ISSN:2229-6093
M Sreenivasulu et al, Int. J. Comp. Tech. Appl., Vol 2 (5), 1573-1576

Enhanced EFCI Congestion Control Scheme for ATM Networks

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Abstract

Traffic management and congestion control are key issues in ATM networks. Congestion control schemes promises effective traffic management and it uses feedback information from the network to specify the maximum rate at which each source can transmit cells in to the network. In this paper, we considered an Explicit Forward Congestion Indication (EFCI) Congestion scheme, developed by ATM forum for ATM networks. This scheme has cell drop problem at intermediate switch and allowed cell rate at source terminals oscillates from lower values to higher values and vice versa. An enhancement to EFCI scheme is proposed. The simulation results shows that enhanced EFCI scheme gives better results than basic EFCI scheme**.**

Keywords: Asynchronous Transfer Mode networks, Congestion, Explicit Forward Congestion Indication, Enhanced EFCI, NIST ATM Simulator.

1. Introduction

Broadband Integrated Services Digital Network (B-ISDN) with Asynchronous Transfer Mode (ATM) technology [2, 9] will offer multimedia communication, video on demand, live television, and high speed data transport and many other services. Asynchronous Transfer Mode technique is designed to provide fast packet (cell) switching over various types and speeds of media at variable rates from 64 Kbps to 2 Gbps and beyond. ATM networks provides good bandwidth, flexibility and can be used efficiently from desktop computers to LANs and WANs. Unlike other packet switching networks, ATM networks support both fixed and variable bandwidth services. One of the services provided by ATM networks is the Available Bit Rate (ABR) which was proposed for data applications to utilize the left-over bandwidth from other ATM traffic types.

Congestion control mechanisms [1,3,5] are essential to provide efficient and fair bandwidth allocation among connections with vague Quality of Service (QoS) requirements. The congestion control is not only essential for regulating the traffic to prevent congestion, but also necessary to provide efficient and fair bandwidth allocation.

Rate based congestion control [2,4,6,8] promises effective traffic management for Available Bit Rate (ABR) service class, which is suitable for data communication in ATM networks. In the rate based congestion control mechanism, cell allowed rate of each source end system is regulated according to congestion information returned by the network.

In this paper, we considered EFCI congestion control mechanism for ATM networks and enhancement to EFCI is presented. These schemes were implemented using NIST ATM simulator and results were analyzed and compared. This paper is organized as follows. Section 2 gives overview of basic EFCI mechanism. Simulation environments and result analysis for basic EFCI are presented section 3. Enhanced to EFCI scheme is presented in section 4. Results for Enhanced EFCI scheme is presented in section 5. Performance comparison between EFCI and Enhanced EFCI is presented section 6. Finally the conclusion of paper is given in section 7.

2. Basic EFCI Scheme

Explicit Forward Congestion Indication (EFCI)[3]is an end-to-end scheme in which most of the control complexity resides in the end systems. An Allowed Cell Rate (ACR) at the source is adjusted according to the congestion status of the network. The congestion is detected at each intermediate switch by monitoring the queue length of the cell buffer. If the queue length exceeds the threshold value of a particular switch, this switch is detected as congested.

To indicate congestion, this switch will mark an Explicit Forward Congestion Indication (EFCI) bit in the header of all passing data cells on the path in forward direction. When the destination end system receives a data cell in which the EFCI bit is marked, it will generate a Resource Management (RM) cell, whose Payload Type Identifier (PTI) is '110'. This RM cell is sent back to the source end system along the backward path. Once the source receives an RM cell, it must decrease its ACR by a rate decrease factor, but no more than *MCR:*

*ACR = max(ACR*DF, MCR)* (1)

Where, *DF* is the rate decrease factor, and *MCR* is the minimum allowed cell rate. A time interval is defined at the destination end systems. Only one RM cell is allowed to be sent back in an RM time interval. Also there is an interval timer in the source end system. The source recognizes no congestion in the network without receiving an RM cell after an interval time. Then the source will increase ACR:

ACR= min(ACR*IF, PCR) (2)

Where IF is increase factor and PCR is peak cell rate.

3. Simulation Environment and Results

3.1 Simulation Environment

The EFCI scheme described in previous section was implemented using NIST ATM Network Simulator [8] for a network configuration shown in fig 1. The NIST ATM Network simulator was developed by National Institute of Standards and Technology (NIST), for studying and evaluating performance of ATM networks.

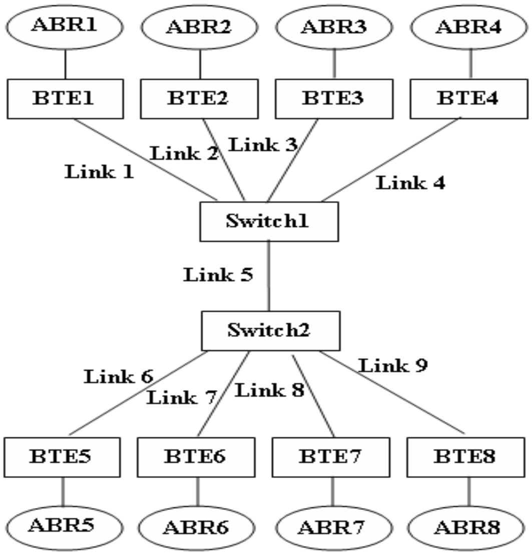

Fig.1 A Sample Network Configuration

In the network, there are two switches, four source end systems (Broadband Terminal Equipment BTE1 to BTE4), four destination systems (BTE5 to BTE8), links (link1 to link9) and ABR applications (ABR1 to ABR8). The ABR applications are attached to source and destination terminals for sending and receiving data. There are four virtual channels in the network. The first Virtual Channel (VC1) is passing through BTE1, Switch1, Switch2 and BTE5. The second Virtual Channel (VC2) is passing through BTE2, Switch1, Switch2, and BTE 6. The third Virtual Channel (VC3) is passing through BTE3, Switch1, Switch2, and BTE7. The fourth Virtual Channel (VC4) is passing through BTE4, Switch1, Switch2, and BTE 8.

The network parameters are as follows: Link bandwidth = 155 Mbps, Source end terminals (BTEs): Initial Cell Rate(ICR) =7.49 Mbps, Minimum Cell Rate (MCR) = 1.49 Mbps, Peak Cell Rate (PCR) =149.76 Mbps, Increase Factor (IF) =0.625, Decrease Factor (DF) = 0.0625; Switch parameters: Low threshold = 600, High threshold = 800, Very Congested Queue Threshold (DQT) = 900. A switch is said to be congested when length of switch larger than high threshold queue.

When queue length exceeds DQT, the switch is said to be in severe congestion state and cells will be discarded without processing.

3.2 Results Analysis for EFCI scheme

Initially, we implemented EFCI algorithm and the results are presented in the form of graphs.

1. Graph of Allowed Cell Rate (ACR) in Mbps over time for source terminal.
2. Graph of % cell drop over time at the switch1.

The graphs for ACR Vs. Time for one source BTE1, and the percentage of Cell Drop Vs. Time at Switch1 are shown in fig. 2 and 3 respectively.

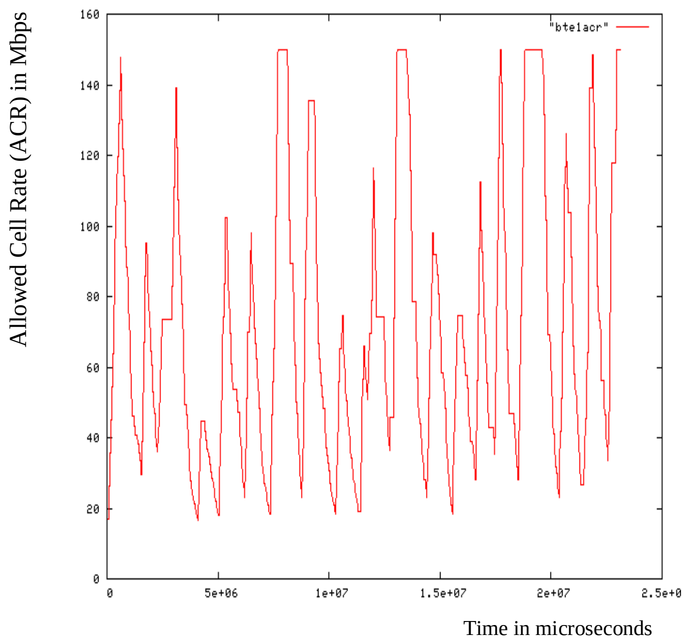

Fig.2. BTE1 ACR Vs Time

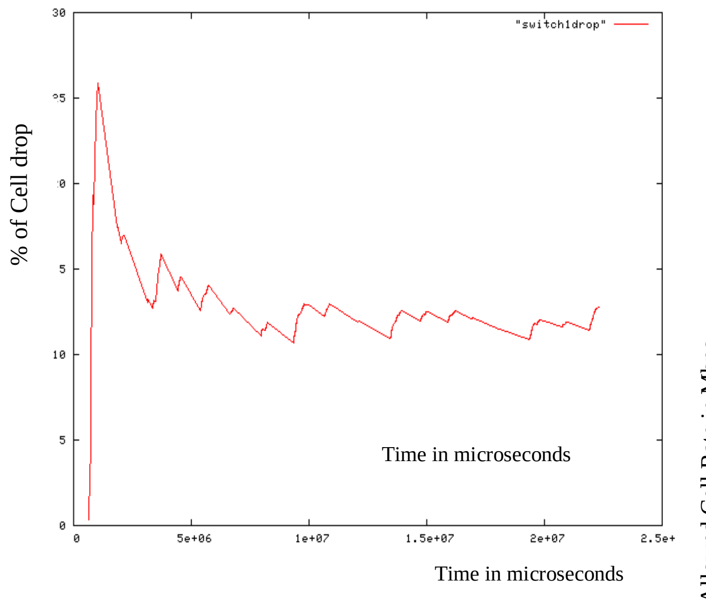

Fig.3: Percentage of Cell drop Vs Time at Switch1

From the above graphs, we can observe that, Allowed Cell Rate (ACR) of source terminals will continuously increases until source terminal receives RM cell from destination terminal. Then it decreases ACR until it receives no RM cell within time interval. So the allowed cell rate of source terminal BTEs oscillate between higher and lower values. As impact, queue will be filled up gradually and congestion state arises. So we can observe that higher percentage of cell drop at switch1.

4. ENHANCEMENT TO EFCI SCHEME

To avoid allowed cell rate oscillate between peak cell rate and minimum cell rate, we shall set ACR to steady state rate by introducing two variables steady low rate (SLR) and steady high rate (SHR). The initial values of SHR and SLR are set as follows:

SHR = link bandwidth * 0.75 (4)

SLR = link bandwidth * 0.30. (5)

The pseudo code for setting allowed cell rate at source terminals is given below:

```
if source receive RM cell with CI bit set to 1 then
    begin
      temp = max (ACR * DF, MCR)
      if (temp < SLR and temp > MCR) then ACR = SLR
      else ACR = temp
    end
if source receive no RM cell within source time interval then
    begin
     temp = min ( ACR * IF, PCR)
     if ( temp > SHR and temp < PCR ) then ACR = SHR
     else ACR = temp
   end
```

5. Results for the Enhanced EFCI scheme

The Enhanced EFCI scheme has been implemented for the network configuration shown in fig 1. The results are plotted again in form of graphs for allowed cell rate vs time for one source terminal BTE1 and % cell drop at switch1, which are shown in fig. 4 and fig. 5.

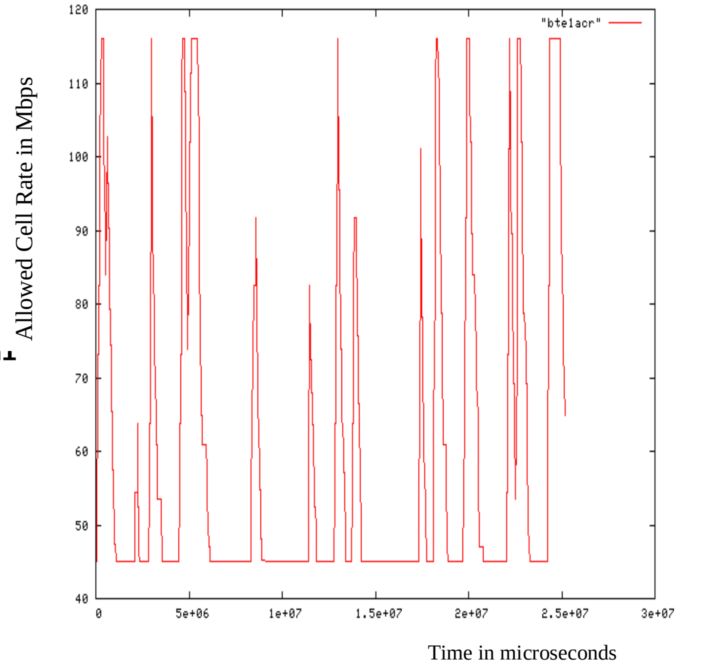

Fig.4:BTE1 ACR Vs Time

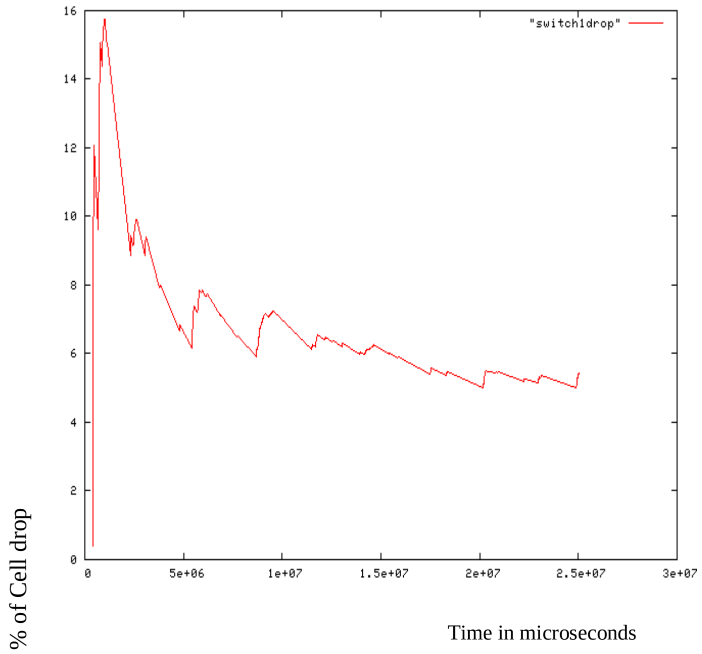

Fig.5: Percentage of Cell drop Vs Time at Switch1

6. Performance comparison of EFCI and Enhanced EFCI schemes

The performance of Enhanced EFCI scheme is compared with basic EFCI scheme based on the following parameters.

1. Percentage of cell drop at switch
2. Allowed cell rate of source terminals

The values of above parameters for EFCI and Enhanced EFCI schemes are shown in below table.1.

Sl. No.	Scheme	% cell drop at switch1	ACR range
1	EFCI	13%	7.49 Mbps to 149 Mbps
2	Improved EFCI	6.3%	46 Mbps to 116Mbps

Table 1. Cell drop % and ACR range

From the above table, we can observe that Enhanced EFCI scheme has lower percentage of cell drop problem than basic EFCI scheme. The allowed cell rate of source terminals oscillates from lower values to higher values and this range has been reduced using Enhanced EFCI scheme. From these results, we can conclude that Enhanced EFCI scheme is better than basic EFCI scheme.

7. CONCLUSION

EFCI congestion control scheme developed by ATM forum for ATM networks is described. An enhancement to EFCI scheme was proposed by setting the allowed cell rate properly by avoiding higher oscillations. From the simulation results presented here, enhanced EFCI scheme gives better ACR for BTEs, and lower cell drop at intermediate switch than basic EFCI scheme. So we can conclude that enhanced EFCI gives better than basic EFCI scheme.

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