메트로폴리탄 에어리어 네트워크를 위한 스위칭 시스템의 성능 분석☆

Performance Evaluation of a Switching System for Metropolitan Area Networks

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요 약

메트로폴리탄 에어리어 네트워크를 위하여 소형 스위칭 시스템 구조를 제안하고, 성능평가를 수행한다. 이더넷과 ATM 기반의 두가지 구조가 가능하나 백본 네트워크가 ATM이라는 점을 고려하여 ATM 방식으로 설계한다. 성능평가를 위해서는 우선 트래픽에 대한 모델링이 필요하다. 이는 엑세스 네트워크가 광대역화 하는 최근의 추세에 비춰볼 때 다양한 서비스로부터 발생하는 트래픽이 버스티한 성격을 띠므로, 이러한 엑세스 네트워크를 백본 네트워크에 연결시키는 메트로폴리탄 에어리어 네트워크는 단순한 포아송 모델로는 모델링이 정확하지 않게 되기 때문이다. 성능평가결과 제안된 시스템이 만족시킬 수 있는 셀손실률이나 지연시간등의 QoS 변수의 하위바운드가 구해진다.

Abstract

ATM and Ethernet are desirable transport mechanisms for the realization MAN(Metropolitan Area Networks). A relatively small sized switching system for MAN based on ATM is proposed and its performance is evaluated in this paper. For the performance evaluation, traffics should be firstly modeled because they are highly bursty. By varing the ratio of VBR traffics, detrimental effect of VBR traffics may be observed. Traffic load at each input port is also varied. From the results of simulation, operation conditions of the system to meet required QoS are obtained.

☞ Keyword : MAN, Switching Systems, Performance Evaluation, Simulation

1. Introduction

For Metropolitan Area Networks, DQDB(Dual Queue Distributed Bus) has been standardized by the IEEE and ANSI [1]. Two major candidates for switching technologies for MAN are ATM (Asynchronous Transfer Mode) and Ethernet technologies. Since current backbone network is mainly based on ATM, MAN switching systems based on ATM has advantage over ones based on Ethernet when connecting to the backbone networks.

Thus, a new ATM switching system for MAN is proposed in this paper. The proposed system should satisfy QoS(Quality of Service) requirements. Thus, performance of the system should be evaluated in parallel or in advance to the implementation of the system[2-4]. If the proposed structure can not satisfy required QoS, the structure should be altered to improve performance. It is intended to be mainly used as the infrastructure interconnecting LANs. Since the input traffics from LANs are usually highly bursty, its performance can not be accurately measured using simple Poisson arrivals. Thus, input traffic must be firstly modeled for the performance evaluation of the proposed switching system.

The rest of the paper is organized as follows. In

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the next section, we introduce the structure of the proposed switching system. Section 3 presents the traffic model which is used to evaluate the performance of proposed system. Performance evaluation of the proposed system is given in Section 4. Assumptions for the performance evaluation are firstly described. The performance of proposed structure is examined by varying the traffic load. Also, the percentage of VBR (Variable Bit Rate) and CBR(Constant Bit Rate) traffics at each traffic load is varied to see the effect of each traffic sources. The paper is finally concluded in Section 5.

2. Structure of the Proposed Switching System

The structure of the proposed switching system, ATM-MSS(MAN Switching System), is shown in Figure 1. It is composed of several modules such as HSN, RSN and EMS. The abbreviations for the name of each module are indicated in the respective figures. Up to five RSNs may be connected to a HSN using four STM-1 links for full duplex communications. EMS is connected to HSN using Ethernet.

HSN is basically 16 × 16 switch. Its primary function is to switch cells between RSNs, RSN and another ATM-MSS, and RSN and other ATM switches. EIA is connected to another ATM switches using

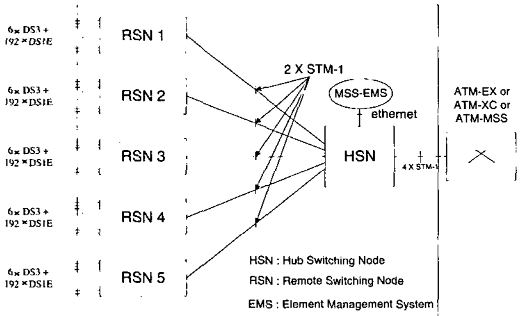

Figure 1. The proposed switching system

eight STM-1 links for full-duplex operation. NIA is connected to RSN using four STM-1 links for full-duplex operation. RSN is 8 × 8 switch. It receives cells from subscribers and switches to HSN or another subscriber which is connected to the same RSN.

SE(Switching Element) used for RSN as well as HSN is a nonblocking 8 × 8 switching element. Input and output ports are operating on *43MHz* clock and, four bits(nibble) are transferred at each clock cycle. Thus, each input or output port provides *155Mbps*. Six bytes of overhead are added to an incoming cell for the purpose of internal routing. Thus, the size of a cell in the SE becomes 118 nibbles. There is a central buffer of 32 cells.

3. Modeling of Traffic

CBR traffic source generates cells periodically. However, most of the traffics provided for the current broadband networks are VBR. There are various VBR traffic sources such as voice, data and video, etc. A single voice source may be accurately described by on/off model[5]. When these on/off sources are multiplexed, high correlation occurs among arriving cells. In this case, IPP(Interrupted Poisson Process) [6,7] or MMPP(Markov Modulated Poisson Process) [8,9] may be used. As in the on/off model, IPP model is composed of active and silent periods. However, arrival process in active period is governed by another Poisson process. MMPP is a doubly stochastic Poisson process. Underlying is a continuous-time m-state Markov chain, where the sojourn time for state j is exponentially distributed with mean v_j^{-1}. When in state j, cells are generated according to a Poisson process with rate λ_j [5].

Since the detrimental effect of VBR traffics is intended to be revealed, performance parameters are observed while varing the ratio of VBR traffics to

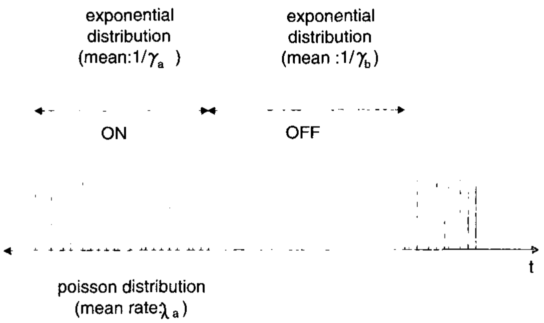

Figure 2. The IPP traffic model

overall traffics. QoS factors such as probability of cell loss and delay are used as performance parameters. The duration of active and silent period are determined stochastically by exponential distribution functions. Their mean times are given as parameters. Even if the durations of active and silent period are stochastically determined, once they are determined, they should not be changed when the ratio is varied. Also, the inter-arrival times between successive cell arrival in active period are set as fixed interval for the purpose of comparison. Let's assume that the total aggregate traffic load over a STM-1 link is L_{total}. If the ratio of VBR traffic is α, the VBR and CBR traffic loads, L_{VBR} and L_{CBR}, are given as follows, respectively.

$$L_{VBR} = \alpha L_{total} \quad (1)$$

$$L_{CBR} = (1-\alpha)\ L_{total} \quad (2)$$

The interarrival times of incoming cells of CBR traffic and VBR traffics in active period, T_{CBR} and T_{VBR}, are given as follows, respectively.

$$T_{CBR} = \frac{1\text{cell}}{L_{CBR}} = \frac{424\text{bits}}{L_{CBR}} \quad (3)$$

$$T_{VBR} = \frac{1\text{cell}}{\beta L_{VBR}} = \frac{424\text{bits}}{\beta L_{VBR}} \quad (4)$$

Here, β is the burstness which is the ratio of peak bandwidth to the average bandwidth of active period. Thus, if β is 2, then the mean times for active period and silent period are same. Using the fact that 64*Kbps* VBR source can be accurately modeled with the mean time of 360*msec* in the active period [5], mean times of VBR traffic, M_{active} and M_{silent}, are obtained as follows.

$$M_{active} = \frac{360\times 64}{L_{VBR}} \quad (5)$$

$$M_{silent} = (\beta-1)M_{active} \quad (6)$$

Here, L_{VBR} is in *Mbps*. In the next section, performance evaluation is presented.

4. Performance Evaluation

Assumptions for the operation of RSN are as follows.

- Output ports are assumed to be nonblocking.
- Input traffic can go to either one of output ports.
- There is a buffer of 36 cells at each input ports.
- 118 clock times are needed to switch a cell.
- There is a central buffer of 32 cells.
- Every incoming cells are assumed to be destined to the output of RSN. Thus, intra-RSN traffics are neglected. This condition gives the lowerbound (worstcase) of the performance of RSN.

Every incoming cells are also assumed to be destined to the output ports of HSN. In other words, intra-HSN traffics are ruled out. Thus, the lowerbound of the performance of HSN may be obtained at this condition. Burstness, β, is assumed to be 2. DES(Discrete Event Simulation) is used as the simulation method.

Figures 3 and 4 show cell loss probability and delay of RSN, respectively. In those figures, the ratio

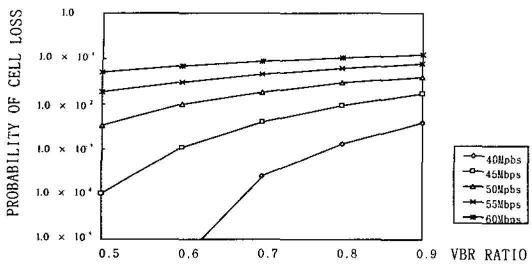

Figure 3. The cell loss probability of RSN

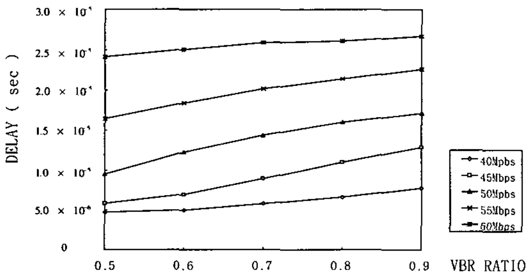

Figure 4. The delay of RSN

of VBR traffic to total traffic is varied from 0.5 to 0.9 (CBR traffic is varied from 0.5 to 0.1). Since VBR must be the dominant traffic, consideration of VBR traffic whose ratio is less than 0.5 is not necessary. In figure 3, as VBR traffic increases (CBR traffic decreases), cell loss probability increases. This clearly shows detrimental effects of VBR traffic. Delay is also increasing as the VBR traffic increases.

Bandwidth of each input link is varied from 40Mbps to 60Mbps. Simulation results show that the input traffic at each input STM-1 link of RSN should be less than 40Mbps to satisfy the required probability of cell loss of 10^{-5}. Delay has been maintained at acceptable level. VBR traffics should not exceed 60% at 40Mbps bandwidth. Since all the input traffics are assumed to be destined to output ports of RSN and there are five to two concentration(i.e. there are five input links and two output links), bandwidth higher than 50Mbps are not recommended.

Figures 5 and 6 show cell loss probability and delay of overall system, respectively. The ratio of VBR

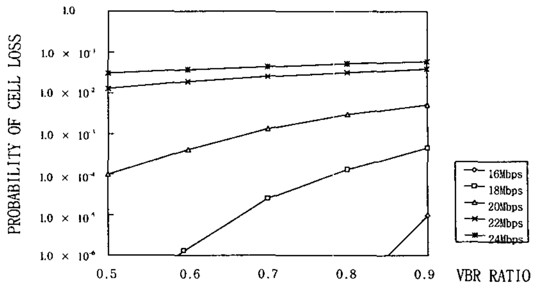

Figure 5. The cell loss probability of the system

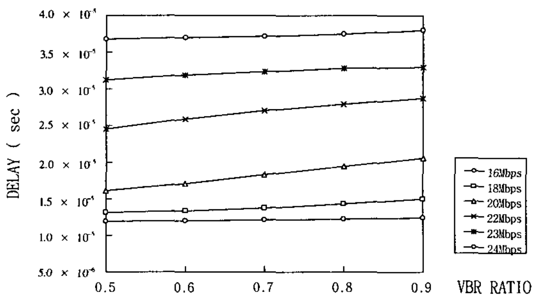

Figure 6. The delay of the system

traffic to total traffic is also varied from 0.5 to 0.9. Bandwidth of each input link is also varied from *16Mbps* to *24Mbps*. Results show similar phenomena as in RSN. These figures provide lowerbounds of the performance of the proposed switching system because intra-HSN traffics are excluded. Input traffics for the overall system at each link should be maintained less than *20Mbps*. If there are intra-RSN and intra-HSN traffics, proposed system may be operating with the higher input bandwidth. Intra-HSN traffics are highly likely because proposed system is intended to be used as the infrastructure interconnecting LANs.

5. Conclusion

A switching system based on ATM protocol for the MAN is proposed. It is composed of several modules such as RSN and HSN. RSN switches cells from users and HSN switches cells from RSNs. To evaluate the performance, the input traffics in the current broadband environment must be firstly characterized. This is because the traffics is now highly bursty. The simple Poisson model for the circuit switching is not valid any more. Thus, the traffic to reflect burstness is modeled and performance of proposed structure is evaluated using simulation.

In the simulation, the ratio of VBR traffics are varied to see the adverse effect of VBR traffics. The bandwidth of input traffics are also varied. From the simulation, lower bounds of performance measures in terms of the cell loss probability and the delay are obtained.

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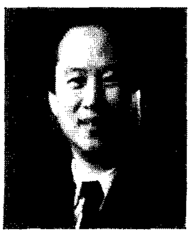

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