TRAFFIC ENGINEERING IP/GMPLS OVER WDM

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To my parents and family

To my beloved fiancé

Thanks for being extremely supportive and understanding all this while.

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ABSTRACT

Internet has very much impacted our life and daily activities. With rapid growth in the numbers of users especially from the industries as well as the development in optical technology, the need of better network with guaranteed quality of service is highly demanded. One potential solution is to adapt Internet with GMPLS network over WDM and is currently widely researched. The GMPLS over WDM network is seen as the most promising network in servicing the users with the capability of providing high quality of service in terms of the information throughput and transfer speed. The project investigates the performance of an IP with GMPLS network over WDM with a constraint, i.e. the availability of lambda. This is conducted using simulation. The simulation work is done using a powerful open sourced network simulator, known as NS-2. A GMPLS WDM network was modeled and a performance study based on the throughput, end-to-end delay, jitter and lambda utilization of the network are presented in this thesis.

ABSTRAK

Internet telah memberi impak yang besar kepada kehidupan dan aktiviti seharian kita. Dengan perkembangan pesat dalam jumlah pengguna terutamanya daripada industri serta perkembangan teknologi optik, keperluan kepada rangkaian yang lebih baik dengan kualiti perkhidmatan yang dijamin adalah amat dikehedaki. Satu penyelesaian yang mungkin adalah mengadaptasi Internet dengan rangkain GMPLS melalui WDM sedang dikaji di seluruh dunia. Rangkaian GMPLS melalui WDM ini dilihat sebagai rangkaian yang terbaik dalam memberi perkhidmatan kepada pengguna dengan kemampuan untuk menyediakan kualiti perkhidmatan yang tinggi dari segi celusan maklumat dan kelajuan pindah. Projek ini menyiasat prestasi satu rangkaian IP dengan GMPLS melalui WDM dengan kekangan, iaitu kebolehsediaan lambda. Projek ini akan dijalankan menggunakan simulasi. Kerja-kerja simulasi dilakukan dengan menggunakan simulasi rangkaian sumber terbuka yang berkuasa, dikenali sebagai NS-2. Satu rangkaian GMPLS WDM telah dimodelkan dan kajian prestasi berasaskan kecelusan, kelengahan hujung-ke-hujung, keketaran dan kegunaan lambda akan dibentangkan dalam tesis ini.

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LIST OF ABREVIATIONS

ATM	Asynchronous Transfer Mode
CoS	Class of Service
CR	Constraint-based Routing
ER-LSP	Explicit Route Label Switch Path
FEC	Forwarding Equivalence Class
Gbps	Gigabits per second
GMPLS	Generalized Multiprotocol Label Switching
i.e.	That is
IP	Internet Protocol
LDP	Label Distribution Protocol
LER	Label Edge Router
LIB	Label Information Base
LSC	Labda Switch Based
LSP	Label Switch Path
LSR	Label Switch Router
MPLS	Multiprotocol Label Switching
OSPF	Open Shortest Path First
PSC	Packet Switch Based
QoS	Quality of Service
RIP	Routing Information Protocol
RSVP	Resource Reservation Protocol
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical network
TDM	Time Division Multiplexing
TE	Traffic Engineering

TTL	Time to Live
VPN	Virtual Private Network
WDM	Wavelength Density Multiplexing

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CHAPTER 1

INTRODUCTION

1.1 Overview of Current Network

The current data network that enables us to communicate with our family and friends is based on the Internet Protocol (IP) technology. This network that is known as the Internet was initially meant for communication between researchers for the development of their research work [27]. As such the Internet is specifically limited in scope to provide the functions necessary to deliver packets from a source to a destination over an interconnected system. There is no service guarantee in the Internet. There are also no mechanisms to augment end-to-end data reliability, flow control, sequencing or other services commonly found in host-to-host protocol [13].

IP, a connectionless protocol, forwards packets of data using best effort method via the shortest path between the source and the destination. The shortest path is determined using the Open Shortest Path First (OSPF) routing protocol [22]. However, since all packets will be routed on the shortest path, burst of traffic could cause congestion in the path and gradually resulting in dropping of packets from the network. With best effort protocol, IP thus has no guarantee over the packets it serves, thus it has no quality of service (QoS).

On the other hand, the Service Provider backbone infrastructure provides multiple services such as TDM leased lines, ATM, Frame Relay, Voice, video and Internet service. ATM backbones are currently the most favored one due to their reliability and versatility in offering multiple service types [27].

Current data networks typically have four network layers:

- IP, for carrying applications and services
- ATM, for traffic engineering and quality of service (QoS)
- SONET/SDH, for multiplexing and transport reliability
- WDM, to provide large capacity over fiber strands.

1.2 Problem Statement

From 2000 until 2005, the world has recorded an increase of 146.2 percent of Internet users' growth [16]. With this high increment across all continents, and more service in demand such as video and voice transfer, a network that could provide better and faster transmission as well as more reliable is highly required.

As stated before, with IP, congestion could occur at the shortest path. With more users to be allocated along the shortest path at the same time, the higher the probability of congestion to occur, hence more calls or packets will be dropped off during transmission. Congestion occurs due to inefficient traffic resource allocation, and this can be addressed by Traffic Engineering (TE) [9]. Therefore the need of a protocol that could engineer the traffic is crucial in improving the quality of service (QoS) of the network. Multi-Protocol Label Switching (MPLS), a hybrid protocol

resulted from combining IP routing with ATM switching like facility seems to cater to this need. With explicit routing, MPLS allows traffic to be offloaded from a congested path and routed to underutilized path in order to reduce the congestion at the shortest path.

However, as network grows bigger, so does the complexity and hierarchy of the network. Thanks to development of optical technology, the speed of transmission can significantly speed up. This also has encouraged the networking people to implement the concept of MPLS to not only packet-based switching, but also to the time-division multiplexing (TDM), wavelength (lambda) and physical (fiber) based switching. Since MPLS lacks the ability to provide common control and traffic engineering for other media, hence a more general protocol known as GMPLS is provisioned.

1.3 Objective

GMPLS is a label switching protocol that extends common control and traffic engineering to other media besides packet switch domain [14]. It promises to provide more quality of service to a network. The main objective of this project is to investigate the performance of the QoS parameters of a MPLS/GMPLS network with an applied constraint. The proposed network should provide:

(i) Acceptable end-to-end delay and jitter

(ii) High packet throughput

(iii) Optimum bandwidth utilization

1.4 Project Scope

The scope of this project is to analyze the performance of a GMPLS network with a constraint using a simulation tool. The constraint applied here is the bandwidth or lambda requirement of a traffic and available bandwidth.

The analysis will be carried out to measure the performance of the GMPLS network in terms of throughput, end-to-end delay, lambda utilization and jitter. The network however will be limited to only the lambda switching network domain.

Analysis of the network performance was carried out using simulation based discrete event technique. The simulation tool used for this project is the Network Simulator version 2 (NS-2) [26].

1.5 Thesis Structure

This report comprises of 6 chapters. The first chapter briefly overviews the trend of current Internet, objectives and scope of this project. Chapter 2 describes the basics of label switching that can be categorized into MPLS and GMPLS and followed by a brief explanation on WDM.

The use of NS-2 in the simulation of MPLS/GMPLS network is discussed in Chapter 3. This is then followed with Chapter 4 that looks into the simulation studies and the analysis of the performance. The QoS parameters investigated for this network model will also be presented and discussed here.

Finally, the findings and discussions from the previous chapter will be concluded and some suggestions have been proposed in order to improve the performance of GMPLS and the work of this project.

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