A New Paradigm for Prioritizing Multiple Class Services in Optical Burst Switched Networks

Aresh Dadlani 1, 2, Ali Rajabi 1, and Ahmad Khonsari 2, 1

1 IPM School of Computer Science, Tehran, Iran
2 Department of Electrical and Computer Engineering, University of Tehran, Tehran, Iran
{a.dadlani, alirajabi, ak}@ipm.ir

Abstract. Quality of service (QoS) differentiation within the optical infrastructure is under constant development due to the direct impact of the ever-rising demand for time-critical and multimedia applications in the Internet. In this paper, we propose an efficient prioritized hybrid model based on two eminent approaches namely, resource-reservation and extra offset-time based QoS that have already been investigated in the literature. We show that this model guarantees better performance with increase in number of traffic classes. We also simulate a complete topologically optical network bearing Poisson traffic to assess the performance of the proposed model as compared with the two aforementioned approaches.

Keywords: Optical burst switching (OBS), quality of service (QoS), resource-reservation based QoS, extra offset-time based QoS, prioritized hybrid model.

1 Introduction

In present day networking, the need for supporting acceptable quality of service (QoS) in emerging multimedia applications such as High Definition Television (HDTV), video conferencing and Internet telephony has become a crucial issue. To satisfy such service demands along with the ever-rising growth of Internet traffic, the surge for higher bandwidth in national as well as international backbones has become inevitable.

In recent years, all-optical WDM networks have been considered as appropriate substitutes for the next generation Internet due to their huge deliverable bandwidth and high data transparency [1, 2]. Among all the QoS provisioning paradigms suggested for the WDM layer, optical burst switching (OBS) [3] has received much attention as it combines the best of the coarse-grained optical circuit switching (OCS) [4, 5] and the fine-grained optical packet switching (OPS) [6, 7] so as to integrate IP over WDM and support diverse services. In [8-10], a novel technique based on extra offset-time has been proposed to provide QoS in OBS networks carrying multiple traffic classes. Resource-reservation based scheme, studied in [11, 12], is another innovation that guarantees differentiation of QoS among traffic classes with little buffering requirements. Although this method has been proposed for an OPS network, the idea can be well applied to an OBS network as well. In [11], the authors offer a
network wide QoS management scheme for OPS which is based on the idea that when encountering congestion in intermediate switches, lower priority classes might be directed to routes other than their original one, while higher priority classes always travel through fixed paths, which guarantees in-order delivery of packets at the destination.

In this paper, we propose a more effective QoS provisioning scheme by combining the two prominent QoS management schemes namely, extra-offset-time and resource-reservation based QoS mentioned above. Through simulations, we prove that with increase in number of traffic classes, our proposed hybrid model guarantees improved QoS in terms of latency and burst blocking probability as compared to the individual schemes.

The rest of the paper is structured as follows. In Section 2, an overview of OBS is provided to gain a better understanding of the concepts that follow. The two major schemes devoted to supporting QoS in multiple traffic classes and thus, forming the basis of our proposed model are highlighted in Section 3, followed by our hybrid model in Section 4. Simulation scenarios and results are brought in Section 5. Finally, in Section 6, we present conclusions and ideas for future work.

2 Preliminaries of OBS

In the literature, all OBS network switches are mainly classified into two types: edge switches and core switches. As shown in Fig. 1, edge switches are the switches that connect the optical network to the outside world, while core switches are the switches that inter-connect the edge switches within the OBS network. Based on their functionality, the edge switches can further be categorized into two types: ingress and egress edge nodes. An edge switch is said to act as an ingress node whenever it aggregates the incoming packets into optical bursts according to their destination edge switch. An egress node is any edge switch at which data bursts are disassembled into packets. For the sake of clarity, Fig. 1 depicts a scenario in which a burst travels from edge switch 1 (E1) to edge switch 3 (E3) via core switches C1, C3 and C4. In this scenario, E1 acts as the ingress node while E3 acts as the egress node.

Most of the common burst assembly algorithms can be classified as timer-based, threshold-based, and mixed timer/threshold based algorithms. In the timer-based approach [16], a timer starts at the beginning of each new assembly cycle, determining the transmission time of the burst into the core network. After a fixed time, all the packets that arrived in this time period are assembled into a burst. In the threshold-based approach [17], a threshold is provided as a limiting parameter to determine when to generate and transmit a burst into the optical network. The threshold specifies the number of packets to be aggregated into a burst or the (minimum or maximum) length of the burst. The incoming packets are stored in the prioritized packet queues in the ingress node, until the threshold condition is satisfied. Once the threshold is reached, a burst is created and sent into the optical core. The timeout value for the timer-based schemes should be set carefully. If the value is chosen to be too large, the packet delay at the edge might become intolerable. On the other hand, if the value is too small, too many small bursts will be generated, resulting
in higher control overhead. In either approach, there is a control packet assigned to each burst which is sent into the network prior to its respective burst in order to reserve the resources required throughout the transmission. While timer-based schemes might result in undesirable burst lengths, threshold-based assembly algorithms do not guarantee on the assembly delay experienced by the packets. A mixed timer/threshold-based assembly algorithm may provide better performance, especially with self-similar traffic, but may have higher operational complexity [18].

A signaling protocol is the procedure through which services such as switching-path establishment, deletion and modification are provisioned. By using a signaling protocol, a control packet can reserve resources for the corresponding data burst by guiding it through a routing path. In an optical network, there are one-way and two-way reservation signaling protocols. In one-way reservation [13-15], a control packet reserves resources along the path for the corresponding data burst without any acknowledgement from the destination node. On the contrary, in a two-way reservation [5], a control packet collects link and topology information instead of reserving resources for the data burst. The acknowledgement packet from the destination node to the source node reserves resources for the corresponding data burst while traversing along the reverse path. After receiving the acknowledgement packet, the source sends the burst along the reserved path. Since one-way reservation protocols are more flexible, have lower latency, and are more efficient as compared to two-way reservation protocols, they are mainly adopted in OBS networks.

The major responsibilities of the core switches comprise of handling contention resolution and forwarding. When an incoming control packet enters a core switch through one of its input ports, it undergoes an optical to electrical conversion (O/E) so that it can be easily processed electrically. Based on the destination information
carried within the control packet, the appropriate output link is determined and the control packet tries to reserve one of the available wavelengths for the time when its corresponding burst arrives at the switch. If any unused wavelength is available, the burst is forwarded to its specified output link and leaves the switch, provided that all the required resources have been reserved beforehand by the control packet. If all the wavelengths are in use, then the burst should wait for one of the wavelength to be freed. Since there is no optical random access-like memory to hold such bursts, they are delayed by employing fiber delay lines (FDLs). Such FDLs serve as optical buffers as they are capable of postponing data burst for a certain amount of time. If a switch is deprived of such FDLs, the burst is immediately dropped out and considered lost. Unlike control packets, data bursts are always transmitted in the optical layer and never undergo any O/E conversion.

2.1 More on Fiber Delay Lines (FDLs)

In this subsection, we examine the structure and functionality of FDLs in more details. Among all proposed structures, we adopt variable-delay fixed-length FDLs, as demonstrated in Fig. 2. As is evident from the figure, each FDL buffer is composed of $D$ delay lines (DL), each of which is capable of delaying an optical burst for a total of $B$ time units, where $B$ is given as:

$$B = b \sum_{j=0}^{m} 2^j,$$

in which $m + 1$ is the number of stages in a DL and $b$ is the amount of delay a single delay element (specified by circular rings in Fig. 2) can produce. The $j^{\text{th}}$ stage of a DL provides a delay of $b2^j$ time units. A burst entering a DL may exit only at the end of any stage, and not in the middle of a stage.

![Fig. 2. The structure of a variable-delay fixed-length FDL buffer. The buffer consists of $D$ delay lines, each having $m+1$ stages. The end of the $j^{\text{th}}$ stage is specified by the square box labeled $j$.](image)

Although FDLs are used to temporarily buffer an optical burst when there is no wavelength available at the instant of burst arrival, they possess specific
characteristics that distinguish them thoroughly from typical buffers studied in queuing theory. This difference between two kinds of buffers may result in ambiguities when an optical switch is modeled mathematically using results of the theory. For example, in standard queuing systems, a typical customer may stay in a buffer as long as all servers are busy serving other customers. But the same scenario does not hold in the case of optical buffers. Once entering a DL, a burst can stay only for a limited amount of time (the length of a DL) before it is served. So it appears that ordinary queuing systems (systems with limited waiting space) are not too powerful to model such phenomena. Instead, queues with impatient customers, in which the waiting time in queue is limited in some way, are more realistic tools of modeling.

3 Previous Works on QoS

In this section we investigate, in great details, two previously reported techniques for supporting QoS in OBS. In fact, our proposed model is a hybrid of these two techniques which, as we will show later, combines the individual benefits of the two techniques. The rest of this section is organized as follows: In subsection 3.1, we delineate the resource-reservation (or resource-allocation) based QoS management technique [7], followed by the novel extra offset-time based technique [10] in subsection 3.2. Finally, in subsection 3.3, we explain our motivations for seeking a new paradigm for QoS support in OBS.

3.1 Resource-Allocation Based QoS Management

The first QoS approach we consider is based on resource (wavelength and FDL) allocation and has been reported in [7]. Although the method was originally intended for OPS, it can also be applied to OBS with slight alterations. The main idea is to allocate high priority classes with more resources than those allotted to classes with lower priority. For the sake of simplicity, it is assumed in [7] that only two classes of service, High (H) and Low (L), are available. The scheme may be applied in either of the following ways:

1. Threshold-based Technique: In this technique, a burst belonging to the H class may be delayed in an FDL longer than a burst belonging to the L class. In other words, let $T_H^l$ and $T_L^l$ be the maximum amount of time that bursts of class H and L, respectively, might be delayed in an FDL when encountering a contention in an intermediate switch. Then, $T_H^l$ is set to be greater than $T_L^l$ ($T_H^l > T_L^l$) and $T_L^l$ is set as the threshold point. In Fig. 3, an example of this technique in presence of three wavelengths ($W$) and 5 FDLs ($B$) is depicted.

2. Wavelength-based Technique: In this approach, a total of $S$ out of $W$ available wavelengths are reserved to be exclusively utilized by class H bursts, while the other $W - S$ wavelengths are shared between class H and L bursts. Note that $W$ is the total number of wavelengths available in a single optical fiber. This technique is illustrated using a graphical example as shown in Fig. 4 with $W = 4$ and $S = 2$. 
Fig. 3. An example of the threshold-based technique applied to a system having two service classes (L and H) with $W = 3$, $B = 5$ and the threshold value set to $T_f$.

Fig. 4. An example of the wavelength-based technique applied to a system having two service classes (L and H) with $W = 4$ and $S = 2$.

### 3.2 Extra Offset-Time Based QoS Management

In this subsection, we briefly describe the novel extra-offset-time QoS management based approach already reported in [10]. Assume $n$ different classes of service (class 0 to $n$-1), where class $i$ prioritized over class $i-1$ ($1 \leq i \leq n$). To each class $i$, an extra offset time $t_o^i$ is assigned (class 0 is assumed to have no extra offset time, i.e., $t_o^0 = 0$). This extra offset time is added to the base offset time $t_{base}$, such that the expression $(t_{base} + t_o^i)$ determines the amount of time between sending a class $i$ control packet and its corresponding data burst. For the sake of simplicity, it is assumed that the base
offset time is negligible as compared to the extra offset time, and hence can be ignored in the rest of the discussion. Also, let:

- $t_{ij} = t_0^i + t_0^j$ be the offset time difference between classes $i$ and $j$.
- $B$ be the maximum amount of time that a burst might be delayed in an FDL (following the structure of variable-delay FDLs, described in the previous section, we suppose $B$ is of the form $\sum_{k=0}^{m} 2^k b$, for some constant $m$).
- $R_{ij}$ be the probability that a class $i$ control packet succeeds in reserving resources (wavelength and/or FDL) for its corresponding data burst while competing with a class $j$ control packet ($R_{ij}$ is referred to as the degree of isolation between classes $i$ and $j$).
- The burst length of class $i$ has an exponential distribution with mean $L_i$.

Then, in order to have $\alpha (=100R_{i,i-1})$ percent degree of isolation between classes $i$ and $i-1$ in FDL and wavelength reservations, we must have, respectively [10],

$$t_{i,j-1}^i = t_o^i - t_o^{i-1} = -\ln(1 - R_{i,j-1})L_{i-1}$$ \hspace{1cm} (2)

$$t_{i,j-1} = t_o^i - t_o^{i-1} = -\ln(1 - R_{i,j-1})L_{i-1} + B.$$ \hspace{1cm} (3)

To derive a direct formula for $t_o^i$ (for wavelength reservation), one may expand (3) as follows:

$$t_o^i = \sum_{j=1}^{i-1} \left( \ln(1 - R_{j,j-1})L_{j-1} \right) + iB.$$ \hspace{1cm} (4)

In the next section, we will use (3) to justify our motivation for seeking a new hybrid QoS management technique.

### 3.3 Motivations for a New Hybrid QoS Management Technique

In this section, we investigate the behavior of (4) for higher number of prioritized classes through two numerical examples. In both examples, we assume:

- All classes have the same average burst length $L = 12\mu s$ (Assuming 1500 byte IP packets, 10 IP packets in each burst, and 10 Gb/sec optical fibers).
- $B = 31\mu s$ ($= \sum_{k=0}^{4} 2^k$).
- $R_{ij} = 0.9 \ (1 \leq i \leq n - 1)$, i.e. we require a 90% degree of isolation between classes $i$ and $i-1$.

We begin with the first example in which the number of classes, $n$, is taken to be 10. Substituting our assumptions in (4), $t_o^i$ (extra offset time associated with the most important class) would be approximately equal to 0.5 ms. This upper bound (less than a millisecond) on latency due to extra offset time is tolerable for many applications. However, let us consider the case when the number of classes grows even larger. In the second example, the number of classes increases to 100. Again, using (4), the
required extra offset time obtained for the class with the highest priority, \( t_0^{99} \), is approximately equal to 6 ms, which is 12 times that of the highest priority class in the first example.

From the above discussion, it becomes clear that with increase in number of service classes, classes with higher priority suffer from greater network latency (due to extra offset time). This increase in latency might be unacceptable for some real-time applications that require both a high QoS and a response time of less than a few milliseconds. Notice that the latency due to extra offset time is only a fraction of the total latency experienced by a packet through its path in the Internet. Hence, it is desirable to reduce the contribution of extra offset time in total network latency, while still maintaining an effective QoS management scheme. The benefit of this technique, however, is that it imposes no load on core switches. In other words, all QoS management is performed in the ingress switches and core switches are left to their original task of processing headers and switching optical bursts.

On the other hand, resource allocation based QoS does not impose any extra latency to the optical bursts since in this case, bursts are simply transmitted to the network core after a base offset time, which is negligible as compared to the extra offset time, yet the QoS management is left to the switches in the OBS network core. Leaving QoS to the core switches introduces another problem: increase in processing time of burst headers. The more the number of classes is, the higher the processing time of headers becomes. Therefore, this method also seems to be vulnerable to such increase in number of classes. From the above discussions, it is apparent that we are in seek of a QoS technique that concurrently satisfies the following set of goals:

- Supporting a large number of classes.
- Keeping network latency, due to QoS management, as low as possible.
- Imposing little load, due to QoS management, on header processing times at the core network switches.

Based upon the inferences made in this subsection, we propose and explain our hybrid model in the following section.

### 4 Hybrid Model

From the foregoing discussions, we learnt that neither of the two classical techniques namely, resource reservation and extra offset-time based techniques serve as appropriate traffic differentiation approaches for large number of service classes, as they impose additional processing overload and unacceptable fractional network latency, respectively, to the OBS infrastructure. However, by merging the advantages of these two techniques, we propose a new model that greatly alleviates the processing time and network latency as compared to the two individual basic techniques by classifying the differentiated services, denoted by \( n \), as follows:

1. In order to reduce the latency imposed due to the extra offset-time based technique in an ingress edge, we divide the set of \( n \) service classes into smaller subsets, each having approximately equal number of service classes. Doing so would make it possible for the ingress switch to assign a single extra offset time to every subset
rather than every single service class. Such classification would reduce the upper bound on latency and thus, make these services appropriate for time-critical applications. Here onwards, we refer to such subsets of service classes as \textit{inter-service classes} and denote them by $C^i_{inter}(i,i-1,...,j)$, where $i$, $i-1$, ..., $j$ denote service classes belonging to inter-service class $k$ and arranged in the descending order of their priority, i.e. class $i$ has a higher priority than class $i-1$, and so on. In Fig. 5, this classification of service classes into inter-service classes at an ingress switch is depicted (as Phase 1), where each inter-service class is composed of two service classes. Rectangular blocks denote service class bursts such that darker blocks represent bursts with higher priority. Also, the curved arrows denote the action of prioritizing classes (in this case, prioritizing inter-service classes using the extra offset-time approach).

![Graphical representation of the proposed hybrid QoS model for $n$ service classes. Darker rectangular blocks denote bursts of service classes with higher priority. In phase 1, the $n$ service classes are partially prioritized into $m$ inter-service classes ($m < \lceil \sqrt{n} \rceil$) at the ingress switch using the extra offset-time approach. In phase 2, the intra-service classes in each inter-service class are prioritized using the resource allocation approach as they reach the core switch.](image)
The new extra offset-time assigned to each inter-service class \( C_{\text{int}}^k \) is determined as:

\[
  t_{k,i-1} = t_n^k - t_{n-1}^k = -\ln(1 - R_{k,i-1})L_{i-1}.
\] (5)

In (5), the average burst length of any inter-service class \( k \), \( (L_k) \), is taken to be a weighted summation of average burst lengths in \( C_{\text{int}}^i \) \( (i,i-1,...,j) \), where the weight of average burst length of class \( q \) \( (i \leq q \leq j) \), is the ratio of the traffic intensity of class \( q \) to the total traffic intensity of inter-service class \( C_{\text{int}}^k \) \( (i,i-1,...,j) \), i.e.:

\[
  L_q = \sum_{q'=i}^{j} \frac{\rho_q}{\sum_{j'=i}^{j} \rho_{j'}} L_{q'}.\] (6)

2. Once the service classes are classified into inter-service classes, they reach the core switch to be further prioritized by the resource allocation based technique. Since these arriving inter-service classes have already been partially prioritized at the ingress switches, the overhead existing in such switches is reduced to merely processing and prioritizing service classes within the inter-service classes rather than the entire set of \( n \) service classes. Hereafter, we refer to service classes within a specific inter-service class as \textit{intra-service classes} and denote them by \( C_{\text{int},k}^i \), where \( k \) denotes the inter-service class to which service class \( i \) belongs. This second phase of intra-service class prioritization is clearly shown in Fig. 5. It should be noticed that the offset time allocated to any \( C_{\text{int},k}^i \) and \( C_{\text{int},k}^i \) belonging to the same inter-service class \( C_{\text{int},k}^i \) is the same, and they are prioritized only in the second phase, where \( C_{\text{int},k}^i \) is provided with more resources (wavelength and/or FDL) with respect to \( C_{\text{int},k}^i \) using the resource allocation based QoS management techniques (shown as a curved arrow).

5. Simulation Scenarios and Results

In this section, we describe the simulation scenarios and justify our hybrid model by comparing it with the two fundamental QoS management techniques. The performance measures taken into account are burst network latency and blocking probability for the topologically available optical network given in Fig. 6. All scenarios described in this section have been created, simulated and compared using the Ptolemy simulator and in accordance with the assumptions made in subsection 3.3. In all figures throughout this section, solid lines denote results obtained using the basic extra offset-time approach, while dotted lines show results obtained through the proposed hybrid model. Hereafter, we use notations \( w \) and \( B \) to denote the number of wavelengths and FDLs, respectively.
Fig. 6. The optical network considered for simulation. The network comprises of three ingress ($I_1, I_2, I_3$), eight core ($C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8$), and three egress ($E_1, E_2, E_3$) switches.

Fig. 7 compares the network latency of the given network with 100 service classes for $w = 40$ and $B = 5$. In this scenario, $w$ is kept constant for both models, while the intra-service classes are prioritized in the hybrid model using the 5 FDLs. As shown, for large number of service classes, the network latency suffered by higher prioritized classes in the hybrid model reduces to a great extent. In the extra offset-time model, since the 5 FDLs are shared among all 100 classes, the network latency highly increases. On the contrary, since the 5 FDLs are prioritized among only 10 intra-service classes (after being partially prioritized into inter-service classes using the extra offset-time approach), this latency is greatly reduced.

Fig. 7. Latency comparison of the extra offset-time and hybrid models for $w = 40$ and $B = 5$. 
In Fig. 8, the blocking probability for the large number of service classes has been studied with the same parameters considered in the preceding scenario, i.e., \( w = 40 \) and \( B = 5 \). It can be observed that the hybrid model tends to reduce the blocking probability of a wider range of intermediate classes (approximately from classes 10 to 55) by reducing the blocking probability difference between every intra-service class of the same inter-service class. However, this reduction in blocking probability for the intermediate classes happens at the cost of slight increase in the blocking probability of the higher prioritized classes (from 55 to 100). But, when compared to the decrease in network latency studied earlier and reduced blocking probability for the intermediate classes, such minor increase in blocking probability is quite acceptable.

![Fig. 8. Blocking probability comparison of the extra offset-time and hybrid models for \( w = 40 \) and \( B = 5 \).](image_url)

In our next scenario, we study the effect of increasing the number of wavelengths on the blocking probability of the service classes. Due to the capability of WDM technology in supporting large number of wavelengths, we can expect a greater set of wavelengths to be available for prioritizing huge number of service classes. By doing so, the number of wavelengths in each subset assigned to every intra-service class in the resource reservation technique would increase and thus promote lesser blocking of service bursts. This fact is clearly illustrated in Fig. 9, where the number of wavelengths, \( w \), is increased from 40 to 60 and \( B = 5 \). As can be seen, with increase in \( w \), the high blocking probability of the intermediate classes is greatly reduced to only a small number of low priority classes (approximately classes 5 to 15) in the extra offset-time model. In the hybrid model, as we approach higher prioritized classes, the increase in blocking probability of such classes (for \( w = 60 \)) is much lesser compared to the case where \( w = 40 \). This proves that for the hybrid model, with increase in \( w \), the increase in the blocking probability of higher classes becomes almost negligible.
Fig. 9. Blocking probability comparison of the extra offset-time and hybrid models with increase of $w$ from 40 to 60 and $B = 5$.

Fig. 10. Blocking probability comparison of the extra offset-time and hybrid models with increase of $B$ from 5 to 15 and $w = 40$.

In Fig. 10, we study effect of increasing the number of FDLs on the blocking probability. We expect to obtain a graph similar to that of Fig. 9. This is because with increase in $B$, bursts can be delayed for a longer time, thus enabling the core switches
to prioritize more number of intra-service classes facing lower blocking probability. In this scenario, \( w \) is set to 40, while \( B \) increases from 5 to 15. As can be observed, in the case of \( B = 15 \), the hybrid model pulls down the high blocking probability of most of the intermediate classes (approximately classes 10 to 55), while adding little to the blocking probability of the higher classes (approximately classes 80 to 100), which is nothing compared to the improved network latency obtained (as shown in Fig. 7).

We now study the trend of our performance measures for a specific service class, say class 60 in the following two figures. Extensive validation experiments have been performed for several parameter combinations. However, for the sake of specific illustration, the results are presented for the following cases only. In Fig. 11, we compare the network latency of our hybrid model with that of the extra offset-time model for three different data sets of \((w, B)\), i.e., \((10, 5)\), \((20, 10)\) and \((40, 15)\). These data sets are chosen in such a way so as to illustrate the prominent changes in the trend. We learn that the hybrid model reduces the latency of the entire network as the number of resources (wavelength and/or FDL) increases, while such does not happen in the case of the extra offset-time model.

![Bar chart showing network latency comparison](chart.png)

**Fig. 11.** Network latency comparison of the extra offset-time and hybrid models for service class 60 with \((w, B) = ((10, 5), (20, 10), \text{and } (40, 15))\).

Similarly, in Fig. 12, we compare the two models on the basis of blocking probability with the same data sets. This figure shows that with increase in resource availability, the blocking probability also increases for our hybrid model. For the data set \((40, 15)\), this probability grows more than obtained for the extra offset-time model. However, such minor increase in blocking probability is quite tolerable when compared to the improved network latency. Thus, we can conclude that for large number of traffic classes and WDM-based implementation of optical switches, the proposed hybrid QoS management technique provides more improved latency and
almost the same blocking probability as the two fundamental techniques namely, extra offset-time based and resource reservation based QoS management techniques.

![Blocking Probability Comparison](image)

**Fig. 12.** Blocking probability comparison of the extra offset-time and hybrid models for service class 60 with \((w, B) = ((10, 5), (20, 10), \text{and} (40, 15))\).

6. Conclusions

The number of service classes has been growing extensively due to the increase in on-demand multimedia and time-critical applications over the Internet. Several techniques have been suggested and analyzed in the literature so as to improve such quality of service (QoS) differentiation in optical burst switched (OBS) networks. In this paper, we have introduced a novel QoS management technique that combines the best of the two prominent techniques already investigated in the literature namely, resource-reservation and extra offset-time based QoS. This prioritized hybrid model has shown to perform better than the two aforementioned techniques in terms of QoS provisioning and latency for large number of service classes. Our future research will extend this work to OBS networks with real-world self-similar traffic conditions dominating the edge switches.

References