UNIVERSITI PUTRA MALAYSIA

A PERFORMANCE STUDY OF ATM MULTICAST SWITCH WITH DIFFERENT TRAFFICS

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By

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Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Computer Science and Information Technology Universiti Putra Malaysia

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This thesis is dedicated to my husband Hazaruddin and

my children Hafiz Aiman and Nur Hanis.

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LIST OF ABBREVIATIONS

ATM	-	Asynchronous Transfer Mode
BBN	-	Broadcast Banyan Network
BGT	-	Broadcast and Group Translators
BISDN	-	Broadband Integrated Services Digital Network
CCITT	-	International Telegraph and Telephone Consultative Committee
CN	-	Copy Network
DAE	-	Dummy Address Encoder
EDD	-	Earliest Due Date
FCFS	-	First Come First Serve
FDM	-	Frequency Division Multiplexing
FIFO	-	First In First Out
FIRO	-	First In Random Out
FIFO-BL	-	First In First Out with Ordinary Blocking
GFC	-	Generic Flow Control
HOL	-	Head Of Line
HOL-PJ	-	Head Of Line with Priority Jumps
ITU-T	-	International Telecommunication Union-Telecommunications
LCN	-	Logical Channel Number
LIFO-PO	-	Last In First Out with Pushout
LQFS	-	Largest Queue First Serve
NNI	-	Network Node Interface

QOS	-	Quality Of Service
RAN	-	Running Adder Network
RN	-	Routing Network
RND	-	Random
STM	-	Synchronous Transfer Mode
TNT	-	Trunk Number Translator
UNI	-	User Network Interface
VPC	-	Virtual Path Connection
VPI	-	Virtual Path Identifier

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science.

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March 1999

Chairman: **Associate Professor Ashwani Kumar Ramani, Ph.D.**

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The demand of multicast service in ATM network such as video teleconferencing, broadband telephony and large file transfer makes the multicast switch very important. The multicast switch is needed to multicast an input cell to a number of selected output or broadcast it to all outputs. Since the cell loss and delay will decrease the performance of an ATM multicast switch, it should be designed so that the degradation is minimised. Hence, to improve the performance, which is characterised by cell loss probability and mean cell delay, this thesis proposes a new architecture of a multicast switch.

In this thesis, the traffic is classified into three categories with different requirements: real-time, near real-time and non real-time. Since the real-time cell is very sensitive to delay, it is given the first priority to be served. Near real-time cell can tolerate a small delay while the non real-time cell is less sensitive to

delay. Hence, the arriving cells of those traffic can be buffered to wait their turn to be transmitted. Two buffering schemes which respectively realise the buffer of near real-time and non real-time cell are implemented: *First In First Out with Ordinary Blocking* (FIFO-BL) and *First In First Out* (FIFO). To achieve a better performance, *Largest Queue First Serve* (LQFS) as a scheduling algorithm is implemented.

The proposed architecture with the above buffering schemes and traffic classes is studied by developing appropriate simulation models. Subsequently, the effect of arrival rate, immediate rate, requested copy number, buffer size and RealTC rate on the switch performance are studied quantitatively and qualitatively. It is concluded that the proposed architecture can support the future different multimedia traffic types, where cell loss probability and delay requirement will be the main factors.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
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KAJIAN TERHADAP PRESTASI SUIS 'MULTICAST' ATM DENGAN PELBAGAI TRAFIK

Oleh

HAMIRUL'AINI BT. HAMBALI

Mac 1999

Pengerusi: **Profesor Madya Ashwani Kumar Ramani, Ph.D.**

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Permintaan terhadap perkhidmatan 'multicast' di dalam rangkaian ATM seperti telesidang video, 'broadband telephony' and penghantaran fail besar menjadikan suis 'multicast' amat penting. Suis 'multicast' diperlukan untuk 'multicast' sel input ke beberapa output yang terpilih atau 'broadcast' ke semua output. Disebabkan kehilangan dan kelambatan sel akan mengurangkan prestasi suis 'multicast' ATM, maka ia perlu direkabentuk supaya pengurangan prestasi dapat diminimumkan. Oleh itu, untuk memperbaiki prestasi yang diwakili oleh kebarangkalian sel hilang dan purata sel lambat, tesis ini telah mencadangkan rekabentuk suis 'multicast' yang baru.

Dalam tesis ini, trafik telah dikelaskan kepada tiga kategori dengan keperluan yang berlainan: masa nyata, hampir masa nyata dan bukan masa nyata. Disebabkan sel masa nyata terlalu sensitif terhadap kelambatan, maka ia diberikan

keutamaan untuk dilayan. Sel hampir masa nyata boleh bertolak ansur dengan sedikit kelambatan manakala sel bukan masa nyata kurang sensitif dengan kelambatan. Maka, sel yang datang dari kedua-dua trafik boleh disimpan untuk menunggu giliran mereka sampai untuk dilayan. Dua skim simpanan yang mana masing-masing mengenal pasti sel hampir masa nyata dan sel bukan masa nyata telah dilaksanakan: *First In First Out with Ordinary Blocking* (FIFO-BL) and *First In First Out* (FIFO). Untuk mencapai prestasi yang lebih baik, algoritma penjadualan, *Largest Queue First Serve* (LQFS) juga telah dilaksanakan.

Rekabentuk yang dicadangkan dengan skim dan kelas trafik di atas telah dikaji melalui pembangunan model simulasi. Berikutnya, kesan perubahan 'arrival rate', 'immediate rate', 'requested copy number', 'buffer size' dan 'RealTC rate' ke atas prestasi suis bagi ketiga-tiga trafik telah dikaji secara kuantitatif dan kualitatif. Ia dapat disimpulkan bahawa, rekabentuk yang telah dicadangkan boleh menyokong pelbagai trafik multimedia masa akan datang di mana keperluan kebarangkalian sel hilang dan purata sel lambat akan menjadi faktor yang utama.

CHAPTER I

INTRODUCTION

In the past few years, ATM or Asynchronous Transfer Mode has come out as a leading technique for high-speed networks. ATM has been accepted as a transport mechanism in Broadband Integrated Services Digital Network (BISDN) and it is a technology, which allows for the transmission of data, voice and video traffic simultaneously over high bandwidth circuits. At the start of 1992, BISDN and ATM became a headline story in all the specialist papers (Kyas, 1995). To know how did they come to take such a dominant position in the world of data communication, the next subsection will discuss on these two technologies.

Broadband Integrated Services Digital Network (BISDN)

BISDN is the next generation of ISDN. Broadband refers to telecommunication that provides multiple channels of data over a single communications medium using frequency division multiplexing (FDM). BISDN is a communication architecture that is being designed to carry the traffic generated by a wide range of services and capable to support multimedia application. The demand for this Broadband ISDN has been recognised, as people want to send voice, data and video through a single physical network quickly and cheaply.

With BISDN today, all the services like sound broadcast, television, video conferencing, video telephone, electronic mail, text facsimile and mobile telephone can be provided over the same network without any degradation to the quality of service.

Asynchronous Transfer Mode (ATM)

The formal international standards body called the International Telecommunication Union – Telecommunications (ITU-T) or formerly called the International Telegraph and Telephone Consultative Committee (CCITT) had chosen the Asynchronous Transfer Mode technology as the communications standard for BISDN. ATM can be used for both local area and wide area networks. The word 'asynchronous' shows that there is no relationship exists between the applications and the network clock. In other words it refers to the untimed relationship between the sender and the receiver. The time between two consecutive cells is only dependent on the information rate of the source. The term 'transfer' comprises both transmission and switching aspects and 'transfer mode' has been defined as the main technique or a specific way of transmitting, multiplexing, switching and receiving information in a network.

Ten years ago, there were major disagreements on the most appropriate transfer mode for BISDN. Many assume that the Synchronous Transfer Mode (STM) to be the appropriate transfer mode. However ITU-T Recommendation designates ATM as the target transfer mode solution for implementing a BISDN. The section Asynchronous versus Synchronous Transfer Mode will present the limitations of STM and the flexibility of ATM so that the differences can be appreciated.

Asynchronous versus Synchronous Transfer Mode

With the 'asynchronous' technology as a transfer mode, ATM or sometimes called unchannelized physical network is able to send only the data associated with a connection when there are actual live data to send. This is contrast to 'synchronous' (channelized) networks where even if a channel is idle, a special bit pattern must be sent in every time slot representing the channel. It means if a channel is not transmitting data, the time slot remains reserved and is still transmitting without any useful payload. Those different transmission methods are shown in Figure 1.

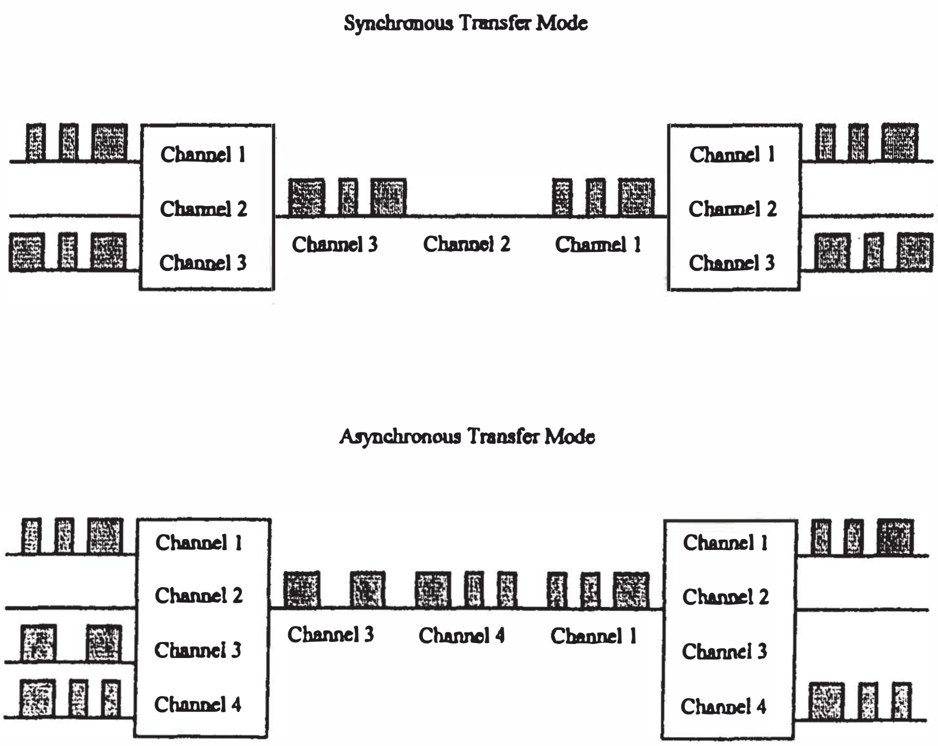

Figure 1: STM and ATM Principles

STM was once a new paradigm but the suitability of the paradigm for BISDN was first questioned about its flexibility in meeting the needs of the future. As mentioned before, BISDN needs to support a different class of services such as data, video and voice. However, the STM technology has little flexibility in its channel when it used to carry a dynamically changing mix of services at a variety of fixed channel rates. It only bests when supports the fixed-rate services. With the synchronous multiplexing techniques, STM also gives every subscriber a specific transmission bandwidth irrespective of how much is actually required, and this can be very inefficient for data transfer. ATM attempts to eliminate these situations. ATM networks, using the multiplexing technology can allocate the available bandwidth in a flexible way according to the different types of traffic whether it is voice, data or video. It also permits all resources to be used by any service such as applications with highly varying bit rates, real-time applications and fixed bit rates.

In comparison to STM equipment, ATM multiplexers and switches are less dependent on considerations of bit rates for particular services. Those of ATM equipment can flexibly support a wide variety of services (Minzer, 1989).

ATM is capable to support a diversity of traffic like data, voice and video for different application requirement on delay and loss performance. It is a packet-oriented switching and multiplexing technique, which allows multiple logical connections to be multiplexed over a single physical interface. The 'multiplexing' technique made ATM possible to carry several separate data streams independently over one and the same physical medium. ATM is also a cell-based technology. This means the information flow of each logical connection from a particular user is assembled into fixed-size packets, called cells. In short, a cell is a primary or a basic unit of data transfer in ATM. The fixed-size packets are chosen to ensure that the switching function can be carried out quickly and easily. This cell and its structure will be described in the next section.

ATM Cell

The ATM cell is defined to be of size 53 bytes. The selection of a short fixed length cell can simplify the design of an ATM switch at the high switching speeds involved. It also reduces the delay most significantly the jitter (variances of delay) for delay sensitive such as voice and video. The 53 bytes ATM cell consists of 5 bytes header field, which is used for routing header and a 48 bytes information of payload field, which is for carrying data. All cells are routed to their various destination by ATM switches or cross-connect that is connected to ATM networks. The cell structure is shown in Figure 2. The cell is also known as a universal carrier of data in which we can put data, video or voice in it.

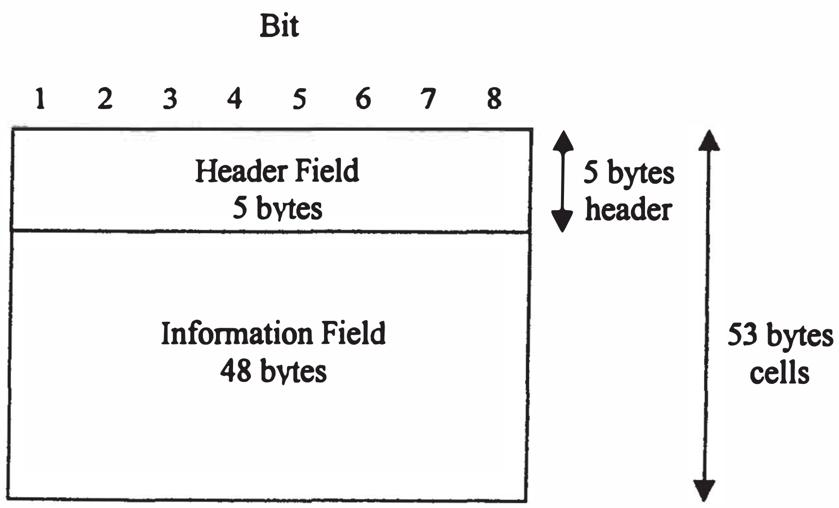

Figure 2: ATM Cell Format

The ATM cell header has the important role that is to identify cells belonging to the various virtual connections. It will be transmitted first, followed by the information field. The size of ATM cell header is 5 bytes but there is a different architecture between the User Network Interface (UNI) and the Network Node Interface (NNI) as shown in Figure 3 (a) and Figure 3 (b), respectively. The differences are the bits allocated to the Generic Flow Control (GFC) field of the cell header at the UNI and the Virtual Path Identifier (VPI) at both UNI and NNI. The UNI is the boundary between customer premises and the ATM network. While the NNI is the point of connection for the access link in the ATM network. The VPI field at the UNI consists of 8 bits but the same field at the NNI is expanded to 12 bits because the GFC field is not allocated here. The expansion of VPI at the UNI allows support for an expanded number of Virtual Path Connections (VPCs).

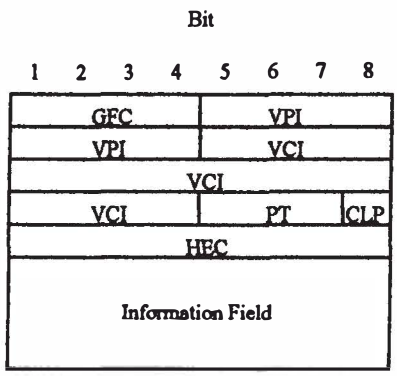

Figure 3 (a): User Network Interface

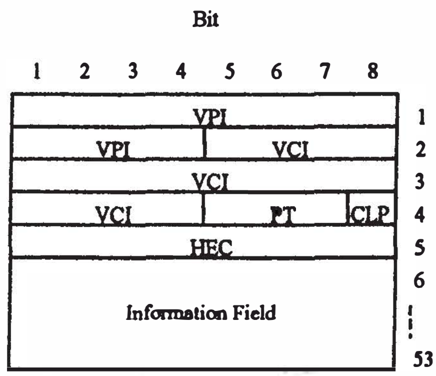

Figure 3 (b): Network Node Interface

The ATM payload, which is 48 bytes long containing data is transported from sender to receiver with no corrective or protective action by the network. Besides of the ATM cells, ATM connections are also an important point in ATM networking. For this reason, the next section will present these connections.

ATM Connections

In ATM networks, there are no physical channels to distinguish the traffic that still must be identified as voice, video or data. This identification is used to preserve the required quality of service (QOS) parameters for each separate service. To do this function, ATM setting up a logical connections between end users. Connections can be point-to-point or point-to-multipoint. ATM connections always guarantee delivery of cells in sequence (Boudec, 1992). These logical connections are established by two-part identifier structure, those are Virtual Channel (VC) and Virtual Path (VP). Each virtual path identifies a group of virtual channels. Figure 4 illustrates these logical connections and Figure 5 shows the relationship of VCs, VPs and transmission path.

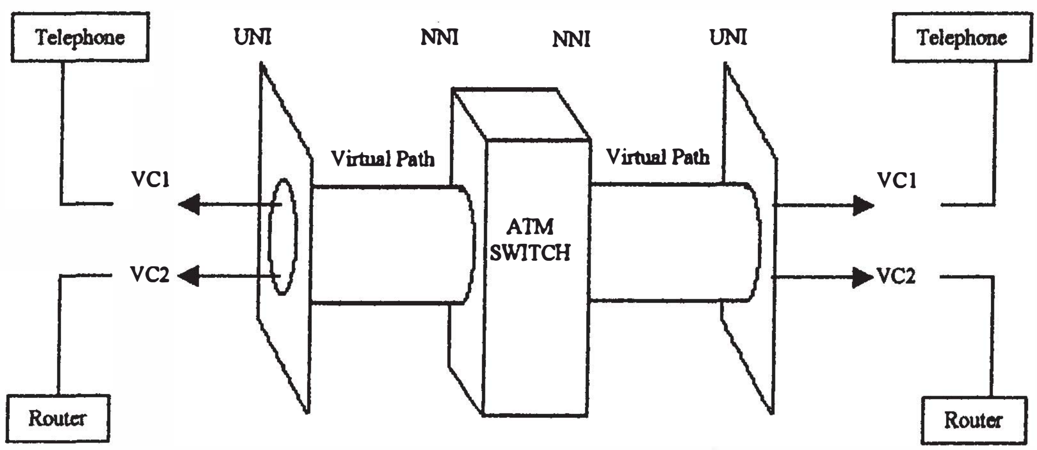

Figure 4: ATM Logical Connections

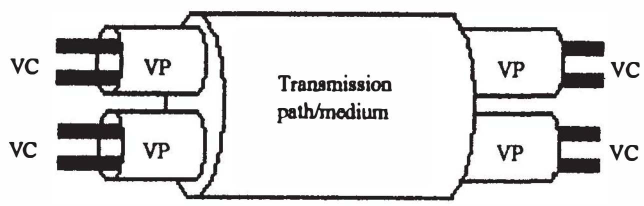

Figure 5: Relationship between Virtual Channel, Virtual Path and Transmission Path.

The Virtual Channel (VC)

Virtual Channel, a basic unit of switching in BISDN, is a logical unidirectional transport of ATM cells between the end/switching points of a link within a particular physical transmission path/medium. Virtual Channels are used for user-network exchange (network management and routing). They are associated by a common unique identifier value, Virtual Channel Identifier (VCI).

The Virtual Path (VP)

Virtual Path is a logical association or bundle of ATM Virtual Channel and each path is identified by Virtual Path Identifier (VPI). These VPs are switched together as a unit. The ATM cells within a particular VC are identified by a particular combination of VCI and VPI. This cell will flow along the transmission path in an ATM network as shown in Figure 5 above.

Routing in ATM network and the determination of how to forward the cell are perfonned by ATM switch. The next section will discuss on the ATM switch.

ATM Switch

The use of switches is an effective technique to increase the performance of the network. An ATM switch contains a set of input ports and output ports and it is a connection oriented. A general architecture of an ATM switch is shown in Figure 6. Input Module (IM) and Output Module (OM) are present at the input and output ports of the switch, respectively. The IM is responsible for recovering