QUALITY OF SERVICE AND TRAFFIC PREEMPTION FOR MULTI-PROTOCOL LABEL SWITCHING / GENERALIZED MULTI-PROTOCOL LABEL SWITCHING NETWORKS

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ABSTRACT

The Multi-Protocol Label Switching (MPLS) framework is used in internet service provider (ISP) and as a backbone to Internet Protocol (IP) to provide guaranteed efficient bandwidth and Quality of Service (QoS) provisioning in the network. This project seeks to investigate the QoS using DiffServ mechanism over MPLS and then compare the network performance in legacy networks. As a result, better network performance is observed with the integration of DiffServ over MPLS. DiffServ over MPLS provide the capability of the microflow traffic for each class-type in an aggregated packet stream with a LSP. Traffic preemption and resource preemption are introduced in QoS over MPLS to demonstrate that the class of traffic can be classless if MPLS setup-priority and holding-priority are pre-determined at user defined level.

The architecture that leverages the QoS capabilities of MPLS is simulated by generating the Class of Traffics Assured Forwarding (AF PHB) and Expedited Forwarding (EF PHB) comparable with Best Effort (BE) traffic. Then, traffic preemption is configured to determine priority traffics in MPLS.

DiffServ over GMPLS is used in simulation to show that QoS will improve the throughput and bandwidth utilization by generating multiple lambda (nλ) and packet classification with class-based-queuing. Finally, network analysis is constructed on the impact of all traffics classification in term of end-to-end delay and jitter

ABSTRAK

Kerangka MPLS digunakan pada penyedia perkhidmatan Internet (ISP) dan merupakan tulang belakang kepada IP untuk menyediakan jaminan kekesan jalur lebar serta kualiti perkhidmatan (QoS) di dalam rangkaian. Projek ini bertujuan menyiasat kualiti perkhidmatan mengunakan mekanisme DiffServ melalui MPLS dan membandingkan prestasinya dengan rangkaian sedia ada. Perbandingan kajian simulasi di antara topologi rangkaian BE, DiffServ dan MPLS adalah untuk tujuan rujukan trafik. Hasilnya, pengukuran prestasi rangkaian adalah lebih baik jika rangkaian digabungkan di antara DiffServ dan MPLS. DiffServ melalui MPLS berkebolehan menyediakan trafik aliran micro untuk setiap klas trafik di dalam aliran packet dengan LSP. Traffic Preemption dan resource pre-emption diperkenalkan di dalam DiffServ melalui MPLS bagi menunjukan bahawa pengkelasan traffic boleh diubah jika penguna mengkonfigurasikan terlebih dahulu setup-priority dan holding-priority.

Kemampuan senibina kualiti perkhidmatan (QoS) boleh dijanakan dengan membandikan simulasikan trafik pengkelasan Assured Forwarding (AF). Expedited Forwarding (EF) dan Best Effort (BE). Seterusnya, konfigurasi traffic pre-emption digunakan untuk memnentukan keutamaan trafik di MPLS.

DiffServ melalui GMPLS digunakan di dalam simulasi untuk menunjukkan bahawa kualiti perkhidmatan akan meningkat dengan kepelbagaian lambda dan klasifikasi paket dengan CBQ. Akhir sekali, satu analisa rangkaian dijalankan berdasarkan impak kesemua klasifikasi trafik dari segi kelengahan hujung ke hujung dan keketaran dan dioah didalam tesis ini.

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B	-	Packet Size
D	-	Exponential Service Time Distribution
E	-	Latency
M	-	Poisson Arrival Process
R	-	Transfer/Service Rate
s	-	Packet Service Time
Q(x)	-	Function
λ	-	Optical Link
ρ	-	Link Utilization
μ	-	Departure
a_j	-	Time Last Bit
d_j	-	Time Last Bit
E_a	-	Error
L_j	-	Size Last Bit
t_q	-	Mean Time
t_w	-	Queuing Delay

LIST OF ABREVIATIONS

AF	Assured Forwarding
ATM	Asynchronous Transfer Mode
FEC	Forwarding Equivalence Class
BA	Behaviour Aggregate
BE	Best Effort
BGP	Border Gateway Protocol
BW	Bandwidth
CoS	Class of Service
CR-LSP	Constraint-based Routing Label Switch Path
CBQ	Class Based Queuing
CR-LDP	Constraint Route Label Distribution Protocol
CBR	Constant Bit Rate
CDR	Commited Data Rate
CBS	Commited Burst Size
CAR	Commited Access Rate
CBWFQ	Class-Based Weighted Fair Queuing
CE	Customer Edge
CPN	Customer Premises Network
DiffServ	Differentiated Services
DSCP	Differentiated Services Code Point

DTS	Digital Transmission System
DRR	Deficit Round Robin
ER-LSP	Explicit Route Label Switch Path
EF	Expedited Forwarding
E-LSP	Experimental inferred Per Service Class Label Switch Path
EXP	Experimental Bit
EBS	Excess Burst Size
ERB	Explicit Route Information Base
FEC	Forwarding Equivalence Class
FIFO	First In First Out
FTP	File Transfer Protocol
GMPLS	Generalized Multi-Protocol Label Switching
IP	Internet Protocol
ISP	Internet Service Provider
IETF	Internet Engineering Task Force
IS-IS	Intermediate System to Intermediate System
ITU	International Telecommunication Union
LDP	Label Distribution Protocol
LER	Label Edge Router
LSP	Label Switched Path
LSR	Label Switch Router
L-LSP	Label inferred Per Service Class Label Switched Path
LC-ATM	Logical Connection Asynchronous Transfer Mode
LIB	Label Information Base
LMP	Link Management Protocol

LFIB	Label Forwarding Information Base
LSPID	Label Switched Path Identification
MPLS	Multi-Protocol Label Switching
MTU	Maximum Transfer Unit
MNS	MPLS Network Simulator
NS-2	Network Simulator Version 2
NCT	Network Control Traffic
nrt	Non Real-Time
OSPF	Open Short Path First
OXC	Optical Cross-Connect
PHB	Per-Hop-Behaviour
PDR	Peak Data Rate
PBS	Peak Burst Size
PE	Provider Edge
PHP	Penultimate Hop Popping
PFT	Partial Forwarding Table
PSTN	Public Switching Telephone Network
QoS	Quality of Service
RED	Random Early Detection
RFC	Request For Comment
RSVP	Resource ReSerVation Protocol
RSVP-TE	Resource ReSerVation Protocol Traffic Engineering
rt	Real-Time
S	Stack
SDH	Synchronous Digital Hierarchy

SONET	Synchronous Optical Network
SLA	Service Level Agreement
ServiceID	Service Identification
SAN	Storage Area Network
TTL	Time To Live
TLV	Type-Length-Value
TE	Traffic Engineering
TCP	Transmission Control Protocol
TDM	Time Division Multiplexing
ToS	Type of Service
TELNET	Remote Terminal Protocol
UDP	User Datagram Protocol
UNI	User Network Interface
VPI	Virtual Path Identifier
VCI	Virtual Channel Identifier
VPN	Virtual Private Network
VoIP	Voice over Internet Protocol
VBR	Variable Bit Rate
WAN	Wide Area Network
WRED	Weighted Random Early Detection

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the best service it can, but there are no controls to preserve higher levels of service for some flows and not others. This inefficient traffic resource allocation causes congestion in the network which eventually leads to a drop in network performance.

Over the years, several approaches have been developed to enhance the internet in order to support the different requirements of different types of traffic and address the QoS problem. DiffServe is one of the mechanisms able to provide QoS.

In DiffServe, traffics are treated differently based on their QoS requirements. Thus, in a Best-Effort (BE) environment, what DiffServe does is attempt to provide better levels of service. However, it is still below par because traffic engineering remains a problem.

DiffServe and MPLS perform a similar set of functions that can be combined when both are implemented in a network. Support of DiffServe in MPLS that was standardized by the IETF can provide QoS guaranteed service, while keeping network resource utilization at high level [13].

GMPLS is a more general protocol that extends MPLS to provide common control and traffic engineering.

Hence, this project studies the Quality of Service (QoS) capabilities and traffic pre-emption for priority fine-tuning in Multi Protocol Label Switching (MPLS) and extended Generalized Multi Protocol Label Switching (GMPLS).

GMPLS is not just about protocols the existing MPLS protocols are reused with relatively small extensions and it is not about any particular technology. It can be applied to many, including TDM, lambda switching, and pre-existing MPLS devices. GMPLS is all about the general software architecture of a network element and network applications on top of the protocol [1].

1.2 Problem Statement

The increasing population of internet users are demanding for faster, more efficient and more reliable service network. As stated earlier, Quality of Service (Qos) is now a prerequisite for the transport of high bandwidth voice and video services, as well as critical data.

An insight into the traditional Best Effort method provides a transparency for the requirements of Quality of service (QoS) and the basis for this project.

In Best Effort (BE), traffic congestion often occurs in the path and this leads to major flaws related to the bandwidth, delay, jitter and packet loss which are the parameters for QoS in a network. These are the contributing factors to degrading network performance. Hence, the need for QoS is vital in order to control and manage the mentioned parameters.

1.3 Objectives of the Project

The main objective of this project is to investigate the QoS capabilities and traffic pre-emption for priority fine-tuning in MPLS and extended GMPLS using Differentiated Services (DiffServ) mechanism. In doing so, the following objectives are to be met:

- To study and compare the Quality of Service (QoS) under different policy based used in MPLS / GMPLS networks by modelling the traffic pre-emption.
- To simulate the performance parameter on DiffServ over MPLS / GMPLS environment using NS-2 software tool.

- To compare results with Class of Service (CoS) such as EF, AF and BE on ER-LSP and CR-LSP in QoS and Traffic Prremption.
- To generate analysis from the results and draw conclusion.

1.4 Scope of the Project

The project will first estimate and identify the provisioning of Quality of Service (QoS) capabilities on DiffServ-aware-MPLS and DiffServ-aware-GMPLS based on RFC2474, RFC2475, RFC2597, RFC2598, RFC3140, RFC3270, RFC3471, RFC3472 and RFC4594 by generating the CBR traffic into different priority levels, and then apply different event schedulings such as the following;

(a) Per Hob Behaviour (PHB);
   1. Expedited Forwarding [EF] or Premium Service
   2. Assured Forwarding [AF]

(b) Best-Effort [BE] – default

(c) CBQ Queuing Mechanism at the nodes.

Second, simulate the resource pre-emption defined in Constrained Routing – Label Distribution Protocol (CR-LDP) on MPLS / GMPLS by generating different CBR traffic.

Finally, compare and contrast both the variation in bandwidth studies obtained and then generate analysis before drawing a conclusion.

1.5 Thesis Structure

This report consists of 7 chapters. Chapter 1 is an introduction presenting a brief overview of QoS and the trend of the current Internet, problem statement as well as objectives and scope of this project. Chapter 2 describes the QoS and label switching that can be categorized into MPLS and GMPLS, followed by a brief explanation on DiffServ. Next, Chapter 3 explains the implementation of QoS in MPLS network.

The use of NS-2 in the simulation of MPLS/GMPLS network is discussed in Chapter 4. This is then followed by Chapter 5 which looks into project methodology and simulation studies. Chapter 6 then presents the analysis of the performance. The QoS parameters investigated for this network model is also presented and discussed here. Finally, Chapter 7 draws a conclusion based on the findings and discussions from the preceding chapters and presents several proposals to improve the performance of MPLS/GMPLS and extensions to the works of this project.

CHAPTER 1

INTRODUCTION

1.1 Overview of QoS and MPLS/GMPLS Networks

The internet industry is growing rapidly with increasing demands for the provisioning of new and more advanced services that are able to dynamically react to changes within the network. In spite of the internet's evolution from a network that provided just Best-Effort (BE) transportation to a network capable of providing a wide range of services, users are seeking for a more efficient and reliable network with guaranteed quality of service.

Quality of Service (QoS) is in itself a measurement of how much a service meets and satisfies its users' needs. Technically, it is a set of qualities related to the collective behaviour of one or more objects [1]. In a network, QoS is measured via bandwidth, delay, jitter and packet loss.

In today's internet industry, Quality of Service (QoS) plays a significant role in the implementation of multiservice and converged networks. The parameters of QoS need to be met to support distinct applications such as voice, video, and data, and multiple network services such as IP, Ethernet, and ATM.

However, bandwidth, delay, jitter and packet loss are the main problems in traditional Best Effort (BE), and as such BE doesn't support QoS requirements. With Best Effort (BE) there is no attempt to differentiate between the traffic flows that are generated by different hosts. As traffic flow varies, the network provides