

Performance analysis of various Scheduling and Routing

Techniques for Optical Network

*A thesis submitted in partial fulfillment of the
Requirements for the award of degree of*

**Master of Engineering
in
Electronics & Communication Engineering**

**Submitted by
Jagtar Singh Dhindsa
Reg. No- 800961026**

**Under the supervision of
Dr. R. S. Kaler
Senior Professor &
Dean (Resource planning and generation)**



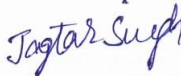
**Department of Electronics and Communication Engineering
Thapar University
Patiala-147004, India
June-2011**

CERTIFICATE


I hereby certify that the work which is being presented in this thesis entitled, "Performance analysis of various Scheduling and Routing Techniques for Optical Network ", in partial fulfillment of the requirements for the award of degree of the Master of Engineering in Electronics & Communication Engineering at Thapar University, Patiala, is an authentic record of my own work carried out under the supervision of Dr. R. S. Kaler (Senior Professor & Dean RPG) and refers other researcher's work which are duly listed in the reference section.


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Date:


Jagtar Singh Dhindsa
800961014

This is to certify that the above statement made by the candidate is correct and true to best of my knowledge.


Dr. R. S. Kaler
Senior Professor (ECED)
& Dean (RPG)
Thapar University
Patiala-147004


Professor & head (ECED)
Thapar University, Patiala


Dr. S. K. Mehapatra
Dean of Academic Affairs
Thapar University, Patiala

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I am highly grateful to **Dr. A. K. Chatterjee**, Professor, Department of Electronics & Communication engineering, Thapar University, Patiala, for provision this opportunity to carry out the present work.

My parents had kept me free from my duties at home so that I can devote more time to my research work. I acknowledge them for their blessings and support.

The arduous help received from the technical staff of the department for their intellectual support is also acknowledging.

Finally, I sincerely thank all the persons who have helped and supported me directly or indirectly in the course of this work.



Jagtar Singh Dhindsa
Reg. No. – 800961026

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Jagtar Singh Dhindsa
Reg. No. – 800961026

ABSTRACT

With recent advancements in greater network speeds and higher bandwidths, the online use of applications that support services such as VoIP, video conferencing, and File Sharing Protocol (FTP) have become more prevalent. While some applications such as web browsing (HTTP), email, and FTP are insensitive to the delay of transmitted information, VoIP and video conferencing are very sensitive to delay, packet losses, and jitter. Queuing disciplines are therefore implemented in routers to govern, control, sort, and to prioritize packets in the buffers prior to their transmission. FIFO, PQ, and WFQ queuing are implemented in OPNET and various parameters including : average queuing delay, average packet drop rate, MOS, jitter, and average end-to-end delay are studied and comparison of these parameters is made for the three queuing disciplines studied in order to pick the right queue for each application.

Routing protocol is taking a vital role in the modern communication networks. A routing protocol is a protocol which is responsible to determine how routers communicate with each other and forward the packets through the optimal path to travel from a source node to a destination node. Open Shortest Path First (OSPF) is the pre-eminent routing protocols. OSPF is a link-state interior gateway protocol based on Dijkstra algorithm (Shortest Path First Algorithm). In the context of routing protocol performance, each of them has different architecture, adaptability, route processing delays and convergence capabilities. This thesis presents a simulation based comparative performance analysis between OSPF for real time applications by using OPNET. In order to evaluate OSPF performance, we have designed two network models. Our evaluation of proposed routing protocols is performed based on the quantitative metrics such as Convergence Time, Jitter, End-to-End delay, Throughput and Packet Loss through the simulated network models.

An analysis of optical cross connect and couplers of high speed LAN in optical networks. In addition, simulation results compare the performance of high speed LAN with respect to the utilization of both optical cross connect and coupler. The delay and collisions occur in both networks have been examined. We have observed the performance and effect of both networks in case of sending and receiving frames. If the frame size is constant 1500 bytes

then the Traffic Received, Delay and Collision is high. But if we reduce the frame size from 1500 to 256 bytes, the performance is improved.

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LIST OF ABBREVIATIONS

BGP	Border Gateway Protocol
EGP	Exterior Gateway Protocol
ETE	End-to-End Delay
FIFO	First In, First Out Queuing
FTP	File Transfer Protocol
IGP	Interior Gateway Protocol
IP	Internet Protocol
LAN	Local Area Network
MAC	Medium access protocol
MAN	Metropolitan Area Network
OPNET	Optimized Network Engineering Tool
OSPF	Open Shortest Path First
OXC	Optical Cross Connect
PPP-DS1	Point-to-Point Digital Signal-1
PQ	Priority Queuing
QoS	Quality of Service
RED	Random early detection
ToS	Type of Service
VoIP	Voice over IP
WFQ	Weighted Fair Queuing

CHAPTER 1

Introduction

1.1 Introduction

Mankind has always throughout its history had the necessity for communication. Initially communication was done through signals, voice or primitive forms of writing. As time passed by there was a need to communicate through distances, to pass information from one place to another. Many different ways to exchange information over long distances have been used throughout history, some of them exotic such as the use of pigeons and smoke signals. All these methods were the evolutionary steps, which have led to today's modern technologies of long-distance communication.

Today's long distance communications involve the transmission and reception of a large amount of information in a short period of time. This report investigates certain aspects of one of these technologies, wavelength-division multiplexing, a technique that involves the transmission of multiple signals over a single optical fiber using different wavelengths of light as the optical carriers. Optical communications are not a privilege of the modern era. In fact, one could say that the Egyptians invented optical communications almost 5000 years ago when they discovered glass and experimented using it together with the sun to transmit signals. In the VI BC century, the Greeks used torches to transmit the fall of Troy. And in 1791 Claude Chapel invented the Semaphore, which is considered to be the first high-speed digital communications system [1].

The Semaphore was a system which consisted of mechanical arms that was installed on the top of a tower and operated manually. Using a chain of such devices it was possible to transmit messages over distances of around 150 miles in only 15 minutes [2]. All these inventions can be considered to be the ancestors of modern day optical fiber communications systems.

1.2 Optical Fiber Communication Systems

The most elementary type of communication system consists mainly of three components, transmitter, receiver and channel [3]. The channel in this system is the medium, be it wire, coaxial cable, air, or an optical fiber. Figure 1.1 illustrates one such system where the fiber is used as the medium.

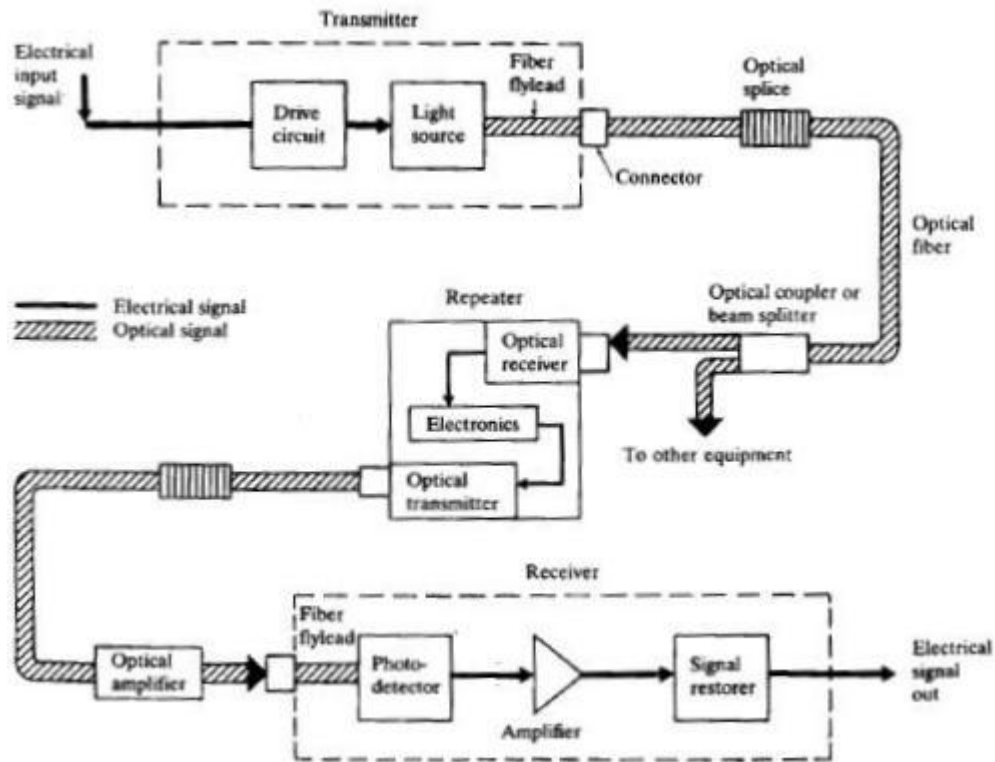


Figure 1.1 Major elements of an optical fiber link are shown diagrammatically

1.3 Development

When the telephone was invented in 1876, there was a complete revolution in the world of communications and for many years' metallic cables consisting of twisted wire pairs was the media of choice. However, metallic cables had limitations and with the demand for telephone services increasing it was necessary to find an alternative medium for telephony to cope with the high demand [4]. In 1966 Kao and Hockham solved this problem by proposing the use of the optical fiber. The optical fiber was a perfect match for the laser, which had been invented in 1960 by Maiman and up to then, had no practical use in communications [5]. The light-guiding properties of optical fiber had been known for many years, but prior to the work of Kao and Hockham their attenuation was greater than 1000 dB/km. Kao and Hockham

showed that these high attenuations were a result of impurities, and that low attenuation might be achieved if the impurities were controlled. This was first achieved in 1970 when Kapro fabricated the first low-loss optical fiber with attenuation around 20 dB/km at a wavelength of 0.63 μm . Eventually, this led to the first commercial deployments of practical fiber systems in 1977-78 . These operated at 0.85 μm , had a bit rate of 50-100 Mb/s and used electrical repeaters spaced 10 km apart to amplify and reshape the signals.

Current optical fiber communication systems operate at 1.3 μm and 1.55 μm where the attenuation is lower than at the shorter wavelengths [6]. These advances are due to not only better fibers but also because of the design of compatible light sources (transmitters) and photo detectors (receivers) at these wavelengths. The emergence of optical amplifier has also contributed to improvements in this field.

1.4 Advantages of optical fiber communications (light wave communications) over electrical cables

- The capacity of fibers for data transmission is huge: a single silica fiber can carry hundreds of thousands of telephone channels, utilizing only a small part of the theoretical capacity [7]. In the last 30 years, the progress concerning transmission capacities of fiber links has been significantly faster than e.g. the progress in the speed or storage capacity of computers.
- The losses for light propagating in fibers are amazingly small: ~ 0.2 dB/km for modern single mode silica fibers, so that many tens of kilometers can be bridged without amplifying the signals.
- A large number of channels can be re-amplified in a single fiber amplifier, if required for very large transmission distances [8].
- Due to the huge transmission rate achievable, the cost per transported bit can be extremely low.
- Compared with electrical cables, fiber-optic cables are very lightweight, so that the cost of laying a fiber-optic cable can be lower.
- Fiber-optic cables are immune to problems that arise with electrical cables, such as ground loops or electromagnetic interference (EMI).

However, fiber systems are more sophisticated to install and operate, so that they tend to be less economical if their full transmission capacity is not required. Therefore, the “last mile” (the connection to the homes and offices) and is usually still bridged with electrical cables, whereas fiber-based communications do the bulk of the long-haul transmission. Gradually, however, fiber communications are being used within metropolitan areas (metro fiber links), and even fiber to the home (FTTH) is being developed – particularly in Japan, where private Internet users can already obtain affordable Internet connections with data rates of 100 Mbit/s – well above the performance of current ADSL systems, which use electrical telephone lines.

1.5 Telecom Windows

Optical fiber communications typically operate in a wavelength region corresponding to one of the following “telecom windows”:

- The first window at 800–900 nm was originally used. GaAs/AlGaAs-based laser diodes and light emitting diodes (LEDs) served as transmitters, and silicon photodiodes were suitable for the receivers [9]. However, the fiber losses are relatively high in this region, and fiber amplifiers are not well developed for this spectral region. Therefore, the first telecom window is suitable only for short distance transmission.
- The second telecom window utilizes wavelengths around 1.3 μm , where the loss of silica fibers is much lower and the fibers chromatic dispersion is very weak, so that dispersive broadening is minimized. This window was originally used for long-haul transmission. However, fiber amplifiers for 1.3 μm (based on, e.g. on praseodymium-doped glass) are not as good as their 1.5- μm counterparts based on erbium. Also, low dispersion is not necessarily ideal for long-haul transmission, as it can increase the effect of optical nonlinearities.
- The third telecom window, which is now very widely used, utilizes wavelengths around 1.5 μm . The losses of silica fibers are lowest in this region, and erbium-doped fiber amplifiers are available which offer very high performance. Fiber dispersion is usually anomalous but can be tailored with great flexibility (\rightarrow dispersion-shifted fibers).

The second and third telecom windows are further subdivided into the following wavelength bands:

Table 1.1 Wavelength Bands

Band	Description	Wavelength range
O Band	Original	1260-1360 nm
E Band	Extended	1360-1460 nm
S Band	Short Wavelengths	1460-1530 nm
C Band	Conventional(“erbium window”)	1530-1565 nm
L Band	Long Wavelengths	1565-1625 nm
U Band	Ultra Wavelengths	1625-1675 nm

1.6 Introduction to Opnet Modeler

OPNET MODELER is used to design and study of communication networks, devices, protocols and optical network applications. It provides a graphical editor interface to build models for various network entities from physical layer modulator to application processes [10].

1.7 Opnet Modeler Tools

OPNET supports model specification with a number of tools, called editors. These editors handle the required modeling information in a manner that is similar to the structure of real network systems. Therefore, the model-specification editors are organized hierarchically. Model specifications performed in the Project Editor rely on elements specified in the Node

Editor. The rest of the editors are used to define various data models, new links and nodes, etc. This organization is described below [11, 12, 13, and 14]:

1.7.1 Project Editor

Project Editor is used to develop network models. Network models are made up of subnets and node models. This editor also includes basic simulation and analysis capabilities. The Project Editor is the main staging area for creating a network simulation. From this editor, you can build a network model using models from the standard library, choose statistics about the network, run a simulation and view the results. It is also possible to create node and process models, build packet formats, and create filters and parameters, using specialized editors that you can access from the Project Editor. In Figure 1.2 an example of the project editor view of a Network is shown.

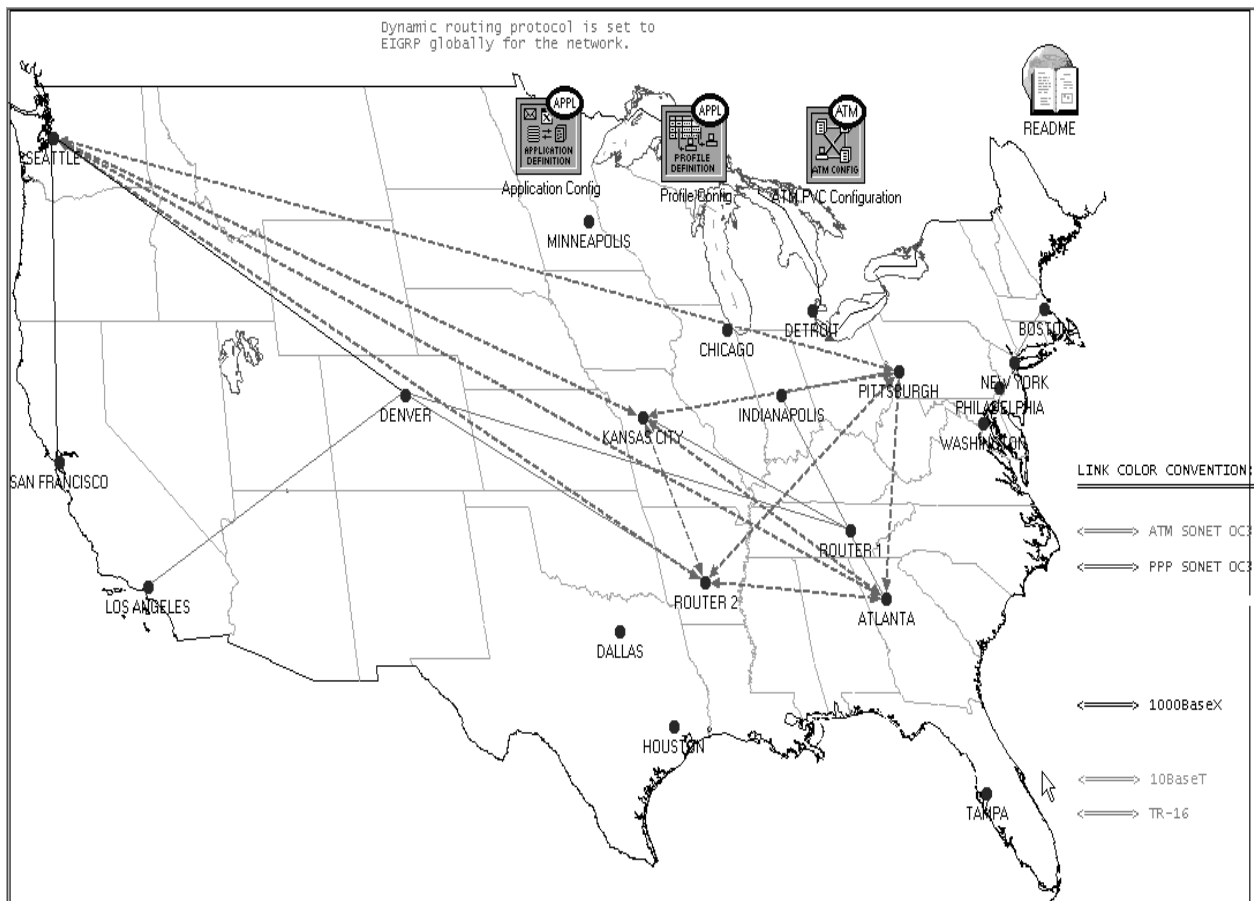


Figure 1.2 Network Model in the Project Editor

1.7.2 Node Editor

Node Editor is used to develop node models. Node models are objects in a network model. They are made up of modules with process models. The Node Editor lets you define the behavior of each network object. Behavior is defined using different modules, each of which models some internal aspect of node behavior such as data creation, data storage, etc. A network object is typically made up of multiple modules that define its behavior. In the Figure 1.3, there are some parts of a router's internal structure, such as a TCP module, an UDP module and an IP module.

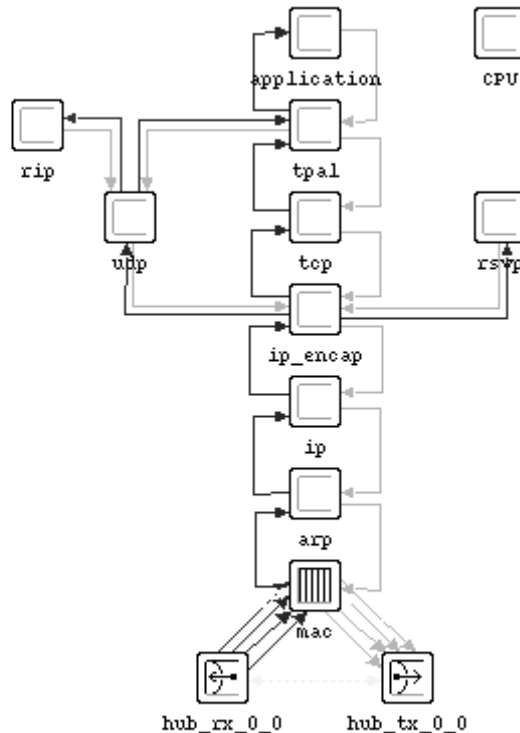


Figure 1.3 Node Editor

1.7.3 Process Editor

Process Editor is used to develop process models. Process models control module behavior and may reference parameter models. This editor lets you create process models, which control the underlying functionality of the node models created in the Node Editor [15].

Process models are represented by finite state machines (FSMs), and are created with icons that represent states and lines that represent transitions between states. Operations performed in each state or for a transition are described in embedded C or C++ code blocks.

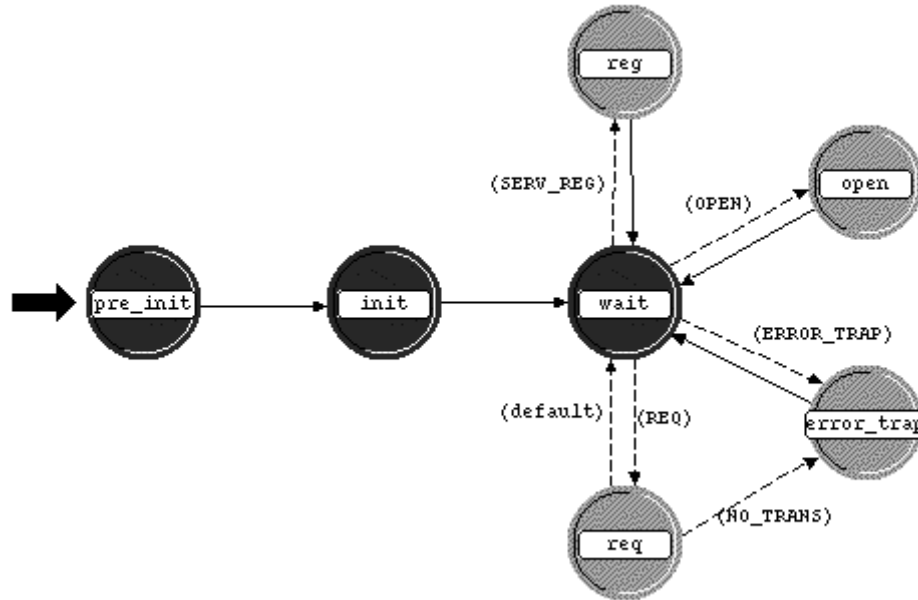


Figure 1.4 Process model

1.7.4 External System Editor

External System Editor is used to develop external system definitions. External system definitions are necessary for simulation.

1.7.5 Link Model Editor

Link Model Editor creates new types of link objects. Each new type of link can have different attribute interfaces and representation. It is also possible to edit and view link models already created.

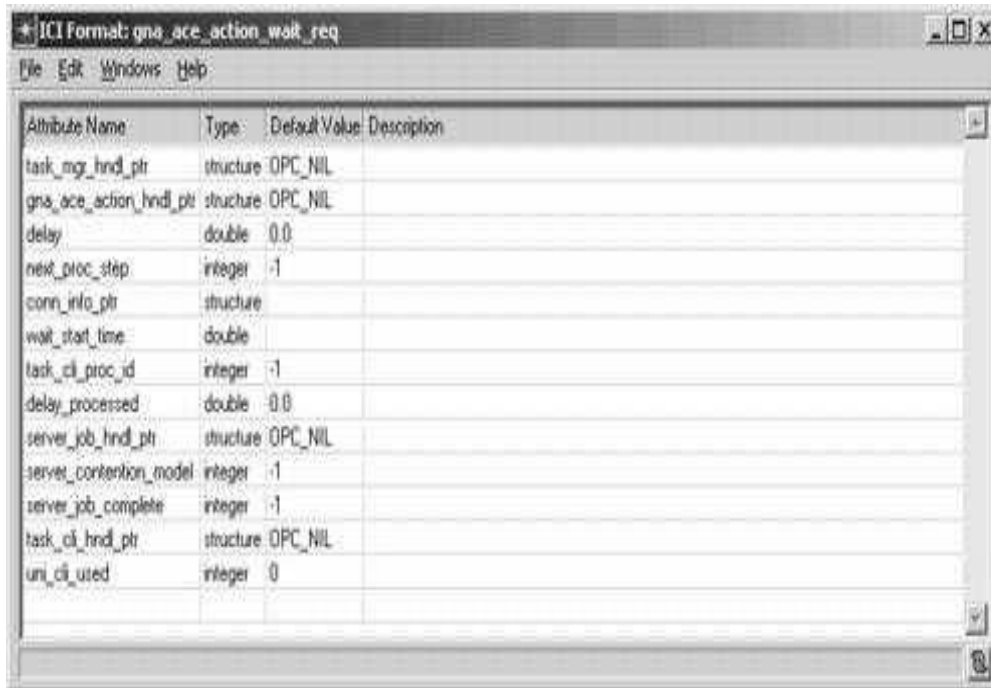
1.7.6 Packet Format Editor

Develop packet formats models are created by using Packet Format Editor. This editor defines the internal structure of a packet as a set of fields. A packet format contains one or

more fields, represented in the editor as colored rectangular boxes. The size of the box is proportional to the number of bits specified as the field's size.

1.7.7 ICI Editor

ICI Editor is used to Create, edit, and view interface control information (ICI) formats. ICIs are used to communicate control information between processes.



The screenshot shows a window titled "ICI Format: gns_ace_action_wait_req". The window contains a table with the following data:

Attribute Name	Type	Default Value	Description
task_mgr_hdl_ptr	structure	OPC_NIL	
gns_ace_action_hdl_ptr	structure	OPC_NIL	
delay	double	0.0	
next_proc_step	integer	-1	
conn_info_ptr	structure		
wait_start_time	double		
task_cl_proc_id	integer	-1	
delay_processed	double	0.0	
server_job_hdl_ptr	structure	OPC_NIL	
server_contention_model	integer	-1	
server_job_complete	integer	-1	
task_cl_hdl_ptr	structure	OPC_NIL	
uni_cl_util	integer	0	

Figure 1.5 ICI editor

1.7.8 PDF Editor

The PDF (Probability Density Function) Editor describes the spread of probability over a range of possible outcomes. A PDF can model the likelihoods associated with packet inter arrival times, or it can model the probability of transmission errors. This editor allows creating, editing, and viewing probability density functions (PDFs).

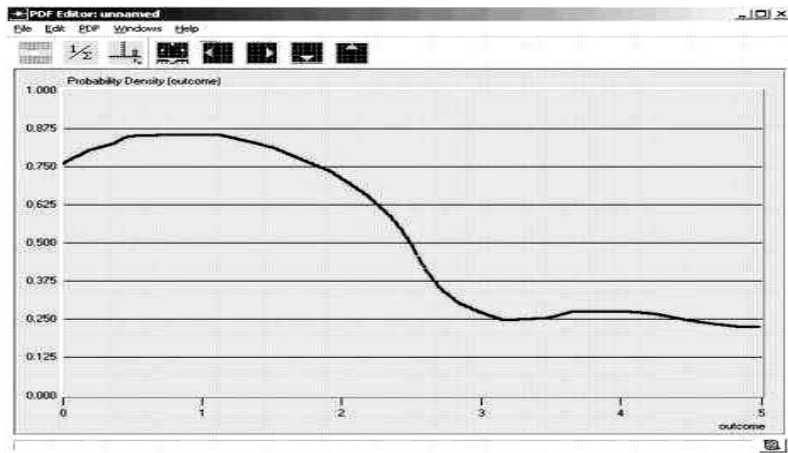


Figure 1.6 PDF editor

1.7.9 Path Editor

Use the Path Editor to create new path objects that define a traffic route. Any protocol model that uses logical connections or virtual circuits (MPLS, ATM, Frame Relay, etc.) can use paths to route traffic.

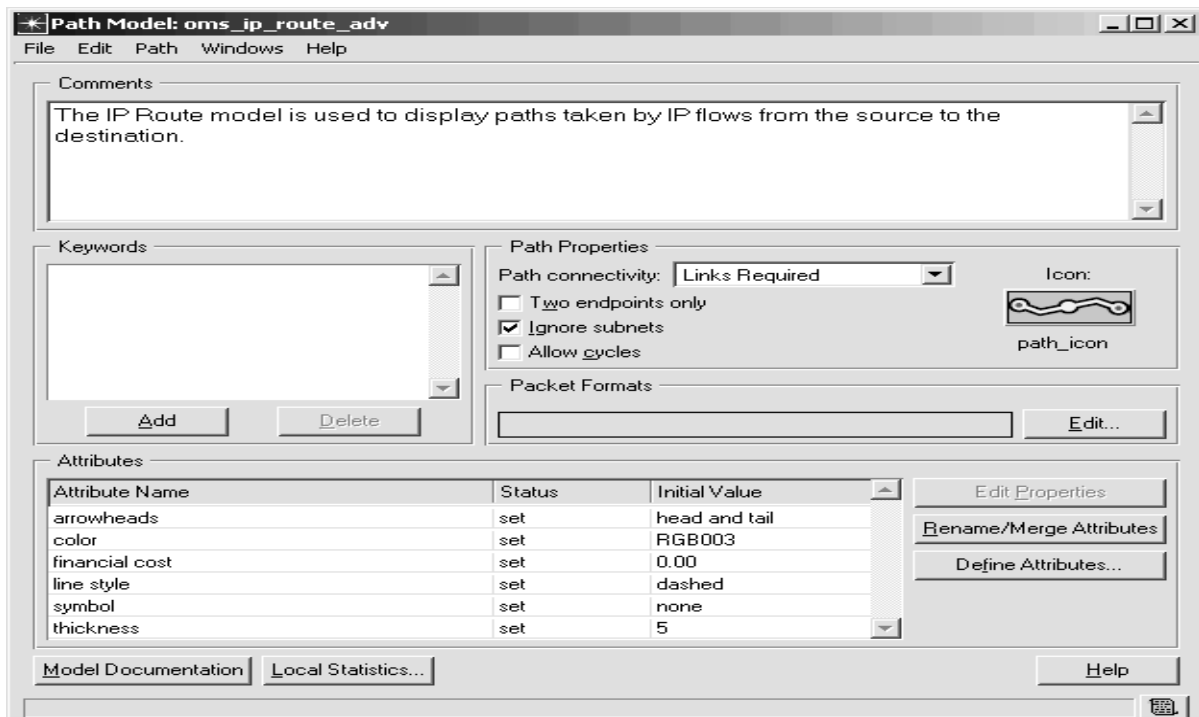


Figure 1.7 Path editor

1.7.10 Demand Editor

The Demand Editor defines demand models; each demand object's underlying model determines its attribute interfaces, presentation, and behavior.

1.7.11 Link Editor

The Link Editor supports the definition of reusable link models that are used to create link objects in the Project Editor. Each link object's attribute interfaces, presentation, and behavior, are determined by the link model that it relies upon. Once all the different interfaces are shown, it is necessary to describe the different steps to build a network model and to simulate it. For the purposes of this thesis work, it's only necessary to work with the project.

1.8 The Modeler Workflow

This section outlines the workflow when using OPNET.

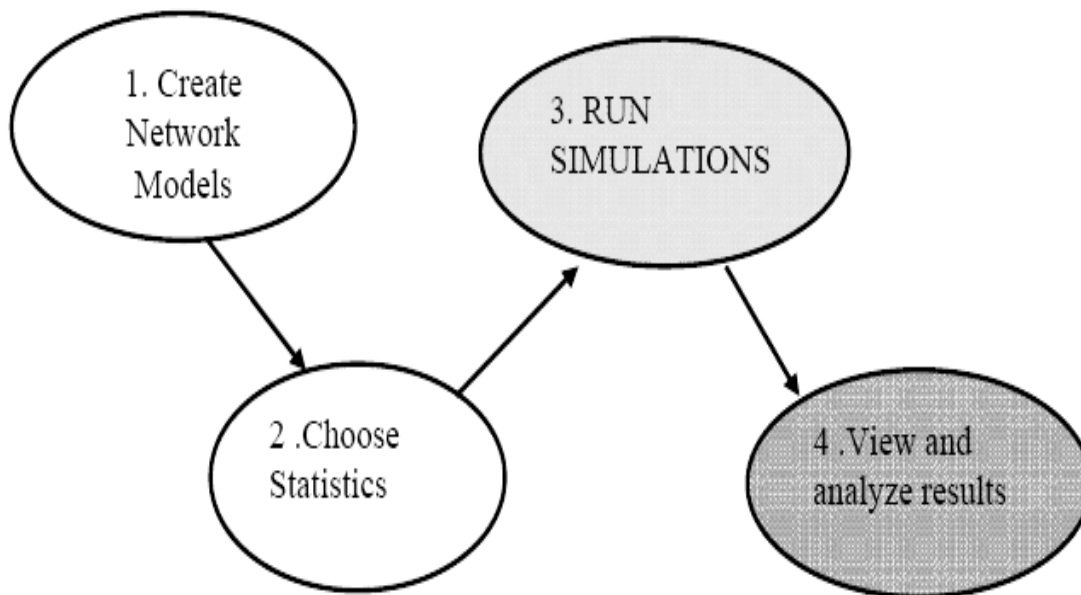


Figure 1.8 Workflow Model

1.8.1 Create Network Model

The first step is to create the networks models. It is necessary to generate the network to simulate in any of the following three ways:

- Placing individual nodes from the object palette into the workspace.
- Using the rapid configuration tool.
- And/or importing the network from an external data.

Furthermore, you have to introduce the traffic you want to run through the network.

There are two main ways of putting traffic in the model:

- a) Importing
- b) Manually specifying

1.8.2 Choose Statistics

Afterwards and before running a simulation, it is necessary to choose the statistics we want to collect. OPNET does not automatically collect all statistics in the system because there are so many available that you may not have enough disk space to store them. Specifying statistics is a straightforward task which is performed through the GUI.

1.8.3 Run Simulation

The third thing to set is configuring the parameters of the simulation and running them. Running simulations is typically thought of as the next-to-last step in the simulation and modeling process, the last step being results analysis. However, simulation is typically done many times in the modeling process to check the rightness of the generated network. There are different kinds of analysis that can be done in OPNET MODELER.

1. Discrete Event Simulation
2. Flow Analysis
3. Failure Impact Analysis
4. Net Doctor Validation

Discrete event simulation provides the most detailed results but has the longest running times. This is because it does a more thorough analysis than the others, handling explicit traffic, conversation pair traffic, and link loads. The other types answer specific types of questions and generate results much faster than a discrete event simulation. A flow analysis, for example, handles only conversation pair traffic (flows) and a NetDoctor validation does

not consider traffic at all. Licenses for generating Discrete Event Simulations (DES) are available for this studies and analysis.

1.8.4 View and Analyze Results

It is the last step of simulation. The results can be watched from the Project Editor or from the Analysis Tool. The Analysis Tool provides the capability to extract data from simulation output files, and to manipulate and display it according to various plotting methods. Data can be manipulated through built-in operations in a different way to get wanted information.

Hence, the final workflow of a project could be as follows:

1. Create project
2. Create baseline scenario.
3. Import or create topology.
4. Import or create traffic.
5. Choose results and reports to be collected.
6. View results and analyze them

Iterate by duplicating the scenario and changing parameters

OPNET uses a project and scenario approach to model networks. Project is a collection of related network scenarios in which each explores a different aspect of network design.

A project contains at least one scenario and a scenario is a single instance of a network containing all the information. It is possible to run all the scenarios of the network at the same time and compare the results of each one. This allows the scenarios to check if a server will support and increment of the traffic, the effect of the increment of the traffic in a link in the response of a service, etc [16].

CHAPTER 2

Literature Survey

2.1 Motivation

Traffic management is an important tool used for the allocation of network resources with the various, complex, and bandwidth demanding applications that have become common on the internet today. Congestion control mechanisms are used to govern situations with excessive network traffic; without the proper implementation of such mechanisms, network delays will cause an increase in congestion through automatic retransmission of information, thereby decreasing network throughput [17]. Real time applications such as VoIP and video conferencing are more susceptible to such delays and as such proper queuing and traffic management at the packet level must be considered to provide the required QoS to the end user.

The thesis will attempt to study the effects and performances of three different queuing disciplines (FIFO, PQ, and WFQ) as applied towards some of the supported OPNET applications (FTP, voice, and video conferencing). Each queuing discipline considered will constitute a scenario in OPNET and the three applications of FTP, voice and video conferencing will be studied separately under each scenario. Comparison of various collected statistics will be made in order to justify the type of queue that would be most suitable to use under each of the applications considered.

Tactical IP networks have special requirements for a routing protocol. The most important ones are fast convergence, short end to end delay and the ability to recover from emergencies quickly. We try to imply ideas that may outperform the various limitations of routing protocols. In terms of performance measurement of routing protocols, convergence times is concerned and as a performance metrics for real time applications are delay variation, end to end delay, jitter and throughput.

2.2 Literature Survey

The relative performance of simple queuing disciplines was studied by Joisane Nzouonta et al. [18]. The focus was on improving the performance of real-time multimedia applications, which are already used in real-life scenarios and have the potential to become the main driving force behind computer networks.

Shih Chiang Tsao et al. [19] investigated the possibility of applying the class-based fair queuing discipline, which was widely and maturely used in scheduling packets, to schedule requests. However, he found that simply applying this discipline to schedule requests would encounter the timing and ordering problems at releasing requests and may not satisfy high-class users. Thus, he proposed a minimum-service first request scheduling (MSF-RS) scheme.

Alexander Sayenko et al. [20] demonstrated that adaptive resource sharing models that work as the superstructure over scheduling disciplines and use the revenue criterion to calculate the optimal parameters for the scheduler. For each scheduler, an analytical model has been created that is capable of allocating resources in such a way that the total revenue is maximized and the QoS requirements are ensured including bandwidth and delay.

Madalina Baltatu et al. [21] proposed protect the network routing protocol and management protocols. Because insider attacks are probably one of the most challenging research problem in network management. In OSPF, a group of router make the network, these routers in that network exchange information and forward packet to each other. In this paper the author analyzes the OSPF and identifying the problems that create in that network during forwarding packets. Because if one router have a problem then whole network disturbed due to this one. So that researcher applies one attack to this OSPF network to analyze the performance of the OSPF routing protocol. That attack very powerful and block the router to update in 60 minutes by simple inter one wrong OSPF data unit. This work fully based on simulation and practice.

Michael P. Howarth et al. [22] proposed the traffic engineering for adapting the routing of traffic to check the performance and be able to use of optical network recourses. In this article, researcher describes the intra domain traffic engineering that works base on the interior gateway protocol. Such as most useful interior gateway protocol is OSPF routing protocol. In this paper author describe the OSPF configuration of links, based on a wide

network view of traffic and topology within a domain. The author also compares different optimization results and collects the data. Main idea of this paper is also analyze the short path routing protocol are able to flow of traffic in large IP network.

Minh Huynh et al. [23] presented that Ethernet has been the indisputable technology of choice for the local area networks (LANs) for more than 30 years. Its popularity is due to its versatility, plug-n-play feature, and low cost. It has transformed from a CSMA/CD technology providing low throughput to a full-duplex link increasing the throughput 1000-folds. Despite these improvements, Ethernet is still restricted to local area networks, and is not ready to become a carrier-grade technology for wider areas. However, there are efforts to assist the transformation of Ethernet from the mainstream LAN technology to the possible adoption for metropolitan area networks (MANs). This paper introduced the movement from basic Ethernet to the carrier grade Ethernet for MANs. The paper describes the underlying technology, offered services, the state-of-the-art, and the comparison between various technologies.

N. Ghani et al. [24] studied the performance of various topology overlay schemes for multi-point Ethernet LAN services, including star, bus, and minimum spanning tree. A comprehensive tiered survivability approach for provisioning these overlays is also detailed using both pre-fault protection and post-fault restoration algorithms. The overall findings show the lowest blocking and/or highest carried load with more advanced minimum spanning tree overlays, particularly when combined with load-balancing routing of sub-connections (i.e., active resource usage state). Finally, the use of post-fault restoration is particularly beneficial and is shown to yield very high recovery rates even with generally lower levels of pre-fault protection reservation. Building upon this work, future efforts will focus on more elaborate shared protection strategies as well as optimization formulations.

2.3 Thesis Scope

The formulation of this thesis consisted of several main stages. Initially, a review work of theoretical groundwork on quality of service in optical networks was carried out. As quality of service in optical is now hot research, many books do not mention this and much of the effort was spent reading and extracting information from relevant journal articles. Following that, a literature review of the queuing scheduling of differentiated services, OSPF routing

protocol and performance evaluation of different high speed LANs connected by optical cross Connect and Couplers in optical networks have been done. The literature review was beneficial in understanding the operation of queuing scheduling in differentiated services. After all of the components had been selected, a block diagram of the all the component used and scenario model was developed so as to enable the designer to have a better visualization of the whole system structure and the components to be used. Then, the design model was implemented into Opnet whereby the traffic dropped; traffic received, end to end delay and collision avoidance results were obtained. All the simulation results for differentiated services, OSPF routing protocol and performance evaluation of different high speed LANs connected by optical cross Connect and Couplers in optical networks were analyzed and compared.

2.4 Objectives

1. To compare the optical queue scheduling disciplines for differentiated services for optical networks.
2. To analyze OSPF Routing Protocol for optical networks.
3. To compare Performance Evaluation of Different high speed LANs Connected by Optical cross Connect and Couplers in Optical Network

2.5 Outline of Thesis

This thesis work has been organized into five chapters. They are briefly described as under: Introduction of the thesis and the tool used, that is Opnet modeler is discussed in chapter 1. The literature review of queuing discipline for differentiated services, OSPF routing protocol for optical networks and high speed Ethernet LANs connected by switches and hub has been studied in Chapter 2. Performance of scheduling disciplines like FIFO (First In First Out), PQ (Priority Queuing), WFQ (Weighted Fairness Queuing) in packet dropping and reception for an high speed network is simulated and analyzed in Chapter 3. The results have been compared in form of traffic dropped, end to end delay and traffic received for live streaming video.

Chapter 4 describes about OSPF Routing Protocol for optical networks. . OSPF is well known routing protocol in internet field .It examines how OSPF can be used to design, build

large and complicated networks. It is link state routing algorithm protocol, which is based on cost. This chapter presents a detailed simulation approach for deploying OSPF routing protocol in optical networks.

Chapter 5 presents an analysis of OXCs and coupler of high speed LAN in optical networks. In addition, simulation results of this paper compare the performance of high speed LAN with respect to the utilization of both OXCs and coupler. The delay and collisions occur in both networks have been examined

Finally, the Chapter 6 highlights the conclusions and the future scope of the dissertation work.

CHAPTER 3

Comparison of Optical Queue Scheduling Disciplines for Differentiated Services for Optical Networks

3.1 Abstract

The Performance of optical networks which carry traffic with a wide range of requirements is greatly influenced by the scheduling disciplines present in the routers and switches. In this chapter performance of scheduling disciplines like FIFO (First In First Out), PQ (Priority Queuing), WFQ (Weighted Fairness Queuing) in packet dropping and reception for an high speed network is simulated. It has been observed that PQ and WFQ perform alike in dropping packets. The bursty nature of WFQ doesn't make it to receive any voice traffic over all intervals of time. Regarding video conferencing traffic a sharp fall in received data was observed for PQ.

3.2 Introduction

The goal of an optical fiber communication system is to transmit the maximum number of data over the maximum possible distance with the fewest errors. So, there are various protocols which are used to route the data over the minimum possible path with the fewest errors and better performance characteristics like end-to-end delay which is the time to send the data from one workstation to another workstation and throughput which defines that the system is congested or not. Since link throughput is the ratio of data sent to the time spent sending it, better routing performance can be inferred by lower values of link throughput. This is because an efficient routing protocol will send fewer overhead messages [25]. A router is a shared resource in our optical network. Many of the problems that we face in our optical network are related limited amount of shared resources (buffer memory [26] and output port bandwidth [27]) to competing users, applications and service classes. A queue scheduling discipline allows us to manage access to fixed amount of output port bandwidth by selecting the next packet that is transmitted on a port. There are many different queue scheduling disciplines, each attempting to find the correct balance between complexity, control and fairness. Congestion [28, 29] occurs when packets arrive at the output port faster

than they can be transmitted. This means that a router interface is considered to be mildly congested if a single packet has to wait for another packet for its transmission. The amount of delay introduced by the congestion can range anywhere from amount of time it take to transmit the last bit of the previously arriving packet to infinity, where the packet is dropped due to buffer exhaustion. It is important to minimize the amount of congestion in our network, because it reduces the packet throughput, increases the end to end delay, causes jitter and can lead to packet loss if there is insufficient buffer memory to store all of the packet that are waiting to be transmitted. So, queue scheduling discipline support fair distribution of bandwidth to each of the different service classes competing for bandwidth on the output port. If certain service classes are required to receive larger share of bandwidth than the other service classes, fairness can supported by assigning weights to each of the service classes.

3.2.1 First in, First out (FIFO) queuing

First in First out (FIFO) [30] queuing is the most basic queue scheduling discipline. In FIFO queuing all the packets are treated equally by placing them in a single queue, and then servicing them in the same order as they were placed in the queue. The advantage of FIFO is that for software based routers, it places low computational load on the system when compared with the more elaborated queuing discipline. The behavior of FIFO queue is very predictable, packets are not recorded and the maximum delay is determined by the maximum depth of the queue. As long as the depth remains short, FIFO queue provides simple contention resolution for network resources without adding significantly queuing delay at each drop.

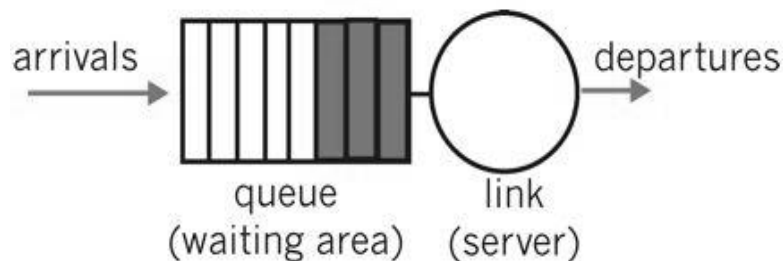


Figure 3.1 FIFO Queuing

As can be observed in Figure 3.1, arriving packets from various applications are put into a single packet buffer in the order in which they arrive, until the buffer is full. Performance deterioration can occur in this queuing discipline as a result of shorter inter-arrival times between packets into the buffer or as a result of variable packet lengths clogging up the queue and causing various delays, jitter, and packet losses. It is also important to mention that due to the limited amount of buffer space available at each router, packets that arrive at a full buffer are dropped, regardless of the flow that a packet belongs to or its importance. These losses present significant problems and degradation of the quality of transmitted signals in real-time applications such as VoIP and video conferencing.

3.2.2 Priority Queuing (PQ)

Priority Queuing (PQ) [31] is the basis for a class of queue scheduling algorithms that are designed to provide relatively a simple method of supporting differentiated service classes. In classic PQ, packets are first classified by the system and placed in different priority queues. Packets are scheduled from the head of a given queue only if all the queues of high priorities are empty. Within each priority queues, packets are placed in FIFO order. PQ offers a couple of benefits over FIFO are that for software based routers, PQ places a low computational load on the system when compared with more elaborated queuing disciplines. PQ allows routers to organize the buffered packet and then service one class of traffic differently from the other classes of traffic. Priorities have been set so that real time applications, such as interactive voice and video, get priority over applications that do not operate in real time.

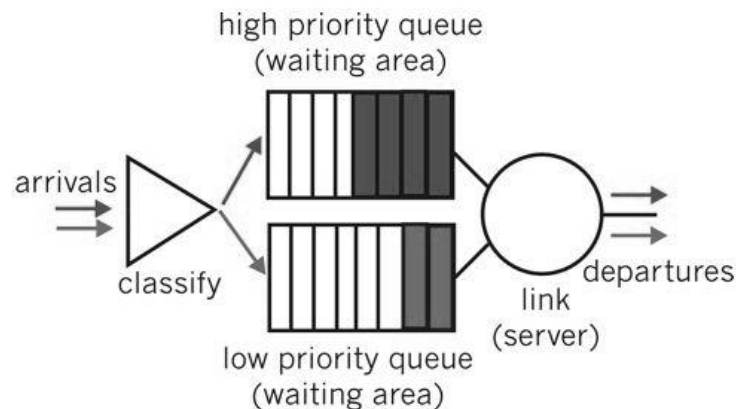


Figure 3.2 Priority Queuing

As can be seen in Figure 3.2, arriving packets are tagged with a certain priority, thus allowing packets with higher priority to cut to the front of the line in the sorted packet buffer. Applications that require negligible delay times can use this queuing method to differentiate and prioritize their packets from other packets in order to manage the limited network resources available such as bandwidth. Real-time applications such as VoIP and video conferencing should in theory observe less delay under this queuing discipline.

3.2.3 Weighted Fair Queuing (WFQ)

Weighted Fair Queuing (WFQ) [32] was developed independently in 1989 by Lixia Zhang and by Alan Demers, Srinivasan Keshav, and Scott Shenke. WFQ is the basis for a class of queuing discipline that are designed to address limitations of PQ model. WFQ supports flows with different bandwidth requirement by giving each queue a weight that assigns a different percentage of output port bandwidth. It also support variable length packet, so that flows with larger packet are not allocated more bandwidth than flows with smaller packets. Supporting the fair allocation of bandwidth when forwarding the variable length packet adds significantly to the computational complexity of the queue scheduling algorithm.

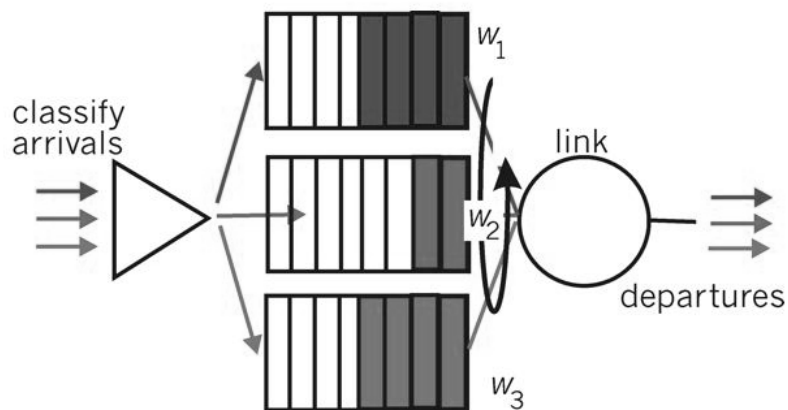


Figure 3.3 Weighted Fair Queuing

In order to control the percentage of a links bandwidth that each flow will get, a weight factor is included and is assigned to the various queues based on the requirements and needs of the client. This method of queuing is called the Weighted Fair Queuing, and is widely used in QoS architectures and in various routers.

Joisane Nzouonta et al. [18] studied the relative performance of simple queuing disciplines. Their focus was on improving the performance of real-time multimedia applications, which are already used in real-life scenarios and have the potential to become the main driving force behind computer networks.

This chapter presents and analyses several resource sharing models that ensure the QoS requirements and maximize service providers revenue. The objectives of the chapter are: (a) to share bandwidth between various service classes with the required level of QoS and (b) to distribute free resources in a predictable and controlled way. Here, a more rigorous bandwidth allocation is proposed. While the QoS requirements determine the minimal required amount of resources, the prices of network services can control the allocation of free bandwidth.

It is intuitively understandable that it is worth providing more bandwidth for those classes for which end-users are willing to pay more.

3.3 Simulation Model

OPNET IT Guru 9.1 provides a virtual network environment that models the behavior of our entire network, including its routers, switches, protocols, servers, and individual applications. By working in the virtual environment, IT managers, network and system planners, and operations staff is empowered to diagnose difficult problems more effectively, validate changes before they are implemented, and plan for future scenarios including growth and failure.

3.3.1 Simulation Setup

Three different setup cases were created using this OPNET model to simulate the packet flow within network to understand the differences and characteristics of the three different queuing disciplines. In order to demonstrate the performance of different queuing Disciplines, a hypothetical network topology is considered as illustrated in our simulations. There are two routers connected. There are three different traffic scenarios, one for each queue scheme there are three types of traffic: FTP, Voice and Video. There is a separate server for each traffic type. To evaluate and compare the performance of different queuing disciplines, the average queuing delay, the average end to- end delay, the average packet drop-rate for each queue scheme was collected.

The effect of using random-early drop (RED) is studied, tested its dominance over drop-tail policy. For FTP traffic, exponential distribution is used for packet arrival, constant packet size and best-effort type of service. For video traffic, low resolution video starting at 10 fps (frames per sec) arrival rate having 128x120 pixels is used and kept increase this rate and size as load increased. The ToS is Streaming Multimedia. For voice traffic, the voice encoder scheme is G.711, the silence and talk spurt lengths are exponentially distributed and ToS [33] is Interactive Voice. All these settings were made using OPNET Application Attributes Profile. For queuing disciplines specification, the maximum queue size was set to be 500 packets. OPNET default weights were implied in case of WFQ. There are three types of classes in all queues whose queue buffer size increases from highest priority to lowest one. A exponential weight factor was set (used to calculate average queue size based on the previous average and current queue size) to be 9.

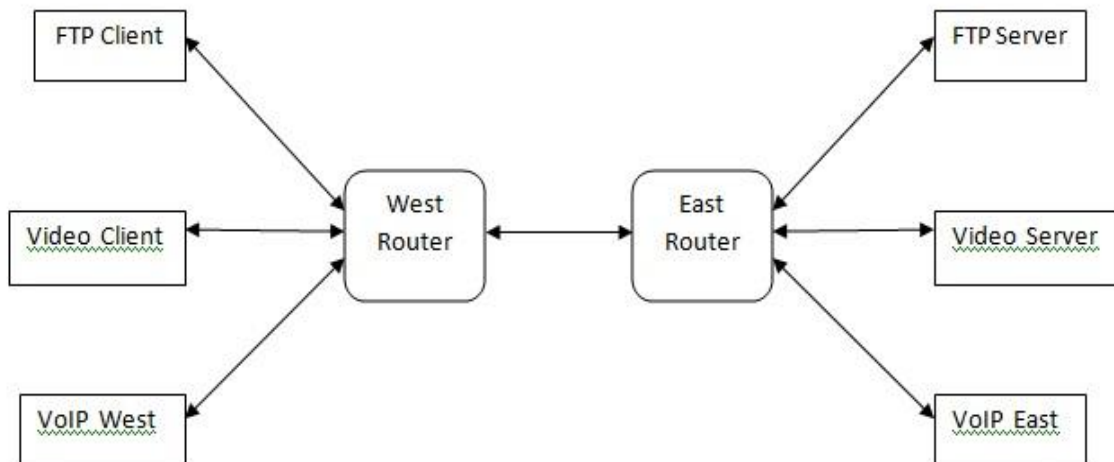


Figure 3.4 Assumed network topology for which simulation is carried out
 In order to analyze and compare the three queuing disciplines described above, a network topology had to be built initially. The scope of this simulation considered three separate scenarios under a 10×10 campus network scale. The three scenarios considered are

summarized in Table 3.1. Simulation was run for five simulation minutes in each scenario.

Table 3.1 Three Scenarios Studied Along with Applications Considered in Each.

	Scenario 1	Scenario 2	Scenario 3
Queuing discipline	First-in, First-out Queuing	Priority Queuing	Weighted Fair Queuing
Simulation Time	5 minutes	5 minutes	5 minutes
Applications considered	FTP VoIP Video Conferencing	FTP VoIP Video Conferencing	FTP VoIP Video Conferencing

3.4 Simulation Results & Performance Comparison

3.4.1 Traffic dropped

Figure 3.5 shows the time average Traffic dropped (packets/sec) for 3 disciplines of queuing. It is clear from the simulated graph that WFQ has the minimum traffic dropped. And at the same time the first in first out has the most traffic dropped .Hence showing larger amount of data transfer using WFQ.

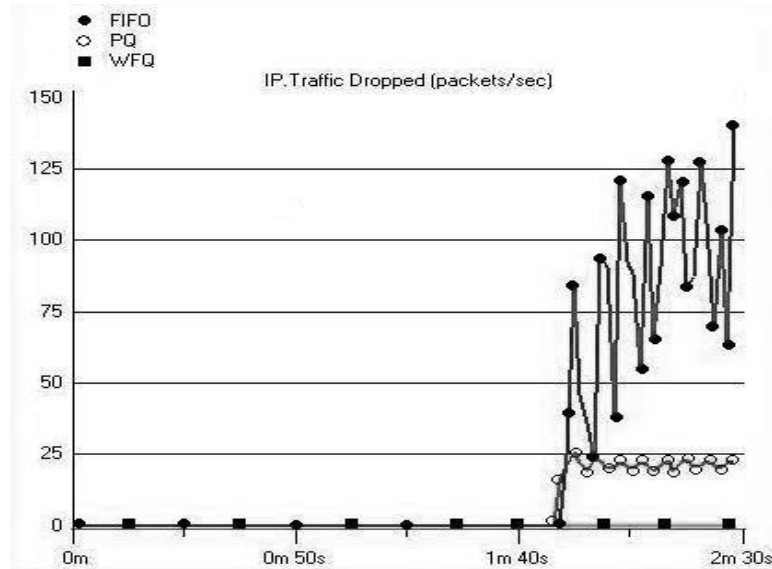


Figure 3.5 Traffic dropped (packets/sec)

3.4.2 End to End Delay

Similar results are obtained for delay jitter for voice traffic. It is clear WFQ (WFQ is not shown on the graph because it is overlapped by the trace of PQ) do not produce good results for this type of performance measures when compared with even FIFO. They try to avoid congestion and maintain fairness and in doing so, delay jitter and end-to-end become less guaranteed. Also in our simulation model, PQ outperforms other queuing disciplines in terms of end-to-end delay and delay jitter for voice traffic.

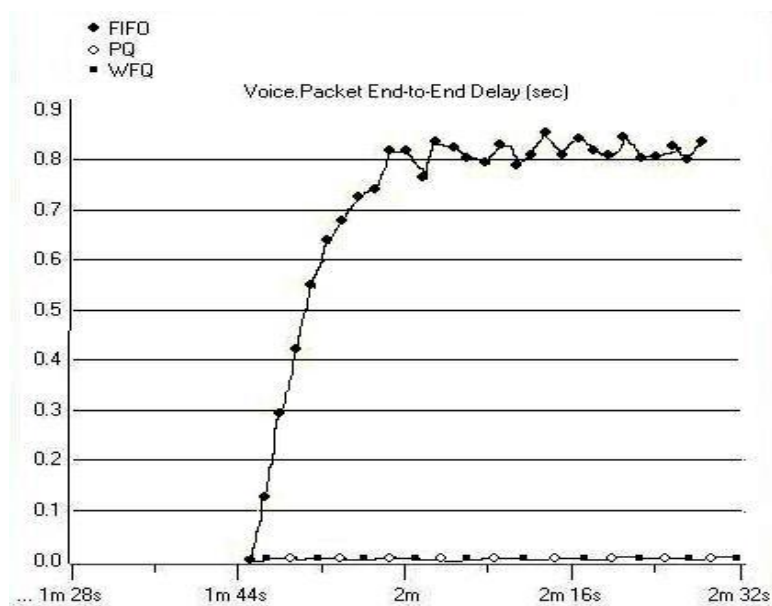


Figure 3.6 End to End delay/sec

3.4.3 Traffic Received for Live Streaming Video

The transmission of live streaming video requires a high quality link [34] and a disturbance less connection. Thus for calculating outstanding performance in Video Conferencing, various protocols have been tried and studied to determine the best suitable low distortion video. Figure 3.7 shows the time average Live Streaming Video Traffic Received (bytes/sec) for 3 disciplines of queuing [35]. It is clear from the simulated graph that WFQ has the maximum traffic received. And at the same time the Priority Queuing has the least traffic received. Hence it is clear that the WFQ based queuing system can provide a higher quality of video link.

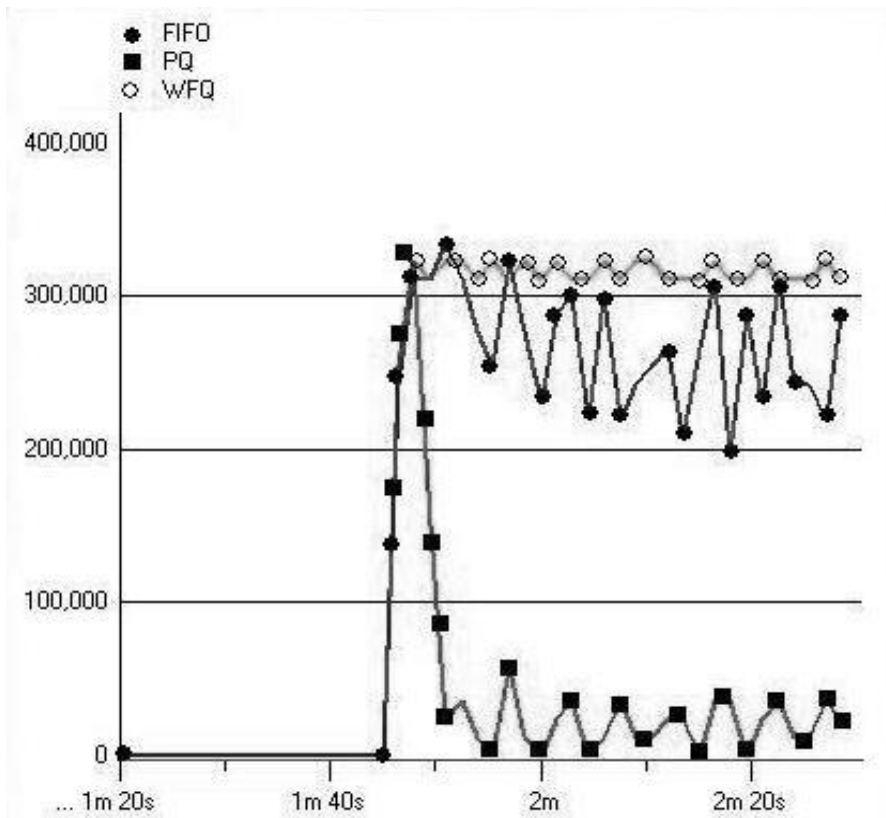


Figure 3.7 Traffic received for video conferencing

3.5 Conclusion

A simulation-based performance evaluation and comparison of three queuing scheduling disciplines for different traffic sources are described. The impact of random-early drop algorithm is compared to drop-tail policy. The simulation results show that WFQ and Priority based PQ outperforms first in first out (FIFO) discipline in terms of average traffic throughput and queuing delay although PQ and WFQ are also very close to it for the considered traffic scenarios. WFQ is best suited for live streaming video. But, it fails to produce acceptable results with respect to end to end delay for video traffic. In such case, PQ provides minimal end-to-end delay and delay jitter. It was also noticed that RED has greatly improved all the performance measures especially with FIFO. The reason is that RED monitors the average queue size and randomly drops packets when congestion is detected. Further work is still required to carefully examine these queuing disciplines and show the impact of self similar traffic and the use of traffic shapers at the edges of the network.

CHAPTER 4

OSPF Routing Protocol for optical networks

4.1 Abstract

Open Shortest Path First (OSPF) protocol is an interior gateway protocol used to distribute routing information within a single autonomous system in optical network. This chapter examines how OSPF works and how it can be used to design and build large and complicated networks. OSPF is well known routing protocol in internet field. It is link state routing algorithm protocol, which base on cost. This chapter presents a detailed simulation approach for deploying OSPF routing protocol in optical networks.

4.2 Introduction

The goal of an optical fiber communication system is to transmit the maximum number of data over the maximum possible distance with the fewest errors. So, there are various protocols which are used to route the data over the minimum possible path with the fewest errors and better performance characteristics like end-to-end delay which is the time to send the data from one workstation to another workstation and throughput which defines that the system is congested or not. Since link throughput is the ratio of data sent to the time spent sending it, better routing performance can be inferred by lower values of link throughput. This is because an efficient routing protocol will send fewer overhead messages. A routing protocol is a protocol that specifies how routers communicate with each other to disseminate information that allows them to select routes between any two nodes on a network [25]. Typically, each router has a priori knowledge only of its immediate neighbors. A routing protocol shares this information so that routers have knowledge of the network topology at large. Routing protocols can be divided into two broad classes, Interior Gateway Protocols (IGPs) [36], and Exterior Gateway Protocols (EGPs). IGPs are intended for use within an Autonomous System, i.e. a set of networks that are under single or closely coordinated management organizations. Routing between different autonomous systems is maintained by the EGPs, of which the Border Gateway protocols (BGPs) [37] are one example. While IGPs are designed to dynamically maintain information about network topology, produce optimal

routes, and respond to changes quickly, EGPs emphasize stability and administrative control above route optimality. As the networking community moves towards further decentralization of control, EGPs are viewed as serving to protect one system of networks against errors or intentional misrepresentation by other systems. In link state routing protocols, such as the Open Shortest Path First (OSPF) protocol [38], every router maintains a representation of the network's topology, and this representation is updated regularly on the basis of the information being exchanged between the network routers. In particular, each router is responsible for discovering its neighboring routers, and then advertising the identities of its adjacent neighbors [39] and the “cost” to reach each. This information is advertised between routers by periodic exchange of link state packets. A link state protocol arms each router with a dynamic map of the network's topology; using this, the router may compute paths to any destination.

Madalina Baltatu et al. [21] proposed protect the network routing protocol and management protocols. Because insider attacks are probably one of the most challenging research problem in network management. In OSPF, a group of router make the network, these routers in that network exchange information and forward packet to each other. In this paper the author analyzes the OSPF and identifying the problems that create in that network during forwarding packets. Because if one router have a problem then whole network disturbed due to this one. So that researcher applies one attack to this OSPF network to analyze the performance of the OSPF routing protocol. That attack very powerful and block the router to update in 60 minutes by simple inter one wrong OSPF data unit. This work fully based on simulation and practice.

Michael P. Howarth et al. [22] proposed the traffic engineering for adapting the routing of traffic to check the performance and be able to use of optical network recourses. In this article, researcher describes the intra domain traffic engineering that works base on the interior gateway protocol. Such as most useful interior gateway protocol is OSPF routing protocol. In this paper author describe the OSPF configuration of links, based on a wide network view of traffic and topology with in a domain. The author also compares different optimization results and collects the data. Main idea of this paper is also analyze the short path routing protocol are able to flow of traffic in large IP network.

4.3 Simulation Setup

A simulation for OSPF routing strategy evaluation should consist of the following basic elements: slip8_gtwy routers, PPP_DS3 links and network traffic information. A simulation setup is built for a campus through the specification of the interested network topology and involved network traffic. The network topology is specified through the arrangement of router and links that interconnect these routers. The network has two cases. First one is No Area and other one is Area. The network traffic is specified in the source router by setting the cost of every link that connects each others. Then setting the following information: the start time, the stop time, the statistical distribution for packet inters arrival times, the statistical distribution for packet sizes and the destination router.

Network use the OSPF routing protocol so that all parameters set to be according to OSPF. After having specified the network topology and traffic, a user specifies performance parameters for network condition evaluation and runs simulation under different routing strategies in the platform. Among many parameters, evaluation for the network performance is focused on network throughput. Then same process can do for other scenario Area. The comparison between the Scenario No Area and the Scenarios Area can be done through the execution of a simulation sequence. Two scenarios can be specified in the configure simulation advanced, differing only by the option for an adaptive routing or a conventional routing and by the output vector file attributes. The execution of the simulation sequence reveals the parameters selected for the network condition evaluation and the comparison of the two scenarios can be done using the view results advanced.

In fact the network topology make for the decisions to transfer data from one point (source) to other Point (destination). Then link these routers with specific link that also describe previous section. The main point of this implementation is that run OSPF on these routers so that firstly select the locations. In other words, OSPF is Interior gate way protocol that selects the routers scheme in one antonymous system in optical network.

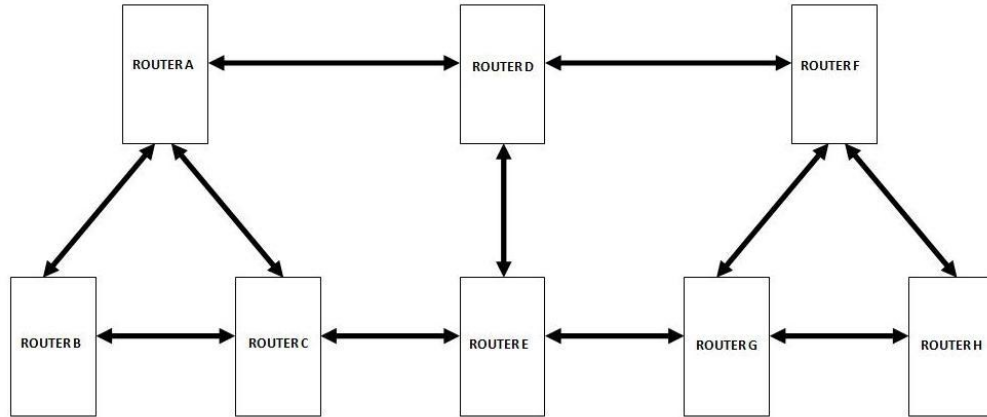


Figure 4.1 Network of router

According to this network topology routers links A, B and C has a same cast. Then that routers D and E links has same cast. Also remaining routers F, G and H have same cast. According to Cisco the formula for the cast also predefined. So implements that formula on these routers and gets the cast of different link according to above conditions. So that OPNET router models also support the formula of Cisco. The default value of the Reference bandwidth is 1,000,000 kbps. (Kilobits per second)

$$\text{Cost} = (\text{Reference bandwidth}) / (\text{Link bandwidth})$$

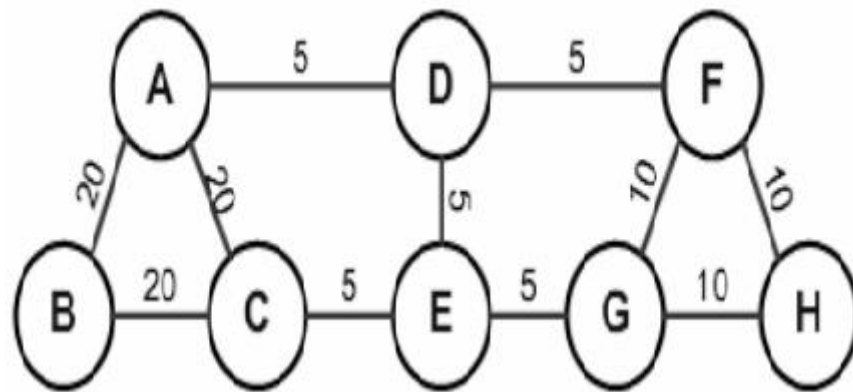


Figure 4.2 Network showing cost

According to that Network topology, in first scenario source destination is router A and destination router C. In this setup no area defined so data chose any way to reach destination

point. In fact when source point select A and Destination point C there is no area defined. Because set the parameters in OPNET module auto assign IP. Run simulation of this one scenario and save the result of graphs.

Then create another duplicate case name Area. Select the path B to H. Also use manually IP (Internet Protocol) to source and destination points. All there routing table also make and auto save in background of OPNET module. Configure the OSPF routing protocol on router. Then collect these two cases and run simulation.

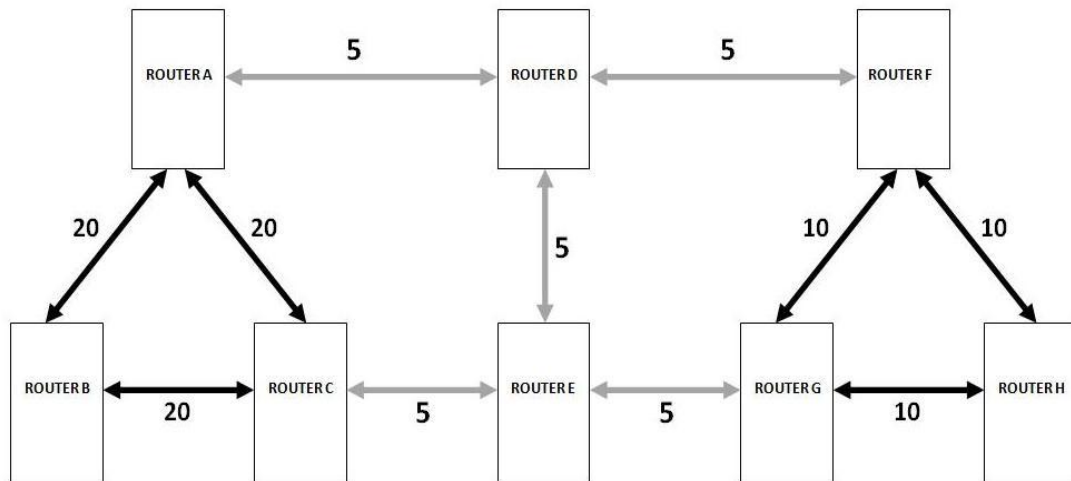


Figure 4.3 Cost in the network of router

4.3.1 Routing Tables

It is found that address 192.0.1.1 belongs to router A and address 192.0.1.2 belongs to router B. This means that the link between router A and Router B carries a common net work address and that they are directly linked. The addresses 192.0.2.1and 192.0.3.1 belong to Router A which are directed to Router C and Router D respectively. IP address.192.0.12.1 belongs to Router A which is nothing but its loop back interface.

Similarly, IP addresses belonging to other routers were also determined.

Router B -192.0.1.2 (Interface 0), 192.0.8.1 (Interface 1), 192.0.13.1(loopback Interface).

Router C- 192.0.2.2 (Interface0), 192.0.7.1(Interface1), 192.0.8.2(Interface2), 192.0.14.1(loop back Interface).

RouterD-192.0.3.2(Interface0),192.0.4.1(Interface1), 192.0.9.2(Interface2), 192.0.16.1(loop back Interface).

Router E -192.0.5.1 (Interface0),192.0.7.2(Interface1), 192.0.9.1(Interface2), 192.0.15.1(loop back Interface).

RouterF-192.0.4.2(Interface0),192.0.10.2(Interface1),192.0.11.2(Interface2), 192.0.19.1(loop back Interface).

RouterG-192.0.5.2(Interface0),192.0.6.1(Interface1), 192.0.10.1(Interface2), 192.0.17.1(loop back Interface).

Router H-192.0.6.2 (Interface 0),192.0.11.1(Interface 1), 192.0.18.1(loopback Interface).

4.4 Results

(a) Source A to Destination C: In this case when no area defined then any one router selects the any path to reach their destination point. Because according to set the area id then the Router A, B and C have same cost. So that in this case router A is source and router C is destination.

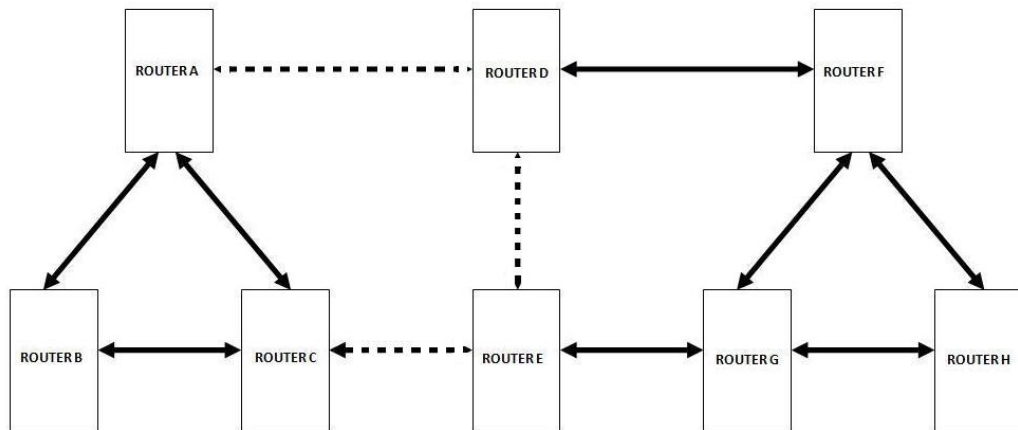


Figure 4.4 Dotted arrowed line show source A to destination C

(b) Source B to Destination H: In this case router selects that path for follow the data.

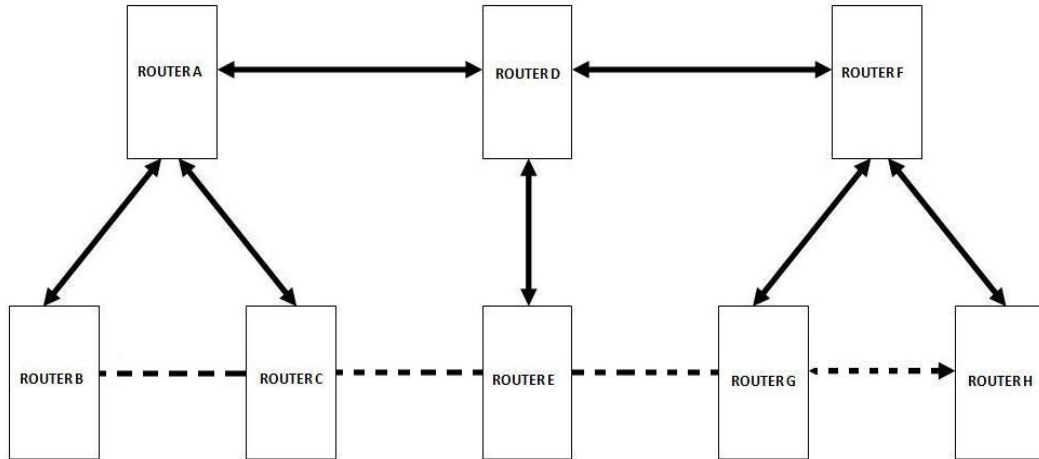


Figure 4.5 Dotted arrowed line show source B to destination H

(c) Source A to Destination C: In this case Area Id to Router A, B and C is 0.0.0.1. For Router D and H is 0.0.0.0, and for the Router F, G and H is 0.0.0.2. So now every router is force that follows the given Id path to reach the destination. When the so the result of A to C is.

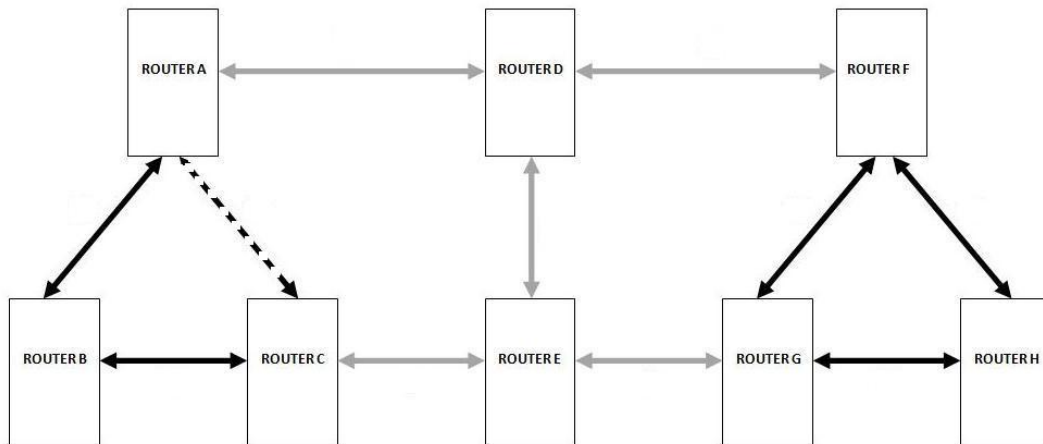


Figure 4.6 Dotted arrowed line show Source A to Destination C

(d) Source B to destination H: In this situation area specify so that router follow the path.

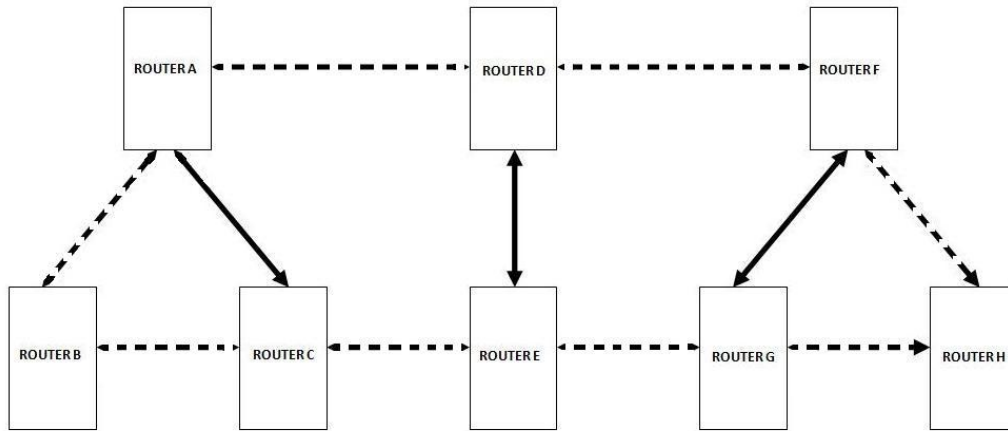


Figure 4.7 Dotted arrowed line show Source B to Destination H

4.5 Conclusion

This chapter presents an OPNET Modeler based simulation platform useful for evaluating the influence of an OSPF routing protocol strategy in optical network performance. The designed platform permits us to understand the impact caused by the routing decisions taken and help us to evaluate the advantages (or disadvantages) of the strategy in terms of particular network topology and traffic range in optical networks.

CHAPTER 5

Performance Evaluation of Different high speed LANs Connected by Optical cross Connect and Couplers in Optical Networks

5.1 Abstract

This chapter presents an analysis of optical cross connect and couplers of high speed LAN in optical networks. In addition, simulation results of this chapter compare the performance of high speed LAN with respect to the utilization of both optical cross connect and coupler. The delay and collisions occur in both networks have been examined. The performance and effect of both networks have been observed in case of sending and receiving frames. If the frame size is constant 1500 bytes then the Traffic Received, Delay and Collision is high. But if frame size is reduced from 1500 to 256 bytes, the performance is improved. The performance metrics used in this work are: Delay, Traffic Sink, Traffic Source, Collision and Packet Size. The simulation results show a good approximation of data traffic observed in the optical network.

5.2 Introduction

In optical networks the number of hosts and the size of network in a LAN are limited. Optical cross connect are used to enable communication between coupler [42]. Optical cross connect (OXC) connects LAN segments, use a table of MAC addresses to determine the segment on which a frame needs to be transmitted, and reduce traffic. OXCs are data link layer devices that let multiple physical LAN segments be interconnected into single larger networks. Instant access to the full bandwidth is received by each host. Collision is avoided in full duplex OXCs, because only one device is connected to each OXC port [43]. Increasing the number of packets in the network also increases the length of the queues at each router. Longer queues, in turn, mean packets are delayed longer in the network, and, hence, the traffic received is dropped. At the same time too conservative approach leads to the drop again as it does not allow enough packets to being sent to keep the links busy [44].

The core job of an OXC is to take frames arrive on a port and forward them to the correct destination. The key problem with which the OXC must deal is the finite bandwidth of its outputs [45]. If frames arrive at an OXC destined for a certain output and their arrival rate is higher than the capacity of that output, then the OXC queues the frames until the contention is reduced. If it lasts for a long time, then the OXC discards frames due to its limited buffer space. If it discards frames too frequently, it means that the OXC is congested. Segments of a LAN are commonly connected by coupler. When a coupler receives a frame, it floods that on all of its ports except at which it is arrived.

Minh Huynh et al. [23] presented that ethernet has been the indisputable technology of choice for the local area networks (LANs) for more than 30 years. Its popularity is due to its versatility, plug-n-play feature, and low cost. It has transformed from a CSMA/CD technology providing low throughput to a full-duplex link increasing the throughput 1000-folds. Despite these improvements, Ethernet is still restricted to local area networks, and is not ready to become a carrier-grade technology for wider areas. However, there are efforts to assist the transformation of Ethernet from the mainstream LAN technology to the possible adoption for metropolitan area networks (MANs). This paper introduced the movement from basic Ethernet to the carrier grade Ethernet for MANs. The paper describes the underlying technology, offered services, the state-of-the-art, and the comparison between various technologies.

N. Ghani et al. [24] studied the performance of various topology overlay schemes for multi-point Ethernet LAN services, including star, bus, and minimum spanning tree. A comprehensive tiered survivability approach for provisioning these overlays is also detailed using both pre-fault protection and post-fault restoration algorithms. The overall findings show the lowest blocking and/or highest carried load with more advanced minimum spanning tree overlays, particularly when combined with load-balancing routing of sub-connections (i.e., active resource usage state). Finally, the use of post-fault restoration is particularly beneficial and is shown to yield very high recovery rates even with generally lower levels of pre-fault protection reservation. Building upon this work, future efforts will focus on more elaborate shared protection strategies as well as optimization formulations.

This chapter is to measure the performance of delay and throughput in optical environment. The simulations have been done in OPNET. It provides a comprehensive development environment for the specification, simulation and performance analysis of communication networks [46], [47]. Many factors such as a heavy load in the network that generates higher traffic, may contribute to the congestion of network interface [48]. Therefore, this paper is significant to be managed in order to predict and measure of data transfers in optical environment.

5.3 Simulation Setup

In figure 5.1, a network with 24 nodes and a coupler that supports 24 optical connections is established. In figure 5.2, the network is modified with two 16 port coupler and an optical cross connect (OXC).

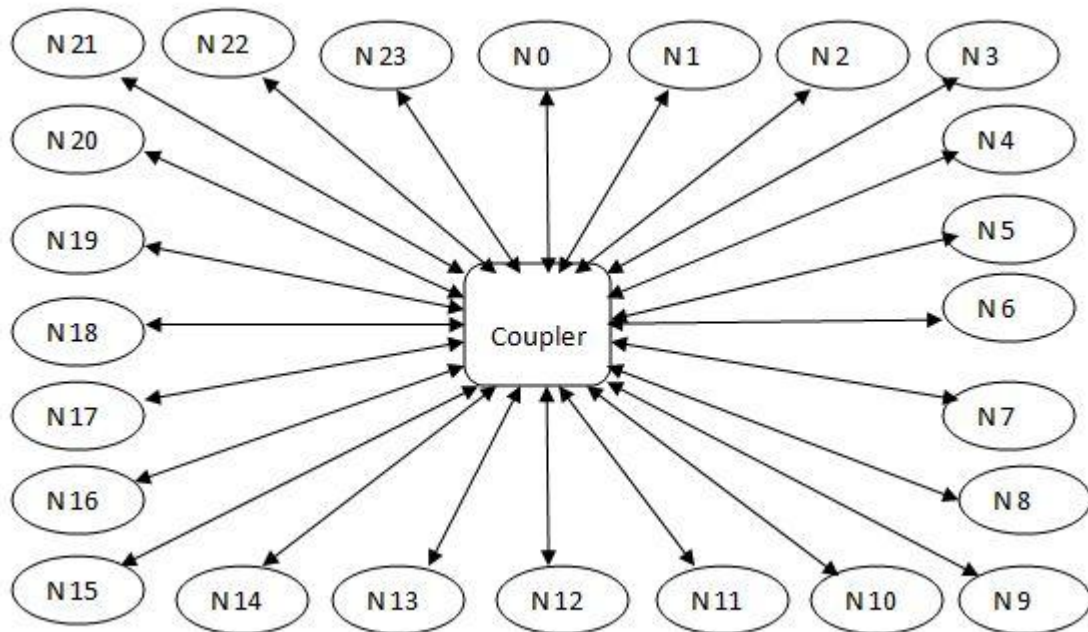


Figure 5.1 Coupler's network with 24 nodes

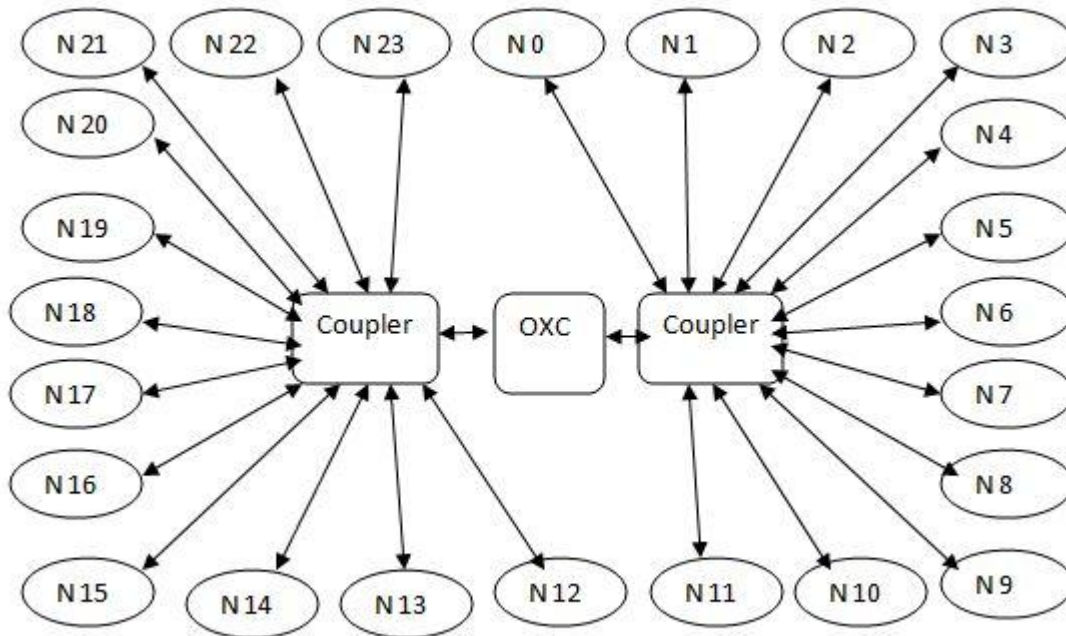


Figure 5.2 OXC's network with 24 nodes

5.4 OPNET Simulation of Different LANs

As it is mentioned above that the main focus of this paper is to examine different LANs' performance in optical network. Using OPNET simulator, the two optical LANs were simulated.

5.4.1 Applications Parameters

OPNET allows choosing different parameters for optical networks [29], e.g. Delay (sec), Traffic Sink, Traffic Source, Collision Count and Packet Size etc. The Delay (sec) shows the end to end delay of all frames received by all nodes. Traffic Sink illustrates the traffic received across all stations. Traffic Source examines the traffic sent across the connected nodes. Collision Count is the total number of encountered collisions during frame transmission.

5.5 Simulation Results

In this section, two setup cases were tested. In the first setup case the frame size was kept 1500 bytes and tested the delay and collision. In the second case, the frame size was tested that was reduced from 1500 to 256 bytes. Figure 3 and 5 show the received and sent traffic of the stations with a constant frame size of 1500 bytes respectively. The received and sent traffic with 256 byte frame sizes are shown in figure 4 and 6 respectively. The delay in case of 1500 byte frame size is shown in figure 7. Figure 8 describes the delay when frame size is 256 bytes. The average collision is given in figures 9 and 10.

5.5.1 Performance Evaluation

Here results are compared in which the packet size was kept 1500 bytes. Figure 5.3 shows the traffic received with a constant frame size of 1500 bytes, but as it is decreased from 1500 to 256 bytes in figure 5.4, it is clear that the throughput (received traffic) is far better. While the traffic sent in both cases is almost identical (figure 5.5 and 5.6). In our result (figure 5.8); the delay, compared to figure 5.7 has also decreased considerably.

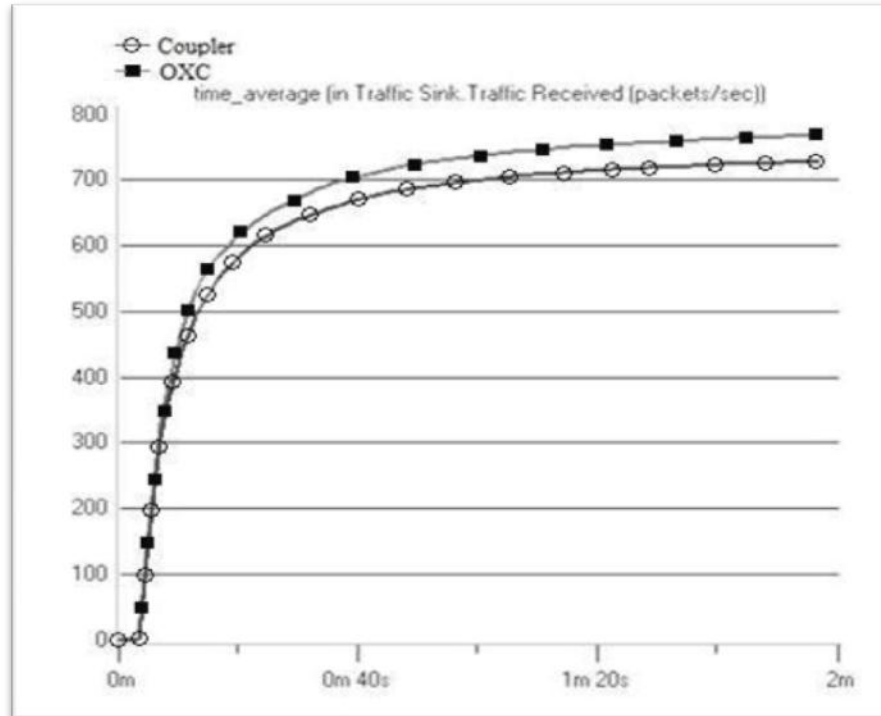


Figure 5.3 Received traffic when frame size is 1500 bytes

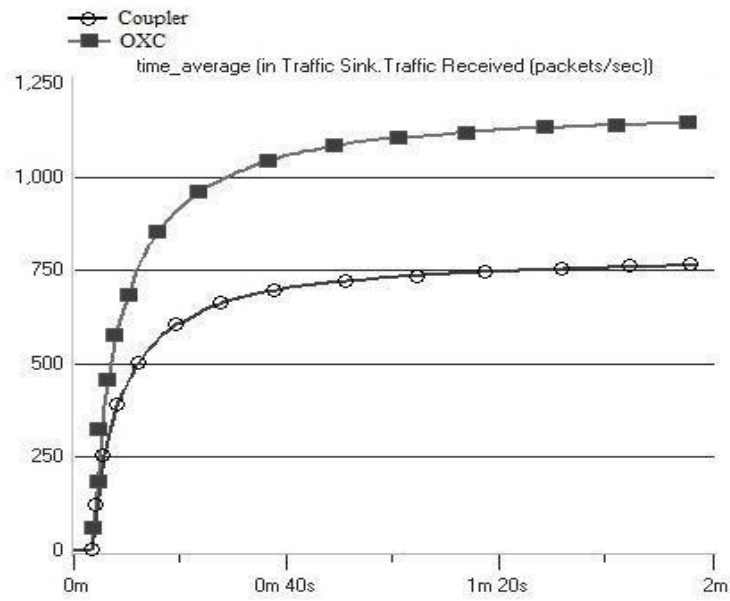


Figure 5.4 Received Traffic when Frame size is 256 bytes

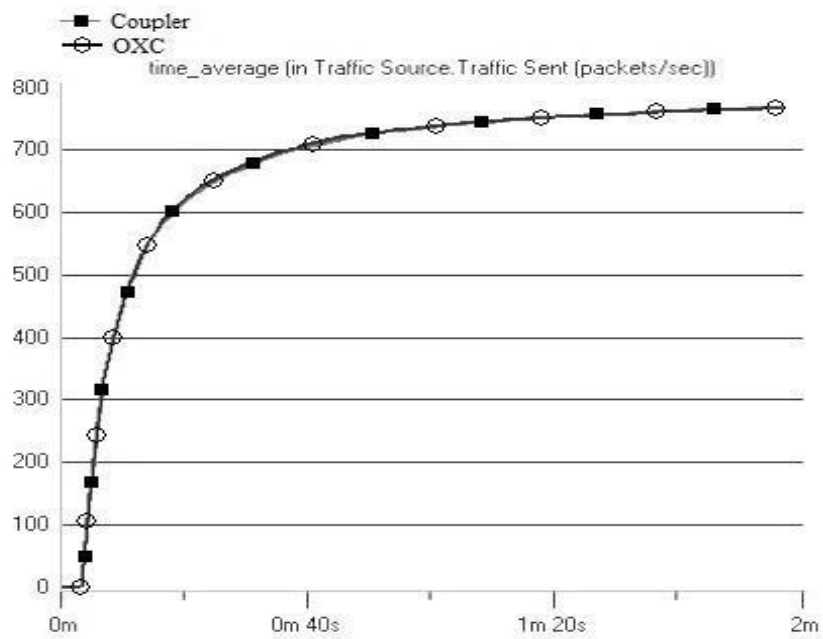


Figure 5.5 Sent traffic While Frame size is 1500 bytes

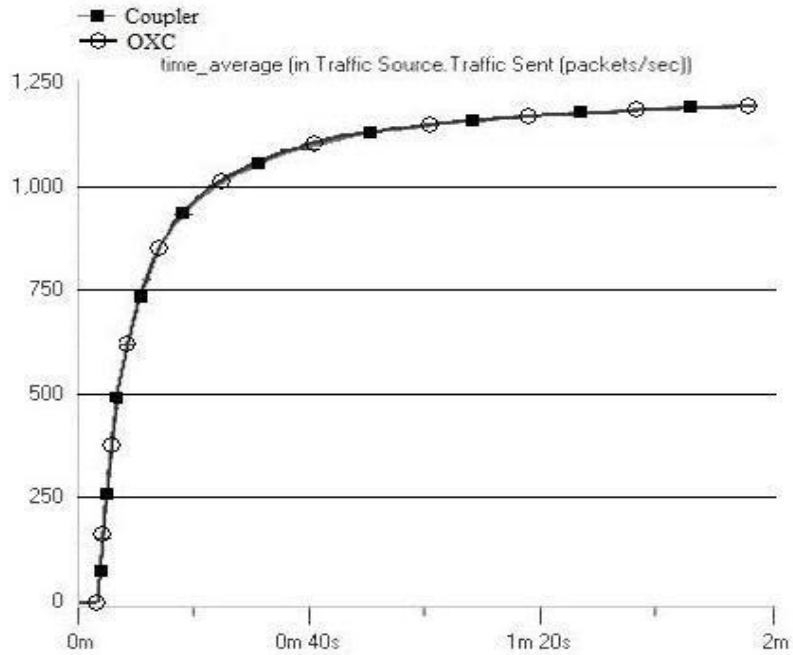


Figure 5.6 Sent Traffic While Frame size is 256 bytes

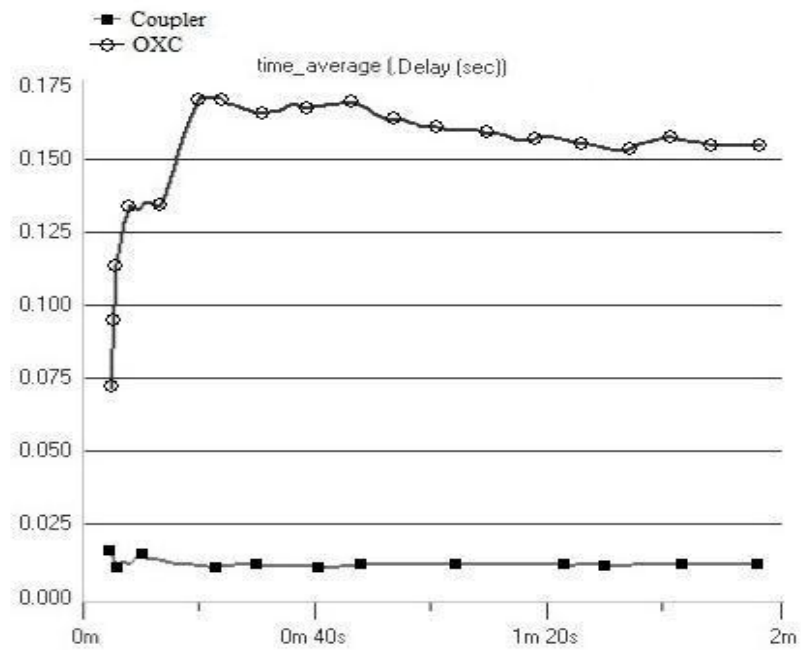


Figure 5.7 Average Delay in case of 1500 byte frame size

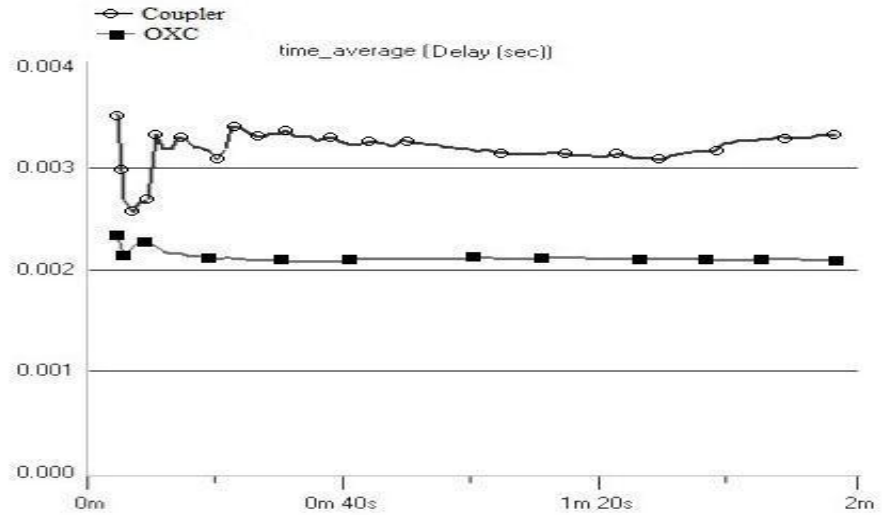


Figure 5.8 Average Delay in case of 256 byte frame size

5.5.2 Collision's Analysis

The use of an OXC makes it possible to reduce the collisions on the network. In optical network, the collision is increased as the network is loaded, and this causes retransmissions and increases in load that produce even more collisions. The resulting network overload slows traffic considerably. But decreasing the size of the frame can differently reduce the collision. The result is shown in figure 5.10 in which the value in case of OXC network is almost 30. While the collision's value in figure 5.9, in which the frame size was kept 1500 bytes is near to 1000.

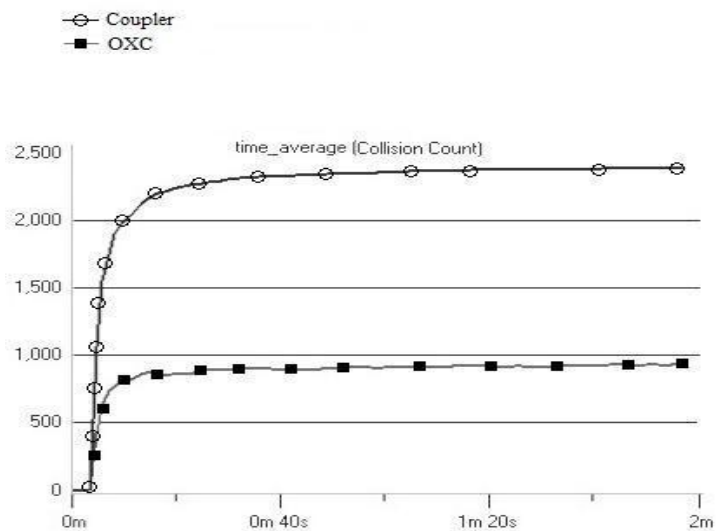


Figure 5.9 Average Collision when Frame size is 1500 bytes

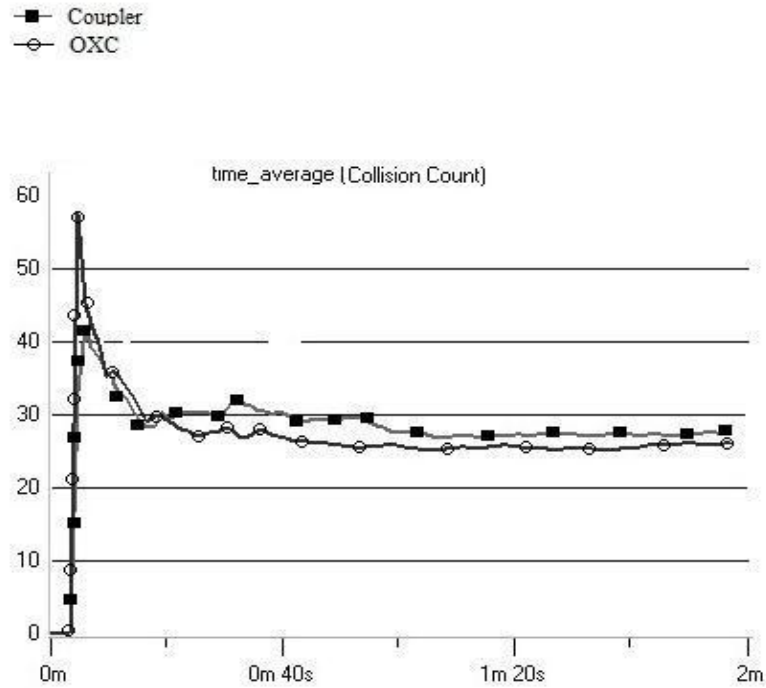


Figure 5.10 Average Collision when frame size is 256 bytes

5.6 Conclusion

In this chapter two optical networks have been observed using OPNET: one with a coupler and the other with two couplers and an optical cross connect in optical networks. In both networks the delay and collisions have been inspected. The performance and effect of both networks has been compared in case of sending and receiving frames delay, traffic sink, traffic source; collision and frame size are the performance parameters. The throughput is improved and collision is decreased as the constant 1500 byte frame size is reduced to 256 bytes. The compared simulation results show a good approximation of data traffic analyzed in the optical networks.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Conclusion

Here, a simulation-based performance evaluation and comparison of three queuing scheduling disciplines for different traffic sources is presented. The impact of using random-early drop is compared to drop-tail policy. The simulation results show that WFQ and Priority based PQ outperforms first in first out FIFO discipline in terms of average traffic throughput and queuing delay although PQ and WFQ are also very close to it for the considered traffic scenarios. WFQ is best suited for live streaming video. But, it fails to produce acceptable results with respect end to- end delay for video traffic. In such case, PQ provides minimal end-to-end delay and delay jitter. It is also noticed that using RED has greatly improved all the performance measures especially with FIFO. The reason is that RED monitors the average queue size and randomly drops packets when congestion is detected. Further work is still required to carefully examine these queuing disciplines and show the impact of self similar traffic and the use of traffic shapers at the edges of the network.

Interior routing protocols like OSPF are widely being used in the optical networking. In this thesis, a comparative analysis of selected routing protocol is presented. The comparative analysis has been done in the different network with same protocol (OSPF) for real time applications. Performance has been measured on the basis of some parameters that aimed to figure out the effects of routing protocol.

Two optical networks have been observed using OPNET: one with a coupler and the other with two couplers and an optical cross connect in optical networks. In both networks the delay and collisions have been inspected. Here the performance and effect of both networks in case of sending and receiving frames delay, traffic sink, and traffic source is compared; collision and frame size are the performance parameters. The throughput is improved and collision is decreased as the constant 1500 byte frame size is reduced to 256 bytes. The compared simulation results show a good approximation of data traffic analyzed in the optical networks.

6.2 Future Work

This thesis studied the effects of three queuing disciplines on three different applications, in order to conclude the best discipline to use for each application considered. Future work should investigate other queuing methods available such as DWRR, Custom Queuing, SPQ, and SFQ. The effects of Random-Early Drop (RED) and drop-tail policy should also be considered . Other applications such as online gaming should also be considered for a more complete report. Furthermore, the study should consider different qualities (resolution, frames, speech quality) in the real-time applications sent in order to better justify the type of queue chosen.

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