A FRAGMENTATION CONTROL APPROACH IN JUMBO FRAME NETWORK

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“Dedicated to my beloved family and friends, without their understanding, supports, and most of all love, the completion of this work would not have been possible.”

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ABSTRACT

Nowadays, an amazing growth of the Internet has impacted tremendously on the network's capability; from hundreds to thousands of Gigabits/s in the center of the network as well as at the access, and may soon to see an amazing amount of packets that needs to be processed. In the future, such a remarkable growth, there is an urgent need for an integration of packets of bigger sizes, called Jumbo frames. Jumbo frame is an approach that permits higher utilization as it decrease the amount of packets processed by the core routers while not having any adverse impact on the link utilization of fairness. The one major problem faced by Jumbo frame networks is that network paths are set not to transmit Jumbo frame capable end-to-end. This approach can't provide a reasonable performance; as in reality, many paths have bigger Maximum Transmission Unit (MTU)s and many Internet networking gear do support bigger MTUs and the performance is highly depends on the size of a packet. This process leads to suboptimal throughput and is wasting Internet resources. Therefore, it is advantageous to discover the link MTU in order to avoid fragmentation when dealing with Jumbo frame. This research proposes the use of the MTU discovery method with Jumbo frame and the modified IP fragmentation mechanism which are used with the Jumbo frame network to reduce packet drop and throughput by decreasing the overhead in the network. And also, on how to discover the return effective MTU for Jumbo frame situation. For the purpose of evaluation, network simulator NS-2.28 was set up together with Jumbo frame and the proposed methods. Moreover, to justify the research objectives, the proposed algorithm and technique for MTU discovery with Jumbo frame were compared against the existing MTU handling mechanism and techniques that are found in the literature review using simulation metrics such as packet drop and throughput.

ABSTRAK

Pada masa ini, pertumbuhan yang mengagumkan di Internet telah memberi kesan yang mendadak pada keupayaan rangkaian, dari ratusan hingga ribuan Gigabits di pusat rangkaian mahupun di akses; dan menyaksikan satu keadaan di mana satu jumlah paket yang banyak diperlukan untuk diproses. Pertumbuhan yang hebat sebegini akan mendesak satu keperluan segera untuk integrasi daripada saiz paket yang lebih besar, yang dikenali sebagai Bingkai Jumbo. Bingkai Jumbo membolehkan pengurangan jumlah paket yang diproses oleh teras router dan tidak mempunyai sebarang kesan negatif terhadap penggunaan pemanfaatan link. Satu masalah utama yang dihadapi oleh rangkaian Bingkai Jumbo adalah bahawa laluan rangkaian tidak digunakan sepenuhnya bagi membolehkan penggunaan paket Jumbo dari hujung ke hujung. Pendekatan ini tidak dapat memberikan prestasi yang sewajarnya, kerana terbukti banyak laluan mempunyai Unit Transmisi Maksimum (MTU)s yang mampu untuk menyokong paket Jumbo dan peralatan rangkaian Internet banyak yang boleh menyokong MTUs yang lebih besar. Proses ini menyebabkan "*throughput suboptimal*" dan pembaziran sumber Internet. Oleh kerana itu,adalah memberi manfaat jika setiap laluan link diketahui MTUnya bagi mengelakkan fragmentasi untuk Bingkai Jumbo. Penyelidikan ini mencadangkan penggunaan kaedah penemuan MTU dengan Bingkai Jumbo dan juga mekanisme IP fragmentasi untuk mengurangkan pakej rugi dan menaikkan "*throughput*" dengan berkurangnya overhed dalam rangkaian itu. Untuk tujuan penilaian, rangkaian simulator NS-2.28 ditubuhkan bersama-sama dengan Bingkai Jumbo menggunakan kaedah yang dicadangkan. Selain itu, algoritma dan teknik cadangan penemuan MTU dengan Bingkai Jumbo telah dibandingkan terhadap mekanisme pengendalian MTU yang sedia ada dan teknik-teknik yang ditemui dalam kesusasteraan menggunakan metrik simulasi seperti pakej rugi dan "*throughput*".

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LIST OF ABBREVIATIONS

ARCNet	Attached Resource Computer Network
AS	Autonomous System
C_b	Capacity Limitation
CRC	Cycle Redundancy Check
DF	Don't-Fragment
DiffServ	Differentiated Services
ECN	Expedited Congestion Notification
FDDI	Fiber Distributed Data Interface
FO	Fragment Offset within the datagram
GRE	Generic Routing Encapsulation
HIP	IP Header
HIPPI	High Performance Parallel Interface
HJG	Jumbo Frame Header
HLIM	Hop-Limit
HP	Physical Header
IBM	International Business Machines
ICMPDP	Internet Control Message Protocol Data Payload
ICMP/PTB	Internet Control Message Protocol / Packet-Too-Big
IEEE	Institute of Electrical and Electronics Engineers
IPHL	Internet Protocol Header Length
ISDN	Integrated Services Digital Network
ISO	International Organization for Standardization
ISP	Internet Service Provider
JFET	Jumbo Frame Encapsulation Timer

JPMTUD	Jumbo Packet Maximum Transmission Unit discovery
LAN	Local Area Network
MF	More Flag Indicator within the datagram
MPLS	MultiProtocol Label Switching
MSS	Maximum Segment Size
MTU	Maximum Transmission Unit
N	Number of encapsulated packets in Jumbo Frame
NS-2	Network Simulator 2
OSI	Open Systems Interconnection
PLPMTUD	Packetization Layer Path MTU Discovery
PMTU	Path MTU
PMTUD	Path MTU Discovery
PPPoE	Point-to-Point Protocol Over Ethernet
PTB	Packet-Too-Big
QoS	Quality of Service
RFC	Request for Comment
SLIP	Serial Line IP
TCP	Transmission Control Protocol
TL	Total Length of data within the datagram
TTL	Time-to-Live
WAN	Wide Area Network
w_q	Queue Weight

CHAPTER 1

INTRODUCTION

1.1 Introduction

Ethernet has been created around 1980 with a frame size of 1500 bytes (Dykstra, 1999). It is being transferred from one node to the other in units called frames. Data is either fragmented or dropped into few smaller pieces or dropped if the network device cannot process a bigger frame larger than its Maximum Transmission Unit (MTU). Historically, a standard Ethernet frame can carry a 1500 byte payload. The official IEEE has standardized MTU for Ethernet is 1500 bytes and as Ethernet is used as the main protocol in Internet, therefore most devices use 1500 as their default MTU.

Any Ethernet packet that is bigger than 1500 bytes is called a Jumbo frame. As of today, there is still no standard size for this. But researchers' common practices for Jumbo frame are to use 9180 bytes which includes the header (Sauver, 2003). But basically anything larger than 1500 bytes can be considered as Jumbo. Jumbo frame aims to reduce the number of packet processed per second and is designed in such a way it will enhance the Ethernet networking throughput and to significantly reduce the CPU utilization by efficiently process larger payloads per packet.

But one main issue is that when having a larger frame the router can break the packet into few pieces if the link does not fit. This means that it splits it into multiple parts which contain enough information for the receiver to join them together again. Fragmentation is undesirable for few numerous reasons and the main reason is due to the fact that it may increase overhead and fragmentation can cause extra processing load on the routers (Christopher and Mogul, 1987).

Therefore, the question is how to send Jumbo frame while still avoiding fragmentation? The solution is to discover the Jumbo packet MTU Discovery. The MTU discovery is a technique to send packets that are as large as possible which is aim to determine the maximum transmission unit (MTU) size on the network path between two Internet Protocol (IP) hosts, while still avoiding fragmentation (Genkov, 2008). In other words, the host will send the largest IP packet size in the fewest number of packets possible in an Internet path. By knowing the minimum MTU, the host will send datagrams that is low enough to be delivered without fragmentation. Put in a different way, the path MTU is the largest packet size that traverses the path without suffering fragmentation. The goal is simple, to avoid fragmentation in order to decrease the overhead.

However, no work has ever linked the MTU discovery for Jumbo frame. Hence, this research study is an attempt to test on the effectiveness of MTU discovery for Jumbo frame. And to suggest on how to improve on the MTU discovery technique so that it can be well delivered for Jumbo frames.

1.2 Motivation

The major network performance issue is that even with a rapid growth in the line of speed, the performance has not scaled proportionally. This is due to the fact that the basic MTU of the network has remained stagnant at 1500 bytes which have been lagging severely behind the network speed. Due to this matter, nowadays most modern Internet gear supports this value.

The approachable solution is that by using the extended Ethernet frame, or known as Jumbo frame. As from often cited Alteon Network study, the need of using large frames in Ethernet systems increased each time the technology moves up in speed. With Jumbo Frames, much larger frames than the Ethernet standard of 1500 bytes are being supported. Jumbo frames encapsulate smaller packets in to larger packet for transmission across the domain. This will benefit the core routers as Jumbo frame reduce the number of packets to be processed at the core router thus increasing network scalability.

With the increasing line speed, the rationale behind increasing the frame size is clear; larger frames reduce the number of packets to be processed per second with little fragmentation, and little overhead (Dykstra, 1999). Jumbo's frame extended size has produced significant increases in network performance. It can deliver a 50% increase in throughput with a simultaneous 50% decrease in CPU utilization, taken from the cited Alteon Networks study which leads to the primary reason for using Jumbo frames.

Therefore, by keeping the data to be encapsulated in the fewest number of packets is a sensible process to do for Jumbo packet. This can be done if the host is able to determine the largest IP packet size or the MTU that is supported by the path. By discovering the MTU and by learning the next-hop MTU of each MTU constraining link on the path continuously is identified as the MTU Discovery.

Therefore, by combining the extended frame size and by encapsulating the fewest number of packets possible using a technique developed for the Jumbo packet MTU discovery may enhance the network performance as a whole.

1.3 Problem Background

Currently, many network paths are set not to transmit Jumbo frame capable end-to-end. The current practice (Braden, 1989) is to use the lesser of 576 bytes or the first-hop MTU as the MTU for any destination. In many cases, many hosts end up in sending smaller datagrams than necessary, because many paths have a MTU greater than 576. This process leads to suboptimal throughput and is wasting Internet resources. This doesn’t work with Jumbo Frame (Sauver, 2003). As Jumbo frame is a large frame, and when a host must send a large chunk of data, the data will be fragmented into too many smaller packets. The fragments can be reassembled at the destination but sometimes this packet fragmentation has several problems involving both efficiency and security. For instance, in order to fragment an IP datagram, there is a small increase in CPU and memory overhead (Genkov D. *et al.,* 2006). That is why it is often preferable that these datagrams be of a largest size that does not require any division anywhere along the path from the source to the destination (Payton R. W. *et al*., 2009). In other words, it is therefore advantageous to discover the path MTU end-to-end in order to avoid fragmenting packets as it is advantageous to encapsulate the data in the fewest number of packets possible in order to increase the network performance. Without discovering the path MTU, hosts are often restricted to send packets around 576 bytes which doesn’t work with Jumbo frame as fragmenting Jumbo frame into several small packets can reduce performance.

The other main obstacle to the introduction of Jumbo packets is the broken path MTU at Layer 3 (Rutherford *et al.* , 2006). This problem is known as the broken path MTU discovery (Sauver, 2003; Shalunov, 2003). These "oversized" packets are being dropped without any notification to the originating station. The originating station treats the packet lost on the way back or due to congestion and will repeatedly retransmit the packet which will consume more overhead.

Thus, by enabling a MTU discovery, a host will either send a Jumbo frame or normal Ethernet frame as it would be such a waste if to use Jumbo frame if the path MTU is less than that. This works by reducing the MTU value included in the ICMP Packet Too Big (PTB) message continuously until when it reached the destination host. Furthermore, by having this larger MTU means less interrupts (Shalunov, 2003) as it can bring higher efficiency with bigger packets being carried but the headers or any underlying per-packet delays remain fixed. And a greater efficiency means a slight increase in bulk protocol throughput.

Therefore, if Jumbo frame being sent across a network how does a host determine what MTU should be used? Hence, this research study presents an approach that applies the MTU discovery in Jumbo frame with an assumption that the paths from the source to destination will become Jumbo capable end-to-end.

1.4 Problem Statement

As mentioned above, to choose the best suitable packet size for encapsulation at the tunnel endpoint is a known challenge. A lot of fragmentation might be performed if a static value of MTU is chosen. Therefore, by discovering the path with a more dynamic MTU, using the Jumbo packet MTU discovery mechanism, fragmentation can be avoided.

Therefore, as mentioned in the previous section, some open issues that may lead to the questions in this research are as follows:

i. How to develop the Jumbo packet MTU discovery by searching for the effective MTU for sending to improve the drop rate in Jumbo frame network?
ii. How can the IP fragmentation algorithm be modified to allow Jumbo packet to be send to improve the throughput in Jumbo frame network?
iii. How to evaluate the findings of performance analysis for Jumbo Frame after applying the proposed Jumbo packet MTU discovery technique and the enhancement IP fragmentation technique?

1.5 Dissertation Aim

The aim of this research is to develop the MTU discovery mechanism into the Jumbo frame. It presents a good search strategy that will obtain an accurate estimate for MTU value for Jumbo frame without causing many packets to be lost in the process. It also presents the results analysis of how the discovery mechanism can improve the network performance.

1.6 Dissertation Objectives

The main objectives of this research are:

i. To develop the Jumbo packet MTU discovery that can search for the effective MTU for sending to decrease the drop rate in Jumbo frame network.
ii. To modify the IP fragmentation algorithm that will lead to improve the throughput in Jumbo frame network.
iii. To evaluate the performance based on the proposed metrics such as throughput and packet drop after applying the proposed Jumbo packet MTU discovery technique.

1.7 Dissertation Scopes

The scopes for this research are defined as follows:

i. This research focuses on modifying the IP fragmentation mechanism and the MTU Discovery in Jumbo frame networks, based on Ethernet network.
ii. This work focuses above IP, in the transport layer more than other layers.
iii. The proposed mechanism will be implemented using the Network simulator NS-2 (Network Simulator 2).

1.8 Dissertation Contribution

This research studied the network performance by using the Jumbo Frame. Furthermore, this research will provide some insight into Jumbo Frames and the tools to enhance and implement into the current network. The following are the major contributions of this research:

i. The development of Maximum Transmission Unit (MTU) discovery mechanism for Jumbo frame that carries the path MTU valuable information that can traverse the path without having any fragmentation which will prevent the drop rate of the “oversized” packets.
ii. The modification of the IP fragmentation algorithm by modulating the size of the fragments in the IP header which is set to the maximum MTU allowed for path from the sender to the receiver, hence increasing the throughput of the network.
iii. The evaluation of the performance is based on measurements of important parameters in Jumbo frame, such as throughput and drop rate.

1.9 Organization of Thesis

This thesis consists of 5 chapter’s altogether. The chapters are organized according to different works that involved in this study. The division is stated as below:

Chapter 1: It presents introduction, problem background, objective, scope and significant of this study, mainly about the domain which is the Jumbo frame and the MTU Discovery and why the study should be conducted.

Chapter 2: This chapter provides the literature reviews of the study area, background on existing MTU techniques, Jumbo frame, problems and potential solutions.

Chapter 3: Describes the framework of the research. It consists of wide description on the flow of this research which includes on how the operational and experimental work has been carried out for the study.

Chapter 4: It provides the research design details and algorithm used in this research with the simulation setup and problem formulation which has been discussed in literature review.

Chapter 5: It discusses the final results on the comparison of the results which is generated from the NS-2 simulator. A brief overview about the NS-2 simulator and its main features is also presented.

Chapter 6: It presents the conclusion of overall chapter and future works in the related area of Jumbo frame MTU discovery and will be discussed to provide a better achievements in future study. This also includes some recommendations of this work.

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