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A Comparative Analysis of Different Queuing Techniques in Wireless LANs.

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صدق الله العظيم

سورة الرحمن الأيات (1-4)

إهـــــــــــــداء

إلى من ينفخ من تحت قدميها أريج الجنة ... و سقتني من فيض حنانها المنسكب

... أمي

إلى من بنى تحت هجير الشمس مملكتي

... أبي

إلى من طوقوني بهالة من الحب و الإخلاص ... إخوتي

إلى الأوفياء دوماً ... أصدقائي

إلى أستاذتي الأجلاء.

إلى روح المرحومة رشيدة سليمان محجوب السباعي.

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ABSTRACT

Wireless Local Area Networks have become an increasingly important technology for today's computer and communications industry. With the rapid transformation of the Internet into a commercial infrastructure, demands for service quality have rapidly developed.

Queuing is one of the important mechanisms in traffic management; each router in the network must implement some queuing discipline that governs how packets are buffered while waiting to be transmitted. The purpose of this study is to investigate the effect of the adaptation of different queuing service disciplines to the wireless network.

First-In-First-Out (FIFO), Priority Queuing (PQ) and Weighted Fair Queuing (WFQ) mechanisms were chosen, selected and employed for the network simulations.

Simulation was carried out using OPNET simulation tool.

المستخلص

شبكات الاسلكي ذات النطاق المحلي تزداد اهميتها في صناعة الاتصالات و الكمبيوتر.

مع التحول السريع لتكنولوجيا الانترنت الي سوق تجاري اصبح هناك حوجة الي تقديم جودة عالية للخدمة.

خوازميات التصفيف من اهم الطرق في ادارة ارسال و استقبال البيانات,

يجب علي أي جهاز توجية ان يدعم احد هذة الخوازميات التي تحدد كيفية تنظيم حزمات البيانات الي حين ارسالها.

الهدف من هذة الاطروحة ان نبحث و ندرس تاثير تطبيق هذة الخوارزميات علي شبكات الاسلكي.

هنالك عدد من مختلف خوازميات التصفيف, في هذة الاطروحة قد تم اختيار "دخول-اول-خروج-اول"و"تصفيف الاولوية"و "تصفيف الموزون و العادل" لامور الدراسة و المحاكاة.

المحاكاة تمت باستخدام برنامج المحاكاة"اوبنت".

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LIST OF ABBREVIATIONS

CBWFQ	Class Based Weighted Fair Queuing
CQ	Custom Queue
EV-DO	Evolution Data Optimized
FIFO	First In First Out
FQ	Fair Queuing
FTP	File Transfer Protocol
GPS	Generalized Processor Sharing
HSPA	High Speed Packet Access
HTTP	Hyper Text Transfer Protocol
IEEE	Institute of Electrical and Electronics Engineering
LTE	Long-Term Evolution
MWRR	Modified Weighted Round Robin

NFC Near Filed Communication

OPNET Optimized Network engineering

QOS Quality of Service

RR Round Robin

SCFQ Self-Clocked Fair Queuing

VoIP Voice over Internet Protocol

WFQ Weighted Fair Queuing

WIFI Wireless Fidelity

WiMAX Worldwide Interoperability for Microwave Access

WRR Weighted Round Robin

WF2Q Worst Case Fair Weighted Queuing

LIST OF SYMBOLS

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N	-	Number of flows
Wi	-	Weight assigned to flow i
i	-	Number of flow
$\sum_{1}^{n} W$	-	Summation of the weights of all the Queues
R	-	Link rate

Chapter One

Introduction

Chapter One

Introduction

1.1 Preface:

One of the most transformative technology trends of the past decade is the availability and growing expectation of ubiquitous connectivity. Whether it is for checking email, carrying a voice conversation, web browsing, or myriad other use cases, we now expect to be able to access these online services regardless of location, time, or circumstance: on the run, while standing in line, at the office, on a subway, while in flight, and everywhere in between. Today, we are still often forced to be proactive about finding connectivity (e.g., looking for a nearby WiFi hotspot) but without a doubt, the future is about ubiquitous connectivity where access to the Internet is omnipresent.

Wireless networks are at the epicenter of this trend. At its broadest, a wireless network refers to any network not connected by cables, which is what enables the desired convenience and mobility for the user. Not surprisingly, given the myriad different use cases and applications, we should also expect to see dozens of different wireless technologies to meet the needs, each with its own performance characteristics and each optimized for a specific task and context. Today, we already have over a dozen widespread wireless technologies in use: WiFi, Bluetooth, ZigBee, NFC, WiMAX, LTE, HSPA, EV-DO, earlier 3G standards, satellite services, and more.

Wireless Local Area Networks have become an increasingly important technology for today's computer and communications industry. With the rapid pace of wireless network development and the continuing adoption of new wireless standards, untethered communication is becoming both a more viable and desirable means of network computing.

Quality of service may be defined as the capability of a network to provide better service to selected network traffic over various technologies. An underlying feature and characteristic relating to Quality of Service (QoS) of a network is the queuing discipline utilized by the network. In order to provide adequate and sufficient quality of service in the wireless local area network, the queuing policies of the networks must be examined. In network traffic, the queuing policies have an important influence and establish how, when and what data gets processed and executed.

1.2Problem Statement:

- The biggest problems in a network are related to the allocation of network resources, as buffers and link bandwidth, to different users.
- One of the main problems in the network is the congestion in the network which is result delay in packet delivery ratio and even huge loss of data.

1.3Proposed Solution:

- Improve and fix the delay and loss of data during the delivery operation by choosing the suitable queuing technique.
- Compare between different queuing techniques to determine which one provide a high level of quality of service.

1.4Aim and Objective:

The aim of this thesis is to investigate the impact of queuing algorithms in WLANs on system performance and user quality.In order to achieve the aim we have three objectives. First objective is to study three different types of queuing techniques. Second objective is to implement each technique to the network and to simulate the result of each method. And finally is to compare between the three different results.

1.5Methodology:

First introducing a brief history of wireless LAN, define the queuing techniques, three queuing techniques taken for wireless LAN (FIFO, PQ and WFQ), next construct the network using the OPNET software, apply the three queuing techniques (FIFO, PQ and WFQ) analyze the results and compare between them.

1.6Thesis Outlines:

Chapter 2 discusses the relevant work done in the area of queuing techniques, a brief history of wireless networks and the background of the Wireless LANs.

Chapter 3 introduces The Queuing theory techniques.

Chapter 4 presents the simulation environment

Chapter 5 presents the results and discussion

Chapter 6 includes the conclusions and the recommendations.

Chapter Two
Background & Related Work

Chapter Two

Background and Related Work

2.1 Introduction:

In recent years, there has been huge growth in the wireless networking industry. With the rapid growth and usage of wireless data services and the increasing Demand for real-time applications, such as voice and videoconferencing, the Issues related to providing quality of service (QOS) and fair channel accessing Among multiple packet flows over a shared and bandwidth-limit wireless channel Have become more and more important(Wang and Tseng,2005).

The success of cellular telephony and the explosive development of internet Service have and will have a great impact on wireless networking. Today's mobile Community wants to utilize the internet for all of its diverse applications and Functionality. The widespread reliance of financial and business organizations and The global markets for the services and applications of the internet are an emphatic Sign of the benefits of wireless high data rate communication. An extensive work Has been done recently to integrate the mobile community into the internet Framework and other traditional networks and support traffic and services. Standards such as the IEEE 802.11 provide priority schemes and aim to serve the (QOS) demands of today's wireless community.

The current most popular standard for wireless LANS is the IEEE 802.11 issued by The institute of electrical and electronic engineers. It offers data rates of 1mbps And recently as high as up to 11mbps, called 802.11b, a newer version IEEE 802.11a offers rates up to 54mbps, then a new class of WLAN standards that Support quality of service, handover and data integrity are necessary to satisfy the Requirement of wireless LANS(Holt, 2007).

A slight drawback in today's indoor wireless communication systems is that some are not designed to provide adequate quality of service (QOS) guarantees needed In the support of different applications. Quality of service (QOS) may be defined as the capability of a network to provide better service to selected network traffic over various technologies. A step in the right direction in combating the problem, of adequate network QOS, is in analysis of queuing service disciplines, which can possibly be implemented and used in wireless local area networks.

So without providing a (QOS) in today's internet network problems such as jitter, Delay and packet loss ratio occur and the performance of a network severely reduced. So, (QOS) for reliable and secure communication between users and between different service classes is used. Classes of service on the internet Network should be different priorities because in application such as email, ftp and (http) the delay parameter is not important while the real-time application such as Voice and videoconferencing, delays of several milliseconds would be effective of Network performance; so to solve the problem, management queuing of traffic in Router is used. Various mechanisms for implementing scheduling disciplines in the Network router such as, first in first out (FIFO), priority queue (PQ), custom queue (CQ) and modified weighted round robin (MWRR) have been introduced(Farhangi et al., 2013).

2.2 Historical:

Wireless technology has a long history, and it began around the time that James C. Maxwell theoretically predicted and then proved the existence of electromagnetic Waves in the1860s, and when Heinrich R. Hertz experimentally confirmed the Actual existence of the electromagnetic wave in 1888.

In 1895, Guglielmo Marconi succeeded in receiving Morse code on a radio wave Transmitted by a spark-gap transmitter with a receiver 2.4 km away. This Experiment demonstrated the basic concept and framework of wireless Communication today.

After that, research into wireless communication was advanced mainly for military Use, and various wireless technologies were developed and improved. Wireless Communication was also expanded on a commercial basis in the area of Broadcasting, one of the significant applications of wireless communication. Radio Broadcasts started in the first half of the 20th century and TV broadcasts started in The second half. Since the late 1980s, wireless communication has been widely Used in mobile phones and other mobile terminals by individuals as these Technologies, principally in semiconductor and software, have rapidly developed In line with the spread of the new infrastructure of the Internet. These are also even changing models of business and social life(Itoh, 2012).

As the technology continues to move from wired to wireless, the wireless LAN (local area network) has become one of the most popular networking Environments, In the early 1990's WLANs found almost no success in selling to Enterprise or campus environments as wired LAN replacements or enablers of Mobility. The WLAN products of that day were far too slow, too expensive, too bulky, and too power hungry. Furthermore, mobile network connectivity was simply not yet a killer application. The "survivor" companies of that age were the Ones who focused on adapting WLAN technology to specialty niches such as Retailing, hospitality, and logistics.

By the middle of the 1990's the WLAN industry had mainly consolidated into 4 Players, Proximal, and Symbol, Lucent (the former NCR WLAN division) and AirNet then still part of Telxon. And silicon suppliers such as Harris Semiconductor, AMD and Hewlett-Packard first started to exert influence on the Industry with low cost chipsets. The crucial PC Card form factor for laptop Computers was achieved and with it came moderate commercial success especially By products such as Symbol's "Spectrum24", Lucent's (WaveLAN), and Proxim's (RangeLAN2) in certain markets such as healthcare and education.

But in the late 1990's the first significant market opportunity for WLANs emerged and it was quite unlike what the WLAN industry to date had largely envisioned. The opportunity was the sharing of a broadband Internet connection within the Home amongst multiple networked devices such as PCs initially, but inevitably Also voice over Internet protocol (VoIP) phones, gaming consoles, media Streamers and home automation appliances. Consumers, not enterprise IT Managers, became the ones to choose what WLAN technology and products would achieve the de facto standard for the decade to follow.

In 1991, the vendors joined together, first proposing, and then building, a standard Based on contributed technologies. In June 1997, the IEEE released the 802.11 Standard for wireless local-area networking this initial standard specifies a 2.4 GHz operating frequency with data rates of 1 and 2 Mbps. With this standard, one could choose to use either frequency hopping or direct sequence. Because of Relatively low data rates as, products based on the initial standard did not flourish As many had hoped.

In late 1999, the IEEE published two supplements to the initial 802.11 standard: 802.11a and 802.11b (Wi- Fi). The 802.11a (Highly Scalable Wireless LAN Standard , 2002), standard (High Speed Physical Layer in the 5 GHz Band) Specifies operation in the 5 GHz band with data rates up to 54 Mb/s, The 802.11 WLAN standard allows for transmission over different media. Compliant media Include infrared light and two types of radio transmission within the unlicensed 2.4-GHz frequency band: frequency hopping spread spectrum (FHSS) and direct Sequence spread spectrum (DSSS). Spread spectrum is a modulation technique Developed in the 1940s that spreads a transmission signal over a broad band of Radio frequencies.

In early 1997, several companies formed the HomeRF working group to begin the Development of astandard designed specifically for wireless voice and data Networking in the home.HomeRF is an open industry specification developed by Home Radio Frequency Working Group that defines how electronic devices such As PCs, cordless phones and other peripherals share and communicate voice, data And streaming media in and around the home.

The development of this working group was motivated by the widespread use of the internet and the development of affordable PCs that can be used in most Homes. This protocol allows PCs in the home to have greater mobility, providing a Connection to the Internet, printers, and other devices anywhere in the home. With All this potential, many members of industry worked to develop the Shared Wireless Access Protocol-Cordless Access (SWAP-CA) specification. Unlike Wi-Fi, HomeRF already has quality-of service support for streaming media and is the Only wireless LAN to integrate voice. Home RF may become the worldwide Standard for cordless phones. In the year 2001, the Working group unveiled HomeRF 2.0 that supports 10 Mbps (HomeRF 2.0) or more.

A network topology of the Home RF protocol consists of four types of nodes: Control Point, Voice Terminals, Data Nodes, and Voice and Data Nodes.

The control point is the gateway to the public switched telephone network (PSTN) And the Internet. It is also responsible for power management of the network. A Voice terminal communicates with the control point via voice only. A data node Communicates with the control point and other data nodes. Finally, a voice and Data node is a combination of the previous two nodes(AlShourbaji, 2013).

2.3 Wireless Local Area Network (WLAN):

Wireless computing is a rapidly emerging technology providing users with Network connectivity without being tethered off of a wired network. Wireless local Area networks (WLANs), like their wired counterparts, are being developed to Provide high bandwidth to users in a limited geographical area.WLANs are being Studied as an alternative to the high installation and maintenance costs incurred by Traditional additions, deletions, and changes experienced in wired LAN Infrastructures. Physical and environmental necessity is another driving factor in favor of WLANs. Typically, new building architectures are planned with Network connectivity factored into the building requirements. However, users Inhabiting existing buildings may find it infeasible to retrofit existing structures for Wired network access. Examples of structures that are very difficult to wire Include concrete buildings, trading floors, manufacturing facilities, warehouses, and historical buildings. Lastly, the operational environment may not accommodate a wired network, or the network may be temporary and operational for a very short time, making the installation of a wired network impractical. Examples where this is true include ad hoc networking needs such as conference Registration centers, campus classrooms, emergency relief centers, and tactical Military environments.

Ideally, users of wireless networks will want the same services and capabilities that they have commonly come to expect with wired networks. However, to meet these objectives, the wireless community faces certain challenges and constraints that are not imposed on their wired counterparts.

2.3.1 Frequency Allocation:

Operation of a wireless network requires that all users operate on a common Frequency band. Frequency bands for particular uses must typically be approved and licensed in each country, which is a time-consuming process due to the high Demand for available radio spectrum.

2.3.2 Interference and Reliability:

Interference in wireless communications can be caused by simultaneous Transmissions (i.e., collisions) by two or more sources sharing the same frequency band. Collisions are typically the result of multiple stations waiting for the channel to become idle and then beginning transmission at the same time. Collisions are also caused by the "hidden terminal" problem, where a station, believing the Channel is idle, begins transmission without successfully detecting the presence of a transmission already in progress. Interference is also caused by multipath fading, which is characterized by random amplitude and phase fluctuations at the receiver. The reliability of the communications channel is typically measured by the average Bit error rate (BER). For packetized voice, packet loss rates on the order of 10–2 are generally acceptable; for uncoded data, a BER of 10–5 is regarded as Acceptable. Automatic repeat request (ARQ) and forward error correction (FEC) are used to increase reliability.

2.3.3 Security:

In a wired network, the transmission medium can be physically secured, and Access to the network is easily controlled. A wireless network is more difficult to Secure, since the transmission medium is open to anyone within the geographical Range of a transmitter. Data privacy is usually accomplished over a radio medium Using encryption. While encryption of wireless traffic can be achieved, it is usually at the expense of increased cost and decreased performance.

2.3.4 Power Consumption:

Typically, devices connected to a wired network are powered by the local 110 V Commercial power provided in a building. Wireless devices, however, are meant To be portable and/or mobile, and are typically battery powered. Therefore, Devices must be designed to be very energy-efficient, resulting in “sleep” modes And low-power displays, causing users to make cost versus performance and cost Versus Capability trade-offs.

2.3.5 Human Safety:

Research is ongoing to determine whether radio frequency (RF) transmissions from radio and cellular phones are linked to human illness. Networks should be designed to minimize the power transmitted by network devices. For infrared (IR) WLAN systems, optical transmitters must be designed to prevent vision Impairment.

2.3.6 Mobility:

Unlike wired terminals, which are static when operating on the network, one of the primary advantages of wireless terminals is freedom of mobility. Therefore, System designs must accommodate handoff between transmission boundaries and Route traffic to mobile users.

2.3.7 Throughput:

The capacity of WLANs should ideally approach that of their wired counterparts. However, due to physical limitations and limited available bandwidth, WLANs are currently targeted to operate at data ratesbetween 1–20 Mb/s. To support multiple Transmissions simultaneously, spread spectrum techniques are frequently employed.

Currently, there are two emerging WLAN standards: the European Telecommunications Standards Institute (ETSI) High-Performance European Radio LAN (HIPERLAN) and the IEEE 802.11 WLAN. Both draft standards cover the physical layer and medium access control (MAC) sub layer of the open Systems interconnection (OSI) seven layer reference model.

The IEEE is developing an international WLAN standard identified as IEEE 802.11. This project was initiated in 1990, and several draft standards have been published for review.

The scope of the standard is "to develop a Medium Access Control (MAC) and Physical Layer (PHY) specification for wireless connectivity for fixed, Portable And moving stations within a local area." The purpose of the standard is twofold:

- To provide wireless connectivity to automatic machinery, equipment, or stations that require rapid deployment, which may be portable, or hand-held or which may be mounted on moving vehicles within a local area
- To offer a standard for use by regulatory bodies to standardize access to one or more frequency bands for the purpose of local area communication

The IEEE 802.11 draft standard describes mandatory support for a 1 Mb/s WLAN with optional support for a 2Mb/s data transmission rate. Mandatory support for Asynchronous data transfer is specified as well as optional support for distributed Time bounded services (DTBS). Asynchronous data transfer refers to traffic that is Relatively insensitive to time delay. Examples of asynchronous data are available Bit rate traffic like electronic mail and file transfers. Time bounded traffic, on the Other hand, is traffic that is bounded by specified time delays to achieve an Acceptable quality of service QoS (e.g., packetized voice and video). Of Particular interest in the specification is the support for two fundamentally Different MAC schemes to transport asynchronous and time bounded services. The First scheme, distributed coordination function (DCF), is similar to traditional Legacy packet networks supporting best effort delivery of the data. The DCF is Designed for asynchronous data transport, where all users with data to transmit Have an equally fair chance of accessing the network. The point coordination Function (PCF) is the second MAC scheme. The PCF is based on polling that is Controlled by an access point (AP). The PCF is primarily designed for the Transmission of delay-sensitive traffic.

2.4 Classification of queuing techniques:

Queuing is one of the important mechanisms in traffic management; each router In the network must implement some queuing discipline that governs how packets Are buffered while waiting to be transmitted.

The queuing algorithm can be thought of as allocating independent quantities: Bandwidth (which packets get transmitted), buffer space (which packets get discarded) and promptness (when packets get transmitted).

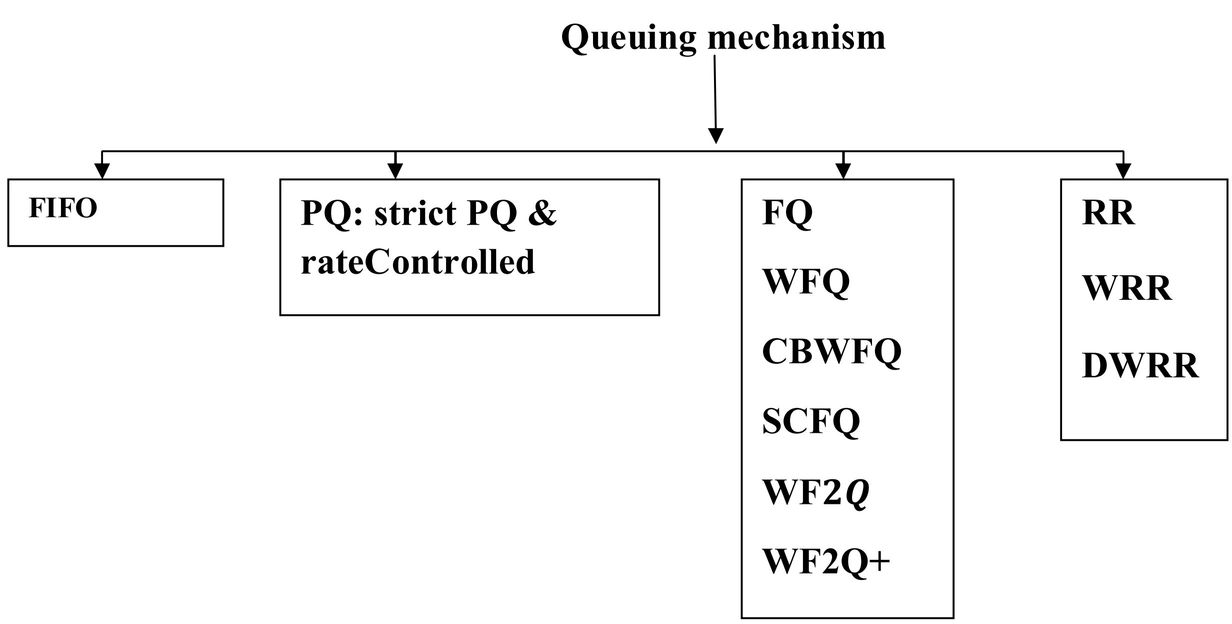

Figure: 2.1Queuing mechanism

2.4.1 First In First Out queuing mechanism (FIFO):

FIFO is an acronym for First-In-First-Out, also known as First-Come-First-Served (FCFS), FIFO queuing algorithm is more like a queue. The first packet to arrive The router is the first packet to be transmitted. And the next packet that arrives Falls into a finite queue. If the queue was full then the packet will be dropped and that is called "Tail drop". FIFO with tail drop is the simplest queuing algorithm and widely used in internet routers.

2.4.2 Priority Queuing mechanism (PQ):

Priority queuing is basically a form of FIFO algorithm, the idea of PQ is to Assign every packet with a priority, then the router will have a different classes of Queues for example: high-priority queue, medium-priority queue and low-priority Queue. In each queue packets will be handled in a FIFO manner. After the router Transmits all the packets in the high-priority queue then it will serve the packets in The medium-priority queue and so. The obvious issue with PQ is that packet with Low priority will not be served until the high priority packets get served.

2.4.3 Fair Queuing mechanism (FQ):

FIFO queuing algorithm doesn't discriminate which traffic is sent from which source. FQ was proposed to solve this problem. it introduced a fair packets sharing and equally wait time between different sources. The idea of FQ is each source will have a separate queue with a limit length if exceeds it, packets will be dropped. Then the router will serve these queues in a form of a round-robin, so it was formed to protect the network capacity from ill-behaved traffic

2.4.4 Weighted Fair Queuing mechanism (WFQ):

In WFQ each flow queue will have a certain weight that determines the Percentage of the output bandwidth allocate to that flow, queues with the largest Percentage has the advantage and will be served earlier. The router classifies the Arriving packets depending on their weights and places each one of them in the Right queue. Then it calculates and assigns a finish time for each packet in each Queue. The packet with the smallest finish time is the next to be served.

Many queuing techniques are developed based on WFQ to address the limitation of (FQ).

2.4.5 Class Based Weighted Fair Queuing mechanism (CBWFQ):

Class-Based-Weighted-Fair queuing is a developed WFQ with a user-defined Traffic classes, you get to define two things: First the matching criteria of the Traffic classes so that each packet satisfies the matching criteria will be included in That traffic class, each traffic class will have a queue. Second the characteristic of The class: the class bandwidth, weight and maximum packet limit.

2.4.6Self-Clocked Fair Queuing (SCFQ):

The Self-Clocked Fair Queuing, SCFQ is enhancement to WFQ that simplifies the complexity of calculating the finish time in a corresponding GPS system. The Decrease in complexity results in a larger worse-case delay and delay increases with the number of service classes. However, it was discovered that calculating The Finish Time (the time at which a packet would have been serviced given a Hypothetical fluid server) for WFQ was complicated/difficult. SCFQ uses a Simplified method of calculating theservice time, based on the transmission delay Of the packet, and the finish time of the packet currently being serviced.

2.4.7 Worst Case Fair Weighted Queuing mechanism (WF2Q):

(Bennett and Zhang, 1996)WF2Q worst-case-fair-weighted queuing based on the idea that the router uses both start time and finish time to govern which packets get transmitted. Start time as the router will only consider the set of packets that already started receiving Service of a queue. And finish time as the router will only serve packets that will finish the service first in that queue. And just like WFQ it offers protection to Well-behaving flows, its flexible however not easy to implement.

2.4.8 Worst Case Fair Weighted Queuing mechanism (WF2Q+):

The Worst-case Fair Weighted Fair Queue + is an enhancement of WF2Q Which implements a new virtual time function that results in lower complexity and Higher accuracy. Scheduler maintains a virtual clock in addition to the real clock And separate queue for each session. When a packet reaches the head of its queue, It is assigned a Virtual Start Time and a Virtual Finish Time. Only the packets at the head of their queues with Virtual Start Time less than or equal to the current Virtual Time are eligible for transmission. Among eligible packets, the one with The least Virtual finish time is picked for transmission.

Table 2.1 Summarization of queuing techniques

S. No.	Queuing Algorithm	Description	Advantages	Limitations	Applications
1	FIFO	-no. of queues= 1 -based on first come first served -packet by packet dispatching -tail drop mechanism used	-simple and fast -no need to configure -low computational load -predictable in nature -no reordering	-unfair bandwidth allocation -causes starvation -causes jitter -do not allow routers to organize buffer packets	gives benefits to UDP flows over TCP flows and gives acceptable results for FTP
2	PQ	-no. of queues= 4 -high priority packets are serviced first -packet by packet dispatching - tail drop mechanism used -designed for low bandwidth links -low processing speed	-low delay to high priority packets -low computational load - allow routers to organize buffer packets	- unfair bandwidth allocation -starvation of lower priority packets -need to be configured -low processing Speed	Used in real time applications as VOIP
3	WFQ	-number of queues are configurable -low volume traffic is given priority -conversational dispatching -Modified tail drop mechanism(drops most aggressive flow) - enabled when bandwidth is less than 2 Mbps	-easy to configure -fair bandwidth allocation -reduced jitter -proportional -Bandwidth for traffic of different priorities	-complex -not applicable to delay sensitive Real time services	Works best for FTP and video Conferencing

2.5 Literature Review:

Many comparisons have been done between different queuing techniques; some of it is presented in the following literature**:**

(Rastogi and Srivastava, 2013)Investigated that in fixed wired networks WFQ Technique has a superior quality than the FIFO and PQ.Yet in the delay Sensitive data the PQ gives the best Results.

(Farhangi et al., 2013) Concluded that, combination of (PQ) and (MWRR) queuing Technique are better than the network configuration in single (PQ) or (MWRR) Technique in more Traffics of Internet network.

(Wang et al., 2008) Introduced a new queuing technique named adaptive rotating priority queue ARPQ Operates with a “priority first, fairness second” policy and guarantees the delay Bounds for the flows with higher priorities and maintain the reasonable throughput For the flows with lower priorities. The ARPQ outperforms all the existing Scheduling algorithms in mobile networks.

(Siris and Stamatakis, 2005)Developed a dynamic class based Weight fair queuing (CBWFQ) queuing mechanism that improves fairness and Aggregate throughput, while supporting weight-based service differentiation in Terms of throughput in a WLAN network.

(Weng and Hung, 2014) Have proposed the multiple flows Distributed weighted fair queuing (DWFQ) architecture for providing weighted Fair queuing in IEEE 802.11e WLANs. The bandwidth received by a flow is in Proportion to the flow’s weight. By assigning higher weight to packet with higher Priority, multiple flows DWFQ can also support QoS requirements of priority Application.

Chapter Three

Queuing Techniques

Chapter Three

Queuing techniques

The queuing discipline or service strategy determines which packet is selected from the queue for processing when a server becomes available. Queuing disciplines play an important role in providing Quality of Service guarantees. Three of the most common queuing disciplines are considered in detail in this Chapter.

3.1 First In First Out Queuing (FIFO):

First in first out (FIFO) is the default queuing discipline in most interfaces. Each queue within a multi queue discipline is a FIFO queue. FIFO is a simple algorithm that requires no configuration effort.

In FIFO there is a Single queue, packets line up on the queue according to the packet arrival time. Packet class, priority, and type play no role in a FIFO queue. The FIFO discipline serves the packet on the top of the queue. Figure 3.1

The FIFO queue is limited; if the queue was full and there is a new arrived packet it will be dropped.

Without multiple queues and without a scheduling and dropping algorithm, high-volume and ill-behaved applications can fill up the FIFO queue and consume all the interface bandwidth.

As a result, other application packets with low volume and less aggressive traffic such as voice might be dropped or experience long delays; FIFO is considered unfair.

FIFO is often considered an appropriate queuing discipline on fast interfaces that are unlikely to be congested; also it’s suited to best-effort traffic.FIFO scheduling is useful for sharing delay among connections and easy to implement efficiently.

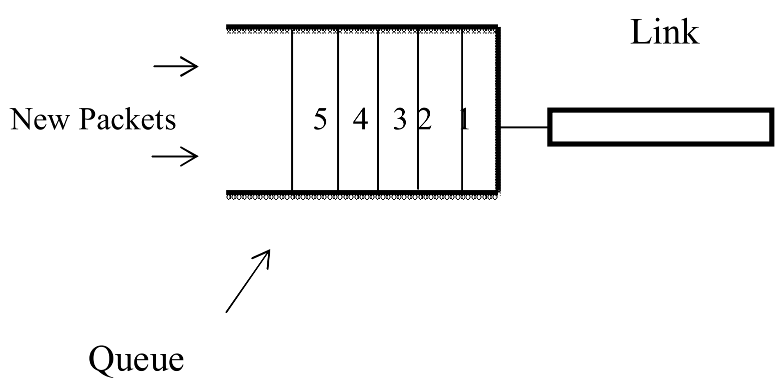

Figure 3.1First In First Out

FIFO Flow chart

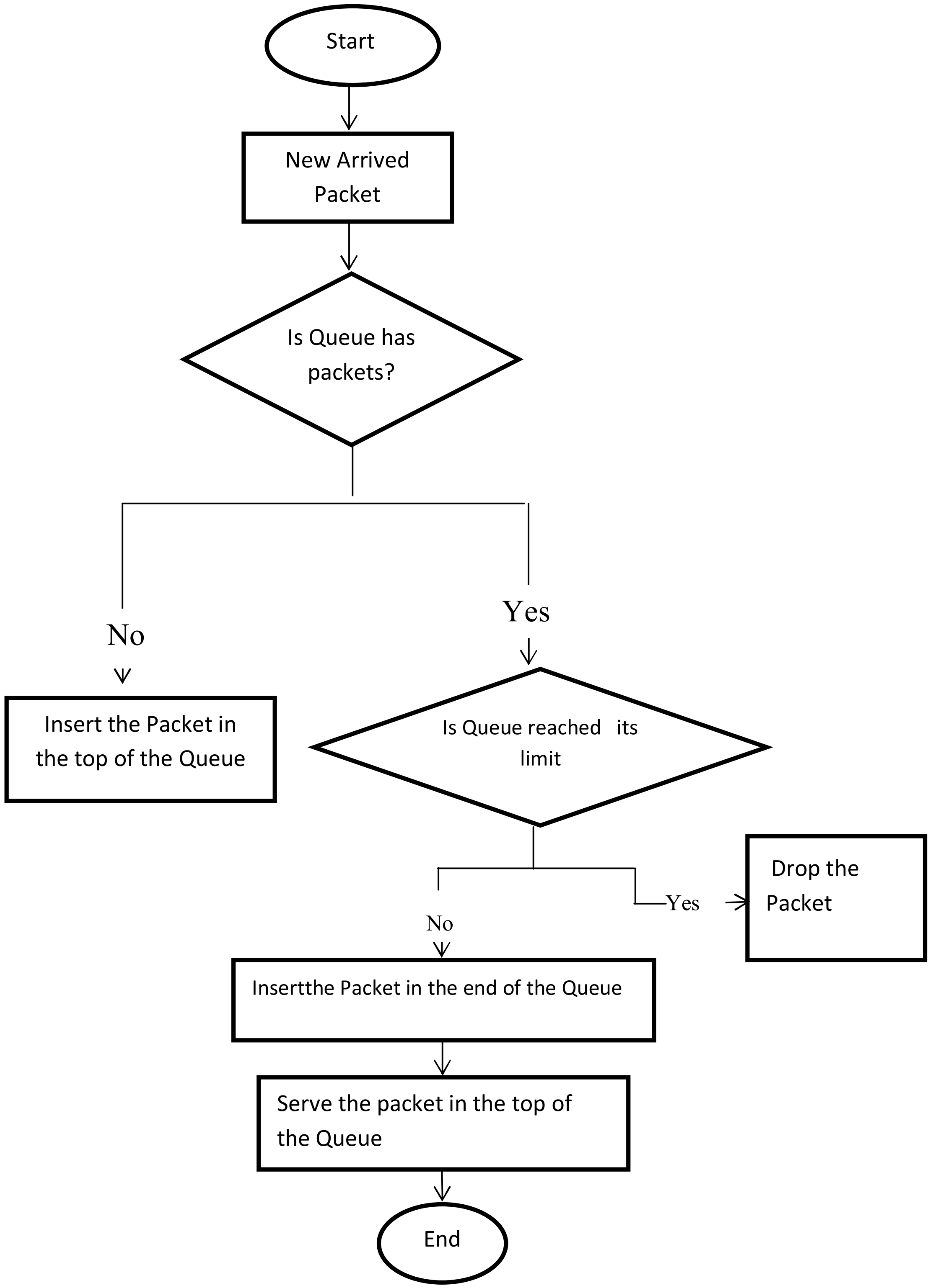

Figure 3.2 Flow chart of FIFO

3.2 Priority Queuing (PQ):

Priority queuing algorithm is a simple variation of the basic First In First Out queuing algorithm. The idea is to mark each arriving packet with priority tag (high, low); the priority tag could be based on for example, the Type of Service ToS field in the IP header, the packet source or destination IP address Or the packet destination port number or any other criteria.

There are different Queues in the priority Queuing algorithm, those Queues are based on the level of the priority of the packets within the Queue, there is (low priority queue) and (high priority queues). After marking the arrived packets with priority tags, each packet will be classified (based on their mark) either in the high queue or the low queue. As showing in figure 3.3

When choosing a packet to transmit, the priority queuing discipline will transmit a packet from the highest priority class that has a non-empty queue. This means Packets of lower priority start transmission only if no higher priority packet is waiting.

To define completely the service discipline, it is necessary to determine whether the priority is absolute or not.

By absolute priority, it is implied that a packet of lower priority is returned to the start of the queue when a packet of high priority arrives, in the queue, the later arrival starting their service immediately.

If the priority is not absolute, when the higher priority packet arrives while a lower priority packet is being transmitted, it waits until the lower priority packet completesPriority queuing is often suggested on lowbandwidth interfaces in which you want to give absolute priority to mission-critical or valued application traffic.

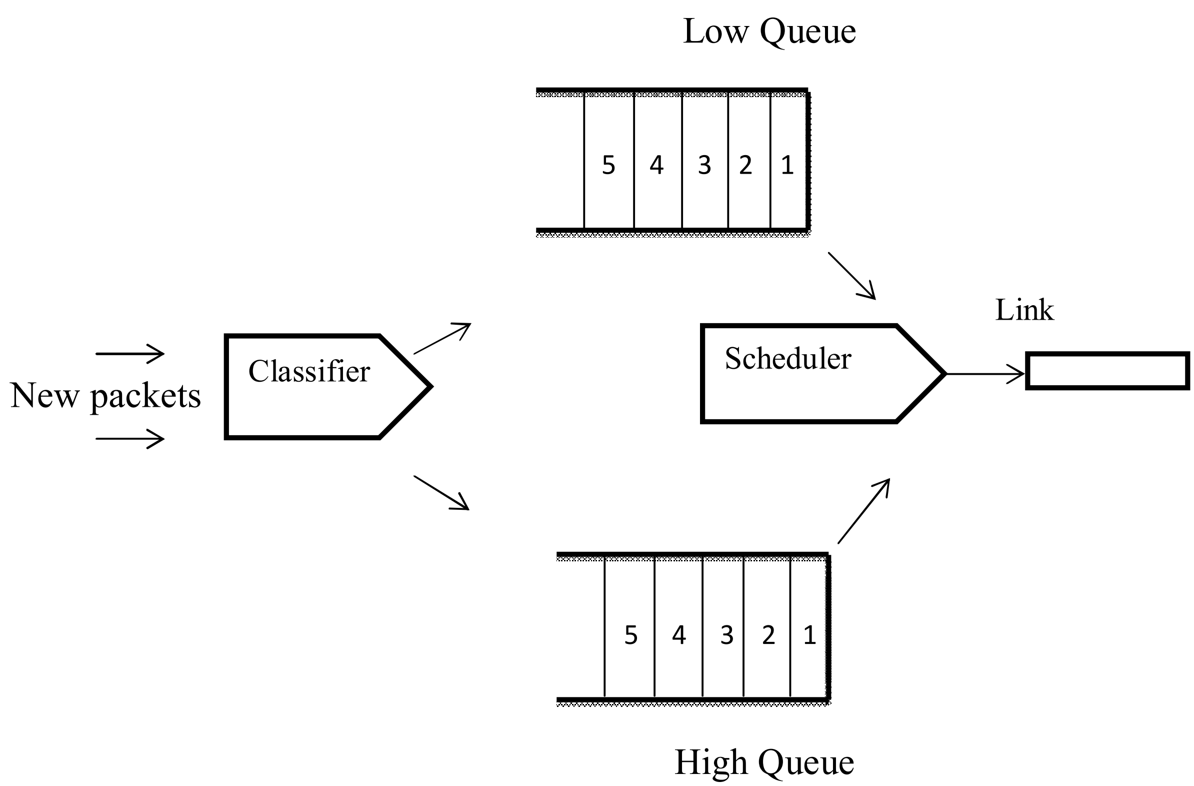

Figure 3.2Priority Queuing

PQ Flow Chart:

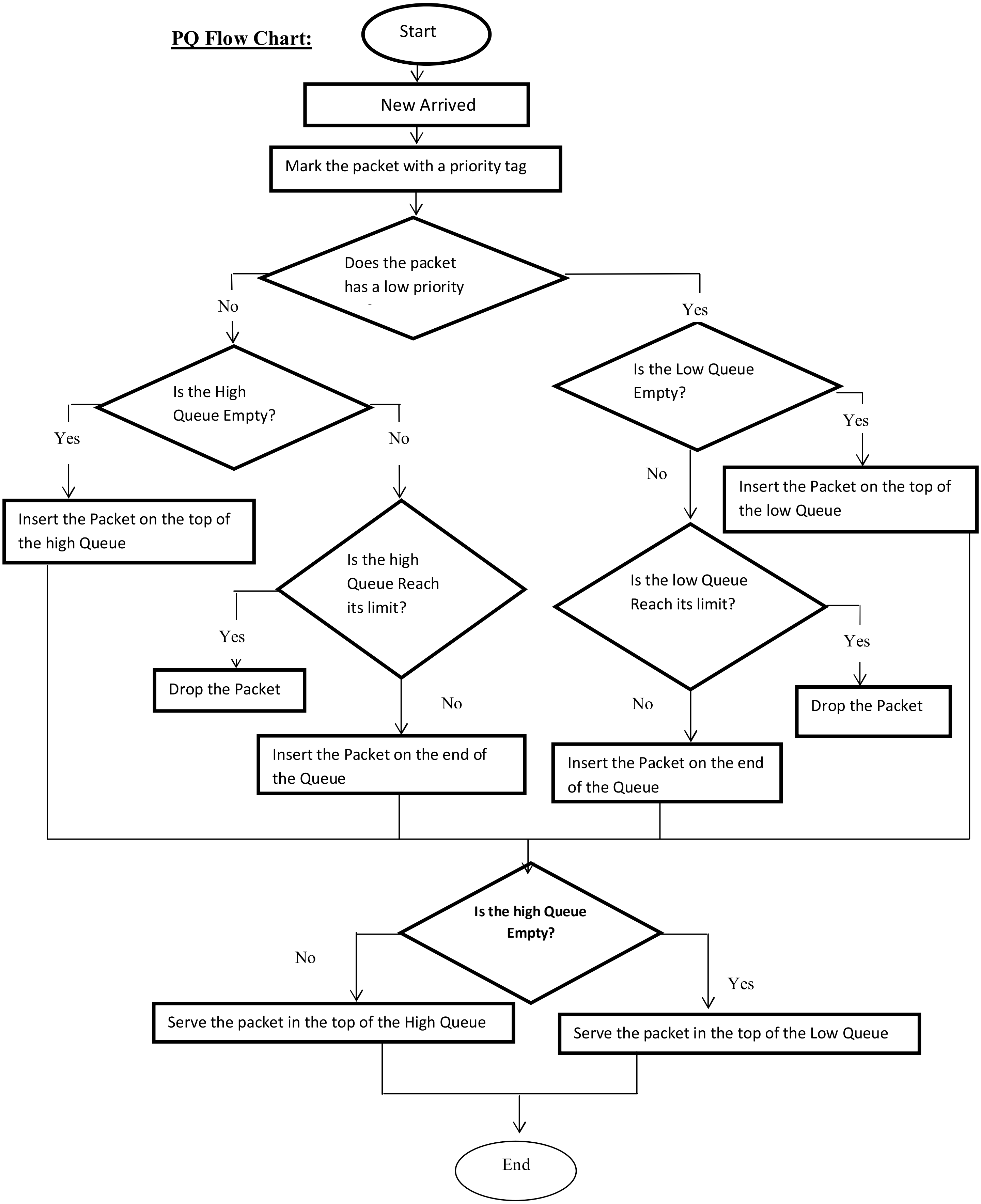

Figure 3.3 Flow chart of PQ

3.3 Weighted Fair Queuing (WFQ):

Weighted Fair Queuing technique is botha packet based implementation of the generalized processor sharing policy GPS, and a natural generalization of fair queuing technique FQ. The Fair Queuing technique shares the link capacity in equal subparts while weighted fair queuing technique allows specifying for each flow which fraction of the capacity will be given.

WFQ offers fair queuing that divides the available bandwidth across queues of traffic based on weights. Each flow or queue is assigned with a weight to ensure that important traffic gets higher priority over less important traffic. In times of congestion each queue is protected and treated fairly according to its weight.

Arriving packets are classified into different queues by inspection of the packet header fields, including characteristics such as source and destination network or MAC address, protocol, source and destination port. In each Queue packets assigned a virtual theoretical departure time and the packet with smallest departure time is served first, Figure 3.5. Weighted Fair Queuing ensures satisfactory response time to critical applications and protects traffic of different queues from each other.

N number of flows is configured with one weight**Wi** for each flow. Then, the flow of number **i,** will achieve an average data rate of

$$= \frac{\boldsymbol{W_i}}{\sum_1^n \boldsymbol{W}} \times \boldsymbol{R}$$

Where: **R** is the link rate. [redacted]

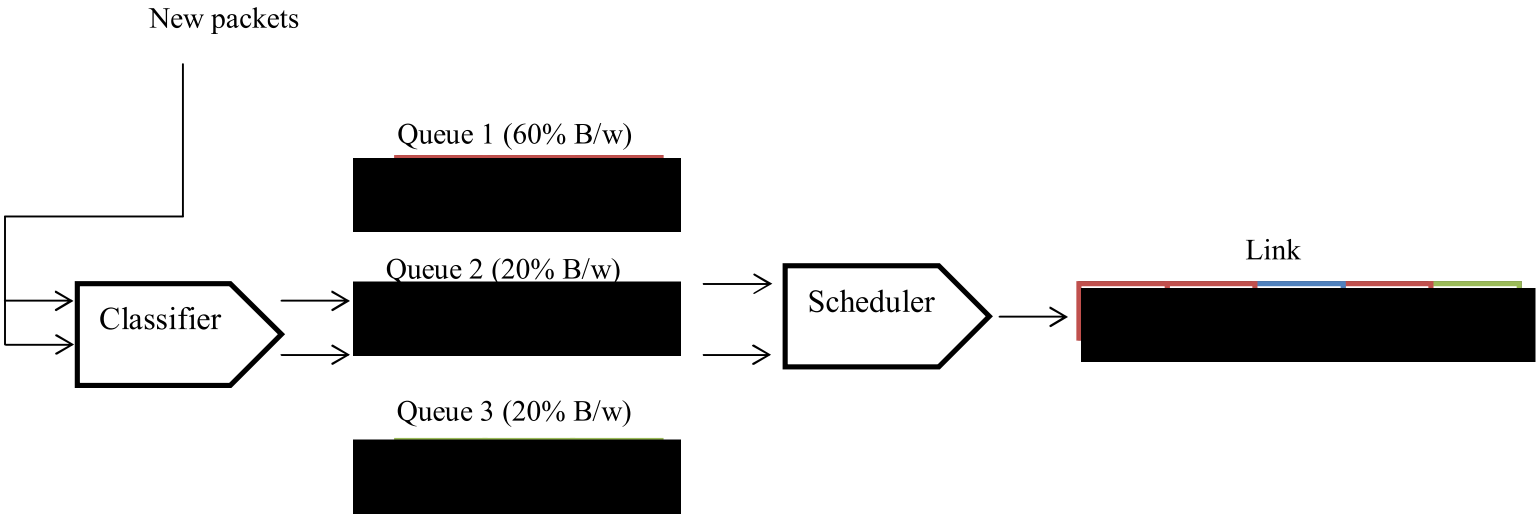

Figure 3.4 Weighted fair Queuing

WFQ Flow Chart:

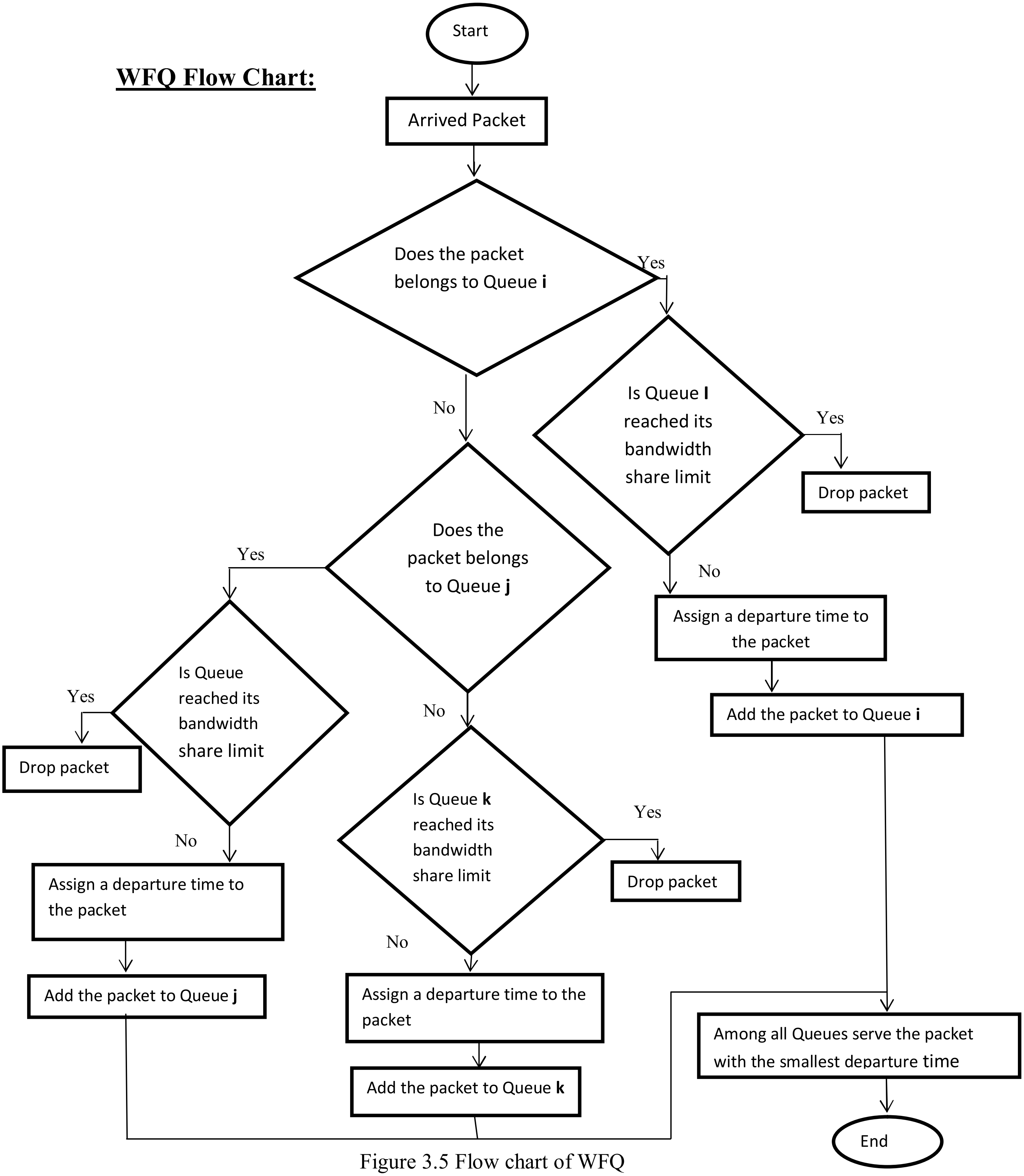

Figure 3.5 Flow chart of WFQ

Chapter Four

The Simulation Environment

Chapter Four

The Simulation Environment

In this chapter we will demonstrate the simulation environment by presenting the network model and stating the comparison metrics alongside with the simulation parameters. Finally the applied scenarios of the experiment will be clarified.

The simulations were performed using the simulation tool OPNET.

OPNET is an engineering system capable of simulating large communication networks with detailed protocol modeling and performance analysis. In order to get the best results possible OPNET was chosen for use in this project because of it is extensive model library and flexibility.

4.1 Network Design:

The networkconfiguration used to establish the simulation is based on a Wireless Local Access Network structure. It contains Four Servers, a Router, an Access Point and Four mobile workstations.

The four servers support four different services using different protocols. The four services are First Web Browsing using Http, Second File Transfer using Ftp, Third Streaming Video using video conferencing and Fourth Voice using VoIP.

The servers are connected to the router wirily with a 100Mbps link then to the access point with 1.544 Mbps link. The access point feeds the four mobile workstations wirelessly. Figure 4.1

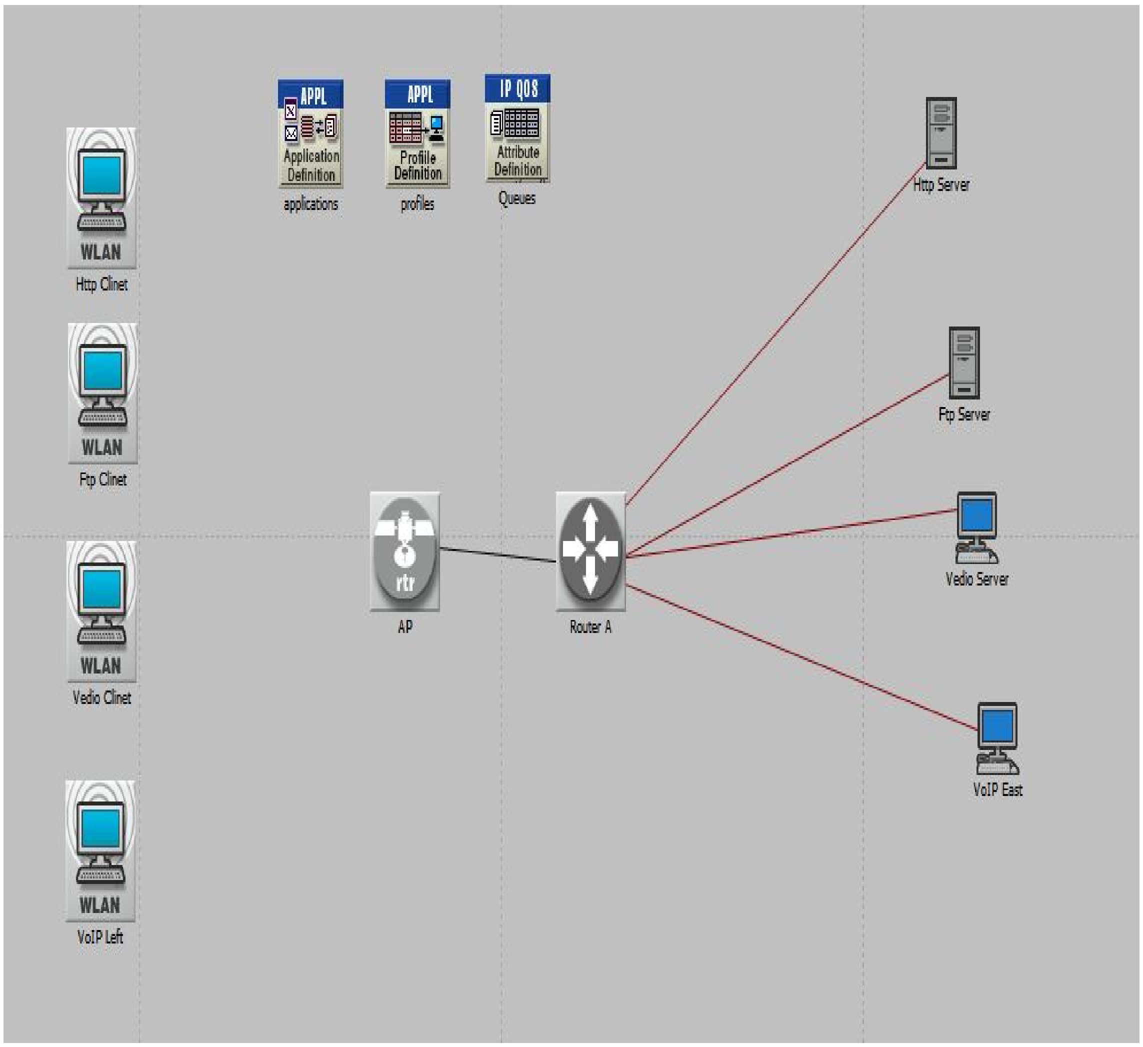

Figure 4.1 A general representation of the network

The following table summarizes the network nodes in the topology.

Table 4.1 Summarized of the network nodes in the topology

Network node name in OPNET	attribute	Network node representation
wlan_server_adv	Fixed node	-Ftp Server -Http Server
wlan_wkstn_adv	Fixed mode	-Video conferencing Server -VoIP Right
ethernet4_slip8_gtwy	Fixed node	-Router
Wlan_ethernet_router_adv	Fixed node	-Access Point
wlan_wkstn_adv	Mobile node	-Ftp Client -Http Client -Video conferencing Client -VoIP Left

4.2 Simulation Parameters:

The simulation runs for approximately 3 minutes handling four traffic profiles each with different parameters detailed as follows:

4.2.1 The File Transfer service:

The traffic of the Ftp profile supports a frame size up to 1 Mbytes with inter-request time equal to 10 seconds.

4.2.2 The Web browsing service:

The traffic of the Http profile supports a Page with properties of 100 Kbytes with a page Inter-arrival Time equal to 10 seconds.

4.2.3 The Video Conferencing Service:

The traffic of the Video Conferencing profile supports a128x120 pixels frame size with a Frame Inter-arrival Time equal to 10 frame/sec.

4.2.4 The voice service:

The traffic of a VoIP profile supports 1 voice frame per packet with frame inter-arrival time equal to 10 seconds.

All the traffic in the network is being monitored after 1m and 45 seconds of the start of the simulation.

4.3 Comparison Metrics:

In this simulation we are using the received and sent data of each traffic beside four performance metrics forcomparison and analysis purposes.

The first performance metric is *delay.* It represents the end-to-end delay. It is the summation of all delays from the clients to the individual routers till it gets to the servers.

The second performance metric is*IP traffic drop*. This is the amount of traffic drop due to buffer over flow.

The third performance metric is *Queuing Delay.* Which is defined as the time that a frame waits until it becomes first in line for transmission.

The final performance metric is *Throughput* .It is a measurement of the average rate of data that can be sent between one user and another.

4.4 Experiment Scenarios:

In order to achieve a fair comparison between the three techniques, the experiment is done using the same configuration of the network model but with three different scenarios.

4.4.1 The first scenario:

On the first scenario the First in First Out Queuing is applied between the router and the access point with one queue having a Maximum Queue Size equal to 200 Packets.

4.4.2 The second scenario:

In the second scenario the Priority Queuing discipline is applied, with four Queues classified as follows:

Table 4.2 PQ queues classification

Priority Level	**Queue Length**	**Classification**
Low Queue	20 packets	Ftp
Normal Queue	40 packets	Http
Medium Queue	60 packets	Video conferencing
High Queue	80 packets	VoIP

4.4.3 The third scenario:

The Weighted Fair Queuing is applied with four Queues, each Queue with a weight equal to 25 accomplishing a bandwidth of 25% for each traffic.

Table 4.3: WFQ queues classification

Queues	Weight	Queue Length	Classification
QueueOne	.25	80 packets	FTP
Queue Two	.25	80 packets	HTTP
Queue Three	.25	80 packets	Video Conferencing
Queue Four	.25	80 packets	VoIP

Chapter Five

Results & Discussion

Chapter Five

Results and discussion

In this chapter the results of the simulation are presented and discussed briefly.

The simulation was done using three scenarios, in each one of them the same network topology and the same traffic of the four service had been used but with applying different queuing technique every time. The effects of the Queuing techniques on the performance of the network were presented.

5.1 The FIFO Scenario:

The First in First Out technique was applied in this scenario. In this scenario with applying the FIFO no flow is guaranteed to outperform any of the other flows. The flow which will send small packets regularly will have a better performance.

The result came as follows:

Figure 5.1shows that the Ftp traffic suffered major delay and a lot of data were dropped.

Figure 5.2 shows The Http traffic experienced a relatively low delay. Http traffic performed better than Ftp traffic because Http traffic is lighter.

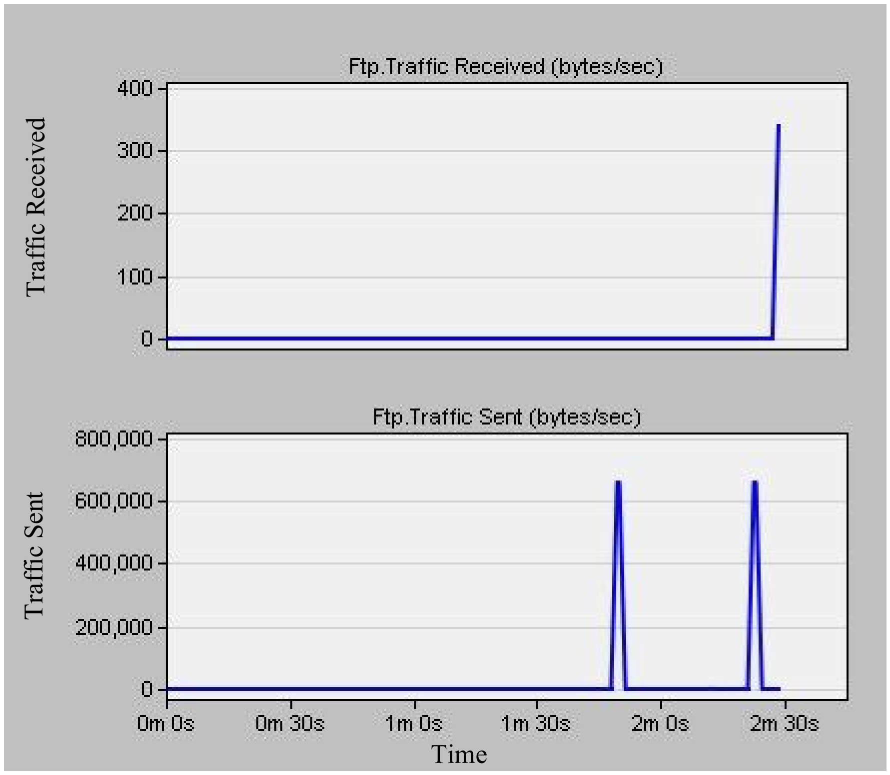

Figure 5.1 FTP traffic with FIFO applied

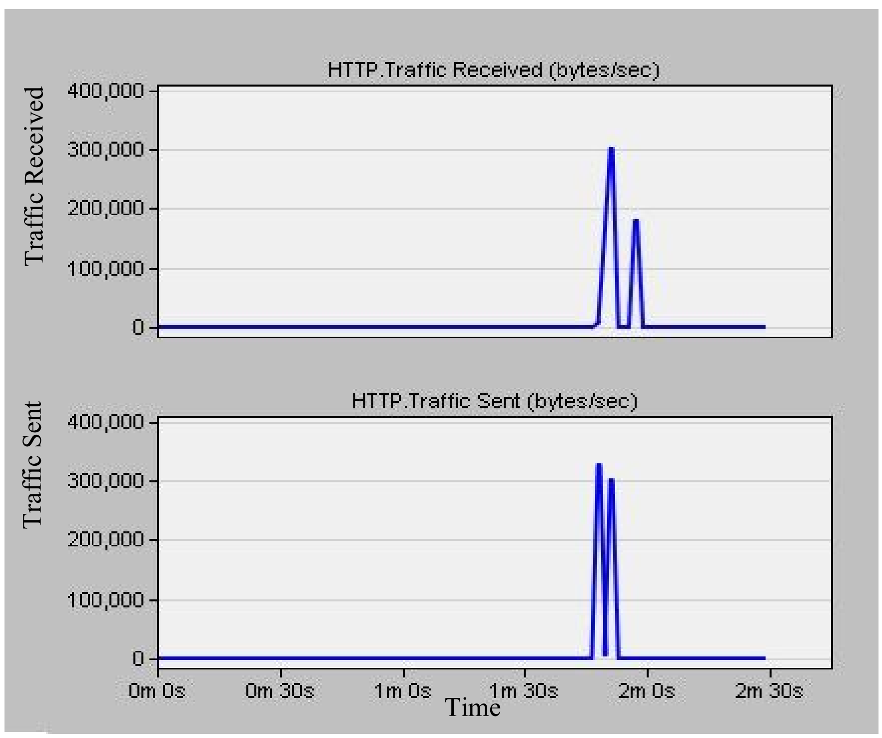

Figure 5.2 HTTP traffic with FIFO applied

Figure 5.3 shows the video conferencing traffic with sent data up to 700 Kbytes per seconds and received data up to 240 Kbytes per seconds figure 5.3 shows low throughput and high data dropping.

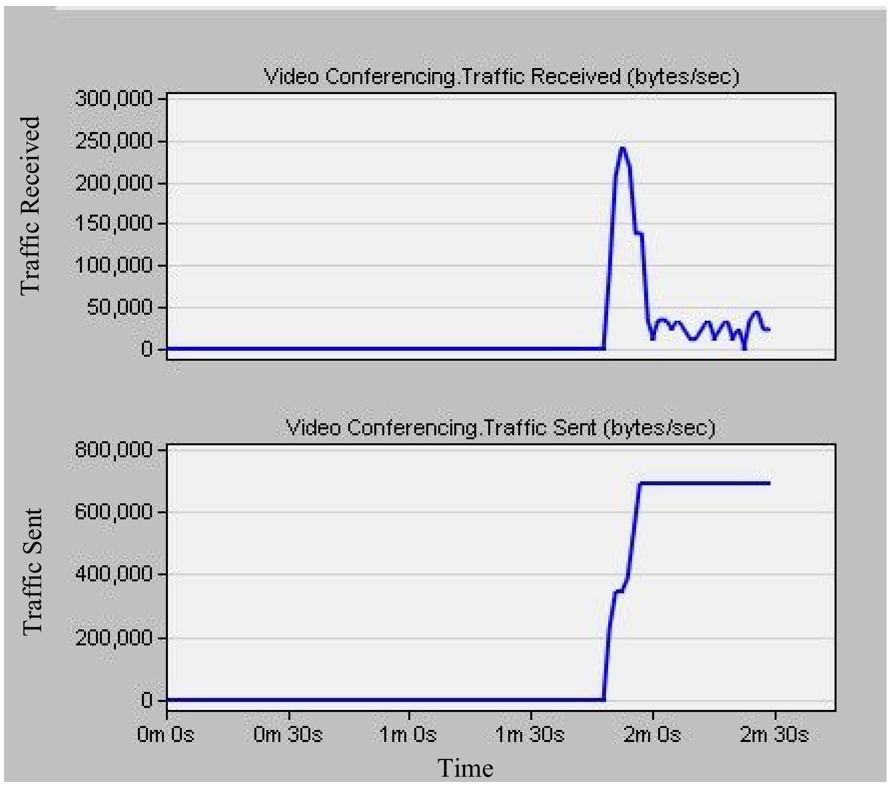

Figure 5.3 Video conferencing traffic with FIFO applied

In figure 5.4 the effect of the FIFO techniques to the voice data is presented. The voice traffic suffered from voice jitter between (0.008 – 0.003 seconds).

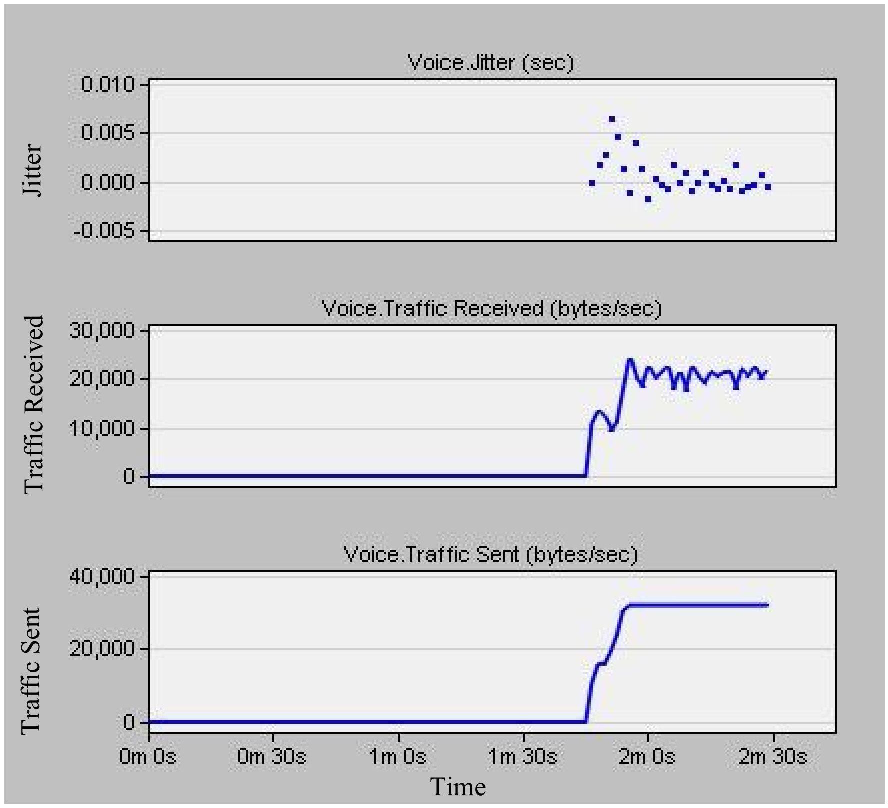

Figure 5.4 VoIP traffic with FIFO applied

5.2 The PQ Scenario:

In this scenario the Priority Queuing was applied to the network and the result of the four traffics were presented.

In this scenario with applying the PQ the voice traffic is expected to deliver the best performance between the four traffics and the ftp flow will be the worst.

The ftp traffic didn't send nor receive any data. Starvation occurred to the flow because it has the lowest priority.

The HTTP traffic show every low data dropping and high throughput figure 5.6, compared to the video conferencing traffic which suffered high data dropping figure 5.7, despite the video traffic priority is higher than theHttp traffic but demands large transmission time which is used by the higher level priority flow i.e. the voice.

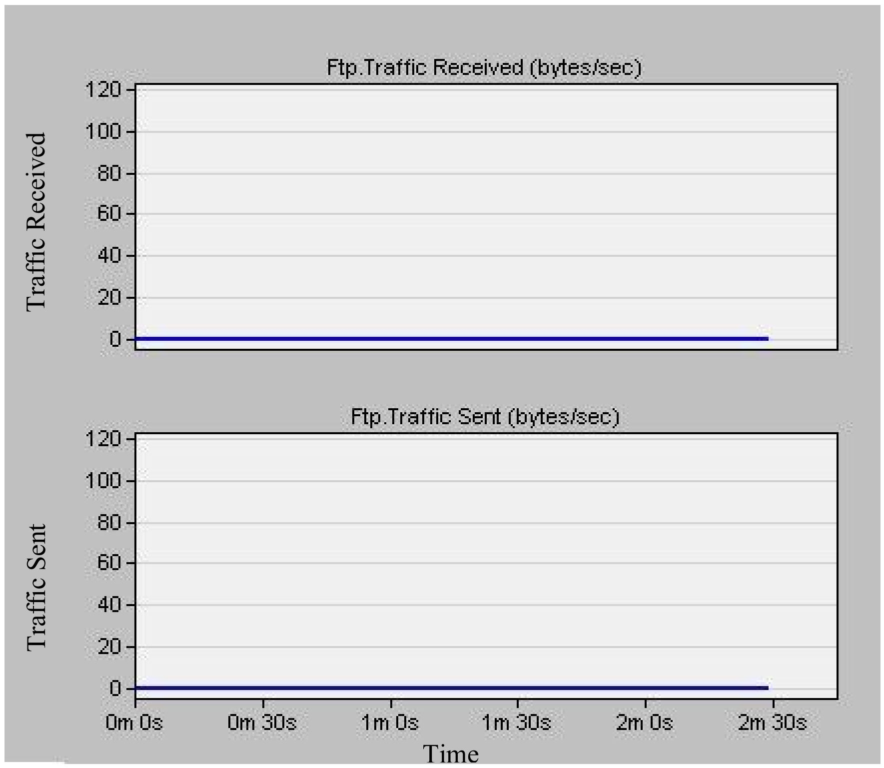

Figure 5.5 FTP traffic with PQ applied

The voice traffic as expected performed greatly with no delay and very high throughput. Figure 5.8

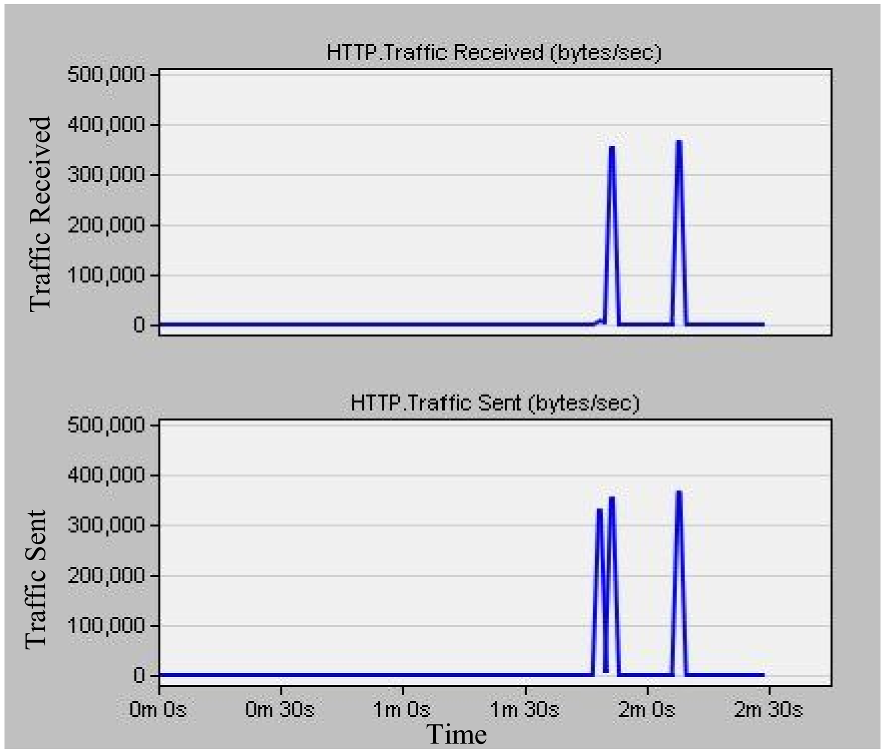

Figure 5.6 HTTP traffic with PQ applied

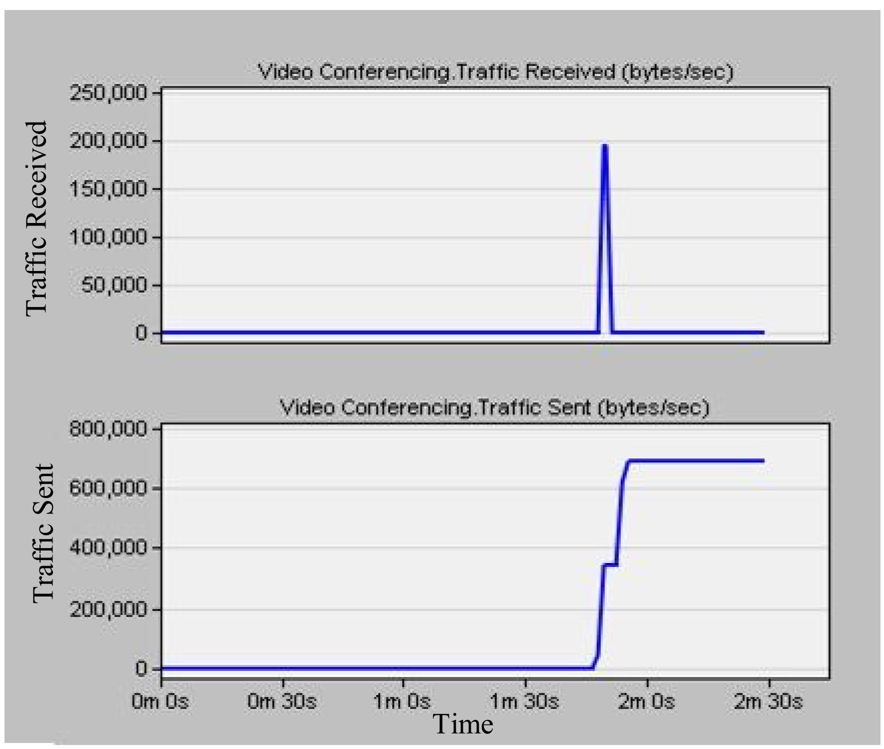

Figure 5.7 Video conferencing traffic with PQ applied

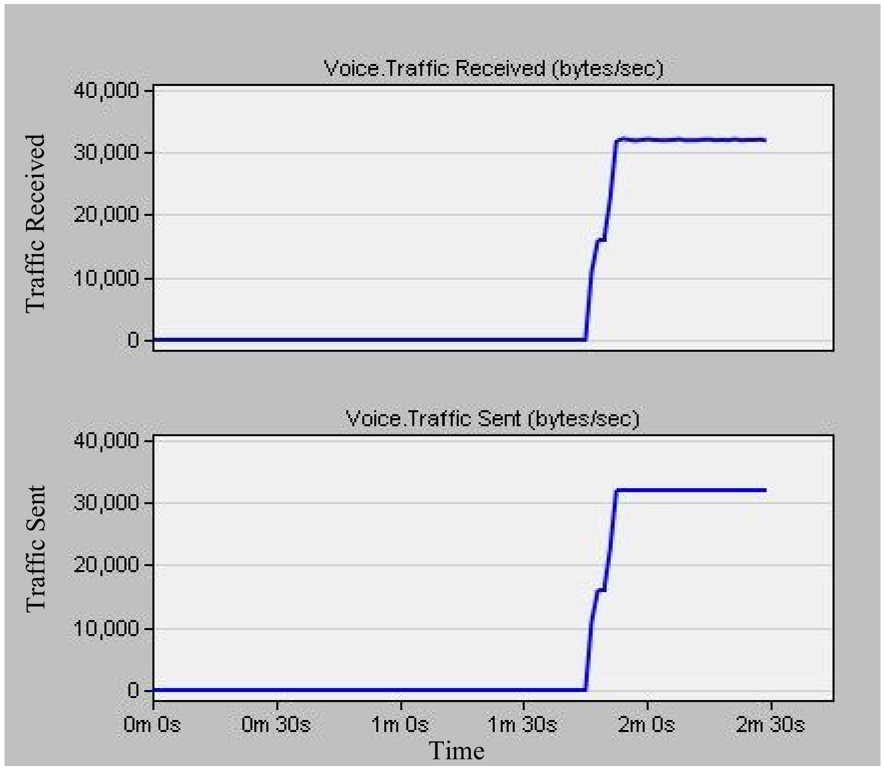

Figure 5.8 VoIP traffic with PQ applied

5.3 The WFQ Scenario:

In this scenario the Weighted Fair Queuing were applied to the network and the changes on the network performance were observed and detailed below:

In this scenario with the applying of the WFQ technique all the flows are expected to deliver a good performance equally. No starvation is expected.

The Ftp traffic with no delay showed the best performance than in the last two scenarios. Figure 5.9

The Http flow showed relatively low throughput than in the PQ however with low delay. Figure 5.10

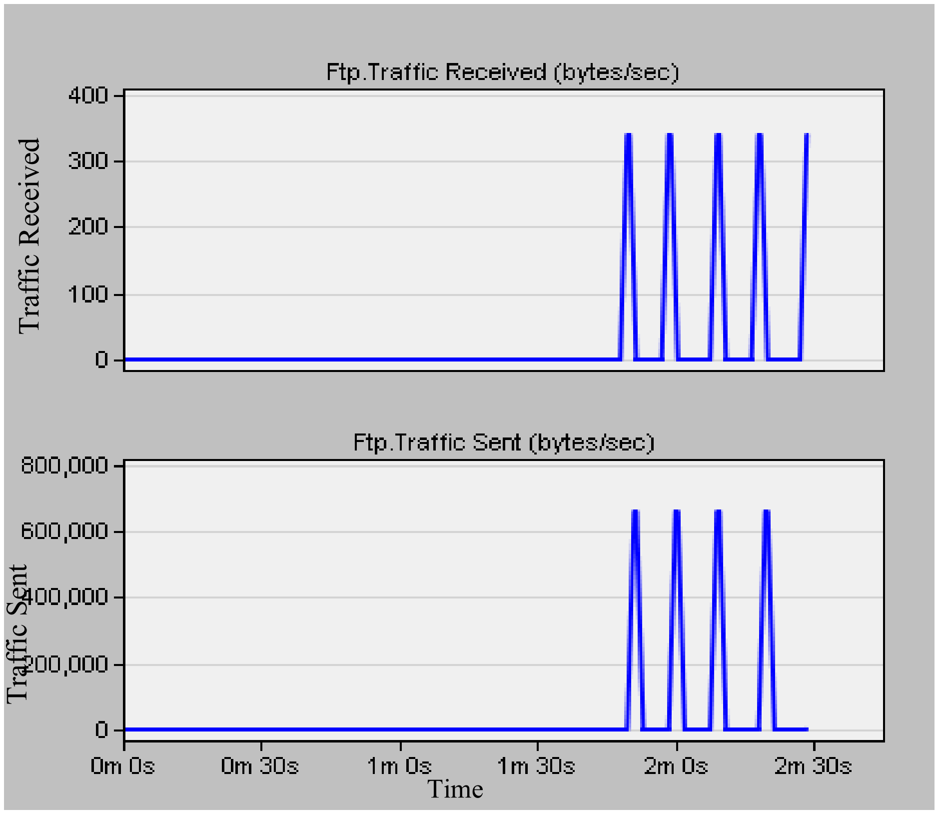

Figure 5.9 FTP traffic with WFQ applied

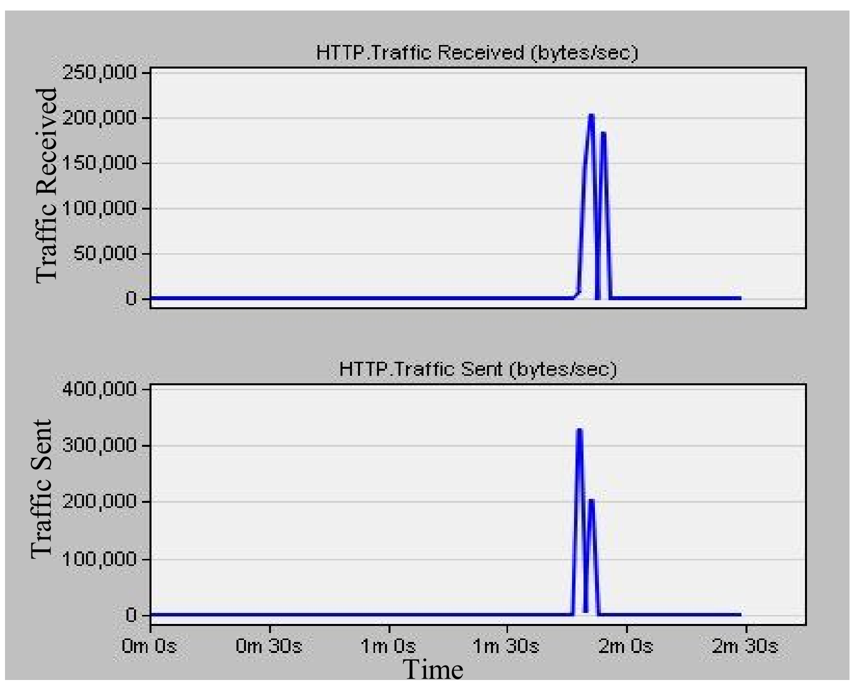

Figure 5.10 HTTP traffic with WFQ applied

The video conferencing traffic showed the best results usin WFQ with sent data up to 700 Kbytes per seconds and received data up to 250 Kbytes per seconds.

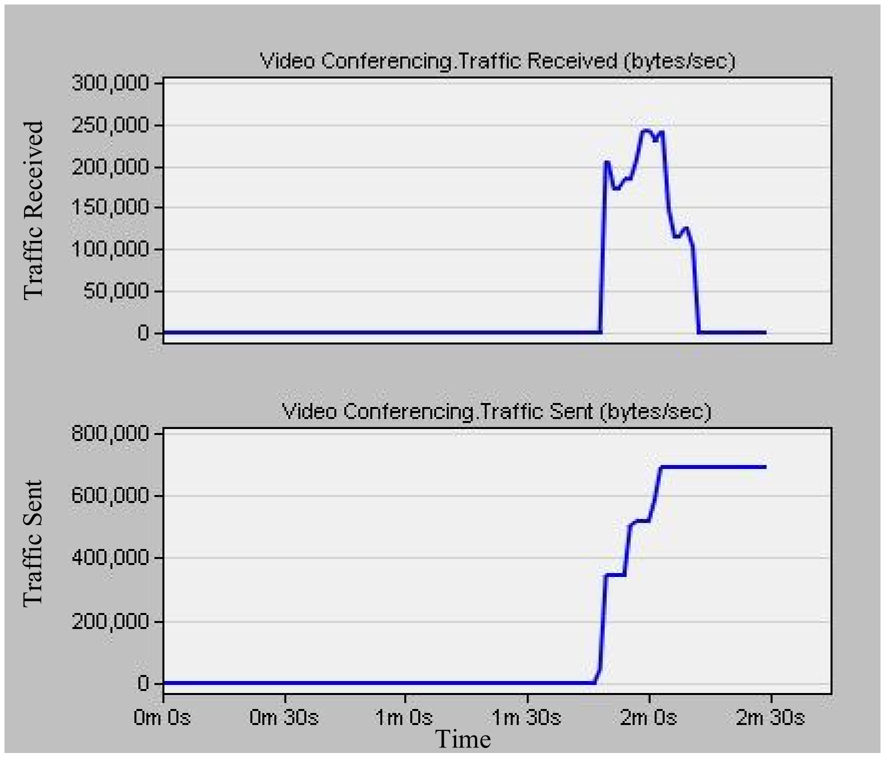

Figure 5.11 Video conferencing traffic with WFQ applied

The voice traffic showed better performance using WFQ than when using FIFO but didn't outperform the voice traffic when using the PQ. Figure 5.12

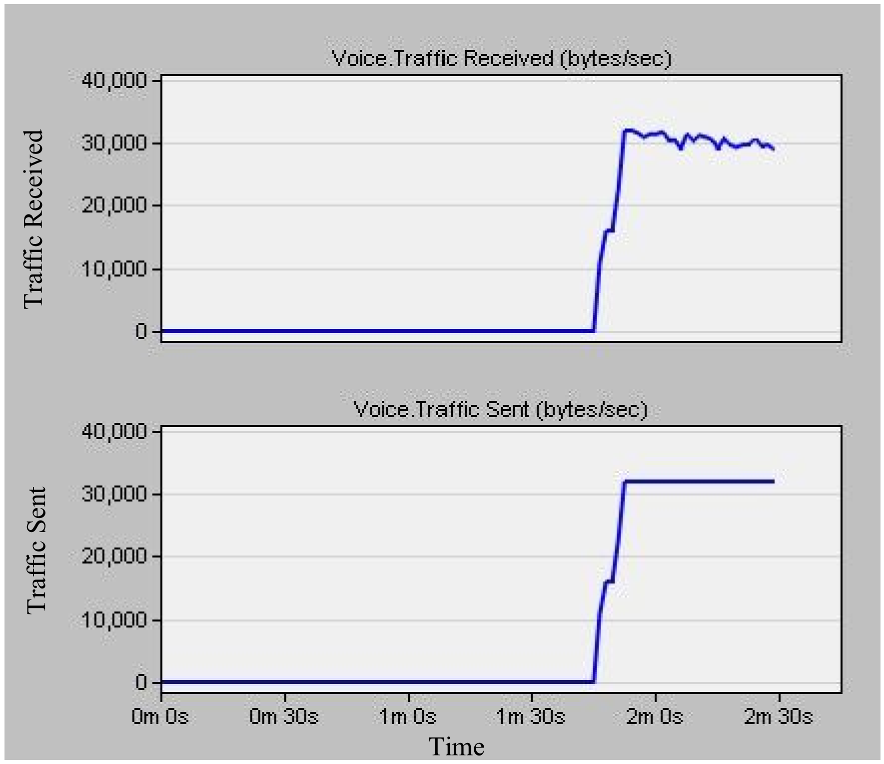

Figure 5.12 VoIP traffic with WFQ applied

5.4The Comparison results:

Below there are four comparative figures to illustrate the difference between the three techniques performance wise.

Figure 5.13 showed the throughput of the wireless network when using FIFO, PQ and WFQ. We can notice that FIFO has relatively high throughput than WFQ, however PQ had the highest throughput between the two.

When using FIFO the network suffered from high delay comparing to using PQ. WFQ delivered the least delay between the two. Figure 5.14

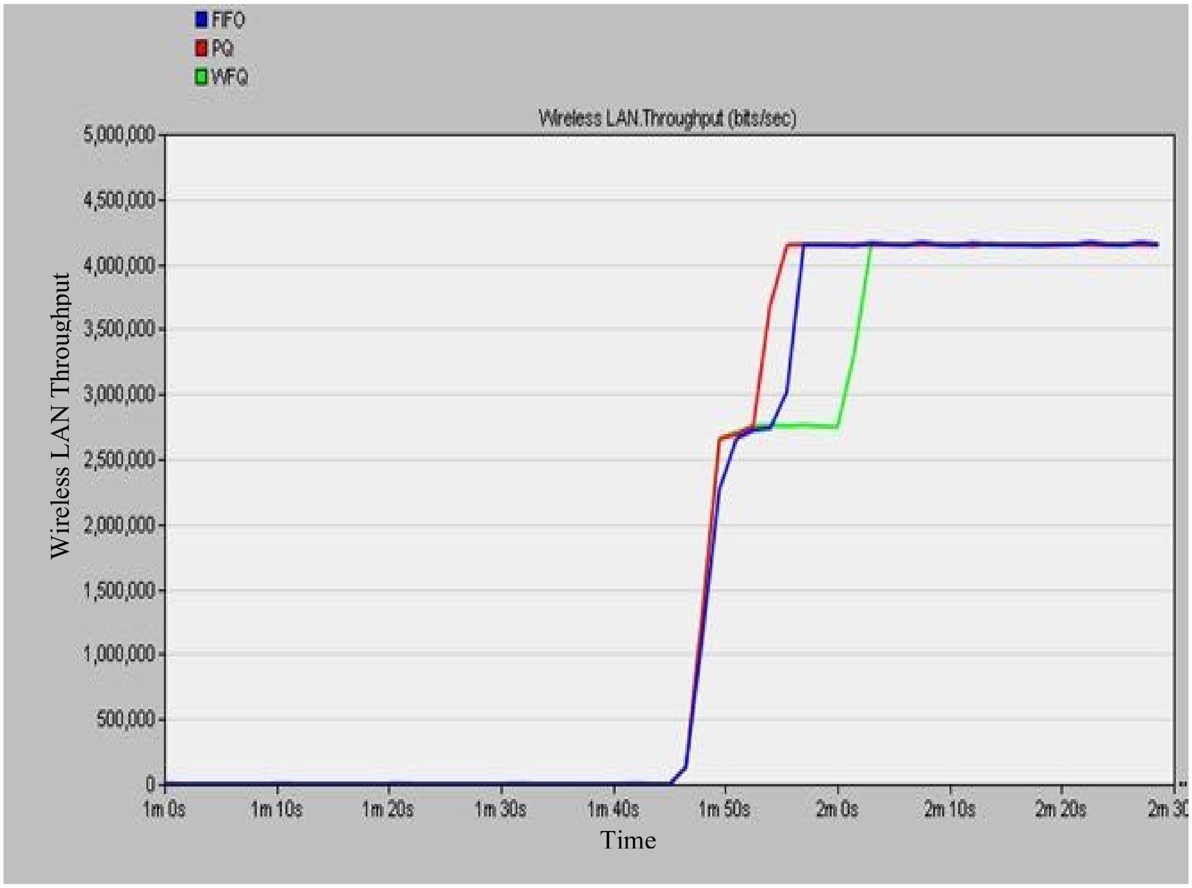

Figure 5.13 Wireless LAN Throughput VS Time

The Queuing delay is showed in figure 5.15. PQ has the lowest queuing delay slightly less than WFQ. FIFO has the highest queuing delay that reached up to .0040 seconds.

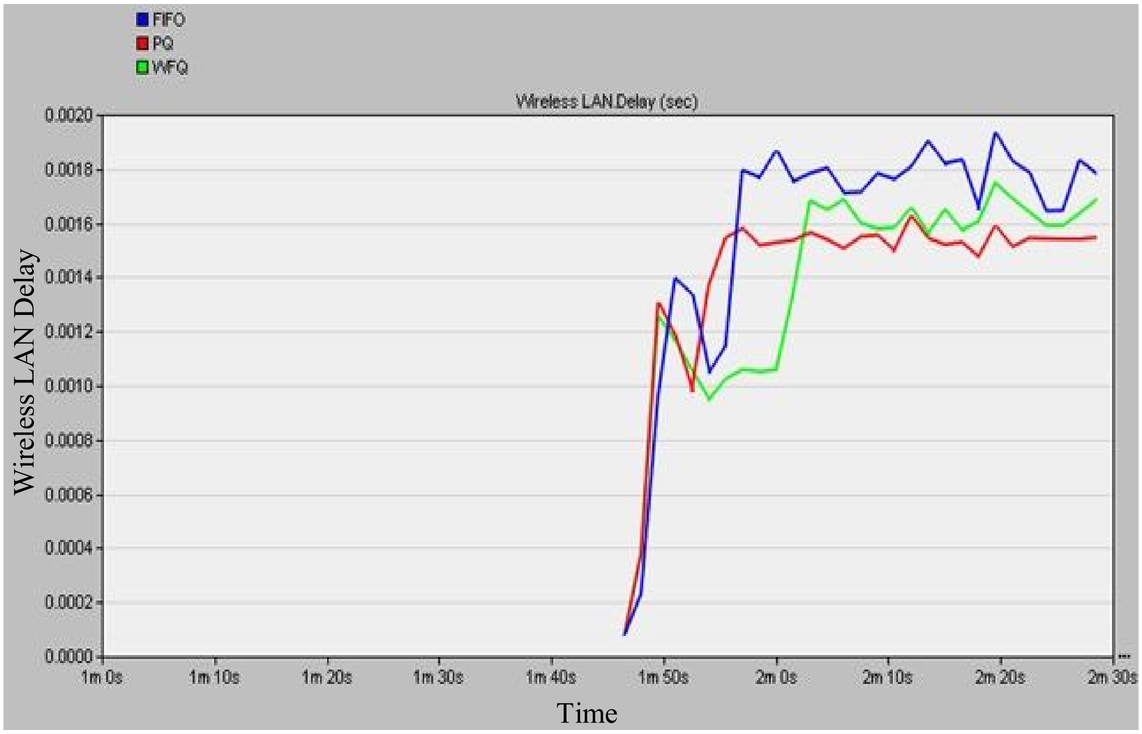

Figure 5.14 Wireless LAN Delay VS Time

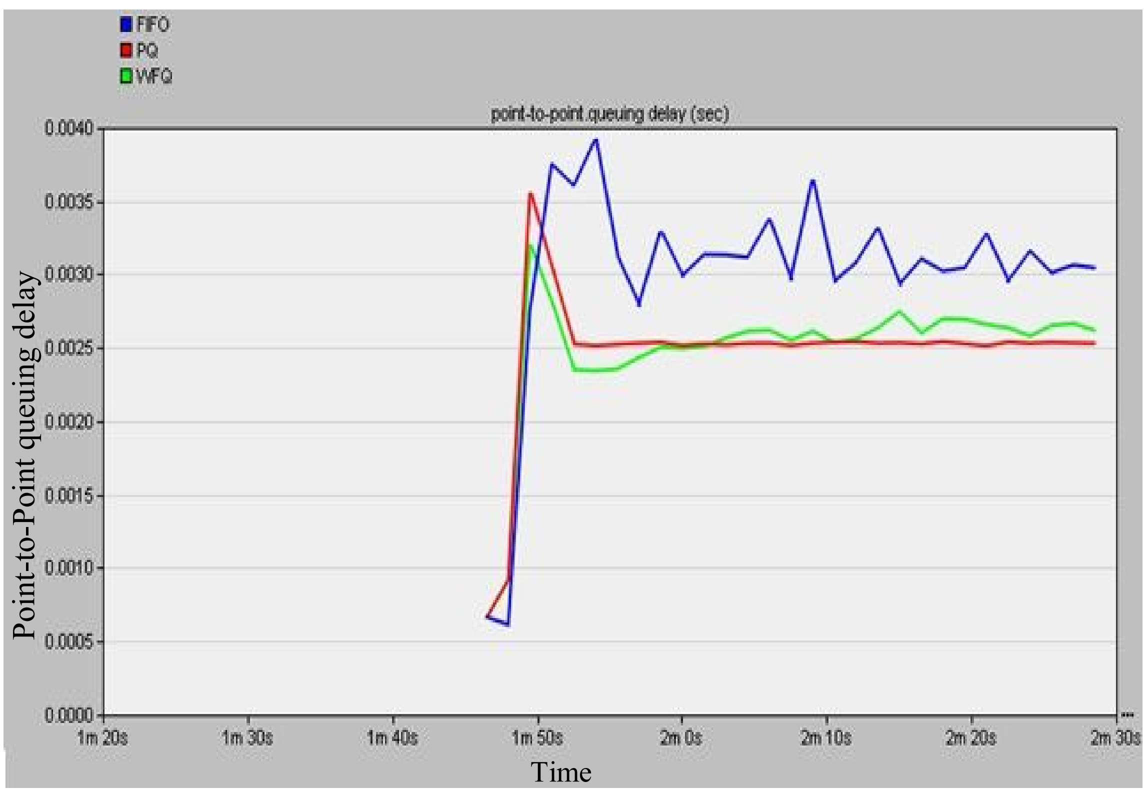

Figure 5.15 Point-to-Point queuing delay VS Time

WFQ and PQ had lower data dropping rate compare to FIFO which had data dropping rate up to 550 packets per seconds. WFQ reached 400 packets per second and PQ had a rate of 350 packets per second. Figure 5.16

Figure 5.16: Traffic Dropped VS Time

Chapter Six

Conclusion

&

Recommendation

Chapter six

Conclusion and recommendation

6.1 Conclusion:

In this thesis a main aim was to research, simulate and analyze the effect of different queuing mechanisms had on the Wireless local area network.

First-In-First-Out, Priority Queuing and Weighted Fair Queuing mechanisms were chosen, selected and applied for the network simulation.

The simulation design was explained and OPNET simulation tool was chosen for the simulation. The simulation process was explained the results were illustrated, and the comparisons were drawn between the three queuing mechanisms and their impact.

It was shown that the wireless local area network load and throughput werehigher when Priority Queuing is adopted as the chosenqueuing mechanism compared to the weighted fair Queuing and first in first out queuing.

The wireless LAN delay and data dropped were much greater when the First in first Out queuing mechanism is applied, comparedto Priority Queuing or Weighted Fair Queuing.

However Data dropped and wireless LAN delay were relatively lower when weighted fair queuing mechanism is applied.

Queuingdelay was lower when priority Queuing mechanismis applied. Weighted fair Queuing has slightly less queuing delay but First In first Out has the highest Queuing delay.

Weighted Fair Queuing performed the best among the three mechanisms in most of the application,

Priority Queuing gave the best result for delay sensitive data such as VoIP. First In First Out can be used in sharing delay among the flows and it's suitable for low traffic data such as HTTP.

From the results presented we can conclude that the implementations of different Queuing mechanisms can have different effects on the performance of the wireless LAN network.

6.2 Recommendation:

The research presented in this thesis can be extended in the area related to the analysis, as of choosing alternative performance metrics in addition to those reviewed, such as Retransmission attempts, Media Access delay, utilization and Packet Loss ratio etc. This would create a further Understanding and a better knowledge on how the queuing algorithm behaves in a Wireless LAN environment.

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