UNIVERSITI PUTRA MALAYSIA

**CELL UTILIZATION EFFICIENCY OF INTERNET PROTOCOL
TRAFFIC OVER ASYNCHRONOUS TRANSFER MODE NETWORKS.**

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By

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LIST OF ABBREVIATIONS

AAL   :   ATM Adaptation Layer

ABR   :   Available Bit Rate

AFI   :   Authority and Format Identifier

API   :   Application Programe Interface

ARP   :   Address Resolution Protocol

ATM   :   Asynchronous Transfer Mode

BER   :   Bit Error Rate

BECN :   Backward Explicit Congestion Notification

BER   :   Bit Error Rate

BOM   :   Beginning of Message

BUS   :   Broadcast and Unknown Server

BW   :   Bandwidth

B-ISDN :   Broadband Integrated Services Digital Network

CBR   :   Constant Bit Rate

CCITT :   Consultative Commitee on International Telephone and

               Telegraphy

CCS   :   Common Channel Signalling

CDV   :   Cell Delay Variation

CLP   :   Cell Loss Priority

CLS   :   Connectionless Service

CMIP   :   Common Management Interface Protocol

COM	:	Continuation of Message
CO	:	Connection Oriented.
CPCS	:	Common Part Convergence Sublayer
CRC	:	Cyclic Redundancy Check
CS	:	Convergence Sublayer
DA	:	Destination Address
DCC	:	Data Country Code
DCE	:	Data Communication Equipment
DES	:	Destination End Station
EOM	:	End of Message
FDDI	:	Fiber Distributed Data Interface
GFC	:	Generic Flow Control
IETF	:	Internet Engineering Task Force.
IP	:	Internet Protocol
ITU	:	International Telecommunications Union
LAN	:	Local Area Network
LANE	:	LANE Emulation
LECS	:	LAN Emulation Configuration Server
LEC	:	LAN Emulation Client
LES	:	LAN Emulation Server
LI	:	Length Indicator
LIS	:	Logical IP Subnet
LLC	:	Logical Link Control
MAC	:	Media Access Control

NMS	:	Network Management System
NNI	:	Network to Node Interface
OSPF	:	Open Shortest Path First
OUI	:	Organizationally Unique Identifier
PDU	:	Protocol Data Unit
P-NNI	:	Private Network to Node Interface
PVC	:	Permanent Virtual Connection
RFC	:	Request for Comments
SAR	:	Segmentation and Reassembly
SDU	:	Service Data Unit
SAP	:	Service Access Point
SONET	:	Synchronous Optical Network
SNAP	:	Subnetwork Attachement Point
TCP	:	Transmission Control Protocol
UNI	:	User Network Interface
UTP	:	Unshielded Twisted Pair
VBR	:	Variable Bit Rate
VC	:	Virtual Circuit
VCI	:	Virtual Channel Identifier
VPI	:	Virtual Path Identifier
VLAN	:	Virtual Local Area Network
VPT	:	Virtual Path Terminator
WAN	:	Wide Area Network

Abstract of the thesis submitted to the Senate of Universiti Pertanian Malaysia in fulfillment of the requirements for the degree of Master of Science

CELL UTILIZATION EFFICIENCY OF INTERNET PROTOCOL TRAFFIC OVER ASYNCHRONOUS TRANSFER MODE NETWORKS

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In the near future, large computer networks will be connection oriented, with at least the data link connectivity being provided by the Asynchronous Transfer Mode (ATM) networks. However, these networks may have to communicate with the existing network which predominantly use Internet Protocol (IP). Running Internet Protocol over Asynchronous Transfer Mode Network has been a contentious issue due to the inefficient segmentation of Internet Protocol packets into Asynchronous Transfer Mode (ATM) cells. In this thesis, the current protocols and standards pertaining to Internet Protocol over Asynchronous Transfer Mode are discussed and overheads involved in placing Internet Protocol packets into Asynchronous Transfer Mode cells, taking Logical Link Control/Sub Network Attachment Point Encapsulation into consideration, are analysed to find out the cell utilization of Asynchronous Transfer Mode cell in carrying the Internet Protocol packets. The Wide Area Network (WAN) oriented traffic for our analysis is collected from the Internet Traffic Archive.

Analysis of the trace results show that the Asynchronous Transfer Mode cell utilisation is better in carrying the user information if the Internet Protocol packet are sizes larger. It is observed that ranges of Internet Protocol packets require similar number of Asynchronous Transfer Mode cells. At small values of Internet Protocol packets, the efficiency of Asynchronous Transfer Mode cell in carrying the user information is significantly low due to the Logical Link Control Encapsulation , padding and the trailer overheads. The Asynchronous Transfer Mode Cell utilization is better in Virtual Circuit (VC) based multiplexing, saving 8 bytes of encapsulation for each packet, thus improving the Asynchronous Transfer Mode (ATM) cell utilization marginally. It is seen that 80% of the Internet Protocol packet length varies from 64 to 200 bytes for which cell utilisation varies from 60% to 82 %. However, the average cell utilisation is 84% in the 20,000 packets observed since 20% of the Internet Protocol packet length is greater than 1000 bytes.

Although multiplexing function of Asynchronous Transfer Mode Adaptation Layer 3/4 could support 2^{10} protocols and thus avoiding 8 byte encapsulation, it is observed that Internet Protocol packets need smaller number of Asynchronous Transfer Mode cells when Asynchronous Tranfer Mode Adaptation Layer 5 is used.

The minimum packet length observed in the trace is 64 bytes of Internet Protocol packet with cell utilization of 60.3 % and the maximum IP packet size is 1518, achieving a cell utilization of 89.5 % It is observed that more than 50 % of network traffic packets is smaller than 512 bytes . It is concluded that a combination of connection-oriented and connectionless approach with RSVP (Resource Reservation Protocol) may be well suited for Internet Protocol over Asynchronous Transfer Mode networks.

Abstrak tesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia untuk memenuhi keperluan Ijazah Master Sains

KEBERKESANAN PENGGUNAAN SEL TRAFIK PROTOKOL INTERNET DI ATAS RANGKAIAN MOD PEMINDAHAN TAK SEGERAK (ATM)

Oleh

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Pada masa akan datang kebanyakan rangkaian komputer akan berorientasikan sambungan, dengan sekurang-kurangnya sambungan pautan data adalah berasaskan rangkaian Mod Pemindahan tak Segerak. Namun begitu rangkaian ini perlulah mampu berhubung dengan rangkaian konvensional yang menggunakan Protokol Internet (IP). Penggunaan protokol internet di atas Mod Pemindahan tak Segerak telah menimbulkan kontroversi disebabkan ketidakcekapan segmentasi paket Protokol Internet ke dalam sel Mod Pemindahan tak Segerak. Di dalam tesis ini, protokol dan piawaian berkaitan penggunaan Protokol Internet pada Mod Pemindahan tak Segerak yang digunakan sekarang dikaji semula dan kerja yang terlibat untuk meletakkan paket Protokol Internet ke dalam sel Mod Pemindahan tak Segerak dengan mengambil kira Pengawalan Pautan Logik/Titik Penyambungan Sub Rangkaian (LLC/SNAP) dianalisis untuk mencari tahap penggunaan sel Mod Pemindahan tak Segerak dalam membawa paket Protokol Internet. Trafik berorientasikan Rangkaian Kawasan Luas

yang digunakan untuk pengaualisisan adalah diperolehi dari Arkib Trafik Internet.

Analisis tersebut menunjukkan bahawa penggunaan sel Mod Pemindahan tak Segerak adalah lebih baik dalam membawa informasi pengguna sekiranya saiz paket Protokol Internet adalah lebih besar. Juga diperhatikan dalam sesuatu julat saiz paket Protokol Internet (IP) memerlukan bilangan sel Mod Pemindahan tak Segerak yang serupa . Pada nilai paket Protokol Internet yang rendah, keberkesanan Mod Pemindahan tak Segerak untuk membawa informasi pengguna adalah agak rendah disebabkan oleh kerja pengkapsulan Pengawalan Pautan Logik/Titik Penyambungan Sub Rangkaian (LLC/SNAP), penebalan dan pengekoran. Penggunaan sel Mod Pemindahan tak Segerak adalah lebih baik dalam Litar Maya (VC) berasaskan Pemultipleksan, dengan menjimatkan 8 bait pengkapsulan untuk setiap paket, seterusnya mencekapkan penggunaan sel Mod Pemindahan tak Segerak. Adalah diperhatikan bahawa 80% daripada panjang paket Protokol Internet berubah 64 ke 200 bait yang mana penggunaan sel berubah dari 60% ke 82%. Walau bagaimanapun adalah diperhatikan penggunaan sel purata adalah 84% dalam 20,000 paket yang dikaji kerana 20% dari pada panjang paket Protokol Internet adalah lebih besar dari 1000 bait.

Walaupun fungsi multipleks Mod Pemindahan tak Segerak Lapisan Penyesuai 3/4 menyokong 2^{10} protokol dengan mengelakkan pengkapsulan 8 bait, adalah diperhatikan bahawa paket Protokol Internet memerlukan sel Mod Pemindahan tak Segerak yang kurang apabila Mod

Pemindahan tak Segerak Lapisan Penyesuai 5 digunakan. Saiz minimum paket yang dilihat ialah 64 bait paket Protokol Internet dengan penggunaan sel 60.3% dan saiz maksimum ialah 1518, dengan penggunaan sel 89.5 %. Juga diperhatikan lebih dari 50 % paket trafik rangkaian mempunyai saiz 512 bait. Maka boleh dibuat kesimpulan di sini bahawa gabungan pendekatan berorientasikan sambungan dan tanpa sambungan dengan Protokol Penempahan Sumber (RSVP) mungkin lebih sesuai untuk penggunaan Protokol Internet pada rangkaian Mod Pemindahan tak Segerak.

CHAPTER I

INTRODUCTION

The world of electronic communication currently has three fundamental different information infrastructures namely, the telephone network for voice communication, the cable television and broadcasting system for video and packet switching technologies for computer networking. The three separate information infrastructures are all moving from analog technology to digital technology for transmission and multiplexing. At some point in future, it will be desirable for these separate information infrastructures to merge so that same network can be used to carry any type of information. Asynchronous Transfer Mode (ATM) technology is a step in the direction of allowing the three information infrastructures to merge. It is a technology that is designed to meet the needs of heterogeneous, high speed networking. ATM employs mechanisms that can be used to set up virtual circuits between users, in which pair of communicating users appear to have a dedicated circuit between them. The result of ATM technology is to provide users with the advantage of circuit switching in that the network can guarantee a certain transmission capacity and level of service between two users. Each user can request the network bandwidth and the high transmission facilities can be shared among all users.

This thesis is concerned with issues in implementing IP over ATM and to evaluate the cell utilization efficiency in IP transport over ATM Network. Cell

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Utilization of ATM cell varies while carrying the IP packet. In particular, the overheads involved due to encapsulation techniques is analyzed.

Background of the Problem

The goal of Broadband Integrated Services Data Network (B-ISDN) is to provide a unique way of transmitting voice, data, and video traffic on a common backbone network. A B-ISDN standard should permit independently designed networks to be interconnected easily. The intense research, experimentation, and standardization efforts resulted in the formulation of the concept of B-ISDN and the acceptance of Asynchronous Transfer Mode (ATM) as a worldwide standard for public wide area networks. While the basic decisions have been made, a large number of problems remain to be solved.

One of the most important and difficult problems in ATM is the implementation of IP (Internet Protocol) over ATM Networks. It is expected that in the near future, large computer networks will be connection-oriented, with at least data link connectivity being provided by the Asynchronous Transfer Mode (ATM). These networks will need to communicate with the existing networks. The worlds largest computer network, the Internet, with millions of computers, uses the connectionless Internet Protocol (IP). For the huge existing investment in IP networks to remain useful, we must device mechanisms to carry IP traffic over ATM Networks.

A unique size for the information that are going to carry broadband traffic and satisfy the requirements for all traffic types is very difficult to determine. There are number of constraints to be considered including, the impact of delay on voice traffic, network delay, processing requirements for header information and transmission efficiency. In particular when an IP traffic is carried over ATM, these constraints are contradictory and some of them point towards a desire for big cells and some towards small cells. Variation in packet size can significantly affect the achieved efficiency, an observation that is especially true for the small IP packets.

Motivation

One of the major justifications for carrying IP traffic over ATM, instead of scrapping Internet Protocol in favour of data transport directly over ATM is that in the Internet Protocol, there is a great deal of experience in designing and building general purpose distributed systems. These systems and semantics of the IP based transport have grown up together and it would be a non-trivial task to adapt distributed applications to the semantics of an ATM based transport . In addition, the global Internet will be a heterogeneous environment for a long time to come and it is the function of IP to hide this heterogeneity from the transport and application layer.

Further, strengthening the case for successfully mapping IP onto ATM is that it also seems clear that ATM is going to provide the fast, inexpensive and scaleable Local Area Network (LAN) technology in the future. It is already the case that

ATM interface cards are less expensive than FDDI interfaces and the cost of ATM is dropping down.

The possibility of using ATM to provide high bandwidth connectivity for sections of Internet has been an area of intense research. An attractive scenario is that ATM virtual connections will replace current long haul Internet Protocol (IP) links, with IP over ATM extending closer to the desk top as ATM itself evolves and expands. The Internet Engineering Task Force (IETF) has been studying the issue of using ATM links to support IP- discussing issues such as Packet encapsulation, signaling and address resolution. However, using ATM has been a contentious issue within the LAN industry. Concerns have been raised over the "inefficient" segmentation of LAN packets. Motivated by this, an attempt has been made to evaluate the relationship between certain LAN traffic types and the resulting ATM traffic. The ' live' IP traffic from an IP based LAN to estimate the likely cell traffic and utilization in a ATM Network using AAL5 was also examined.

Problem Definition

Every link layer technology has limits on the maximum Protocol Data Unit (PDU) size they will support. Ethernet can support 1,500 byte IP packets. IEEE 802.3 using an IEEE 802.2 connectionless mode LLC can support 1,492 byte IP packets. This size must be known by the IP layer so that it can fragment over sized IP packets into suitably sized chunks. The value is known as the Maximum

Transmission Unit (MTU) for a given subnet.

routers, the router will fragment packets that are too large for new subnet.

AAL 5 can support AAL_SDU up to 64 Kilobytes long.

transmitting such a large IP packets may be significant if the packet will eventually

leave the B-ISDN and travel even part of their way across links with smaller

MTUs. With this in mind, the Network Working Group has produced a new

document called " Default IP MTU for use over AAL 5" .

all IP over ATM nodes must support is to be 9,180 bytes.

The goal of RFC 1483 is to develop a standard for carrying multiple protocols,

of which IP is one.

multiple protocols.

creation of virtual channel is possible.

to open up virtual connection for its own use. However, situation arise where it is

not possible to create virtual connection fast or simply due to scarce resources. In

this situation, IEEE 802.3

multiplex different protocols onto single AAL5 connection.

Efficiency may be defined as the average fraction of the 53 bytes ATM cells

that are actually used to carry user data (IP packet) .

last cell will carry padding (wasted bandwidth) added to ensure that CPCS_PDU

is multiple of 53 bytes. Thus segmentation of packets into fixed sized cells does

lead to potentially inefficient use of bandwidth.