RCES REVIEW OF COMPUTER ENGINEERING STUDIES

ISSN: 2369-0755 (Print), 2369-0763 (Online)
Vol. 4, No. 3, September 2017, pp. 98-102
DOI: 10.18280/rces.040303

A publication of IIETA

IIETA International Information and Engineering Technology Association
Advancing the World of Information and Engineering
http://www.iieta.org/Journals/RCES

Optimizing optical networks by using CWN algorithm

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ABSTRACT

Deploying TCP Vegas in Optical Burst Switching (OBS) networks reduces the performance of the network due to the misunderstanding of the congestion in the networks. In OBS networks, beside congestion in the network we have burst contention which causes the packet lost in the network. When the traffic is low and a contention happens, TCP Vegas assumes the contention as the congestion and reduces the size of congestion window (cwnd) wrongly. If we can find the best numbers for packets and wavelengths we can optimize our network. For this purpose we use CWND algorithm. By using CWN algorithm we obtain the best number of wavelengths for data and packet controls to have the best performance in the network and we can increase number of packets that are sent. In this scheme we try to minimize the effect of the contention on the performance of the network. The simulation results show that this algorithm increases the performance of the network and prevent wasting the bandwidth in the network.

Keywords: Optical Burst Switching, TCP Vegas, Transport Control Protocol (TCP), WDM (Wavelength Division Multiplexing).

1. INTRODUCTION

Due to the increase in the use of TCP in the networks, a lot of researches have been conducted to adapt this protocol to the new networks [1-8]. Most of the researches were on the 3 categories: Loss-based TCP (such as TCP Reno [5] and TCP Sack [6]), delay-based TCP (such as TCP Vegas [7] and Fast TCP [2-3]) and explicit notification-based TCP (such as XCP [8]). There are a couple of switching techniques in optical networks. One of the useful and popular methods is WDM or Wavelength Division Multiplexing techniques. This technique mainly used in Optical Burst Switching (OBS) networks. OBS is a switching technique in context of wavelength division multiplexing that can deal with large amount of data in the network [9]. In OBS networks when packets arrive at the edge nodes, they are aggregated in a burst then they are sent throughout the network. As a result, we have two types of nodes in the edge and a type inside the networks. The edge nodes contain ingress and egress nodes. The duty of the ingress nodes is receiving the packets and assembling them into a burst and sending them in the network. On the other side of the network we have egress nodes which their responsibility is receiving the bursts and disassembling them into the individual packets. Inside the network we have core nodes. Their duty is forwarding the bursts in the network.

We have a process in OBS networks that is called burst reservation. It means before sending a burst in the network by the ingress nodes, they send a control packet in the network to reserve the resources they want. This control packet is sent over an out-of-band channel. These control packets contain information such as the burst length and offset time. When a control packet is sent in the network, ingress nodes wait an amount of time before sending the main burst. This time is called offset time [10].

The media in OBS networks is a fiber. The bandwidth in a fiber link is enough to carry a large amount of data, because of that in OBS networks links are divided to distinct channels to carry the bursts separately. This is called wavelength division multiplexing (WDM).

One of the most important problems in OBS networks is existence of contentions between the bursts. It means there is a probability that bursts will drop even in low traffics due to the burst contentions. This occurs because of the buffer less nature of the network. Normally, TCP interprets a packet drop as a congestion indicator in the network however in OBS networks sometimes it does not show the heavy traffic. As a result, it causes a reduction in the performance of the network. Finding a way to prevent effect of the contention on the performance of the network is an important consideration.

Explicit signaling from the OBS layer to the TCP layers is one of the schemes that tries to cope with the false congestion detection in the network [11]. This algorithm can help the network to have an appropriate performance but generating a random signal for bursts makes extra overhead in the network.

Burst retransmission and deflection scheme at the OBS layers is one of the proposed schemes to deal with the false congestion detection. This method tries to hide some of the burst losses from the upper levels of the TCP [12-14]. So it reduces chance of false congestion detection problem in the network. With burst retransmission or deflection, contented bursts are retransmitted at the edge nodes or can be deflected to alternative routes, respectively. This method has a shortcoming. By enabling deflection routing in the network, optical buffers needed to be used [15].

Another algorithm to solve this problem is a threshold based one. It adjusts the congestion window size by considering Round Trip Times (RTTs) of packets received at TCP senders. If the number of RTTs that are longer than minimum RTTs exceeds the threshold, it indicates congestion occurrence in the network, otherwise there is no congestion in the network [15].

Coordinated burst cloning and forward segment redundancy is another method to prevent packet loss during random contention in the network [9].

Another proposed algorithm to deal with this problem is optimizing TCP Vegas for optical networks by using a fuzzy logic approach [16]. In this algorithm, OBS network is divided to several parts by using fuzzy logic to distinguish a traffic-based packet drop and a contention based one.

When a burst with segment from various TCP flow is removed, the synchronization of TCP flows is made and it makes TCP flows reduce transmission rate at the same time. This method examines the capacity of bandwidth that needs to be provisioned in OBS links transporting synchronized flows comparing to a non-synchronized scenario. Three different variants of TCP that are TCP Tahoe, TCP Reno and TCP New Reno have been examined in [17].

Throughput results from an experimental study of TCP source variants, Tahoe, Reno and New Reno is represented in this paper. Considering the network parameters such as, bandwidth, packet size and congestion window size throughput of each variant is measured. The influence of number of burstifiers on TCP performance for an OBS network has been investigated in [18]. This paper shows increasing number of burst assemblers, TCP goodput grows Effects of several flow-aware and flow-unaware mechanisms have been studied in [19]. Improved mechanisms of TCP fairness over OBS networks is proposed in this paper. In [20] a mechanism for dealing with multicast routing overhead for TCP over Optical Burst Switching networks has been studied. This scheme is based on specialized nodes in All Optical Networks (AONs) called as Virtual Source (VS) nodes. The goal of this mechanism is increasing the capabilities of virtual source nodes in order to reduce number of failed requests, thus reducing number of bursts retransmission required. The interworking between different access network and an Optical Burst Switched network is considered in [21] that presents the influence of assembly timeout in different access contexts. There are some other modifications in [22-30].

In this paper we propose a new algorithm called CWN. By using this algorithm we can find the appropriate number of the wavelengths for data and control packets so we can prevent wasting bandwidth and increase the performance of the paper. The aim of this algorithm is to reduce the effect of the bursts contentions in the network.

The rest of paper is organized as follows. Section 2 describes TCP Vegas as background for the research. Section 3 presents the CWN algorithm and the proposed scheme. Packet level simulation results come in section 4 and finally concluding remarks are given in section 5.

2. TCP VEGAS

The proposed algorithm is implemented in OBS networks which are running under TCP Vegas. As a result, in this section we are going to have a brief review on it.

2.1 TCP vegas

Measuring the RTT of each packet is the key feature of TCP Vegas to avoid the congestion. For estimating the available bandwidth in the network and congestion status TCP measures the RTT of the packets. TCP Reno and TCP Vegas are different on the congestion avoidance phase. Each packet lost in TCP Reno is an indicator of the congestion. It means before a packet lost TCP Reno has no mechanism to deal with the traffic. On the other hand, in TCP Vegas we have estimated and measured throughput in a specific time window. TCP Vegas compares these two throughputs for detecting the traffic in the network. Expected throughput is calculated by using equations 1:

$$\text{Expected} = \frac{\text{cwnd}}{\text{BaseRTT}} \tag{1}$$

The actual throughput is calculated by using equation 2:

$$\text{Actual} = \frac{\text{cwnd}}{\text{RTT}} \tag{2}$$

In these equations cwnd is the current congestion window size.

By comparing these two throughputs and difference between them TCP Vegas adjusts the cwnd (denoted as diff):

$$\text{Diff} = \text{Expected} - \text{Actual} = \left(\frac{\text{cwnd}}{\text{BaseRTT}} - \frac{\text{cwnd}}{\text{RTT}}\right)\text{BaseRTT} = \text{cwnd}\left(1 - \frac{\text{BaseRTT}}{\text{RTT}}\right) \tag{3}$$

This value is used two adjust the next cwnd. In Vegas we have two threshold values, denoted as α and β for changing next size of cwnd. TCP Vegas uses these two thresholds and next congestion window is set as follow:

$$\text{cwnd} = \begin{cases} \text{cwnd} + 1 & \text{diff} < \alpha \\ \text{cwnd} & \alpha \leq \text{diff} \leq \beta \\ \text{cwnd} - 1 & \text{diff} > \beta. \end{cases} \tag{4}$$

When actual throughput is much smaller than expected, it means network may be congested and we must decrease flow rate. On the other hand, when the actual throughput is close to expected, it means available bandwidth in the network is not used efficiently and we must increase flow rate [7-11-15-33].

3. CWN ALGORITHM

3.1 CWN algorithm

This section explains CWN algorithm. As it was said, in OBS networks we have the contention problem which causes a reduction in the performance of the network. It means, sometime the traffic is low but a contention occurs in the network and it makes TCP Vegas reduce the sending rate by mistake. The reason of this misunderstanding is TCP Vegas is designed for the wired networks which each packet lost has only one source, traffic; But in OBS networks beside the traffic, burst contentions can lead to packet losses.

If we could find the cause of the contentions in the network and reduce its effects, we can improve our performance. The most important reason for having contentions is the bufferless nature of the network. It means when a node tries to send two bursts in the network and both of them are trying to reserve the same wavelength, they will contend and one of them will drop. The scenario behind this event is the few numbers of the wavelengths for the data and control packets. If we have few numbers of them we will have a lot of contentions in the network and having a lot of them costs a lot. If we can find appropriate numbers for the wavelength and control packets routes, we can reduce the effect of the contentions significantly. As a result, we will have three scenarios in the network: 1. finding the best number for the wavelengths. 2. Finding the best numbers for the control packets routes. 3. Finding the best number using both of them in the network.

The first scenario is finding the best number for the wavelengths. For this purpose we use a linear equation:

$$W_{n+1}= W_n \qquad (5)$$

Which W_{n+1} shows the next number of the wavelength.

We examined more than 30 wavelengths. The following table shows the 5 important numbers.

W_1	W_2	W_3	W_4	W_5
2	4	8	16	32

Table 1. The number of wavelengths

The next scenario is finding the best number for the control packet routes. Like the first scenario, we use a linear equation to obtain the next value:

$$C_{n+1}= C_n \qquad (6)$$

Which C_{n+1} shows the next number of the control packet routes. We examined more than 30 control packets routes. The following table shows the 5 important numbers.

C_1	C_2	C_3	C_4	C_5
1	2	4	8	16

Table 2. The number of control packet routes

Finally, the third scenario is a combination of the numbers in table 1 and 2. It means after finding the 5 best numbers, we use both of them in the network.

C_1- W_1	C_2- W_2	C_3- W_3	C_4- W_4	C_5- W_5
1-20	1-40	1-80	2-160	2-320

Table 3. The number of the wavelength and control packet routes

By using these numbers, we can find the best number for the wavelengths and control packets routes for having an appropriate performance in the network.

3.2 CWN algorithm performance

In this section we study CWN algorithm performance in comparison with TCP Vegas. In order to study performance of the proposed model, we implement CWN algorithm by making some modifications over TCP Vegas module of ns-2 software package and incorporate modules required to implement OBS. In this simulation, we use the network topology shown in Fig. 1 in which there are 16 edge nodes and 3 core nodes. In this network each edge node is connected to the core nodes with a 1ms propagation delay. Edge node is connected to the core node with a 100Mbps optical link.

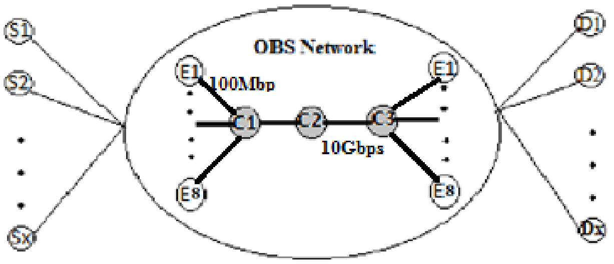

Figure 1. The network topology adopted in the simulation

Figure 2 shows throughput of various numbers of the wavelengths in different contention probability. According to this figure, when the wavelengths number is 16, we have the best performance in the network.

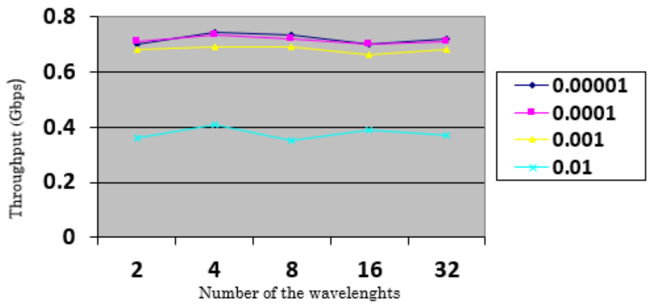

Figure 2. Throughput of the networks under different wavelengths numbers

Figure 3 shows throughput of various numbers of the control packets routes in different contention probability. According to this figure, when the control packets routes number is 2, we have the best performance in the network by considering the cost of having more ones.

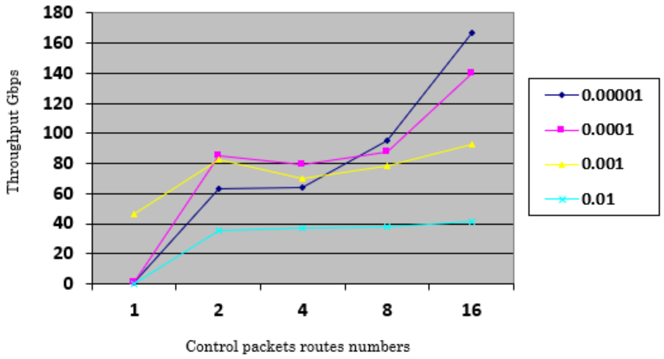

Figure 3. Throughput of the networks under different control packets routes numbers

Figure 4 shows throughput of various numbers of the wavelengths and control packets routes in different contention probability.

As we can see in the figures, the best numbers for the wavelengths is 16 and the best one for the control packets routes is 2. The reason of this performance is the suitable ratio between the numbers.

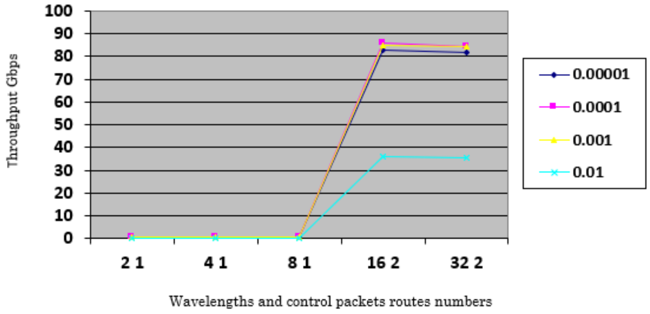

Figure 4. Throughput of the networks under different wavelengths and control packets routes numbers

Figure 5 shows throughput of various numbers of the wavelengths and control packets routes compared by TCP Vegas in different contention probability. The network used in TCP Vegas has 1 control packet route and 8 wavelengths for carrying the data. As we can see, using appropriate numbers for wavelengths and control packets routes can have a huge effect on the performance of the network.

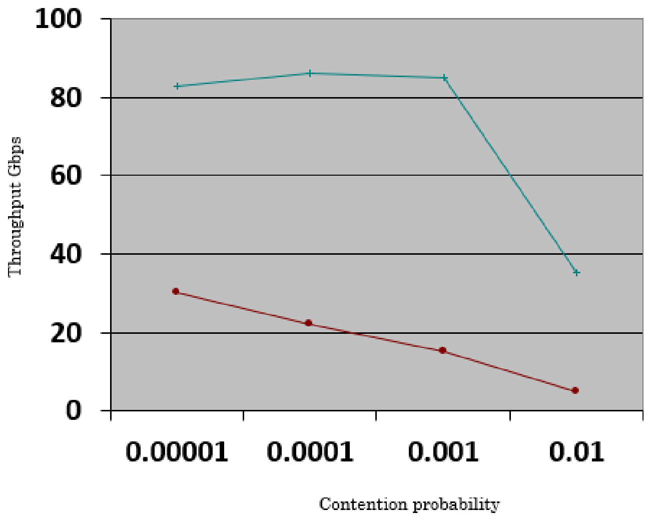

Figure 5. Throughput of TCP Vegas and CWN algorithm

4. CONCLUSION

There is a conventional problem in OBS networks called false congestion problem detection that can have a great effect on the performance of the network. In this paper we proposed CWN algorithm to obtain the best numbers for data wavelengths and control packets routes. By using this algorithm, we succeeded to increase the performance of the network. Simulations results in ns-2 environment showed that using CWN algorithm can reduce the effect of the false congestion detection in OBS networks.

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