**Journal of Advanced Computing and Communication Technologies** *(ISSN:* **2347 - 2804***)*
***Volume No.2 Issue No. 4, August 2014***
*(ETACICT-2014)*

# Performance Evaluation of Bandwidth Optimization Algorithm (BoA) in ATM Networks

By

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## ABSTRACT:

All the traffic control schemes have limited application domains: none of them are suitable, alone, for the wide range of traffic services expected in ATM-based networks. Therefore, some integration of these basic schemes should be considered. In this paper, we propose a new traffic control algorithm, called the Bandwidth optimization Algorithm (BOA). BOA is a multi-level control algorithm that attempts to optimally manage network resources and perform traffic control among a wide range of traffic services in ATM-based networks. The basic objective of BOA is to meet the quality of service requirements for different traffic sources, while making the best possible use of network bandwidth. In addition. BOA attempts to minimize network congestion in a preventive way.

***KEYWORDS:*** Asynchronous Transfer Mode, Bandwidth Optimization Algorithm, Short Period Reservation, Long Period Reserves

## 1. INTRODUCTION

Recent advances in network technology allow for the integration of different services on the same networking infrastructure. Thus, voice, data and video or multimedia traffic share the same transmission, switching and storage resources over a single network [1]. This integration offers the user a single access facility to all communication services through a unified interface. Since Asynchronous Transfer Mode(ATM) networks support diverse services such as voice, data, video etc. therefore ATM has been chosen for the use in the Broadband Integrated Service Digital Networks (B-ISDN).

These new telecommunication services differ greatly from existing telephony services in having a much wider range of bandwidth requirements and performance requirements or qualities-of-service (QoS).. In this study we propose a new traffic control algorithem, Called the Bandwidth optimization. Algorithm (BOA) which attempts to efficiently and effectively manage network resources and perform traffic control in a multi- level and flexible contracting strategy. This proposed traffic control algorithm is for ATM – like telecommunications systems.. The packet in an ATM is a fixed length cell containing 53 bytes. This unit of transmitted information carries a 48 bytes payload and a 5-bytes header, or overhead [5] and [10]. One of the original motivations for ATM to employ cells and implement virtual circuits was so that significant statistical multiplexing gain could be exploited by capitalizing on the inherent burstiness of many applications.

QoS refers to the capability of a network to provide better services to selected network traffic over various technologies. The advent of high-speed networking technology has enabled many multimedia applications like video conferencing, Medical imaging and VoIP[11]. These applications have different performance requirements of bandwidth, delay, jitter and loss rate which leads to an important issue of how to support QoS on the modern high-speed networks. Among the multiple contract types proposed in BOA Short- Period Reservation (SPR) contract is of special interest because it adds dynamic control to BOA by introducing band width contracting at the burst – level.

## 2.THE BASIC PRINCIPLES OF BOA

This section provides a brief introduction to the basic principles of BOA. BOA allocates bandwidth to network users in terms of bandwidth contracts to effectively apply statistical multiplexing schemes [13]. However, the feature of no bounds on delay or delay variation makes it possible to introduce dynamic traffic control schemes for these applications. In this paper, we first address the important issues involved in defining BOA for bursty traffic. Then, we give a formal description of a burst-level control Scheme called the short period Reservation(SPR), contract, which is a part of our Bandwidth optimization. Algorithm (BOA). BOA supports two types of bandwidth contracts:- General contracts and Reserve contracts. General contracts reserve no bandwidth for a connection. That is. Users are allowed to transmit traffic without any bandwidth reservation. In reserve contracts., The contracted bandwidth must be absolutely reserved. In other words, the network keep the amount of bandwidth of a granted reserve comtract available for the connection. The required bandwidth of a reserve contracts based on the user's request. According to the contract's effective time period. Reserve contracts are further divided into two types: long period reserves( LPR) contracts and short-period Reserve (SPR) contracts. LPR contract is negotiated at connection establishment and lasts for the connection's lifetime. SPR allows users to dynamically negotiate with network for a reserve contract bandwidth allocation for short time intervals during the call. The effective time of a SPR contract is based upon the source's request.

Furthermore, BOA uses a colouring scheme. The colouring mechanism monitors the traffic flow and discriminates the packets based on the granted bandwidth contracts. Packets are coloured with one of two colours: green, or red. If the source obeys reserve contracts, the submitted packets are green. If the source violates Green contracts, the submitted packets are demoted to red in this way; the source traffic is divided into two classes and transported by the network with different priorities. Red packets have lower priority and may be delayed or discarded at intermediate nodes in the event of congestion along the connection. BOA attempt to make good use of network resources also provide acceptable quality of service for network users. The user's cooperation is not essential in BOA. There is no necessity for all the user terminals to be "smart" enough to cooperate with the bandwidth allocation.
Based on analysis of burst – level reservation holding times, two sensible SPR schemes have been defined SPR-IA/ER and SPR-DA/IR.. SPR-IA/ER has a reservation holding time of on+Rt, where the reserved bandwidth in the Rt part is wasted. By using both delayed reservation and implicit release. SPR-DA/IR avoids bandwidth waste by reducing the reservation holding time from on +Rt to on. This paper studies the performance of these SPR schemes in Local Area Network (LAN) reference model. This paper first defines the LAN reference model under study and then evaluates the performance of two SPR variants. SPR-IA/ER and SPR-DA/IR, through the techniques analytical modeling.

In this paper first a network reference model with a single ATM LAN switch is given in section 3.1, second the source traffic model considered for this study is described in section 3.2 and third a SPR queuing model is developed in section 3.3 to model the SPR schemes at the burst-level. Three performance parameters are defines: SPR Service Denial probability ($\alpha$), average SPR waiting time ($\beta$) link output ($\psi$). Based on the steady – state probabilities of the SPR queuing model the computations of these three performance parameters are also developed. Numerical examples are presented to show the performance differences between SPR-IA/ER and SPR-DA/IR .Finally the observations obtained in this paper are summarized in section

# 3. LAN REFERENCE MODEL

Figure 3.1 shows a network model of an ATM LAN, which is used as the LAN reference model in this study. Figure 3.1 is based on the LAN reference model proposed in [16] which is client-server model connected through a single ATM switch. As shown in figure 3.1 An independent client computers are connected to the ATM switch and communicate with single server through a shared output link of the switch.. The output link is assumed to be OC – 3 which, has a transmission capacity of about 150 Mbps, or 353.773 ATM cells per second.

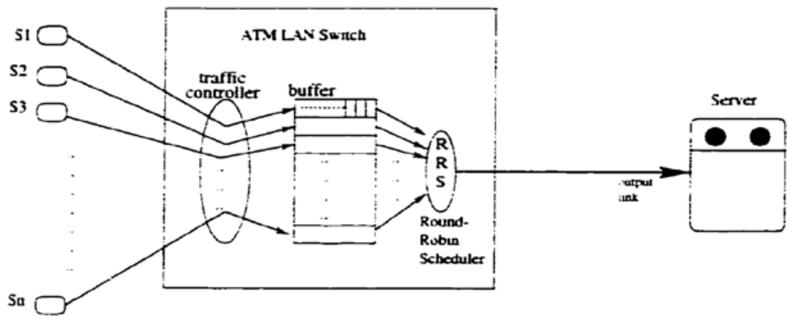



Figure 3.1: LAN Reference Model

There is an output buffer in the ATM switch as shown in Figure 3.1, we assume that the buffer is allocated on a per-connection basis, i.e., each connection has a buffer allocated at connection establishment. The output port transmits the cells in the buffer to the output link at the constant rate of the output link. The buffer of the accepted connections is vacated by the output port in a Round-Robin fashion implemented by the Round-Robin Scheduler (RRS).

Each connection buffers is First – In First –Out (FIFO) buffer, it is filled by the arriving cells from the source and is vacated by a Round-Robin Scheduler. The process of transmitting cells from a source to the buffer is dependent on both the source traffic model and the chosen traffic control scheme.

## 3.1 Source Traffic Model

The characteristic of the traffic streams generated by network users are described as source traffic models. Effects have been contributed on appropriately modeling the traffic source expected in ATM networks .Common traffic models use general n – state Markov representation to approximate a wide range of traffic source .In particular then n = 2 case is used model bursty ON/OFF traffic source. By ON/OFF traffic, we mean the source is either in the OFF state (idle) and generating no traffic or in the ON state (active) and generating traffic at its peak bit rate.

## 3.2 SPR LAN Queuing Model

As a burst-level traffic control scheme, SPR introduces bandwidth reservation and release at the burst level. Assume n connections from n independent sources are accepted. SPR reservation requests from these n sources arrive at the network to request bandwidth reservation on the shared switch output link of the LAN switch. This forms a single service centre queuing system, where the service centre is the shared network link and the customers are the connection source. The shared network link can support m = [link/peak] source simultaneously in the ON state that is it can service m customers at the same time.

The service centre in the queuing system has m services that are identical and operate independently and in parallel. With ON/OFF input traffic each source alternates between ON and OFF states so the SPR queuing system is a closed with system with finite population of n customers. Due to the two-state Markov chain model both ON and OFF period are exponentially distributed so that SPR request arrival and services form Poisson processes. Therefore the SPR request arrival and service at the shared network link can be modeled as a closed Markovain queuing system M/M/m/∞/n, where ∞queue size indicates no blocked SPR requests are lost due to queuing.

## 3.3 Queue Parameters of SPR-IA/ER and SPR – DA/IR

In the SPR queuing system there are four parameters: the arrival rate ( λ ) , the service rate ( μ ) , the number of servers (m =[link/peak]) and the number of customers ( n). The number of servers (m) depends on the ratio of the link capacity to the peak bit rate of the source. The number of customers (n) is the number of accepted connections that can be controlled by a connection admission control (CAC) scheme. So, neither m nor n is protocol-specific. However, the arrival rate (λ) and service rate (μ) are protocol-specific. The service rate (μ) is the reciprocal of the average reservation holding time for a burst transfer. As discussed in Section 2.3 the average reservation holding time with SPR-IA/ER scheme is on +Rt. while with SPR-DA/IR scheme it is on. The arrival rate (λ) is the reciprocal of the average interval time between two successive SPR reservation requests that is the average time for the source being idle before requiring the next SPR reservation request.

The required SPR bandwidth is allocated Rt later. Since there is no traffic generated by the source during the Rt time, SPR-DA/IR adds a Rt to the source idle time period between completing a burst transmission and requiring next SPR. That is with SPR DA/IR, the SPR request arrival rate (λ) is 1/off+Rt. & for SPR-IA/ER, it is 1/off.

# 4. PERFORMANCE METRICS

In this section we discus the performance metrics that are used to evaluate the SPR schemes under study. We are interested in three performance metrics, SPR Service Denial probability (α,). Average SPR queuing waiting time (β) , & Contract out put (ψ).

SPR Service Denial probability (α,).

When all m servers are busy a newly arriving SPR request is blocked. So, the denial probability (α) off SPR request is the probability that the number of customers (k) in the service in the service center is equal to or greater than the number of servers (m).From the solution of the steady-state probabilities, we have

**The denial probability(α ) ,**

$$= \sum_{k=m}^{n} \pi_0 \cdot \left(\frac{\lambda}{\mu}\right)^k \cdot \frac{1}{m!} \cdot \frac{1}{m^{k-m}} \cdot \frac{n!}{(n-k)!} \qquad (3.1)$$

**Average SPR queuing waiting time (β)**

Average waiting time (β) measures the average time for blocked requests waiting in SPR queue. Let $N_q$ denote the average number of customers in the SPR queue and O the average burst throughput. From little's law, therefore, the average waiting time β for a reservation request is:

$$\frac{N_q}{O} = \frac{\sum_{i=m+1}^{n}(i-m)\cdot\pi_i}{\sum_{i=1}^{m} i\cdot\mu\cdot\pi_i + \sum_{i=m+1}^{n} m\cdot\mu\cdot\pi_i}.$$

Equ-3.2

**Contract out put (ψ).**

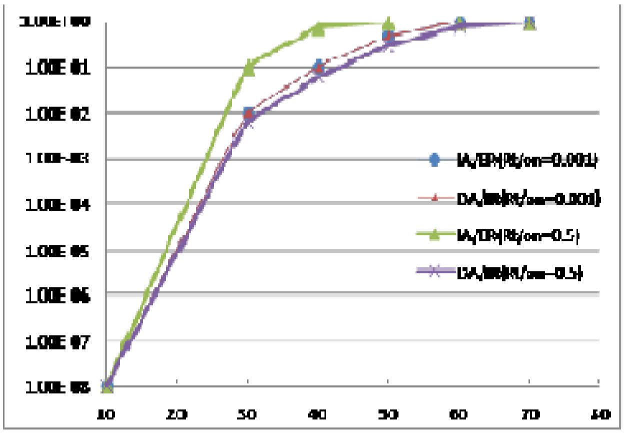
By contract output, we mean the bit rate at which user data units without cell loss are delivered to the applications. That is output measures the bit rate of use output data correctly transferred by the network. Since SPR scheme achieve no cell loss by reserving peak bit rate at burst-level all data delivered to the destinations is counted as output, So link output can be computed based on average burst throughput O. The average on period, and the peak bit rate of sources. That is:

ψ = O.on peak (3.3)

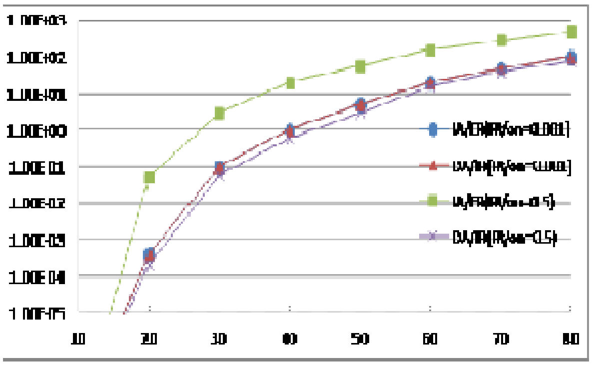
In order to investigate the performance sensitivity of SPR –IA/ER and SPR- DA/IR to the round-trip delay. we consider two different ratios of Rt to on: 0.001 and 0.5. The numerical results are given in Figure 3.5 to Figure 3.7 for SPR denial probability, average SPR queuing time, and link output.

It can be seen from Figures 1 to 3 that, when Rt is one thousand of on, it does not have any impact on SPR queuing system. So, the two curves corresponding to Rt/on = 0.001 for both SPR-IA/ER and SPR DA/IR coincide in Figures1 to 3. However, when Rt is relatively large, for example, half of on SPR- IA/ER results are greatly different from SPR –DA /IR results. Figure 1 shows that the denial probability with SPR-IA/ER increases significantly as Rt increases due to the cost of a round-trip delay added to the reservation holding time, but the denial probability with SPR- DA/IR decreases as Rt increases due to the cost of a round-trip delay added to the average idle time. Figure 2 illustrates that a longer waiting time results from a longer Rt for SPR- IA/ER because of its lower service rate.

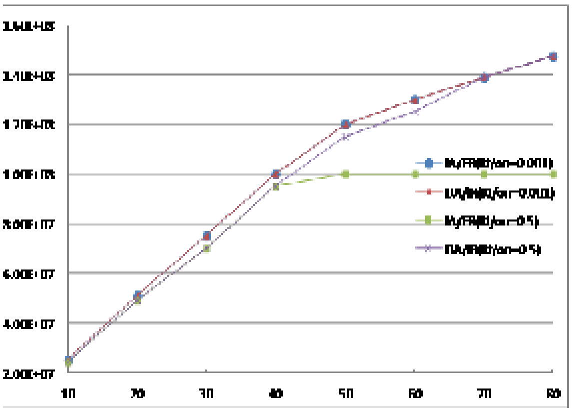
Particularly. When the shared network link is over loaded (i.e.n > 60). The denial probability Curves shown in Figure 3.5 are 1 or very close to 1.



Number of VCS Accepted
FIGURE 1: SPR DENIAL PROBABILITY



Number of VCS Accepted
Figure 2: Average SPR Queuing Time (ms)



Number of VCS Accepted
Fig 3: SPR Link Output

Figure 3 shows that link output with SPR-DA/IR increases continuously as the number of accepted connections increases, regardless of the round-trip delay.

# 5. SUMMARY

In summary the SPR queuing model analysis show that SPR-IA/ER and SPR-DA/IR are different only when the round-trip delay is relatively large compared to the average ON periods. This implies that when Rt is relatively small ,say less then one thousand of on, SPR-DA/IR is not worth consideration because of its higher implementation cost. However when Rt is relatively large, SPR-DA/IR is butter than SPR-IA/ER. In particular as the number of connections increase the output drops of SPR-IA/ER become much worse than those of SPR-DA/IR. This observation makes SPR-DA/IR much more attractive than SPR IA/E R as a burst-level control scheme to accommodate heavy network traffic. Also by considering the performance measures under over loaded network traffic (i.e.. the cases n>60) we find that over loaded traffic greatly degrades the performance of the SPR scheme such as a denial probability of 1, constant increases of SPR queuing time and significant user output drops. This indicates that over loaded traffic is not desirable for the burst-level control schemes such as SPR

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