

A QoS-Oriented Scheme for a Real Time Admission Control in OBS Networks

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Abstract— Optical Burst Switching (OBS) technology offers a promising solution for the next generation Internet backbone. However, call admission control (CAC) constitutes a critical issue in its services developments. Some studies have considered the CAC problem in OBS networks. Yet, all proposed schemes are limited to the use of mean values of some network parameters (MVA: Mean Values Approach), which may lead to false decisions in terms of traffic admission, and so the degradation of the network performances. In this paper, we propose a QoS-oriented scheme for a real time admission control in OBS networks. This may allow more accurate decision; thus, better QoS provision and more efficient resources utilization. We develop an analytic model for a mathematical formulation of the proposed scheme. We also propose a simulation that we conducted to validate the proposed scheme and evaluate its performances.

I. INTRODUCTION

Optical burst switching (OBS) [1,2] is a promising optical data transport technique that can potentially provide efficient network resources utilization. However, the current state of this technology does not offer a call admission control (CAC) scheme that can efficiently handle QoS provision and network resource utilization, which may constitute a major challenge in OBS services development.

Some studies have considered the CAC issue in the development of OBS networks [3, 4]. Nevertheless, all proposed schemes are limited to the use of mean values of some network parameters; (MVA: Mean Values Approach). In [3], authors propose a burst admission control scheme that is based on the use of mean values of optical signal quality parameters such as signal-to-noise ratio (SNR) and bit error rate (BER). In [4], authors propose a QoS-based CAC protocol that is based on the use of mean values of two QoS parameters: the traffic loss mean rate, and the average burst blocking delay. Based on the use of mean values of some network parameters, a burst admission control scheme, may lead to false decisions in terms of traffic admission. This may lead to the degradation of the network performances in terms of QoS provision and network resources utilization.

In this paper, we introduce a novel approach for a real time admission control in OBS networks. The introduced approach is based on the use of real time (instantaneous) estimation of traffic parameters instead of mean values. This may reduce decision errors, and improve the network performances. Hence, resolve the above mentioned shortcomings. Mainly, we address the development of a real time QoS-oriented CAC protocol for a previously proposed OBS network architecture suitable for contention resolution and QoS provisioning [5]. The proposed scheme is based on a real time estimation of the QoS that can be provided to a data burst of a given traffic type. Received at a given interval time, a data burst transmission request is accepted when the available network resources on such period of time are sufficient for burst transmission.

The presented study is mainly based on the development of an analytic model for a mathematical formulation of the proposed scheme and a dynamic analysis of the considered OBS network architecture. A simulation is also conducted to validate the proposed scheme and evaluate its performances. Simulation particularly address the comparison of the performances of the developed scheme to the performances of a previously proposed MVA-based QoS-oriented CAC protocol [4]. Numerical results illustrate the capacity of a real time admission control to ensure more efficient resources utilization.

The remaining part of this paper is organized as follows. Section 2 discusses the basic aspects of the considered OBS network architecture. Section 3 presents an analytic model for a dynamic analysis of its performances. Section 4 presents the proposed real time QoS-oriented CAC scheme. Section 5 presents a simulation model developed to validate the proposed scheme and evaluate its performances. Section 6 concludes the paper.

II. OBS NETWORK ARCHITECTURE

The reader can find in [5] a complete description of the OBS network architecture we consider in this paper.

A. OBS Node Architecture

An OSB node is mainly composed of: a switching unit, a waiting unit, a switching control unit, an input processing unit, and an output-processing unit. The switching unit is responsible of the transfer of input traffic units to the intended output channels, or to the waiting unit in the case of output port contention. The waiting unit is composed of a set of shared multi-wavelengths fiber delay line (FDL) buffers, used for output ports contention resolution. The switch control unit supervises the switching unit activity and makes reservation of the needed resources. An input processing unit is associated with each input channel. It is mainly used for the reception and the Optical/Electrical (OE) conversion of burst header packets. An output processing unit is associated with each output channel. It is mainly responsible for wavelength conversion in the case of output port contention.

B. Signaling Protocol

Different traffic types are considered. A traffic type is defined by a set of QoS attributes. A data burst is a pure payload composed of a set of fixed-length segments of the same traffic type. In addition to offset time, burst length and routing information, the following control information are considered for the specification of the burst's QoS constrains:

- Delay constraint: Burst transfer delay threshold.
- Loss constraint: Burst sensibility level of the traffic loss. Used for contention resolution.

C. Contention resolution

Based on dynamic parameters of the observed traffic, the adopted contention resolution scheme works as follows. For every data segment S_i , we consider two parameters, (S_i_MBD , S_i_BD), that denote the maximum network-wide blocking delay, and the estimated network-wide blocking delay. In case of an output channel contention between two segments S_i , and S_j , the SCU compares the differences ($S_i_MBD - S_i_BD$), and ($S_j_MBD - S_j_BD$). The segment that has the lower difference is privileged. In case of equality, the segment of the least tolerant traffic type in terms of traffic loss is privileged. The privileged segment is switched to the appropriate output channel, while the other is routed to another available wavelength, if any. If no wavelength is available, a FDL buffer is used. If no FDL buffer is available, it is then dropped. A data segment is dropped when the maximum authorized blocking delay is exceeded.

III. OBS NETWORK MODELLING

In the following, we present the analytic model developed for a network path analysis.

A. Notations and Modeling Assumptions

We consider a network path of length L : (N_1, N_2, \dots, N_L). Time is slotted, and the duration of a time slot is equal to a

segment transmission time (segtt). The arrival of segments of type i , at the input of the considered path (node 1), during an interval of time (time slot) I_k ($[k \cdot \text{segtt}, (k+1) \cdot \text{segtt}]$, $k \geq 0$) is assumed to be a Poisson process with rate $\lambda_{i,1,k}$. Let m_i , $0 \leq i \leq N-1$, denotes the maximum network-wide WU-visits numbers for a type i data segment. $ST_{i,j}$, $0 \leq j \leq m_i$, represents segments of class i which has been delayed j times through the considered path. Let $\lambda_{i,j}^{n,k}$, and $\gamma_{i,j}^{n,k}$, $0 \leq j \leq m_i$, $1 \leq n \leq L$, $k \geq 0$, denote the arrival and the departure rate of $ST_{i,j}^{n,k}$ data segments at node n during interval of time I_k . Let $B_{i,j}^{n,k}$ and $F_{i,j}^{n,k}$ denote the blocking probability of a $ST_{i,j}^{n,k}$ data segment, at node n , during I_k , due to the lack wavelengths and FDL buffers, respectively.

B. Analytic Model

Once the above assumptions are made, it becomes easy to model a network path. The model, which is depicted by Figure 1, is an open queuing network system composed of $2 \cdot L$ stations: L M/D/k/k preemptive priority queuing stations representing the transmission units of the different nodes of the path, and L M/D/d/d stations to model the waiting units. The whole system is assumed to handle different customers classes; a customer class corresponds to one of the considered traffic sub-types. Received at a node n , $1 \leq n \leq L$, of the considered path, a customer of class $ST_{i,j}$, $0 \leq i \leq N-1$, $0 \leq j \leq m_i$, can be: directly transmitted to the next node, transmitted to the next node as a customer of a class $ST_{i,k}$, $j < k \leq m_i$, after being delayed $(k-j)$ times at node n , or dropped when the total WU-visits number threshold is exceeded, or when it is switched to the waiting station, and all servers are busy.

C. Model Analysis

The analysis of the developd model is mainly based on the analysis of the departure and the arrival rates of the different traffic sub-types at a node n during an interval of time I_k : ($\lambda_{i,j}^{n,k}$, $\gamma_{i,j}^{n,k}$), $0 \leq j \leq m_i$, $1 \leq n \leq L$, $k \geq 0$. Based on the developed model, the following expressions have been established:

$$\gamma_{i,j}^{1,k} = \lambda_{i,j}^{1,k} \cdot (1 - B_{i,j}^{1,k}), \quad 0 \leq j \leq m_i \quad (1)$$

$$\gamma_{i,0}^{n,k} = \gamma_{i,0}^{n-1,k} \cdot (1 - B_{i,0}^{n,k}), \quad 2 \leq n \leq L \quad (2)$$

$$\gamma_{i,j}^{n,k} = (1 - B_{i,j}^{n,k}) \cdot \left[\gamma_{i,j}^{n-1,k} + \left(\sum_{l=0}^{j-1} \gamma_{i,l}^{n-1,(k-j)+l} \cdot \prod_{t=l}^{j-1} B_{i,t}^{n,(k-j)+t} \cdot (1 - F_{i,t}^{n,(k-j)+t}) \right) \right] \quad (3)$$

$B_{i,j}^{n,k}$ and $F_{i,j}^{n,k}$ denote the blocking probability of a $ST_{i,j}^{n,k}$ data segment, at node n , during I_k , due to the lack wavelengths and FDL buffers, respectively. These parameters can be analyzed based on a new conservation law [6], as it is shown in [7].

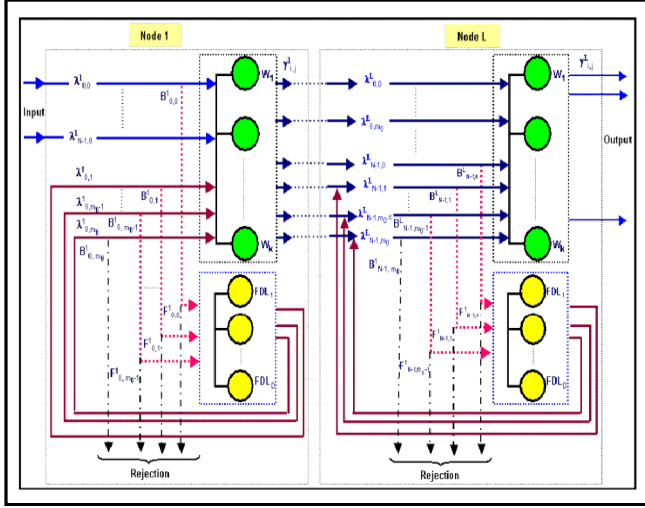


Figure 1: Network Path Modeling

IV. REAL TIME QoS-ORIENTED BURST ADMISSION CONTROL

Based on the adopted contention resolution scheme, an absolute transmission delay is guaranteed for each data burst [5]. For that reason, the proposed QoS-oriented CAC scheme is based on a real time estimation of the traffic loss that can be provided to a data burst of a given traffic type. Hence, a type i data burst, received during an interval time I_k , is accepted at an OBS core node n of a given lightpath, only when the following condition is satisfied:

$$P(TL_i^{n,k} \leq MTL_i) \geq (1-\varepsilon) \cong 1 \quad (4)$$

$TL_i^{n,k}$ denotes type i real time traffic loss measured at node n at the beginning of interval of time I_k . MTL_i represents type i maximum authorized traffic loss. ε : a network parameter that may represent the tolerance degree of the considered CAC scheme.

Based on the developed analytic model, $TL_i^{n,k}$ can be given by the following expression. $X_{ij}^{n,k}$ denotes the number of ST_{ij} data segments measured at node n at the beginning of I_k .

$$TL_i^{n,k} = \frac{\sum_{j=0}^{m_i} X_{ij}^{n,k} \cdot B_{ij}^{n,k} \cdot F_{ij}^{n,k}}{\sum_{j=0}^{m_i} X_{i,0}^{n,k-j}} ; F_{i,m_i}^{n,k} = 1 \quad (5)$$

V. RESOURCES RESERVATION IMPACTS

Based on the proposed burst admission control scheme, an OBS network node reserves, when it accepts a burst transmission request, the needed resources (wavelengths, ODLs) for the transmission of the corresponding data burst. Once reserved, these resources cannot be considered for the transmission of other data bursts. Reserved resources may be

released when the burst transmission request is rejected at a downstream node. Resources resources will be unused, although one can find several contending bursts that have been rejected due to resources unavailability. This may lead to an inefficient network resources utilization, as well as an important request rejection.

In order to validate the introduced real time CAC approach, we have found it valuable to evaluate its impact on the network resources utilization. To do, the flooring paramer has been considered: the average failed resources reservation ratio. A reservation is considered as failed when the corresponding data burst transmission request is rejected at a downstream node. The analysis of this parameter is mainly based on the analysis of the probability that a resources reservation made for a type i data burst at a node n , during an interval time I_k , will be failed; $PFR_i^{n,k}$. Based on the above presented analytic model, the following expression can be established for the analysis of $PFR_i^{n,k}$:

$$PFR_i^{n,k} = P(TL_i^{n,k} \leq MTL_i) \cdot \sum_{j=1}^{L-i} P(TL_i^{n+j,k} > MTL_i) \cdot \prod_{l=1}^{j-1} P(TL_i^{n+l,k} \leq MTL_i) \quad (6)$$

VI. PERFORMANCES EVALUATION

A simulation model has been developed to validate the proposed scheme and evaluate its performances. Simulation particularly considers the capacity of the proposed real time CAC scheme to ensure more efficient resources utilization.

A. Simulation Model

1) *OBS network configuration*: Figure 2 shows the topology of the OBS network on which simulation is conducted. The network is composed of N core nodes (C_1, \dots, C_N) and a set of edge nodes (E_1, \dots, E_8). Each core node is composed of two input/output ports. Each port is assumed to handle w wavelengths. A core node is also equipped of a WU of capacity d segments. The traffic received at an input port of a network node is supposed to be uniformly distributed between its two output ports. Two network configurations have been considered: an OBS network architecture that implements a previously proposed MVA-based CAC scheme [4], and an OBS network implementing the proposed real time CAC scheme.

2) *Traffic model*: Three traffic types (type 0, type 1, type 2) are considered, where type 0 is the least tolerant one. The inter-arrival time between two successive bursts is assumed to be exponentially distributed.

3) *Performance metrics*: One metric has been considered: the average failed resources reservation ratio.

B. Simulations Results

Figures 3-4 present the impact of the transmission and buffering capacities variation on the average failed resources reservation ratio for the aforementioned OBS network configurations (MVA-based CAC, Real time CAC) respectively. The figure shows that the real time CAC scheme

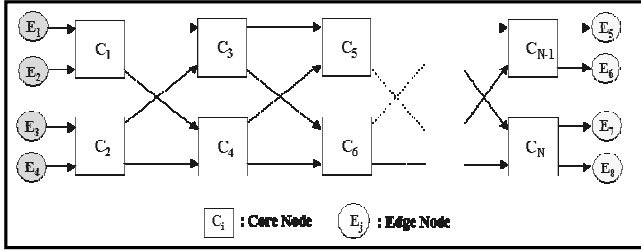


Figure 2: Simulated Network Architecture

ensure less failed resources reservation. This illustrates the capacity of the real time CAC scheme to reduce the average failed resources reservation ratio, and so ensure a more efficient network resources utilization. We also observe that, the average failed resources reservation ratio decreases with the increase of the buffering and transmission capacities. This is because the increase of the buffering or the transmission capacity may decrease the contention probability, which may reduce a data burst real time estimated traffic loss (TL_i^{nk}). This will reduce the number of rejected requests, and thus decrease the average failed resources reservation ratio.

Figures 5 plots the average failed resources reservation ratio versus *Burstl* for both OBS network configurations. Like figures 3-4, this figure validates the capacity of the developed real time CAC approach to reduce the failed resources reservation ratio, and thus improve the network resources utilization. The figure shows that the average failed resources reservation ratio increases with the increase of the burst length. This is because the increase of *Burstl* increases the contention probability, and so increases the number of failed resources reservation.

VII. CONCLUSION

A novel QoS-oriented scheme has been proposed for a real time admission control in OBS networks. An analytic model has been developed for a mathematical formulation of the proposed scheme. Simulation experiments have been also conducted to validate the proposed scheme and evaluate its performances. Numerical results illustrate the capacity of the introduced real time admission control approach to ensure more efficient resources utilization.

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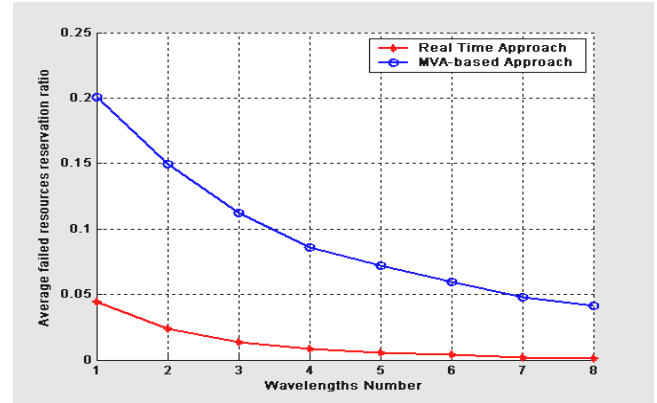


Figure 3: Average failed resources reservation ratio vs. Wavelengths number

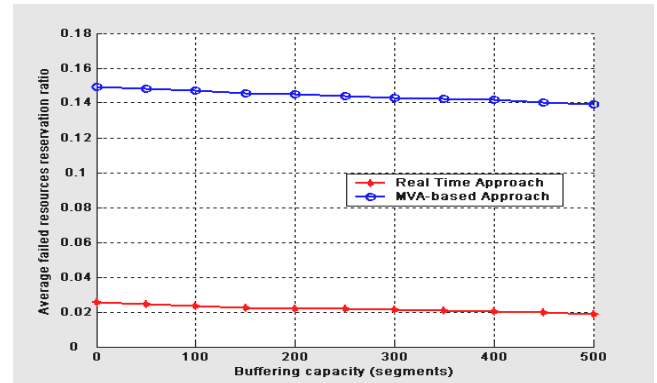


Figure 4: Average failed resources reservation ratio vs. Buffering capacity

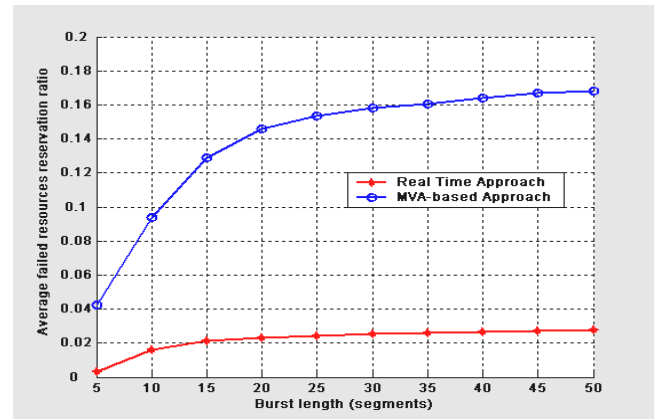


Figure 5: Average failed resources reservation ratio vs. Burst length