ISLAMIC UNIVERSITY OF TECHNOLOGY

WiFi-PAP WiFi Based Prioritized Access Point

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Declaration of Authorship

This is to certify that the work presented in this thesis is the outcome of the analysis and investigation carried out by Asif Muhammad Yousuf and Saud Mohammad Mostafa under the supervision of Dr. Muhammad Mahbub Alam in the Department of Computer Science and Engineering (CSE), IUT, Dhaka, Bangladesh. It is also declared that neither of this thesis nor any part of this thesis has been submitted anywhere else for any degree or diploma. Information derived from the published and unpublished work of others has been acknowledged in the text and a list of references is given.

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Abstract

Internet plays a vital role in every day life activities. There are several ways to access the internet. Communication is also facilitated through the internet. Internet can be accessed through wired or wireless networks. The basic building blocks of WLANs is Basic Service Set (BSS). BSS has two types of architecture namely ad hoc and infrastructure network. Most popular means of internet access are WiFi based Wireless LANs where the network is infrastructure network having an Access Point for the exchange of packets between the main server and clients or between clients. MAC layer mechanism uses IEEE 802.11 which defines Distributed Coordination Function (DCF). DCF employs CSMA/CA with binary exponential backoff. With the advance in technology the mobile devices are upgraded to incorporate WiFi interfaces so that it supports WiFi hotspots. But the performance of WiFi hotspots are extremely poor compared to the demand in using these technologies. The reason being that a single Access Point has to handle all the downlink flow to its clients or stations though getting the same opportunity to access the channel by contention with the other stations. In case when the downlink traffic flow is greater than the uplink traffic flow the AP has backlogged packets and packets are dropped consequently degrading the performance at the AP. This creates an asymmetric situation at the AP. The objective of our paper would be to reduce the traffic asymmetry and provide strict fairness to all the competing stations and the AP. We alter the access method of the AP to remove the asymmetric condition at the AP. AP will be given higher priority to access the medium hence when it has some packets to send then AP will send it first. Stations would compete normally but due to AP having shorter IFS therefore the AP gets access much more. In case of a collision it would normally backoff as in CSMA/CA. Our proposed scheme removes asymmetric condition due to the assignment of higher priority to the AP therefore no queue build up at the AP. This also reduces the overall delay during communication and the collision probability reduced. Our proposed scheme might provide better fairness among AP and the stations as it contends normally. .

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Chapter 1

Introduction

1.1 Background

Wireless LANs are used for communicating with devices without any means of wired connection between the devices. A wireless is one in which a mobile user can connect to a local area network through a wireless (radio) connection. The IEEE 802.11 group of standards specify the technologies for wireless LANs. 802.11 standards use the Ethernet protocol and CSMA/CA (carrier sense multiple access with collision avoidance) for path sharing and include an encryption method, the Wired Equivalent Privacy algorithm. IEEE 802.11 performs the underlying working of communicating among them. In case of WLANs, wireless terminals or stations communicate with the help of Access Point (AP). Wireless access points are specially configured nodes on wireless local area networks (WLANs). Access points act as a central transmitter and receiver of WLAN radio signals. Access points used in home or small business networks are generally small, dedicated hardware devices featuring a built-in network adapter, antenna, and radio transmitter. Access points support Wi-Fi wireless communication standards. WLANs are designed in such a way that it supports a few associated clients with symmetric uplink/downlink traffic flow. Symmetric computer network, all devices can transmit and receive data at equal rates. But in case of busy area where there presents a lot of wireless devices which are wanted to use Access Point (AP) for their communicating purpose, asymmetric traffic condition arises in the downlink traffic at Access Point (AP). Asymmetric networks, on the other hand, support disproportionately more bandwidth in one direction than the other. So, in case heavy downlink traffic, a lot of packets can be queued at Access Point (AP), some packets can be dropped and reduces network throughput. So the Access Point (AP) has to have the scope of serving all associated clients efficiently as well as give opportunity to the clients. We propose WiFi-PAP (Wi-Fi Based Prioritized Access Point) which gives the solution of asymmetric traffic condition as well as gives good throughput for both uplink and downlink traffic. It also provides fairness to all the stations and the AP.

1.2 What is WLANs and Wi-Fi:

Wi-Fi stands for wireless Fidelity. Wi-Fi is the name of a popular wireless networking technology that uses radio waves to provide wireless high-speed Internet and network connections. Wi-Fi works with no physical wired connection between sender and receiver by using radio frequency technology, a frequency within the electromagnetic spectrum associated with radio wave propagation. When an RF current is supplied to an antenna, an electromagnetic field is created that then is able to propagate through space. The cornerstone of any wireless network is an access point. The primary job of an access point is to broadcast a wireless signal that computers can detect and "tune" into. In order to connect to an access point and join a wireless network, computers and devices must be equipped with wireless network adapters. Many devices can use Wi-Fi, e.g. personal computers, video-game consoles, smart phones, some digital cameras, tablet computers and digital audio players. These can connect to a network resource such as the Internet via a wireless network access point. Such an access point (or hotspot) has a range of about 20 meters (65 feet) indoors and a greater range outdoors. Most Wireless LANs (WLAN) are Wi-Fi based. They use Wi-Fi for getting access to the Internet. At present the demand for the wireless device is increasing day by day because of their ease of use. The proliferation of mobile devices equipped with Wi-Fi interfaces, such as laptops, smart phones and personal multimedia devices has high lightened this trend.

Building Blocks of Wireless LAN is Basic Service Set (BSS). BSS is a component of the IEEE 802.11 WLAN architecture. This network architecture is built around a Basic Service Set (BSS), which is actually a set of STAs (the component that connects to the wireless medium such as a network adapter or NIC) that communicate with each other. When one access points (AP) is connected to wired network and a set of wireless stations it is referred to as a Basic Service Set (BSS). BSS is defined as a single AP that provides network connectivity for its associated clients. You could have several APs in your system, but they would each be offering a separate WLAN, and you could not "roam" between the APs; your laptop would need to associate itself with each new AP when you lost signal from the old one as you walked around the building. Due to the presence or absence of Access Point (AP), we divide the WLANs are of two types.

1. Ad hoc network 2. Infrastructure network

Ad hoc network: A wireless ad hoc network is a decentralized type of wireless network. The network is ad hoc because it does not rely on a pre existing infrastructure, such as routers in wired networks or access points in managed (infrastructure) wireless networks. Instead, each node participates in routing by forwarding data for other nodes, so the determination of which nodes forward data is made dynamically on the basis of network connectivity. In addition to the classic routing, ad hoc networks can use flooding for forwarding data. An ad hoc network typically refers to any set of networks where all devices have equal status on a network and are free to associate with any other ad hoc network device in link range. Ad hoc network often refers to a mode of operation of IEEE 802.11 wireless networks. An ad-hoc network is a local area network (LAN) that is built spontaneously as devices connect. Instead of relying on a base station to coordinate the flow of messages to each node in the network, the individual network nodes forward packets to and from each other.

Infrastructure Network: Infrastructure BSS is part of the 802.11 wireless network standard. It includes access points and stations in a wireless connection scenario. An 802.11 networking framework in which devices communicate with each other by first going through an Access Point (AP). In infrastructure mode, wireless devices can communicate with each other or can communicate with a wired network. When one AP is connected to wired network and a set of wireless stations it is referred to as a Basic Service Set (BSS). An Extended Service Set (ESS) is a set of two or more BSSs that form a single sub network. Most corporate wireless LANs operate in infrastructure mode because they require access to the wired LAN in order to use services such as file servers or printers. Infrastructure networks are those in which there is need of Access point (AP). All traffic goes with the help Access Point (AP). Any traffic from any source to destination is performed with the help of Access Point (AP). So the network architecture with Access Point (AP), we call it Infrastructure network.

Here in the figure the right portion is the example of an Ad hoc network architecture and in the right portion is the example of an Infrastructure Network architecture. The difference is only the presence of Access Point (AP). For the first one there is no Access Point (AP) and in the second one there presence Access Point (AP).

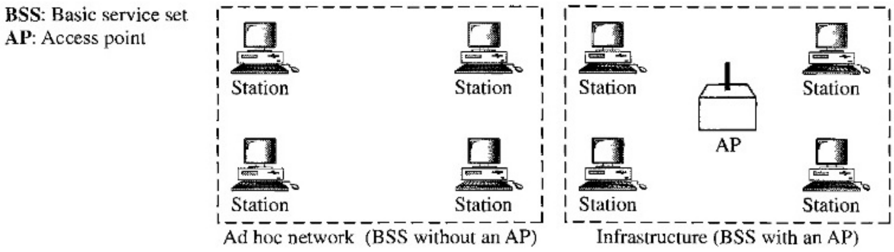


Figure 1.1: Adhoc and Infrastructure BSS

1.3 How WLANs Work:

WLANs use IEEE802.11 for communicating among various wireless devices. They follow CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) for avoiding collision among stations. CSMA/CA is a protocol for carrier transmission in 802.11 networks. Unlike CSMA/CD (Carrier Sense Multiple Access/Collision Detect) which deals with transmissions after a collision has occurred, CSMA/CA acts to prevent collisions before they happen. In CSMA/CA, as soon as a node receives a packet that is to be sent, it checks to be sure the channel is clear (no other node is transmitting at the time). If the channel is clear, then the packet is sent. If the channel is not clear, the node waits for a randomly chosen period of time, and then checks again to see if the channel is clear. This period of time is called the backoff factor, and is counted down by a backoff counter. If the channel is clear when the backoff counter reaches zero, the node transmits the packet. If the channel is not clear when the backoff counter reaches zero, the backoff factor is set again, and the process is repeated. IEEE802.11 uses DCF (Distributed Coordination Function) for giving access to all stations. The DCF is a protocol which uses carrier sensing along with a four way handshake to maximize the throughput while preventing packet collisions. A packet collision is defined as any case where a node is receiving more than one packet at a time, resulting in neither packet being correctly received. The basic functionality of 802.11 is as follows. Assume that a node has data that it needs to transmit. First it will wait a random backoff time. This is a random number of time slots which is within a contention window. If at any time the node senses that another node is using the channel, it will pause its timer until the other node has finished transmitting. When the backoff time has expired, the node will ”sense” the channel to determine if there is another node transmitting. If the channel is clear, it will then wait for a short time and sense the channel again. If the channel is still free, it will transmit a request to send (RTS) the the destination. The destination will respond with a clear to send (CTS) if it is available to receive data (i.e. if it is not receiving data from another node). When the source node receives the CTS, it will transmit its data. Along with both the RTS and CTS, a network allocation vector (NAV) is transmitted, which is explained below. After correct reception of the data, the destination will transmit an acknowledgment (ACK) back to the sender. At this point, if the sender has more data to transmit, it will again begin its backoff and repeat the process.

For avoiding collision there are two type of procedures: 1. Physical Sensing 2. Virtual Sensing

Physical Sensing is performed at Physical Layer and Virtual Sensing is done at Data Link Layer. In 802.11, carrier sensing is the primary method used to avoid collision. Carrier sensing is accomplished by simply measure the amount of energy received on the channel. If that energy is above a threshold, the sensing node determines that another node is currently transmitting and that it must remain silent. Along with carrier sensing, interframe spacing is primarily used to ensure that the channel is truly free. When a node is sensing the channel, it must be free for the length of the DCF interframe spacing (DIFS) period. The short interframe spacing (SIFS) is used as the wait time between the RTS, CTS, DATA and ACK frames. Since the SIFS is always shorter than the DIFS, this ensures that another node does not incorrectly determine that the channel is idle during the handshake and that priority is given to the transmission in progress. As an alternative to carrier sensing, the network allocation vector (NAV) is used to inform other nodes how long the current node will need the channel. Any nodes overhearing the NAV know that they have no need of sensing the channel for the time indicated. Since idle sensing of the channel is one of the biggest uses of energy in a network, the NAV reduces the amount of idle sensing required at any nodes which can overhear it, thus saving energy at all nodes in the network. To provide fairness, each node which is transmitting first performs a random countdown, where the length of the countdown is within the length of the contention window. During the countdown, if the node senses that another node is transmitting, it will pause its countdown and continue at that same number after the other transmission is finished. When the countdown reaches zero, the node will sense the channel and, if the channel is still free, transmit the RTS. The range of values which can be chosen for the random backoff time is referred to as the contention window. The size of the window is very important and can change based on network conditions. If the window is too small, there is an increased chance that two nodes will attempt to transmit at the same time. If the window is too large, the nodes may be idly waiting for a long time before transmitting. The window size can increase by a factor of 2 if a transmission fails (i.e. a collision or a node which doesn't respond to an RTS).

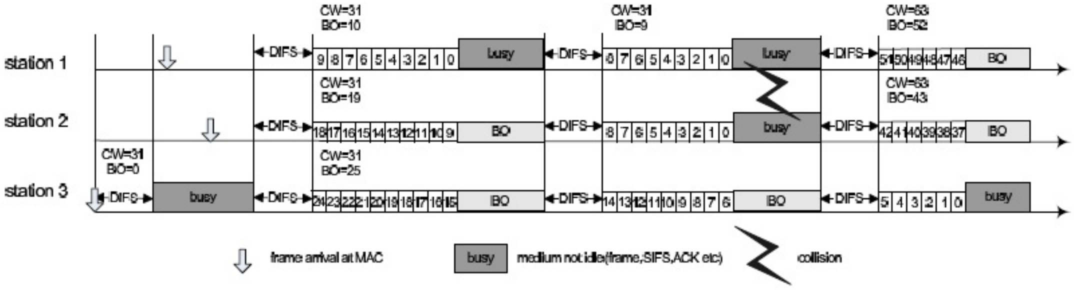


FIGURE 1.2: Timing Diagram of accessing channel

Here is a scenario of contending for channel access by stations. According to IEEE802.11 DCF all stations get equal opportunity for packet transmission. At first all the stations which are intending for transmitting packets sense the medium. If they find it is idle, all will wait DIFS time. Then according to their Contention Window value, they uniformly choose Backoff value and try to decrease the Backoff value by the factor of 1. When decreasing Backoff value one station can get access to the medium, all subsequent stations pause their Backoff (BO). They again sense the medium and if they find idle, again wait for DIFS time then resume their Backoff (BO) value and decrease by the factor of 1. When the Backoff (BO) value becomes 0, that station can send traffic and other will defer the medium weather it is idle or busy.

In the worst case two stations can choose the same Backoff (BO) and reach to 0 at the same time. So try to transmit at the same time and collision occurs. At that time the two colliding stations will increase their Contention Window (CW) and Backoff (BO) value exponentially sothat they can't collide again. In this way IEE802.11 DCF handles collision and channel access mechanism.

1.4 Problems in WLANs:

In many WLANs scenarios, the load transmitted from the AP to the clients (Downlink), far outweighs traffic demand from the clients to the AP (Uplink), thereby yielding traffic asymmetry. Moreover , when many clients associate with a single AP, the clients can cause a disproportional amount of medium contention compared to the AP, producing contention asymmetry. We present Dual Wi-Fi, a MAC architecture and protocol that minimizes MAC overhead by matching spectrum resources to traffic asymmetry. Dual Wi-Fi separates uplink and downlink data traffic into two variable-width independent channels, each allocated in accordance to the network's traffic demand. Our experimental and simulation results demonstrate that Dual Wi-Fi matches downlink vs. uplink throughput ratio to demand ratio within 3-5 under any client density and traffic load. Through this matching capability, Dual Wi-Fi offers unbounded downlink gains as congestion increases, minimizing and in some cases eliminating retransmissions and contention time.Wireless LANs use Access Point (AP) for their communication process. All stations send traffic to Access Point (AP) individually. Wireless Access Point (AP) is responsible for sending traffic to all stations in the network. For giving service to all stations, Access Point (AP) needs to access the medium more. But IEE802.11 supports DCF which provides equal channel access probability for both station and for Access Point (AP). So when Access Point (AP) gets access to the medium once, it will get access again after all station's access. This causes traffic asymmetry at Access Point (AP). As downlink flow is queued at Access Point (AP), if the queue is fulfilled, some packets can be dropped at Access Point (AP). At the same time it also creates the problem of queue delay at Access Point (AP).

Access Point (AP) is connected with wired LAN to support wireless devices. Here the load on downlink traffic at Access Point (AP) is heavier than that of stations. But due IEEE802.11 backlogged packets are queued at Access Point (AP) and degrade the network overall throughput. In case of limited number of stations, Access Point (AP) serves well with IEEE802.11 DCF. But with heavy downlink traffic, it can't accommodate. As the environment is distributed, stations can join or exit. Permanent is only Access Point (AP).

In the following page asymmetric traffic condition is shown using a figure:

1.5 Challenges:

We have proposed a detection method for copy-move forgery which is robust comparing to others. The major contributions of our thesis are summarized as follow:

- Contention and Collision:

  A type of network protocol that allows nodes to contend for network access. That is, two or more nodes may try to send messages across the network simultaneously. The contention protocol defines what happens when this occurs. The most widely used contention protocol is CSMA/CD in case of wired network, and CSMA/CA for WLANs. The situation that occurs when two or more devices attempt to send a signal along the same channel at the

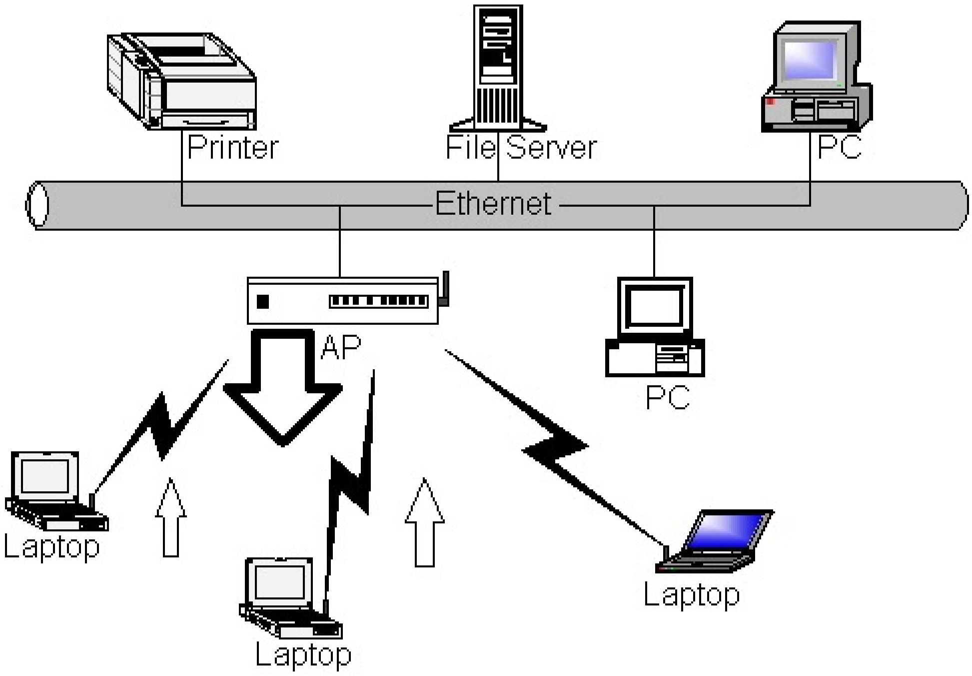


FIGURE 1.3: Asymmetric Traffic Situation

same time. The result of a collision is generally a garbled message. All computer networks require some sort of mechanism to either prevent collisions altogether or to recover from collisions when they do occur. If in a wireless environment only one device presents, there is no meaning of contention. The consideration of contention comes when there presents more than one device who are interested in transmission of packet. The percentage of contention increases as long as the number of stations increases their number. As more stations contend for channel access, chance of collision is also higher.

- Fairness:

  Fairness measures or metrics are used in network engineering to determine whether users or applications are receiving a fair share of system resources. There are several mathematical and conceptual definitions of fairness. Fairness means the channel access needs to be fair. This does not mean that as Access Point (AP) has heavier downlink traffic, it will get access all the time, all the stations then starve. This also reduces the network throughput. This means Access Point (AP) and station should treat in such a way that their overall performance increase.

- Delay:

  Delay is an important consideration in case of multi rate environment. The delay of a network specifies how long it takes for a bit of data to travel across the network from one node or endpoint to another. It is typically measured in multiples or fractions of seconds. Delay may differ slightly, depending on the location of the specific pair of communicating nodes. delay into several parts: Processing delay - time routers take to process the packet header , Queuing delay - time the packet spends in routing queues , Transmission delay - time it takes to push the packet's bits onto the link , Propagation delay - time for a signal to reach its destination. Although the theoretical peak bandwidth of a network connection is fixed according to the technology used, the actual bandwidth you will obtain varies over time and is affected by high latencies. Excessive latency creates bottlenecks that prevent data from filling the network pipe, thus decreasing effective bandwidth. The impact of latency on network bandwidth can be temporary (lasting a few seconds) or persistent (constant) depending on the source of the delays. In case of real time traffic, delay reduces the value of traffic. Due to DCF of IEEE802.11 Access Point (AP) has backlogged packets as well as queue. The longer the queue length value, the longer the delay.

- Traffic Asymmetry:

  In telecommunications, the term asymmetric (also asymmetrical or non-symmetrical) refers to any system in which the data speed or quantity differs in one direction as compared with the other direction, averaged over time. Asymmetrical data flow can, in some instances, make more efficient use of the available infrastructure than symmetrical data flow, in which the speed or quantity of data is the same in both directions, averaged over time. Many wireless devices demand at Access Point (AP). Access Point (AP) is responsible for giving service to all these demanded wireless devices. If all get equal opportunity to access the medium, it reduces the problem of starvation but creates the problem of symmetric traffic condition. As Access Point (AP) serves all stations, it needs to access medium more than that of stations. But due to IEEE802.11 DCF, traffic asymmetry problem occurs at Access Point (AP).

- Starvation:

  In WLANs when one station gets access for a prolonged period then other stations might starve. If one gets longer access to the medium, it will also create the problem of starvation. So, the access should be maintained in such a way, no station or Access Point (AP) gets starvation. That means if Access Point (AP) gets higher priority than others, there will be a probability of starvation for the user stations.

Chapter 2

Literature Review

2.1 Related Work:

In CSMA/CA, as soon as a node receives a packet that is to be sent, it checks to be sure the channel is clear (no other node is transmitting at the time). If the channel is clear, then the packet is sent. If the channel is not clear, the node waits for a randomly chosen period of time, and then checks again to see if the channel is clear. This period of time is called the backoff factor, and is counted down by a backoff counter. If the channel is clear when the backoff counter reaches zero, the node transmits the packet. If the channel is not clear when the backoff counter reaches zero, the backoff factor is set again, and the process is repeated. IEEE802.11 uses DCF (Distributed Coordination Function) for giving access to all stations. The DCF is a protocol which uses carrier sensing along with a four way handshake to maximize the throughput while preventing packet collisions. A packet collision is defined as any case where a node is receiving more than one packet at a time, resulting in neither packet being correctly received.

In case of 802.11, all nodes use DCF for contention. In a network we have multiple nodes and one Access point. According to DCF all devices get equal opportunity to access the medium. But AP has to serve all nodes. This creates asymmetric traffic condition. The AP downlink traffic load is greater than the uplink traffic load. So this creates problem. Our target is to balance uplink and downlink traffic. For solving this asymmetric traffic condition, some mechanism needs to be followed. As WLAN environment is distributed, devices can be added or removed. So there is no work at stations. The work can only be performed at Access Point (AP). Many works have been done at Access Point (AP) to solve this asymmetry problem. All try to give the Access Point (AP) to get higher accessing priority to the medium.

2.2 Performance Enhancement on Asymmetric Traffic:

An adaptive algorithm proposal to adapt the MAC layer settings to the system traffic load, based on the tuning of the contention window parameters. This algorithm is based on the number of packets remaining in the stations queues, when a new data packet is inserted in them. We have implemented two different versions of the algorithm. The first one works as follows. Denote the number of packets remaining in the AP queue as NQAP, and the average number of the packets remaining in the US queues as NQUSm (this value is computed taking into account the 10 last packets transmitted by all the US). When a new data packet is generated at the AP and it is introduced in the corresponding transmission queue, the AP verifies if $NQAP > \alpha.NQUSm$, If this condition is true, the AP changes its minimum and maximum contention window value to CWmin = 8 and CWmax = 32. Finally when a new data packet is generated at any of the US and it is introduced in the corresponding transmission queue, the US verifies if $NQAP > \alpha.NQUSm$. If this condition is true, the US increases its priority factor to PFus=6. On the other hand, the second algorithm proposed works as follows. For each new data packet generated at the AP and introduced in the transmission queue, the AP verifies if $NQAP > N_AP$, where NAP corresponds to a fixed threshold of packets. If this condition is true, the AP changes its contention window values to CWmin = 8 and CWmax= 32. Finally, for each US data packet introduced in the transmission queue, the US checks if $N_QUS <= N_us$, where NQUS corresponds to the number of packets remaining in the US queue, and Nus stays for a fixed threshold of packets. If this condition is true, the US increases its priority factor to PFus = 6. Both algorithms working procedures are basically the same. The main difference is that using the first one, an additional information exchange between AP and US has to be performed, whereas employing the second proposal no extra messages interchange is needed.

2.3 DAT (Dynamic and Adaptive Transmission Scheme):

The aim of this technique is also to assign higher priority to Access Point (AP). It also work on to reduce the rate anomaly problem of the stations at the same time. When in a multi rate environment, multiple stations perform in transmission, it is not wise to think that all stations transmit using same transmission rate. In the worst case if one station having poor transmission rate gets access to the transmission medium, it will hold the channel for a long time and thus it will prevent other stations to access the medium. Solutions of individual problems is done using the same parameters like CW, TXOP or IFS. There is no plan to modify the basic operations of IEEE 802.11. First attempt is to provide solution for performance anomaly problem. The transmitter with high data rate will send more data frames whether the transmitter with low data rate will send less number of data packets. That means all mobile stations occupy almost the same channel time. In the proposed scheme , the AP is designed to transmit packets in such a way that are equal to the summation of traffic each mobile station can send one time to solve the asymmetric traffic condition. If any network there are some stations having the transmission rate scenario like R1¡R2¡R3. ¡Rm. Here Rm has the highest transmission rate. So the Access Point (AP) uses that transmission rate when accessing the medium. Suppose a station has transmission rate of Rj, when it gets access to the medium, it will send Q1=Rj/R1 packets. But when Access Point get access to the medium it will send the following number of packets

$$Q_{AP} = [n_1 + \frac{R_2}{R_1} \times n_2 + \frac{R_3}{R_1} \times n_3 + \cdots + \frac{R_m}{R_1} \times (n_m - 1)]$$

Figure 2.1: Access Probability of AP

Thus it reduces the traffic asymmetry problem as well as anomaly problem. This paper has proposed a dynamic and adaptive transmission scheme (DAT) for both solving the asymmetric link sharing problem and the performance anomaly phenomenon in a multi-rate WLAN which operates in the infrastructure mode. Simulation results show that the DAT mechanism can provide higher performance in terms of throughput and uplink/downlink bandwidth share than previous related work. Taking a closer look at the experimental data, we observed that when the number of stations increases, the performance of the DAT scheme will degrade in all the simulation scenarios.

2.4 Balancing Uplink and Downlink Delay of VoIP in WLANs using Adaptive Priority Control (APC)

Both uplink and downlink delay are dominated by the queuing delay when the channel is very congested, considering that the transmission and propagation delay in IEEE 802.11 wireless networks are very small relatively to the queuing delay. In particular, the queue size of the AP is much larger than that of wireless nodes when there are a large number of VoIP sources because the AP receives all packets to all the wireless nodes, thus the queuing delay is also much bigger than the one of wireless nodes. Therefore, the AP needs to have more chance to transmit frames in order to balance the uplink and the downlink delay. In this paper, we propose APC which differentiates the priority of AP from that of the wireless nodes adaptively according to the wireless channel condition and the uplink and downlink traffic volume. Before we mention how to decide the optimal priority of the AP to balance the uplink and downlink delay, we discuss how to apply the priority of the AP at the MAC layer. This is because the methods to apply the priority usually cause overhead and the overhead affects the priority decision algorithm. In IEEE 802.11, there are three well-known methods to control the priority of wireless nodes. All three methods are used in IEEE 802.11e in order to differentiate the priorities of frames according to the Access Category (AC). The first method is to control contention window (CW) size. The backoff time of a frame is chosen randomly between 0 and CW value. When nodes have a smaller window size, the backoff time becomes smaller and the transmission rate be-comes higher. The problems of this method, however, are that the collision rate increases as the window size decreases, and that it is difficult to accurately control the priority since the backoff time is chosen randomly within CW size. In particular, the first one is a big overhead we wished to avoid. The second method is to change the Inter-Frame Spacing (IFS). A smaller IFS causes the backoff time to decrease faster and the transmission rate to increase naturally, and the node with the smaller IFS wins the channel when two nodes try to transmit frames at the same time. However, we cannot control accurately the transmission rate using this method because the backoff time is still decided randomly, as in the first method. The last method is to transmit multiple frames contention free (without backoff) when a node gets a chance to transmit a frame, and control the number of frames sent contention free, and this is called Contention Free Burst (CFB) in IEEE 802.11e. APC uses CFB because it allows us to control the transmission rate precisely according to the priority without overhead. Every node including the AP has the same chance to transmit frames in average in IEEE 802.11. Thus, if the AP sends P frames contention free when it gets a chance to transmit a frame, then the AP gets exactly P times higher priority than other wireless nodes. For fairness between the downlink (the AP) and uplink (wireless nodes) in a Basic Service Set (BSS), when uplink and downlink have the same amount of traffic, the AP and the wireless nodes need to be able to send the same number of packets within a given interval. Then, intuitively, the AP needs to send N frames while N wireless nodes transmit a frame each (We call this 'semi-adaptive method' in this paper since it is adaptive to the change in the number of the active wireless nodes, but not to the change in the uplink and downlink traffic volume). In VoIP traffic, when a single packetization interval is used for all VoIP traffic in a BSS, the uplink and downlink traffic volumes are symmetric, in general with large number of VoIP sources, thus we can apply the semi-adaptive method to balance the uplink and downlink delay. However, when more than one packetization interval is used for VoIP in a BSS, the traffic volume of the uplink and downlink becomes asymmetric: even when the number of active wireless nodes and Ethernet nodes are the same, the number of packets from the wireless nodes and the Ethernet nodes depends on the packetization intervals of the active nodes. For example, when ten Ethernet nodes with 10 ms packetization interval and ten wireless nodes with 20 ms packetization interval are talking with the same 64 kb/s voice bit rate, the volume of the downlink traffic from Ethernet nodes is larger than the uplink traffic volume because of the overhead such as packet headers, even if the total voice data size is the same. In such a case, we need to consider the traffic volume of uplink and downlink in deciding the priority of the AP. We propose to use the ratio of the number of packets in the queue of the AP and an average queue size of all wireless nodes as the priority of the AP when the queue of wire-less nodes is not empty, and the number of active wireless nodes when the queue is empty. That is, P is calculated as follows:

$$P = \begin{cases} \lceil \frac{Q_{AP}}{Q_{Node}} \rceil & \text{if } Q_{Node} \geq 1 \\ N_e & \text{if } Q_{Node} = 0 \end{cases}$$

Figure 2.2: Access Probability of AP

where, QAP is the queue size of the AP, QNode is the average queue size of the wireless nodes, and Ne is the number of active Ethernet nodes. Therefore, transmitting QAP = QNode packets contention free results in the same packet processing time in the AP and wireless nodes, which means that the AP and wireless nodes have the same queuing delay.

2.5 WiFox : Scaling WiFi Performance for Large Audience Environments

Objective is to assign priority to AP. There are two settings used in this proposed scheme. High setting which follows parameters of IEEE 802.11e. Default setting which follows DCF parameters of IEEE 802.11. The DCF-based IEEE 802.11 MAC is designed to give the AP the same opportunity to the wireless medium as the STAs in the basic service set even though the AP has the greatest amount of the traffic to transmit. Under heavy downlink load coupled with high contention from many active STAs, the AP cannot flush its traffic quickly, thus becoming a performance bottleneck and suffering a high rate of packet losses from both transmission queue overflow and collisions due to high contention. This motivates the need for a mechanism enabling a controlled preferential treatment to the overloaded AP over STAs for medium access. We cannot give the AP high priority over STAs by default. It has an adverse effect on network performance: because the uplink traffic in the form of client requests from the STAs will be stiffled, it will lead to a decreased downlink traffic which in light network load, can reduce the network good-put. Therefore a balance is required between uplink and downlink traffic in order to optimize network throughput. We propose an APC scheme wherein the percentage of downlink traffic being given priority is proportionately controlled based on the dynamic traffic load at the AP. This ensures that at low load the STAs get an equal opportunity as the AP to transmit requests and at higher loads the AP have a higher access priority proportional to the amount of downlink traffic. APC is designed in two steps. First, we deal with a priority model to define fine-grained MAC-level priority levels which are easy to control. Second, we develop an algorithm for adaptive control of priority levels that adjusts the channel access priority of the AP according to dynamic downlink traffic load. In case of heavy traffic load , high setting is used otherwise default setting is used. For high setting , the channel time of the AP is divided into continuous intervals of time T. Each unit of T is further divided into n slots of duration T/n If AP has priority level $k > n$, then k random slots out of n slots within each T are high priority slots and rest are low priority slots. In case of high priority slots the AP works in high setting hence getting more priority. It is rational to assume that the provision of priority to the downlink traffic at the AP needs to be closely related to the dynamic traffic load at the AP. Dynamic downlink traffic load at the AP can be reliably estimated by the instantaneous transmission queue size of the AP where the maximum queue size is limited by an upper bound, Qmax .Therefore, we design adaptive priority control(APC) models determining the priority level

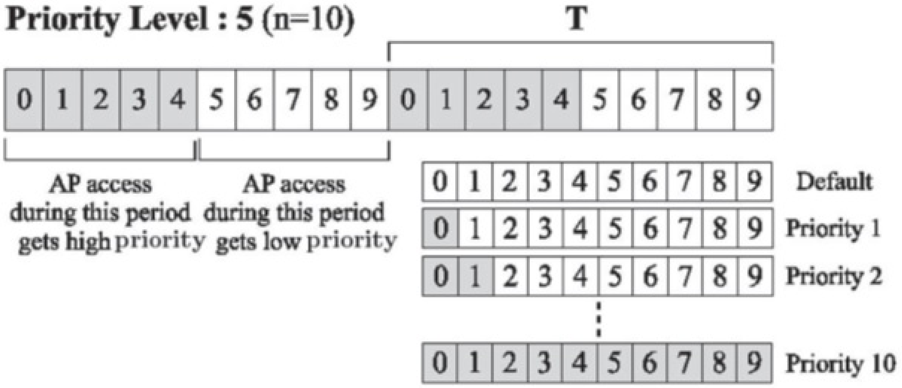


Figure 2.3: Priority Level Of AP

depending on the transmission queue size at the AP for WiFox. Here, we map 10 priority levels into the slotted queue size whose maximum, Qmax is 50. We apply two intuitive criteria in designing APC models. First, APC models should have the lowest priority (e.g., no downlink) at zero queue size and the highest priority at max queue size. Second, the priority level of APC models should be monotonically increasing as the queue size increases. There may exist uncountably many models satisfying the criteria but amongst them, we choose 4 representative models which lead to totally different behaviors in the priority control and in the queue size variation. WiFox integrates a fairness control with APC. It does not advocate one particular notion of fairness over another. Instead it others a framework in which the system designer can plug in his own implementation of a control algorithm that best suits his needs. WiFox can help realize the potential of AP only fairness control. During the period of heavy downlink traffic, WiFox assigns a high priority level to AP, and thus, AP packets will always get high priority over uplink packets. Since the channel time will be consumed mostly by AP with its prioritized accesses, this ensures that channel time allocation asymptotically follows whatever notion of fairness the implemented control strives to accomplish. WiFox offers a framework where the AP only fairness algorithm is implemented as a kernel module of the AP which functions in the IP layer just above the MAC layer (where APC runs). The module contains a separate transmission queue for each active destination STA. It uses Netfilter architecture to capture outgoing packets using the POST ROUTING hook before they reach the MAC layer. If the captured packets are destined for the wireless interface, they are enqueued in their queues corresponding to their destinations. Queues are dynamically created and deleted on an as needed basis.

The system designer can plug in his own fairness control algorithm here. For instance, time fairness can be implemented as follows. The kernel module maintains a channel occupancy time table of which entries maintain exponentially weighted moving averages of channel occupancy time for all destination queues it current holds. The module periodically monitors the instantaneous transmission queue size in the MAC layer. If space is available, the scheduler picks a non-empty queue with the minimum channel occupancy time and sends a packet from that queue to the MAC layer for transmission. If two or more queues have the same minimum channel occupancy time, it selects one in a round robin manner. The channel occupancy time of a transmitted packet is computed based on its size and the estimate of the current data rate. The channel occupancy times of all the queues are periodically updated by taking a moving average with the total channel occupancy time that their packets transmitted since the last update. It should be noted that our post-routing netfilter hooks filter out TCP data packets and queue them in appropriate destination queues and all other packets traverse directly to the AP's TxQ. This ensures that WiFox does not interferes with the network stack traversal of other packets and can easily support functionalities like pure link layer forwarding etc.

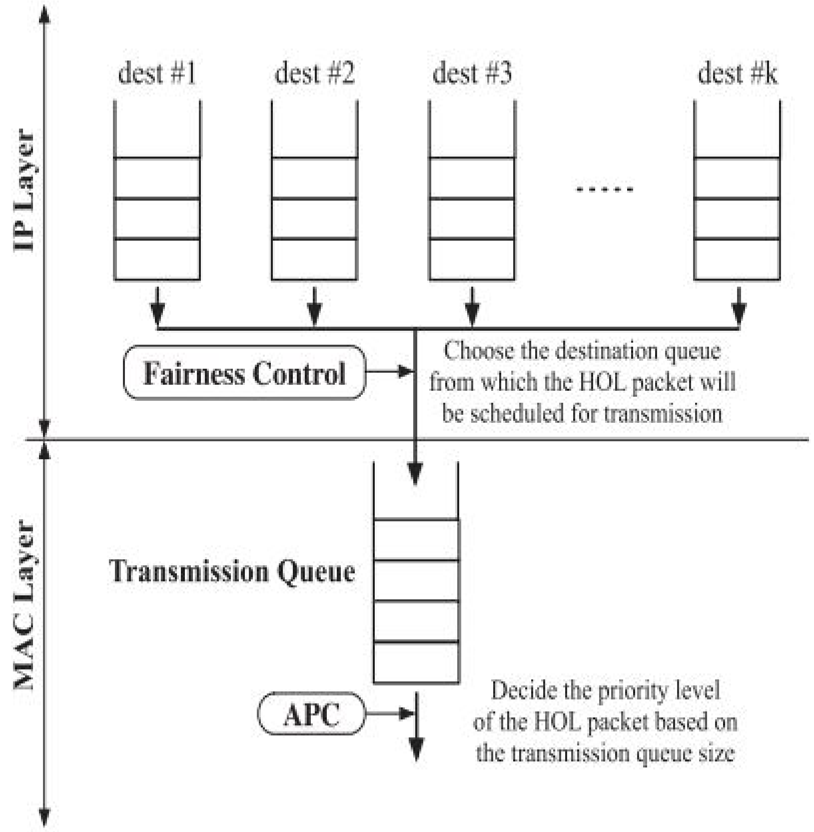


Figure 2.4: Fairness Control

Chapter 3

Proposed Method

3.1 Motivation

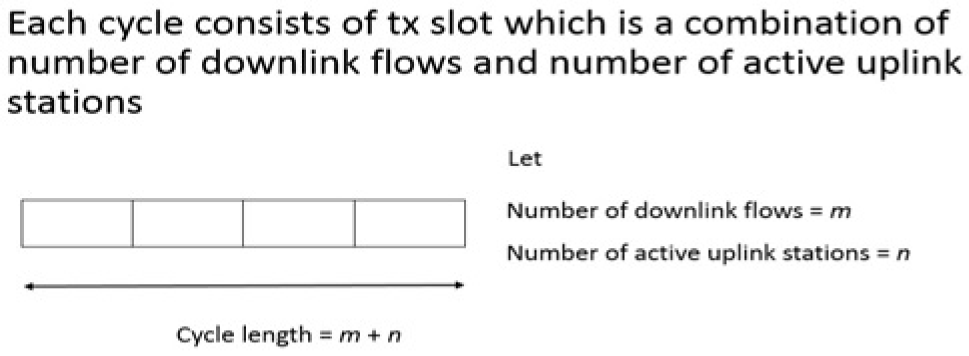
Previous papers have given solution to the asymmetric traffic at the AP in many different ways but none of them are as efficient and fair which are needed to solve the problem. Our proposed scheme overcomes the problem of the asymmetric problem as well as provides fairness to both AP and stations. AP is given higher priority when it has data packet to send but we take care that the stations are not starved i.e. allow them to send too. Our main objective is to give more priority to the AP so that it doesn't get congested or incur queuing delay which might drop packets when the queue is full. This will reduce the throughput of the system and degrade the performance. In other words our objective would be to remove the asymmetric traffic at the AP. The AP uses IEEE 802.11e parameters in order to achieve higher priority. Other stations use EDCA to contend between themselves to gain access. Hence the AP gets more higher priority and the stations get their fair access.

3.2 Methodology

Our objective is to provide more priority to the AP when the AP has some data packets to send and also provide fairness to both AP and all stations. In order to assign more priority we use AIFS (Arbitrary Interframe Space) for AP with no backoff i.e. no binary exponential backoff. We assume that the AP has global LAN knowledge. In particular it has knowledge of how many data packets it has to send and also how many active uplink stations are there in the system. With this knowledge it can create a cycle to represent the knowledge and also contend accordingly to get channel access whenever it needs to send the data packets. Each cycle is divided into tx time slots where each time slot is occupied with consecutive AP and stations.

- AP has global LAN knowledge about the following factors : - Number of downlink flow - Number of active uplink station

Let the number of downlink flows be ”n” and the number of active uplink stations be ”m” then the cycle size would be ”n+m”.



Each cycle consists of tx slot which is a combination of number of downlink flows and number of active uplink stations

Let

Number of downlink flows = m

Number of active uplink stations = n

Cycle length = $m + n$

Figure 3.1: Formation Of Cycle

The access method in our proposed scheme is as follows:

- All stations uses EDCA
- AP uses the shortest AIFS, i.e., AIFS[0] alone
- Stations uses higher AIFSs, i.e., AIFS[1]-AIFS[3]
- AP does not need the backoff, because there is no chance of collision This reduces the collision probability
- However, to give equal opportunity to the stations, AP access the medium alternatively AP can access at most m/n slots successively, when m ¿ n, otherwise AP accesses 1 slot when n/m slots are used by the Stations

3.3 Parameter estimation:

- Maintains separate list for uplink and downlink flows

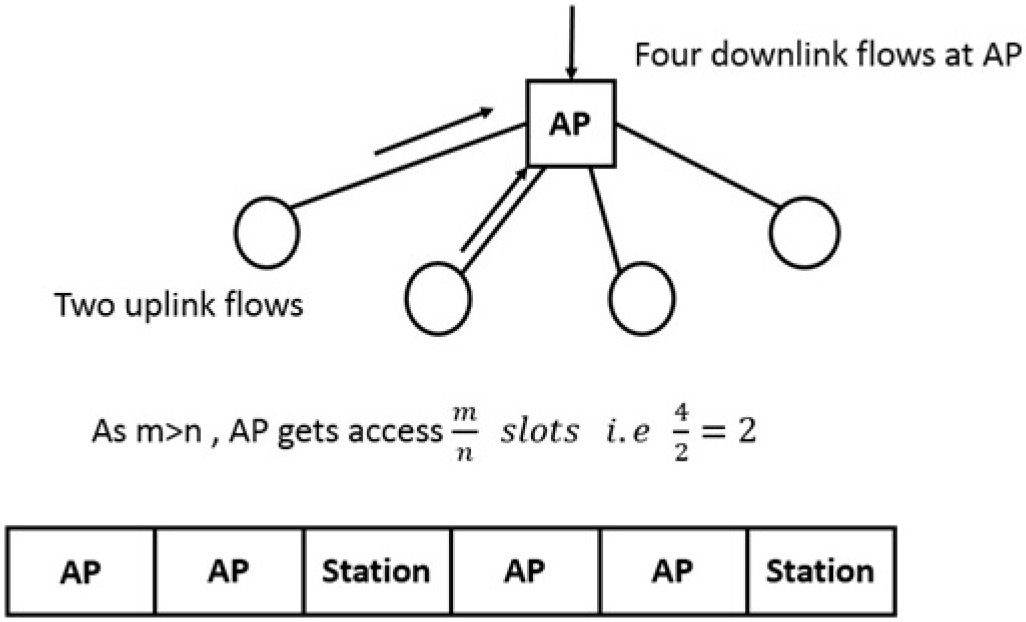


FIGURE 3.2: Timing Slots For Getting Access

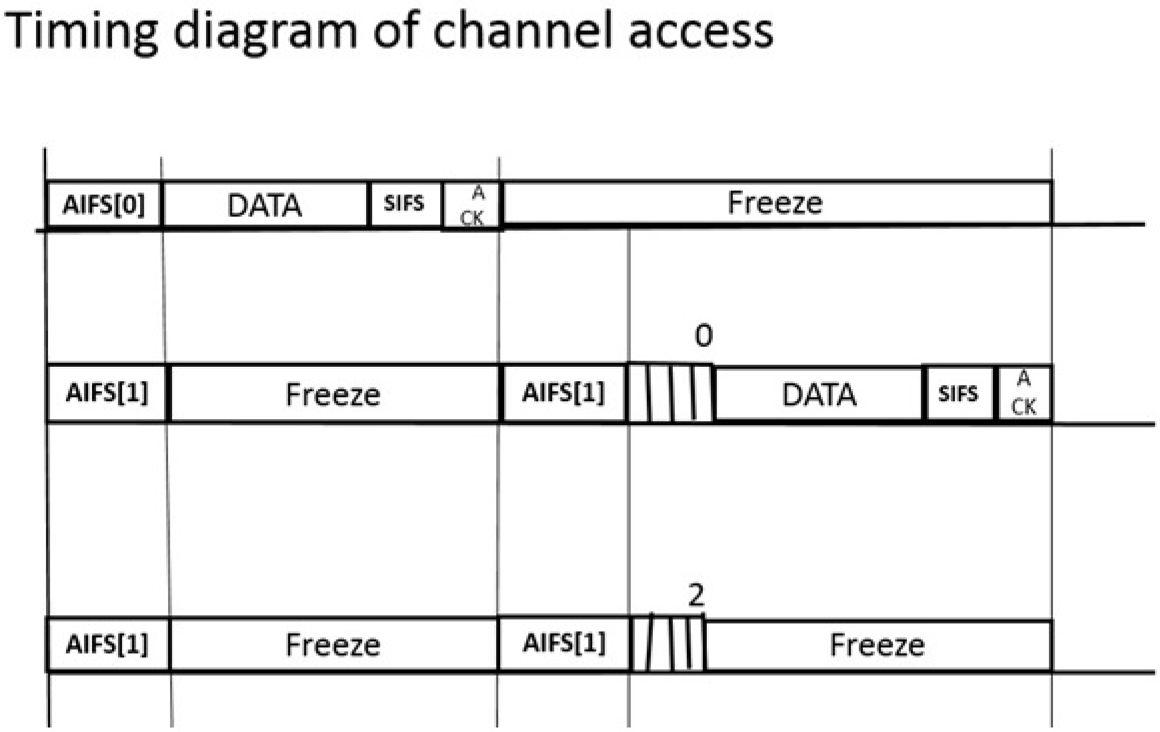


FIGURE 3.3: Timing Diagram

- For each entry, individual timers are used
- If a new flow is initiated then new timer value is set which increases the n or m value
- If the timer is not reset then the specific entry is deleted so the cycle entry is updated

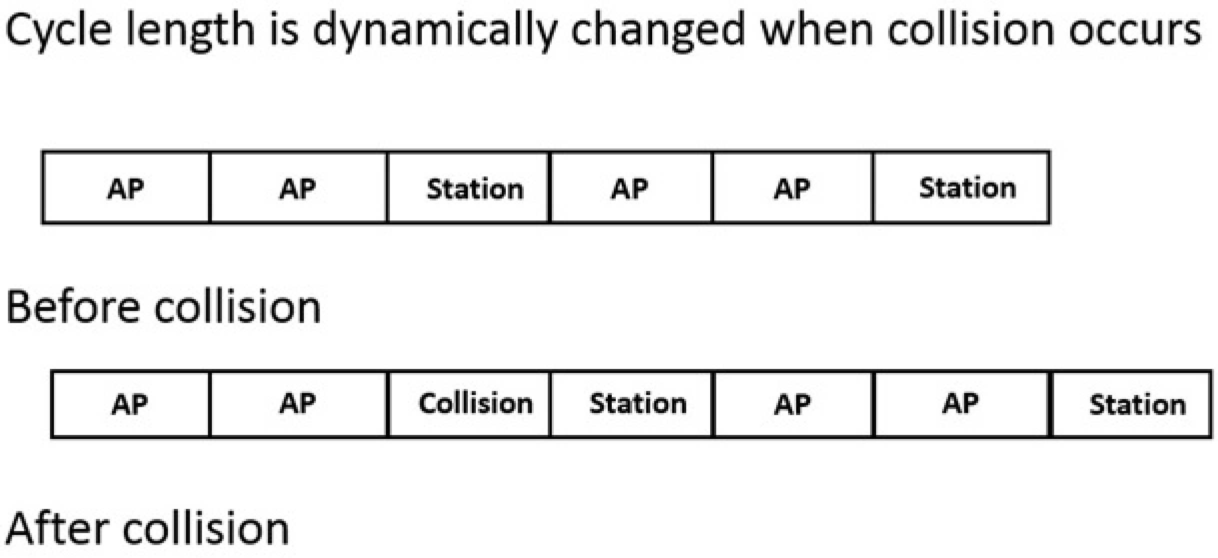


Figure 3.4: Scenario Of Dynamically Changed Slots

3.4 Justification of our proposed method

Our proposed method completely removes the asymmetric problem at the AP as we are giving higher priority to the AP so that it sends whenever it has data packet to send but sends only after one station has also transmitted. In this way it wouldn't starve the stations. There is no queue build up in AP as it always will transmit whenever it has data to send hence providing more priority to the AP. As there is no queue build up, the queuing delay is also decreased therefore eliminating the asymmetric condition in the AP. Apart from removing the asymmetric traffic at AP, our proposed scheme also provides strict fairness. This fairness is ensured by providing both the AP and the stations to transmit in consecutive tx time slots with the AP having higher priority than the stations.

Chapter 4

Simulation Strategy

4.1 Simulation Set up Plan:

Our simulation has been done in ns-3. Our objective is to reduce asymmetric traffic condition in AP. Previously we discussed that due to 802.11 all stations get equal access. We tried to change the asymmetric traffic condition and tried to implement 802.11e at Access Point. In our proposal we said that we need to change the default behavior of Access Point. Thus we use edca parameters in access point. For implementing our proposed algorithm WiFi-PAP, we need to know about active uplink and down link traffic. After getting those values, we need to assign backoff strategy for AP and stations. But we didn't able to change the default behavior of Access Point. Except this we implement the edca parameters for assigning priority to Access Point. We experimented some sort of measurement and measured the computed values and plot diagram. We only analyzed how the asymmetry is reduced. We used two things quality of service and nqos. We measured value of nqos for asymmetric value. Then we measured the value of qos. Then plot a diagram and observed the condition of AP. In the figure we can easily see that throughput of QoS is greater NqoS.

4.1.1 Scenario1:

In the first analysis we saw that in case of QoS outcome is better than that of Nqos. Here black line indicates the QoS. In that analysis we used 1 AP and along with this 10 stations are used in a sequential manner. We did the same experiment in case of both QoS and NqoS supported AP. We observed that QoS supported AP provides better performance in case of removing traffic asymmetry.

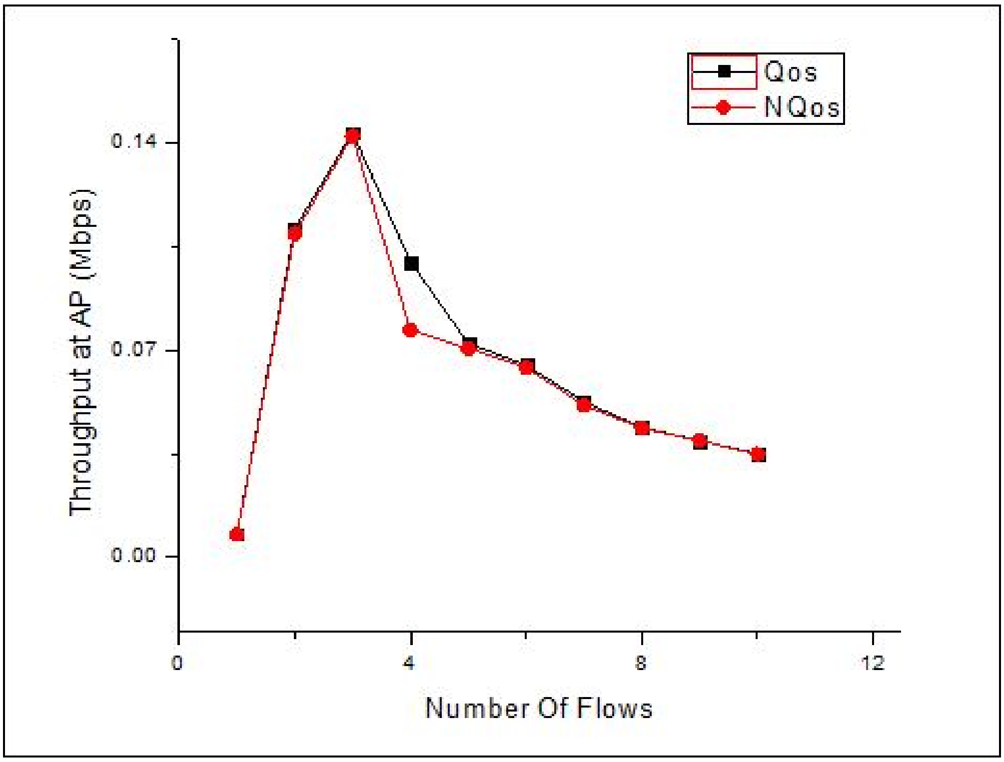


FIGURE 4.1: Comparision Between QOS and NQOS AP In Case Of Flows

Table is given below:

TABLE 4.1: Comparision Between QOS And NQOS AP In Case Of Number Of Flows

Number Of Flows	QOS	NQOS
1	0.00794	0.0079
2	0.111	0.10928
3	0.14337	0.1423
4	0.0997	0.07673
5	0.07232	0.07053
6	0.06492	0.06404
7	0.05259	0.05143
8	0.04394	0.04366
9	0.03953	0.03946
10	0.03508	0.03486

4.1.2 Scenario2:

In our second analysis we work with varying number of packets and analysis the qos and nqos traffic analysis. Here also black line indicates the QoS performance of Access Point. Like previous it gives good result than normal NqoS. Though the increase of number of packets performance degrades but in case of QoS, we get good result. Here we varied the number of packets in case of QoS and NqoS supported

AP. We analyzed for 1, 2,3,4,5 packets in both cases. The QoS supported one provides the better performance.

Every stations want to access the medium. The station with higher priority means QoS supported access the medium earlier and increase the throughput. In case of varying packet size, performance will also change.

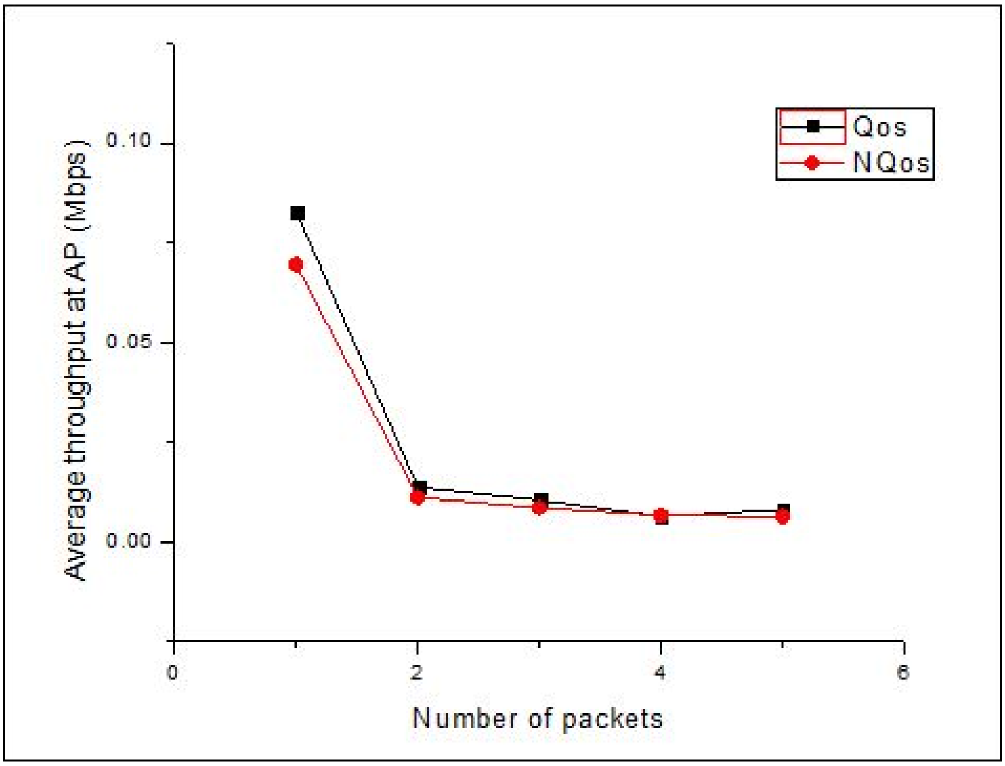


FIGURE 4.2: Comparision Between QOS and NQOS AP In Case Of Number Of Packets

Table is given below:

TABLE 4.2: Comparision between QOS And NQOS AP In Case Of Number Of Packets

Number of Packets	QOS	NQOS
1	0.08281	0.06949
2	0.01362	0.01103
3	0.01037	0.00841
4	0.00628	0.00654
5	0.00793	0.00618

4.1.3 Scenario3:

Here we used various packets with varying size. We used 512,1024,2048,4096 sized packets. But the performance is again better in case of QoS. With the increase of the size packets, overall performance becomes low.

We only tried to implement edca. But we were not able to modify the default behavior of AP which is explained in our proposed method scheme. Using edca and dcf we try to reduce asymmetry. We proposed that our AP will be smart enough to control over the network. We could not provide that facility.

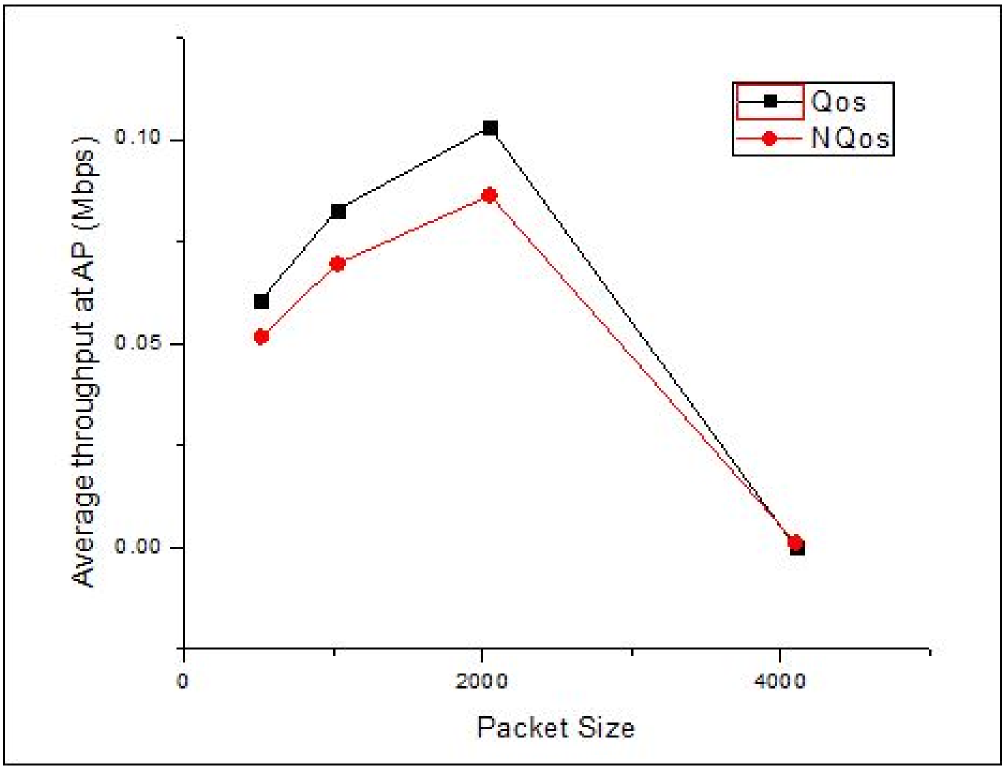


FIGURE 4.3: Comparision Between QOS and NQOS AP In Case Of Number Of Packet Size

TABLE 4.3: Comparision Between QOS And NQOS AP

Packet Size	**Qos**	**Nqos**
512	0.06056	0.05158
1024	0.08281	0.06949
2048	0.10299	0.0863
4096	0.0	0.00106

4.2 Performance Measurement

We use

- ConstantSpeedPropagationDelayModel : the propagation speed is constant and the attribute is speed where the unit is in m/s.

- LogDistancePropagationLossModel : a log distance propagation model. This model calculates the reception power with a so-called log-distance propagation model. When the path loss is requested at a distance smaller than the reference distance, the tx power is returned. Attributes are Exponent , ReferenceDistance , ReferenceLoss.
- ConstantPositionMobilityModel : Mobility model for which the current position does not change once it has been set and until it is set again explicitely to a new value.

In the script we created node container. In that we created wifinode for stations and a node for Access Point. Then we configured the channel and physical medium. For doing that we used the above models. For configuring QoS, we used QoS supported true in case of AP. For NqoS, we used QoS supported false in case of stations. Thus Quality of service is maintained and traffic asymmetry is also reduced. For Access Point, we set ConstantPositionMobilityModel as the mobility model. Then we installed the mobility models for AP as well as stations. We installed AP node and stations in Internetstackhelper. We then assigned addresses to those devices. We created flows from different nodes and by using flow monitor we measured the throughput.

Chapter 5

Conclusion

5.1 Summary of Contributions

Many existing solutions are available for the asymmetric problem in infrastructure networks. None of the approaches are completely fair as it gives more priority to the AP, the stations don't get equal opportunity to transmit. Moreover if the AP gets channel access then it transmits for TxOP Limit. The AP gets more priority by following the parameters of IEEE 802.11e namely AIFS , Contention Window , TxOP Limit. The AP wins the access whenever it will contend with the stations. In our proposed scheme, we assign more priority to the AP by allowing it to gain channel access whenever it has data packet to send. The AP has global LAN knowledge by which it forms a cycle depending on which the AP makes decisions to gain channel access. To provide fairness among stations and AP the time slots are used consecutively among them. So far, we have implemented EDCA for AP and DCF for stations. Access Point gets higher priority for getting access to the channel. Using EDCA at the Access Point the average throughput at Access point is greater than that of DCF implemented Access Point. We compared our performance with some parameters. In the first case we compared with number of flows. We did this for both Access Point with QoS enabled and NqoS enabled case. We observed better performance in case of QoS supported Access Point.

In our second case we compared with using different number of packet sizes. We gradually increased the number of packets and observed the performance. We used 1 to 5 packets for both QoS and NqoS AP. In case of QoS AP we observed better performance.

In our third case we used varying packet sizes. We used 512, 1024, 2048 and 4096 sized packets. We also did this for both QoS AP and NqoS AP.

5.2 Future work

We proposed to improve the Access Point performance gain. For this we proposed our Access Point to be smart enough to support varying traffic. We proposed that our AP will have to have overall global LAN knowledge. But we did not do that much. For reducing asymmetric traffic we tried to give priority to AP by tuning EDCA parameters at AP. We provided EDCA at Access Point and DCF at stations. By tuning the EDCA parameters at the AP we gave it more priority to access the channel compared to the other stations that use DCF to contend and access the medium. Thus removes asymmetry little bit as the AP gets more priority and accesses the medium more often to that no packets at backlogged at AP and dropped. But for better outcome of our proposed method would be sufficient. In future we will try to assign high priority at Access Point by tuning shortest AIFS values i.e. we give both the AP and the stations EDCA parameters but in case of AP we will set it to the shortest AIFS so that it accesses the medium easily. We set the stations are higher AIFS so that it would take more time for it to access the medium hence providing the AP with more priority. We will also try to make Access Point backoff free i.e. the AP when it receives the packet transmits immediately hence also reducing the collision probability. The AP will be made smarter and it would keep global knowledge of its active uplink flows and downlink flows. From the packet header we will try to know the source and destination of the packets and figure out the number of flows in the upward and downward direction. The AP will also maintain a timer to remove the uplink flows when the timer expires showing that the uplink flow is no more active. Thus we can measure the number of uplink and downlink flows to make a cycle at the AP. The AP will be allocated slots for the downlink flows as well as slots for both stations and AP to contend to access the channel. We will also calculate the slot tome from that value. In times of collision we will also try to give the facility of extending the slot time. We will also try to provide some sort of fairness among stations for accessing the channel in case of contending among themselves. Stations will use longer AIFS value for contending among themselves. They will use their backoff values to avoid collision and provide little fairness. Fairness should be ensured so that other stations do not starve due to higher priority to the AP. This could be implemented as a round robin or any other queuing technique which have not yet been thought of. So far, we only remove asymmetry by tuning EDCA parameters at Access Point. But for getting better outcome, we will have to make Access point as smart device and provide fairness among competing stations also.

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