniques. All of this result in very high throughput (theoretical limit of 6.9.Gbps). This thesis proposes to investigate areas of performance enhancement in 802.11ac.

1.2 Research motivation

802.11n has been offering many advantages in indoor environments and is competitive with mobile networks in outdoor environments as well. However, there are areas which need improvement. My study proposes to investigate the areas of performance improvement in 802.11ac (draft) WLAN standard over existing WLAN and cellular networks. If it breaks the gigabit speed barrier and other performance enhancements are implemented, it should be particularly good for high speed applications.

Limitations in 802.11n have been primarily due to:

i. **Quality of Service (QoS)**
ii. **Interference**

The motivation for this research came from the idea that, if these limitations are critically studied and improvements suggested, it is possible to communicate more data, over larger distances, with less power and higher accuracy.

Schedulers have been **well designed** in cellular networks (both LTE and WiMAX) primarily because of their Media access mechanisms which are

deterministic and also because of advanced features (not available with earlier WLANs).The same has not been possible in WLANs because of above mentioned limitations.

However, with 802.11ac (operating in 5 GHz band)and with addition of newer features- transmit beamforming (TBF) and MU MIMO, it is possible to improve performance.

1.3 Area of Study

The 802.11n standard was published in 2009. It is well appreciated that there will be increased usage of 802.11ac wireless based networks and also there is not much research done on IEEE 802.11ac performance.802.11n had come with additional features which can be grouped as belonging to MAC and PHY layers. On the MAC, features added are frame aggregation, block acknowledgement and reduced inter-frame spacing. On the PHY, we have transmit beam forming, SM (spatial multiplexing), channel bonding (20/40 MHz), MRC (Maximal Ratio Combining), STBC (Space Time Block Coding), short GI and additional MCS.

802.11ac has enhanced these features. While basic implementations of 802.11ac have been achieved based on the draft version (mandatory features are implemented), research is required on determining feasibility of using optional features for performance improvement.

1.4 Objectives of the Research

This research is intended to study the performance of 802.11ac and investigate its improvement over the previous standards.

The objective involves accomplishment of the following sub-objectives:

1. Investigation of individual enhancements of 802.11ac compared to 802.11n through simulations – Baseline performance (Throughput, Jitter, Delay) with the following features - more spatial streams, Channel BW, 256QAM.(Wave1)
2. To assess the performance of TXBF (Wave2)

3. To assess MU-MIMO performance (Wave2)
4. Study Rate Adaptation applications for 802.11ac.
5. Compare the above performance with cellular networks and explore the feasibility of a holistic scheduler (as in mobile networks) combining the benefits of the above enhancements can be recommended (as a future research area) to improve performance further and reduce the existing limitations.

1.5 Overview of research approach

1. Detailed study of the 802.11ac standard and 802.11n.
2. Literature review of existing mechanisms for improving performance of WLANs.
3. Feasibility of usage of the existing tools (ns2, ns3 [1], Matlab [2], OMNET, OPNET and QUALNET) suitable for 802.11ac is carried out.
4. MAC layer related simulations and analysis is done with NS3 while PHY layer work is performed using MATLAB.
5. A study of Schedulers in LTE and WiMAX has been done.
6. ***Evaluation of the feasibility of a scheduler for 802.11ac WLANs is undertaken which will holistically combine the benefits of each of the features studied.***

1.6 Contribution of research

Following standardization of IEEE 802.11ac by Wi-Fi Alliance, it is expected that there will be a huge deployment of 802.11ac client devices in 2017 which will have to incorporate newer enhancements to be compatible with products supplied by other vendors. The Research is planned to encourage designers to consider the concept of a holistic scheduler which will improve the performance of WLANS similar to cellular networks.

1.7 Outline of thesis chapters

Chapter 2 discusses the features of 802.11n and 802.11ac WLANs

Chapter 3 presents a detailed account of the work carried out so far in the area of QoS mechanisms for 802.11 WLAN with the aid of literature review of various QoS Mechanisms. Also a review of existing transmit beamforming, MU-MIMO and scheduling mechanisms is included.

Chapter 4 deals with performance evaluation through simulations and analysis for the following:

- Performance evaluation of IEEE 802.11ac and 802.11nthrough parameters like throughput, jitter and delay
- The effect of rate adaptation techniques like Ideal and Minstrel on both 802.11n and 802.11ac protocols is analyzed.
- Effect of TBFon different MIMO configurations is simulated
- Influence of MU-MIMO on the performance of 802.11ac WLAN.

Conclusions are summarized and an optimized scheduler is proposed in Chapter 5 taking into account the various techniques like rate adaptation, TxBF and MU-MIMO in different communication scenarios. This recommendation is the outcome of the research done to investigate the performance of 802.11ac (draft) WLANs.

Recommendations for future work are given in chapter 6.

Appendix-1 provides brief information about Simulation tools which were explored for the research. Background information regarding WLANs is explained in Appendix-2 and the mechanisms available to enhance QoS in WLANs in Appendix-3. Appendix-4 contains the details regarding scheduling in cellular networks, with emphasis on LTE and WiMAX. General characteristics of VoIP traffic are described in Appendix-5.Performance data collected through simulation is in Appendix-6. Modifications to 802.11 standard due to the addition of MU-MIMO feature is explained in Appendix-7. Publications based on this thesis are in Appendix-8.