EXECUTIVE SUMMARY

This thesis deals with investigating performance issues in IEEE 802.11ac WLANs. IEEE 802.11ac is a Very High Throughput (VHT) WLAN standard that is designed to achieve data rates in the order of 7 Gbps in 5 GHz range of frequency.

Firstly, problems faced in legacy LANS are discussed in detail. QoS and interference have been identified as the major limiting factors in WLANs. A study is undertaken with respect to the concepts underlying the 802.11n standard (prior to 802.11ac) followed by the enhancements in 802.11ac in the MAC and PHY layers.

NS3 simulations show the superior performance of 802.11ac standard with respect to 802.11n. Features verified are spatial streams, channel bonding, guard interval and MCS while performance is measured with parameters such as jitter, throughput and delay. It is seen that these features contribute to enhanced throughput and reduced delay.

Next, the 802.11ac performance with rate adaptation (RA) algorithms is simulated in NS3. Performance is measured for both 802.11ac and 802.11n WLANs with throughput versus SNR in the presence of parameters such as channel bonding and different spatial streams. A comparison is done to study the effect of Ideal Wi-Fi and Minstrel RA algorithms in 802.11n and 802.11ac. With Ideal RA, both 11ac and 11n perform consistently. With Minstrel, both 11ac and 11n behave similarly at 20 MHz CBW, but for 11ac, there is inconsistency at all other BWs and number of SSs. For 11ac, both Ideal and Minstrel are suitable at 20MHz and 40 MHz, but Minstrel is not recommended for 80 and 160 MHz CBWs. It is to be noted that 802.11ac standard has not yet defined rate adaptation mechanisms.

Transmit beamforming (TBF) in MIMO technology is employed to improve SNR at the receiver. It was added to 802.11n WLAN as an optional feature but not implemented. In 802.11ac, as this technique is highly simplified and also

standardized, it is expected to be a key contributor in improving performance and is expected to be extensively used in 802.11ac devices. TBF can thus be thought of as directing a beam using phase shifts towards a particular receive antenna. As the TBF technique can converge or cancel a beam by introducing appropriate phases, it can apply the same concept to cancel interfering signals in the direction of the receiver. This feature is studied in depth through simulations in MATLAB and the performance improvement is measured (using parameters like received power, EVM and constellation diagrams) comparing the results to another MIMO mechanism - Spatial Expansion. On studying the various scenarios in which TBF is used, it can be deduced that TBF contributes to performance improvement and also aids in reducing the magnitude of EVM. It is demonstrated that in case a receiver has the beamformee functionality built-in, SNR can be augmented with TBF in contrast with transmission using spatial expansion. As the received power is increased with TBF demodulation is more reliable and transmission with higher MCS can be opted.

MU MIMO is a technique of MIMO technology added to 802.11ac WLANs which is expected to be the major innovative feature in improving performance. Simulations of some scenarios are performed in MATLAB. It is seen that MU MIMO helps in distributing data to four users simultaneously using the space streams obtained through smart antennas. This is a major improvement over the limitation imposed by the MAC algorithm used in WLANs where stations can only gain access to the channel, one following the other. Hence, latency and also throughput can be increased for multimedia applications.

The following functional blocks have been identified to be key components in MU MIMO performance. Sounding, Precoding and detection techniques in the PHY layer and Aggregation, TXOP and back off mechanisms in the MAC layer. These areas would then be the points of interest to future researchers who wish to enhance MU MIMO performance.

As a conclusion of the research undertaken, the following inferences are arrived at:

1. 802.11ac has been verified to be superior in performance compared to the existing WLANs. It is found that individual benefits from independent features like MCS, CBW, SS, TxBF and MU-MIMO are good and can aid in working towards QoS improvement.

2. The performance of cellular networks with respect to QoS has been looked into to identify areas differing from WLANs - the scheduler. The concept of a scheduler is not specified by the IEEE WLAN standard unlike in cellular networks such as LTE and WiMAX. Also, link adaptation is clearly defined in mobile communications, whereas, RA mechanisms are loosely coupled to system flow in WLANs.

3. Also, approaches used in literature for applying scheduling techniques to WLANs are analyzed. The scheduling approaches which have been recommended for WLANs and are based on the following layers / mechanisms: Traffic Scheduling schemes, Polling, Token Passing, MAC layer (Aggregation and TXOP), PHY layer (scheduling using Resource Blocks), Cross platform and Out of band approaches.

Based on the above investigations (1 to 3), it is recommended to employ a scheduler for 802.11ac for assuring QoS guarantees, a major issue since long. Moreover, there is also a demand for schedulers based on the emerging applications and their QoS requirements. Additionally, there is a need to integrate RA with the scheduler for performance improvement. With individual features, performance enhancement is modest but with a combination of the WLAN features we can hope for remarkable improvements. These combination and cross layer approaches are discussed. Scheduler is the ideal framework for managing flows using these combined features - to achieve optimum QoS based on different scenarios.

Regarding the other limiting factor in legacy WLANs, namely interference - 802.11ac operation is only in 5GHz. The choked 2.4GHz frequency faces trouble from bluetooth devices, ovens, etc. which operates in the same band and is avoided. Also, Beamforming counters interference for optimum communication between Access Points and clients.

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 (TBF and MU MIMO) to be compatible with products supplied by other vendors. The outcome of the Research is expected to encourage designers to consider the concept of a holistic scheduler which will improve the performance of WLANS on the lines of cellular networks.

Since the next generation WLAN standard, IEEE 802.11ax will be further enhanced with Uplink MU_MIMO, the studies conducted in the thesis will prove as useful pointers in the design of a scheduler for the new standard also.