Performance Evaluation of ATM Switch Structures with AAL Type 2 Switching Capability

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Abstract—In this paper, we propose ATM switch structure including AAL type 2 switch which can efficiently transmit low-bit rate data, even if the network has many endpoints. We simulate the architecture of ATM switch fabric that is modeled in computer program and analyze the performance according to offered loads. ATM switch proposed in this paper can support cell switching for all types of AAL cells which consist of AAL type 1, AAL type 2, AAL type 3/4, and AAL type 5 cells. We propose two switch fabric methods; One supports the AAL type 2 cell processing per input port, the other global AAL type 2 cell processing for every input port. The simulation results show that the latter is superior to the former. But the former has a strong point for easy implementation and extensibility. The proposed ATM switch fabric architecture is applicable to mobile communication, narrow band services over ATM network.

Index Terms—ATM, AAL Type 2, ATM Switch Fabric

I. INTRODUCTION

ATM(Asynchronous Transfer Mode) is expected to be applied to the IMT-2000(next generation multimedia mobile communication system), which will transmit various traffics such as data, video, voice and so on[1].

ATM technology has an effectiveness in usage of network resources and support of various services. However, conventional AAL types are inefficient in the services supporting low bit-rate packet with short and variable length.

The AAL type 2 provides for the bandwidth-efficient transmission of low bit-rate, short, and variable length packets in delay-sensitive applications[2][3].

Therefore, AAL type 2 is expected to be widely applicable in not only the support of the Wireless ATM (WATM) but also the support of narrow band service through the ATM networks or satellites[4].

AAL type 2 uses ATM cell effectively by multiplexing the AAL 2 channels in a VCC (Virtual Channel Connection).

Therefore, switching of the AAL type 2 CPS Packets within ATM cell payload is needed to manipulate in the method different from that of the previous ATM cell switch.

In this paper, we propose a structure of ATM switch including the AAL type 2 switch and analyze the performance through the computer simulation.

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II. AAL TYPE 2

A. Structure of AAL type 2

The AAL type 2 is subdivided into the Common Part Sublayer(CPS) and the Service Specific Convergence Sublayer(SSCS).

AAL type 2 CPS provides the capabilities to transfer CPS-SDUs from one CPS user to one other CPS user through an ATM network. It provides CPS-SDU data transmission. It multiplexes and demultiplexes the various AAL type 2 channels and preserves the CPS-SDU order in each AAL type 2 channel. However, damaged CPS-SDU can not be retrieved by the re-transmission. Different SSCS protocols may be defined to support specific AAL type 2 user services, or groups of services. The ATM trunking using AAL type 2 for narrowband services offers bandwidth savings.

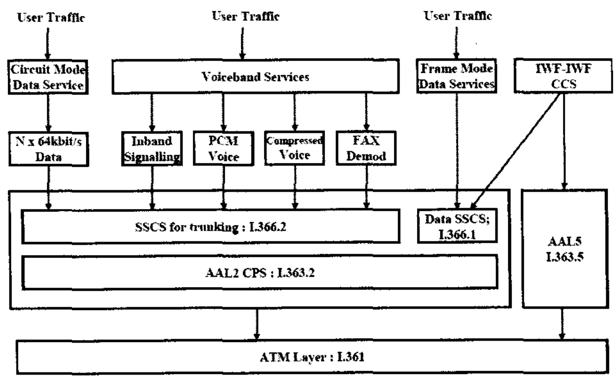

Fig. 1 ATM Protocols that support the services.

Effective transmission of the following data can be provided through the AAL type 2 protocol [5][6][7].

- Voice band data through modem detection.
- Fax data through demodulation and remodulation.
- circuit mode data for Nx64kbps channel.

- DTMF(Dual Tone Multi-Frequency) information through the DTMF packets.
- Frame mode data through SAR functionality.

B. Format and assembly of AAL type 2 CPS-PDU

Following describes the format of CPS-Packet and process in which CPS-Packet is packed into the AAL type 2 CPS PDU. A CPS-Packet is composed of 3-octet CPS-Packet Header (CPS-PH) followed by a CPS-Packet Payloads (CPS-PP). The Format of CPS-Packet is shown in figure 2. CID (Channel Identifier) value identifies the AAL type 2 CPS user of the channel. The value '8'..'255' are used to identify the users of the AAL type 2 CPS.

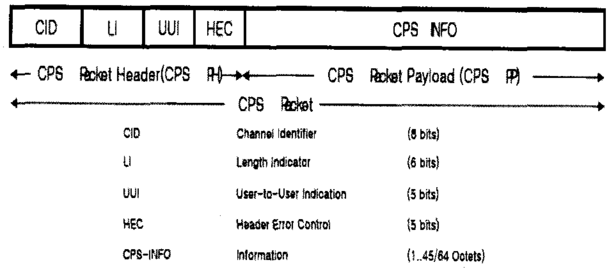

Fig. 2 Format of AAL Type 2 CPS-Packet

LI(Length Indicator) field is binary encoded with a value that one less than the number of octets in the CPS-Packet Payload and 6-bit wide. The CPS-PDU consists of an octet STF(Start Field) and 47-octet payload. The CPS-PDU payload may carry zero, one or more(complete or partial) CPS-Packets. The 48-octet CPS-PDU is the ATM-SDU. The size and positions of the fields of the CPS-PDU are shown in figure 3.

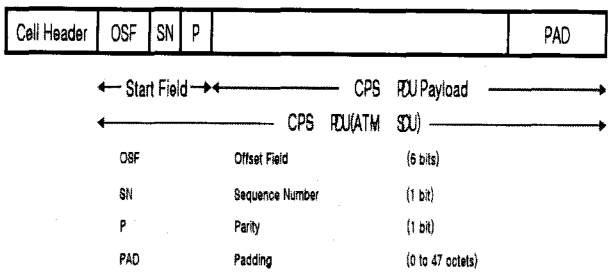

Fig. 3 Format of CPS-PDU

C. AAL type 2 cell switching

CID in the CPS-Packet header enables switching in the ATM network in the same way as the VPI/VCI in the ATM header. AAL type 2 cell is demultiplexed as CPS-Packets in AAL type 2 switch and then the CPS-Packets with the same destination are assigned into a new AAL type 2 cell. Simple routing can be performed in the small-scale network using global CID. To deal with the large-scale network, switching is established in the following process.

1)VPI, VCI in ATM header, and CPS packet are taken out of the AAL type 2 cell.
2)VPI/VCI and CID are converted into a new VPI/VCI and CID.
3) HEC of each CPS packet is generated.
4)CPS packets with the same destination are assigned into a single AAL type 2 cell.
5)If CPS packet is divided into two parts, the value of OSF is calculated.

III. STRUCTURE FOR AAL TYPE 2 SWITCH SYSTEM

AAL type 2 switch proposed in this paper must be able to multiplex into ATM cell after getting AAL type 2 ATM cell from the various ATM connections and extracting the CPS-Packet. AAL type 2 switch is composed of a Header Converter, a Reassembly Controller, a CPS-Packet Cut Buffer, a Reassembly Buffer, a Delay Time Controller and an Output Controller.

Overall structure of AAL type 2 switch is shown in figure 4. If the AAL Type 2 cells arrive, the switch converts not only its VPI/VCI but also its CID and saves the CPS Packets in the AAL Type 2 Cell in the Reassembly Buffer with the same destination. Each entry of the Reassembly Buffer is a new AAL Type 2 cell. CPS-Packet Cut Buffer is used to store the partially received CPS packet. In case ATM cell Payload of reassembly buffer exceeds 47-octet, it signals the output controller and emits AAL type 2 cell from the switch. Then, reassembly buffer setups the STF again and waits for the next CPS-Packet. Delay time controller signals to the output controller in case cell exists when the delay time has expired after entering into the reassembly buffer. Then it adds padding information to the timer-expired partial cell and emits it from the switch.

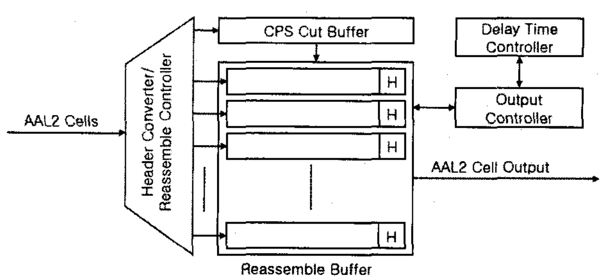

Fig. 4 An example of structure for AAL type 2 switch

IV. PROPOSAL OF ATM SWITCH ARCHITECTURE COMBINED WITH AAL TYPE 2 SWITCH

The overall performance evaluation of this paper is performed using ATM switch of VOQ (Virtual Output

Queue) structure[8][9] and the iSLIP[10][11][12] as the scheduling algorithm.

A. Proposal 1

The reason why a conventional ATM switch can not switch AAL type 2 cell at once is that ATM switch is capable of switching by the value of VPI/VCI but AAL type 2 switch requires switching of the CID value including those two. Thus it can not be located inside the ATM switch.

As figure 5, AAL type 2 switch exists outside the ATM switch and sends the AAL type 2 cells to the ATM switch after completing the switching in AAL type 2 switch. Demultiplexer 1 separates incoming cells into AAL type 2 cells and other AAL cells. It sends other AAL cells to Other AAL Cell Buffer and AAL type 2 cells to the AAL type 2 switch to perform the switching process. Multiplexer 2 gives priority to the cells that have been came out of the AAL type 2 switch. When there exist AAL type 2 cells, it sends AAL type 2 cell to the ATM switch in advance and performs the switching.

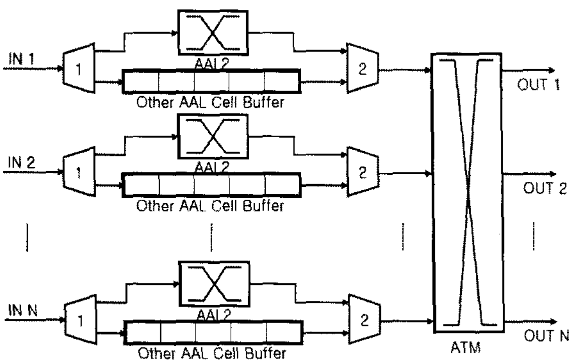

Fig. 5 An ATM switch architecture including AAL type 2 switch(Proposal 1)

B. Proposal 2

In proposal 1, Other AAL Cell Buffer is located in the front stage of VOQ and its cell competes with the AAL type 2 cells from the AAL type 2 switch. After that it is inputted to VOQ. Also AAL type 2 switch takes place in each input port in proposal 1. However, in proposal 2, the incoming cells from each port are distributed by the demultiplexer 1 as figure 6 whether they are the AAL type 2 cells or other AAL cells.

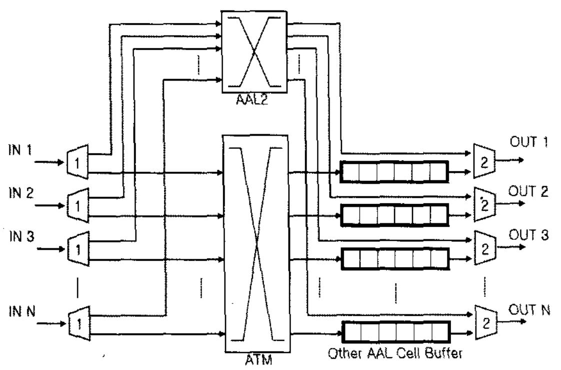

Fig. 6 An ATM switch architecture including AAL type 2 switch(Proposal 2)

After cells are switched by each switch system, they are inputted to the multiplexer of output port. Multiplexer 2 of output port gives priority to the cells that has been out of the AAL type 2 switch and provides the service to the AAL type 2 cells when existing. Other AAL Cell Buffer makes other AAL cell to wait in the output port buffer for a while and get it outputted when AAL type 2 cell does not exist.

V. THE PERFORMANCE ANALYSIS OF THE ATM SWITCHES

A. Computer simulation model

We have simulated the proposed switch models of proposal 1 and 2 mentioned above by using C program. We have acquired the optimal buffer size by increasing the offered load of AAL type 2 cells and checking the cell loss rate and maximum size of the Other AAL Cell buffer. Also We have checked that of AAL type 2 cell in proportion to the increase of Offered Load to compare the performance of proposal 1 and 2.

We have performed the performance evaluation by setting up the 8-port switch, 256 buffers for each destination of VOQ, and 256 Other AAL Cell Buffer size, 256 AAL type 2 reassembly buffer size. We have performed the performance evaluation for each proposal to compare the size of Other AAL Cell Buffer and VOQ buffer. The length of each simulation run is one million cell cycles after 0.1 million cell cycles to achieve steady-state in the switch. The cells inputted to each switch port are generated in random uniform traffic.

B. Performance evaluation for proposal 1

When offered loads of AAL type 2 in ATM switch are inputted as 20, 40, 60, 80, 90, 95%, the performance is shown in figure 7.

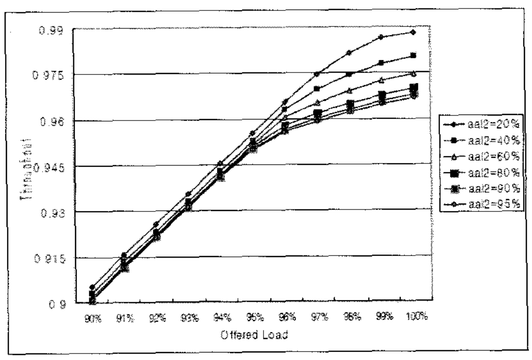

Fig. 7 Throughput of ATM switch according to offered load of AAL type 2(proposal 1)

The cell loss rate for each offered load of ATM switch is shown in figure 8. We can confirm that the cell loss rate of ATM switch increases according to the increase of an offered load for AAL type 2 cell. This informs us that cells inputted to the AAL type 2 switch is less than the cell outputted due to the delay time.

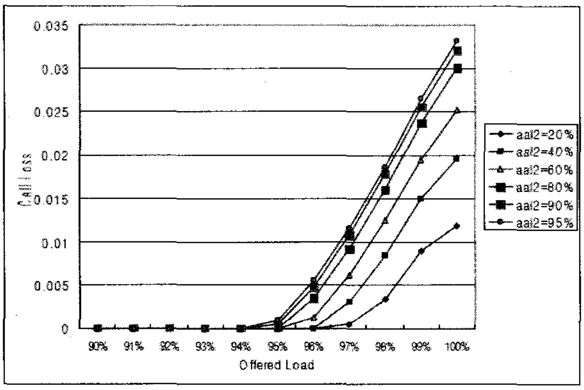

Fig. 8 Cell loss ratio of ATM switch according offered load when load of AAL type 2 cell is changed(proposal 1)

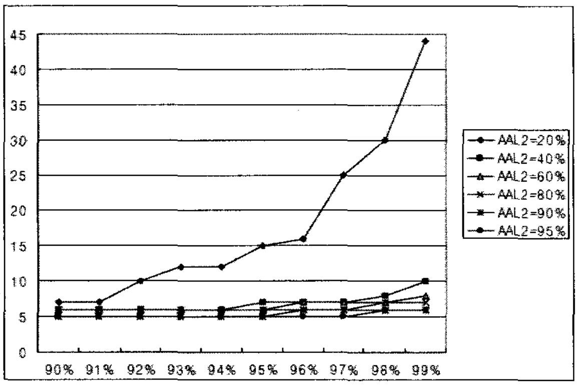

Fig. 9 Maximum buffer sizes of other AAL cell(proposal 1)

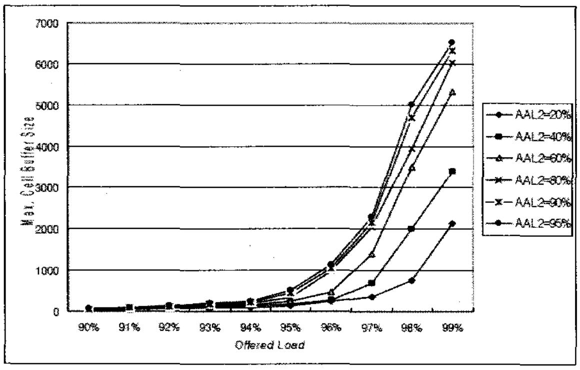

Fig. 10 Maximum sizes of VOQ input buffer(proposal 1)

Figure 9 shows the maximum size of the Other AAL Buffer. It is capable of switching without cell loss even if there exist only 44 buffers except when it reaches 100%. Figure 10 shows the maximum size of VOQ buffer for the ATM switch. It reveals that the buffer size of VOQ increases in accordance with the offered load of AAL type 2 cells and whole ATM cells. The reason is that since AAL type 2 switch exists respectively in each input port, the throughput of the AAL type 2 increases in accordance with the increase of cell emission due to delay time. To solve this matter, delay time should be raised to over 256-cell time, which is previous delay time.

C. Performance evaluation for proposal 2

We have performed the performance evaluation in the same condition as proposal 1. Figure 11 shows the performance when offered loads of AAL type 2 increase. Figure 12 shows the cell loss rate of Other AAL Cell Buffer in output port when other AAL buffer size is 256. Figure 13 shows the maximum size of VOQ input buffer in the ATM switch.

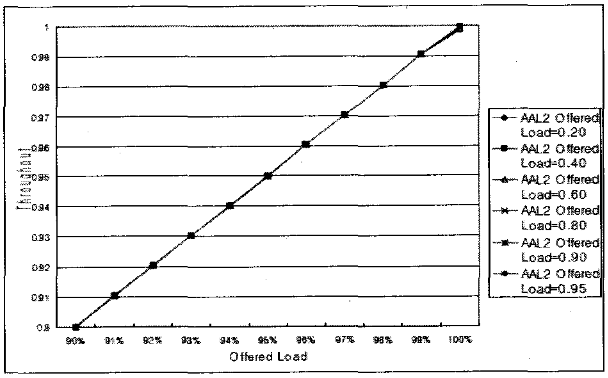

Fig. 11 Throughput of ATM switch according to offered load of AAL type 2(proposal 2)

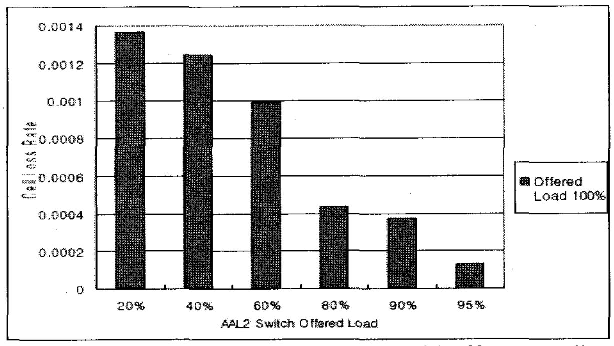

Fig. 12 Cell loss ratio of other AAL cell buffer according offer loads of AAL type 2(proposal 2)

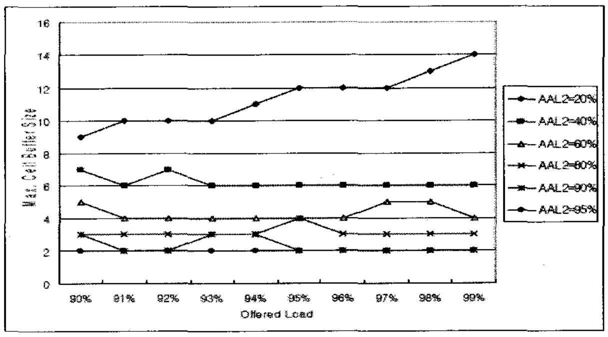

Fig. 13 Maximum sizes of VOQ input buffer(proposal 2)

It reveals that the cell loss of Other AAL Cell Buffer of figure 12 is found only when it reaches 100%. In proposal 2, overload of ATM switch is avoided by not inputting AAL type 2 cell to ATM switch and we can confirm it with ideal Throughput shown in figure 11. It reveals that the buffer utilization decreases when offered load of VOQ input buffer or AAL type 2 cell increases.

D. Comparison of proposal 1 and 2

In proposal 1, We have confirmed that the cell loss of reassembly buffer is not generated by using method which inputs AAL type 2 cells to VOQ by switching it in each input port and also 44 cells are stored in the buffer except when usage of Other AAL Cell buffer reaches 100% through the simulation. However, outcoming cells increase in waiting time since the input ratio to the AAL type 2 switch is lower than proposal 2 due to the location of the port. It eventually causes the increase of Throughput and generates the cell loss by overload of the VOQ input buffer. Also it is revealed that the size of VOQ input buffer increases in accordance with the maximum size of the VOQ input buffer.

In proposal 2, AAL type 2 cell is classified in the input port and undergoes switching process with the AAL type 2 switch. It is then outputted after competing with the other AAL cell. As shown in the simulation result, Since the conventional ATM switch is not responsible for switching of AAL type 2 cells, the cell loss is not generated in the ATM switch. However, proposal 2 has shortcoming that it needs to have output buffer in a larger scale which is the problem of the output buffer method. We can find out, however, that maximum output buffer size is 249 except when the offered load reaches 100%. Other AAL cell loss decreases in accordance with the increase of an offered load for AAL type 2. The reason is that the increase of AAL type 2 cell affects in decrease of Other AAL cell preventing the generation of overload in VOQ.

The size of VOQ input buffer increases in accordance with the increase of Offered Load for AAL type 2 cell in proposal 1 but proposal 2 shows the contrasting result. From this, it is revealed that switching process for the AAL type 2 cell and Other AAL cell respectively has a merit which prevents the overload of ATM switch.

Proposal 1 can also increase throughput by increasing waiting time of the reassembled cell but longer waiting time may cause the obstacles to network.

When the buffer size is set to 256 in simulation, the cell loss is not generated when the offered load of AAL type 2 reaches 94% in proposal 1 and 99% in proposal 2.

Ⅵ. CONCLUSIONS

ATM technology has an effectiveness in usage of network resources and support of various services. However, conventional AAL types are inefficient in the services supporting low bit-rate packet with short and variable length.

The AAL type 2 provides for the bandwidth-efficient transmission of low bit-rate, short, and variable length packets in delay-sensitive applications. However, to support AAL type 2 service, additional process is required compared to that of the conventional ATM switch.

In this paper, We have simulated the AAL type 2 switch models of proposal 1 and 2, analyzed the performance of each model and discussed on two models. Proposal 2 is superior in overall performance but actual performance enhancement is yet trivial. When considering the implementation of the proposals in aspect of hardware, proposal 2 is a lot more complicated than proposal 1. Proposal 1 can be implemented by locating switch in input port and use AAL type 2 switch effectively regardless of the number of the ATM switch.

The proposed ATM switch fabric architecture is widely applicable to mobile communication, narrow band services over ATM network and wireless ATM as well as general ATM switching fabric.

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