Field Trial and Quality Test of ATM Switching System In Korea

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Abstract

This paper describes the characteristics, quality and application of ATM switching system in the Network Testbed which is established to test interoperability between B-ISDN elements. The switching system in the Network Testbed manages connections of PVC type. Test result of the switching system shows cell loss probability of 10^{-10} . The cell loss probability between two terminals that are about 200Km away from each other in the Network Testbed was order of 10^{-9} . The Network Testbed will be upgraded and used until 1998.

Keywords

Quality Test, Network Test-Bed, Throughput, Switching System, Delay, Variation

1 INTRODUCTION

ATM is recommended as the transfer mode for B-ISDN. ATM switching system is one of the core element of B-ISDN. The ATM switching system should have the ability to operate properly under various load conditions. Generally, quality parameters in ATM network are cell loss, cell misinsertion, cell delay and cell delay variation. Therefore, it is required to design systems which fulfill the quality parameters to provide satisfactory services to users. This paper describes the test results of an ATM switching system. Tests are carried out under mixture of various traffic and are summed by quality parameters such as cell interarrival time,

cell delay time and cell loss probability. Also described is the operation of Network Testbed which consists of ATM switching systems, B-NT, B-TA, private ATM switches, and terminals.

2 ATM SWITCHING SYSTEM

The ATM switching system used in Network Testbed is developed for use in public B-ISDN by ETRI since 1992. The system, called TDX-ATM switching system, has the switch size of 256×256 which is reconfigurable into 32×32 , 64×64 or 128×128 according to the traffic. As shown in Figure 1, the system consists of 3 kinds of subsystems: ALS(ATM Local Switching Subsystem), ACS(ATM Central Switching Subsystem) and IWS(IWS:Interworking Subsystem).

Figure 1 TDX-ATM Switching System

The ALS is a subsystem which consists of a single stage self-routing switch, interfaces for various subscribers and other ATM switching system, and a processor for connection and call control. An ALS itself can operate as a small switching system. The architecture of ALS is shown in Figure 2. The switch network of the ALS is 32×32 . Since the link speed of switch is 155.52Mbps, medium(DS3, 45Mbps) or low(DS1E, 2.048Mbps) rate subscribers are multiplexed. The communication between processors in each subsystem is done through the switch network. Thus 32 links of the switch network are used by subscribers, the processor, and the ACS. If the traffic to other ALS is not high, then most of links are allocated for subscriber interfaces and trunk interfaces and only a few links for the connection of ALS and ACS. Thus the switch network in ALS can concentrate input traffic with concentration ratio from 8:7 to 29:2 according to the configuration.

The ASNM(ATM Switch Network Module) is 32×32 folded switch consists of 16×16 switch elements as shown in Figure 3. The 16×16 switch element adopts limited shared buffer type. As shown in Figure 4, each 16×16 switch has many buffers: a common buffer to store cells, 16 cell address buffers to store cell addresses from 16 links, a buffer to store multicasting address, a buffer to store multicasting routes, and a buffer to store usable addresses of the common buffer. The common buffer can store 4,096 cells from 16 links. Each link of 16×16 switch element is transformed serial-to-parallel at the input and parallel-to-serial at the output

to lower the operating speed of the switch.

ACS is a subsystem which connects ALSs and IWSs. The ALS consists of switch network and a processor(OMP) for the operation and management of the switching system. The switch of ACS is the same as that of ALS. The processor(OMP) also communicates through the switch network with other processors. IWS is the subsystem for PSTN subscribers. An IWS has the switching capacity of 1,024 time slots. Hence, an IWS can accommodate 8,192 subscribers if concentration ratio of 8:1 is assumed.

Figure 2 The Structure of ALS(ATM Local Switching Subsystem)

Figure 3 The Structure of ASN

Figure 4 The structure of 16x16 switch

3 TEST OF TDX-ATM SWITCHING SYSTEM

TDX-ATM switching system is tested under various mixture of loads. Tests are carried to find QoS parameters such as cell loss ratio, cell delay and cell interarrival time. In addition to these QoS parameters, we also tested the switch overflow and the stability of the switching system.

3.1 QoS test of TDX-ATM switching system

ATM cells that pass the switch are user cells, signaling cells or OAM cells. User cells may be switched in one stage or 3 stages according as whether the calling subscriber and the called subscriber are accommodated at the same ALS. Several tests are carried for the connection of subscribers of the same ALS or different ALSs. For all of tests, we used test system which can generate traffic and analyze the test result by comparing sent traffic and received traffic.

QoS for the connection of subscribers of the same ALS

The input and output of the test system are connected to the same ALS of the switching system as shown in Figure 5. Two tests are carried out for the connections: first test with CBR load of single channel of 7.488Mbps and second test with load of 100 channels of 1.4976Mbps.

Figure 5 Connection of the test system and TDX-ATM switching system

Test results in Table 1 shows average cell delay time of 53.3 μ s and maximum cell delay variation of 6.1 μ s for one way path. Most of the delay is caused by the switch and the link between subscriber interfaces and the switch. This delay may be said as the fixed delay in the reference^[1]. In case of two way path, cell delay times are doubled approximately as expected.

Table 1 Cell interarrival time and cell delay time
(single 7.488Mbps/100 channels of 1.4976Mbps)

	two way path		one way path	
	(single/100 channels)		(single/100 channels)	
	CTD(μ s)	CIT(μ s)	CIT(μ s)	CTD(μ s)
Minimum	52.6/52.9	53.8/280.2	50.6/280.2	103.1/120.5
Maximum	55.9/55.8	59.9/286.2	62.6/286.1	109.1/121.1
Mean	53.3/54.0	56.62/283.1	56.6/283.1	104.4/120.8

CIT: Cell Interarrival Time

CTD: Cell Transfer Delay

QoS for the connection of subscribers of different ALSs

The input and output of test system are connected to the same ALS of the switching system as shown in Figure 6. Test cases and the load are the same as before. The path consists of three switches ALS-ACS-ALS. The central switch, ACS, connects subscribers of different ALSs. Test results in Table 2 shows almost the same cell interarrival time. However, cell delay time is doubled approximately as expected

Figure 6 Connection of the test system and TDX-ATM switching system

Table 2 Cell interarrival time and cell delay time
(single 7.488Mbps/100 channels of 1.4976Mbps)

	one way path		two way path	
	(single/100 channels)		(single/100 channels)	
	CIT(μ s)	CTD(μ s)	CIT(μ s)	CTD(μ s)
Minimum	53.8/280.1	106.7/106	50.6/280.1	216.5/216.5
Maximum	59.8/286.2	110.0/109.4	62.7/286.2	219.8/222.5
Mean	56.62/283.1	107.6/54.0	57.1/283.1	218.7/220.1

QoS for multiple paths of subscribers of different ALSs

In this test, two test systems are connected to TDX-ATM switching system. Two paths are established to know whether there is influence between two paths.

(a) In case of two independent paths

Two test systems are connected to TDX-ATM switching system as shown in Figure 7. There are 8 connections switched through the path for test system 1. The bandwidths of 8 connections are: 45, 40, 30, 15, 7.488, 5, 4, 3.272 Mbps. The total load of 8 connections is 149.760Mbps which is full load for the STM-1 link. The other path switches CBR load of 100Mbps which is generated by the test system 2. As shown in table 3, test results are similar to those of previous tests. The result may be interpreted that there is not any noticeable influence between two independent paths.

Figure 7 The connection of test systems and TDX-ATM switching system

Table 3 Cell interarrival time and cell delay time for CBR traffic of 7.488Mbps(independent paths)

	cell interarrival time(μ s)	cell delay time(μ s)
Minimum	56.5	213.5
Maximum	57.1	214.1
Mean	56.6	213.7

(b) In case of two dependent paths

Two test systems are connected to TDX-ATM switching system as shown in Figure 8. The external connections are the same as before. But internal paths are arranged so that the traffic from two test systems are mixed internally. Two test systems generate traffic loads different from the previous test. Generated traffic loads are: 45Mbps CBR traffic by test system 1 and VBR traffic with average of 86.79Mbps and peak of 149.76Mbps by test system 2. As shown in the Figure, since part of the path are shared by traffic load from two test systems, cells are buffered when total traffic is more than 149.76Mbps. The buffering of cells means delay of the buffered cells. In this test, we get cell delay times of minimum 207.6 μ s, maximum 211.0 μ s, and average 209.9 μ s if only the test system 1 generates traffic. When both of two test systems generate traffic, there is an increase of maximum cell delay time by 54 μ s. This test shows that the system switches mixed traffic of CBR and VBR well with a little increase of cell delay.

Figure 8 The connection of test systems and TDX-ATM switching system**3.2 Test of performance and stability of the switching system**

Test of performance and stability of the switching system is carried by the long-term operation of the switching system and by test of influence from the variation of traffic and

overload. The test is performed by stability test of switch and performance test.

(a) Stability test of switch

Figure 9 shows the configuration to test the stability of 32x32 switch fabric in ALS. All of the subscriber boards are looped together to form a path. The path switches CBR traffic of 149.76Mbps generated by the test system. There is no cell loss during the test which continued 24 hours. From this result, it may be said that TDX-ATM switching system has stable switch.

Figure 9 Stability test of the switch

(b) Performance test

In this test, test systems and the switching system are so configured as to test the performance of the switching system. Thus 149.76Mbps CBR stream or the mixture of CBR stream and bursty stream is applied to every port of the switch. In the first test, test systems and the switching system are connected as shown in Figure 10. Each path is independent that traffic stream is not mixed with the stream from other paths. Each of two test systems generates CBR stream of 149.76Mbps. After the test of 38 hours, we get cell loss ratio of $1.1E-11$.

Now, test systems and the switching system are connected, as shown in Figure 11, differently from that of previous test. The traffic streams are distributed and mixed together in the switching system. During this test, traffic streams are generated by two test systems: CBR stream of $0.7(=0.7 \times 149.76\text{Mbps})$ by test system 1 and VBR stream of maximum 149.76Mbps and average 0.0625(=9.36Mbps), or 0.1875(=28.08Mbps), or 0.2875(=43.056Mbps) by test system 2. If CBR traffic and VBR traffic are applied together, there happen 7 hot spots as shown in the figure. After 38 hours of test, we get the test result shown in table 4. According to the result, the switching system operates with load of 0.7625 and 0.8875)

Figure 10 The connection of test systems and the switching system

Table 4 Cell loss ratio(independent paths)

	<i>Load(0.7625)</i>		<i>Load(0.8875)</i>		<i>Load(0.9875)</i>	
	<i>CBR(0.7)+VBR(0.0625)</i>		<i>CBR(0.7)+VBR(0.1875)</i>		<i>CBR(0.7)+VBR(0.2875)</i>	
	<i>CBR(0.7)</i>	<i>VBR(0.0625)</i>	<i>CBR(0.7)</i>	<i>VBR(0.1875)</i>	<i>CBR(0.7)</i>	<i>VBR(0.2875)</i>
cell loss ratio	3.3E-10	1.0E-9	2.3E-10	5.0E-10	3.9E-7	9.5E-7

* VBR Traffic applied in Baseline Document MPEG-II Core Service in Table1/Annex2/ IVS /Baseline Document/ITU-SG13/19-94

Figure 11 The connection test systems and the switching system

Table 4 Cell loss ratio(independent paths)

	Load(0.7625)		Load(0.8875)		Load(0.9875)	
	CBR(0.7)+VBR(0.0625)		CBR(0.7)+VBR(0.1875)		CBR(0.7)+VBR(0.2875)	
	CBR(0.7)	VBR(0.0625)	CBR(0.7)	VBR(0.1875)	CBR(0.7)	VBR(0.2875)
cell loss ratio	3.3E-10	1.0E-9	2.3E-10	5.0E-10	3.9E-7	9.5E-7

4 APPLICATION OF TDX-ATM SWITCHING SYSTEM

Network Testbed^[2] is established mainly to test the interoperability between B-ISDN systems such as public ATM switching system, B-NT, B-TA, private ATM switch, etc. As shown in Figure 12, there are 4 public ATM switching systems in the Network Testbed: 3 systems in Seoul and 1 system in Taejon which is about 200Km away from Seoul. Currently, users are restricted to government organizations, Universities, and libraries. Up to now, most of traffic is for VOD, video telephone, and data communication between LANs. In the connection of Figure 12, we get the cell loss ratio of 2.04E-9 for the end to end connection between subscribers of 200Km away.

Figure 12 Network Testbed

In addition, The following equipments are operating on service in the Network Test Bed

(a) *Video-TA*

- Features: STM-1, DS3, VC Connection, DPCM(Differential Pulse Code Modulation)
- Function: Services that let you converse with high-quality voice and video through the ATM Network

(b) *LAN-TA*

- Features: STM-1, SVC Connection, LAN-Router
- Functions: Terminal adaptor that connects LANs with ATM Network

(c) *B-NT(CANS:Centralized Access Node System)*

- Features: CANS have 1 line of STM-1 at Tb interface point, and 4 lines of STM-1 at Sb interface point(Concentration Ratio(Tb/Sb) = 1/4)
- Functions:Network termination that connects subscribers, terminals to ATM network

(d) *Work-Station and Personal Computer with ATM Card*

- Features: STM-1, DS1E, MPEG, JPEG
- Functions:
 - High-speed data transmission service between LANs via ATM network
 - Access to multimedia DBs will be available via Internet
 - Transfer the video programs in the Video server via the ATM network
 - Multiparty conferences in which you can exchange data and voice while seeing one another via ATM network

(e) *Private switch :*

- Products: Fore Co. switch, 3Com. Co. switch, Private ATM Switch made in Korea.
- Features: STM-1, DS3, E1, LAN-router
- Functions: Private network that connect subscribers, terminals or local area network to ATM network

5 CONCLUSION

This paper presents test results for the ATM switching system developed by ETRI. According to the results, the switching system shows maximum cell delay of 110 μ s under normal operation. Also, the test results show the stability of the ATM switching system. The ATM switching system, called TDX-ATM, will be improved in quality, features, and economy by software upgrade and hardware upgrade using ASIC chips and new commercial chips.

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6 BIOGRAPHY

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