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Performance Comparison of JIT and JET Protocols on the OBS Networks

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Abstract

Over the past few years, internet traffic has been explosive growth due to users' need for more applications and services. All these developments on the internet need more bandwidth. The Optical Burst Switching (OBS) mechanism along with Wavelength-Division-Multiplexing (WDM) technology is very useful in meeting the high bandwidth requirements. However, the OBS network uses a one-way resource reservation mechanism, as well as it is a buffer lack at the intermediate (core) node. Therefore, the OBS network depends on contention resolution mechanisms to achieve acceptable levels of performance. In this paper, the Deflection Routing (DR) mechanism is used to overcome contention. The performance of the OBS network has been estimated by executing Just-In-Time (JIT) and Just-Enough-Time (JET) signaling reservation protocols with the DR. NCTUns-6.0 simulator was employed to verify the performance of the OBS network based on two metrics: throughput and packets dropped in the network. The results show that the bandwidth resources utilization in the OBS network with JET and DR (OBS-JET-DR) is better than in the OBS network with JIT and DR (OBS-JIT-DR). However, the average number of packets dropped in OBS-JET-DR is less than OBS-JIT-DR by 21%. In addition, the throughput of OBS-JET-DR has increased by 4% compared with OBS-JIT-DR.

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Keywords: Optical Burst Switching (OBS), Contention resolution, Just-In-Time (JIT), Just-Enough-Time (JET), Deflection Routing (DR).

1. Introduction

Recently, the users' demand for bandwidth has been rising day by day as a result of growing applications and Internet-based services, which include multiple social networking applications, online banking services, online marketing, e-commerce, telemedicine, and many more real-time multimedia applications. However, the only way that addresses ever-increasing bandwidth demand is to use fiber optic links [1]. Researchers presented different technologies to increase the optical-backbone internet capacity.

WDM technique is perhaps the most excellent way to employ the capacity of optical fiber's massive bandwidth. However, this technique lacks buffers and processing in the optical field at the bit level. Therefore, many switching mechanisms are used to smooth transmission data over the WDM technique efficiently, such as optical circuit switching (OCS), optical packet switching (OPS), and optical burst switching (OBS). Hence, the best switching technique is the OBS technique, because it sends the Internet Protocol over Wavelength Division Multiplexing (IPoWDM) in an all-optically strategy with a one-way reservation mechanism to provide high scalability of transmission rate and minimize the switching process overheads [2]. Furthermore, it combines the benefits of OCS and OPS and avoids their restrictive [3].

The architecture of the OBS network consists of edge and core nodes in addition to interconnected WDM links [4], as shown in Fig. 1. The edge node functions as an ingress or egress node. The data packets from the access network are assembled at the ingress node to create a data burst (DB). Then it generates a Burst Control Packet (BCP), which includes information about (the burst length) of DB (IP sours/destination), and burst arrival time (offset time). Hence, the ingress node will send the BCP at offset time before the DB to a core node to resource reservation required for transmission.

Upon receiving the BCP at a core node, it configures its Optical-Cross-Connect (OXC) to switch its DB at the appropriate time after offset time. Fig. 2 illustrates the core node architecture in an OBS network. Generally, the Control Unit (CU) receives and processes the BCP through an Optical-Electronic-Optical converter (O/E/O). But the data payload assembled in Data Burst (DB) will be transmission all-optically over OXC when it arrives after offset time to the core node in the OBS network.

Signaling scheme at the OBS network using BCP out-of-band burst over control channels in different wavelengths from its DB that travel over data channels. However, the conflict in a core node occurs when more than one burst tries to reserve a particular wavelength simultaneously in an output port of the core node as a consequence of the one-way-reservation approach in the OBS network [5]. Therefore, an appropriate contention resolution policy is critical to achieving acceptable performance levels for the OBS network. Various contention resolution methods have been investigated in the literature, the most important one of which is the deflection routing (DR) mechanism. This mechanism deflects the incoming competing burst to another available output port instead of dropping it. Also, it achieves lower burst loss in the OBS networks than other contention resolution techniques. Additionally, it enhances overall network throughput effectively [6].

Nomenclature & Symbols

OCS	Optical Circuit Switching	IPoWDM	Internet Protocol over Wavelength Division Multiplexing
OPS	Optical Packet Switching	DR	Deflection Routing
OBS	Optical Burst Switching	JIT	Just In Time
WDM	Wavelength Division Multiplexing	DB	Data Burst
IP	Internet Protocol	BCP	Burst Control Packet
JET	Just-Enough-Time	OXC	Optical Cross Connect
CU	Control Unit	NSFNET	National Science Foundation Network
TAG	Tell and Go	TAW	Tell and Wait
FCFS	First-come-first-served	RAM	Random-Access Memory
ns	BCP Processing time	KB	DB length
QoS	Quality of Service	LAUC-VF	Latest Available Unscheduled Channel with Void Filling

In this paper, we utilized a deflection Routing (DR) mechanism to resolve the contention at a core node by dealing with two famous reservation techniques, which are JIT and JET that are executed within the OBS network. These protocols differ from each other in their bandwidth reservation techniques. In the JIT signal, resources are reserved as early as the BCP is processed in an immediate reservation scheme [7]. While the JET depends on a delayed reservation system [8]. Then we compared the performance of the OBS network under JIT and JET protocols with the Deflection Routing (DR) contention resolution scheme based on the National Science Foundation Network (NSFNET) topology under NCTUns6.0 simulation.

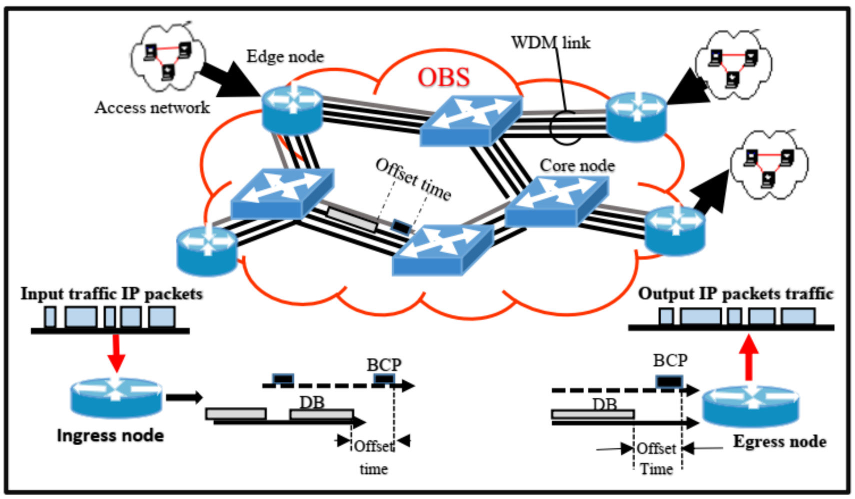

Fig. 1. The optical burst-switching architecture

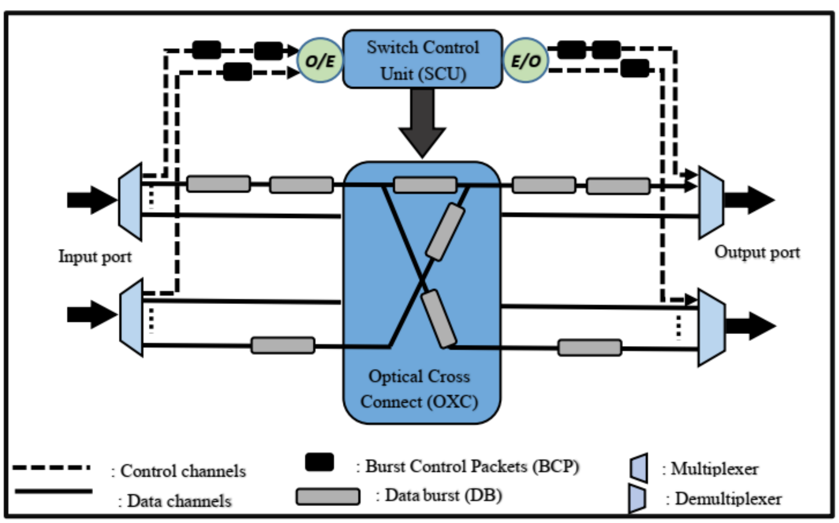

Fig. 2. Core Node of OBS network

2. Signaling Protocols

The signaling protocols are used in an OBS network to configure optical switches and assign resources at each optical core node to pass the Data Bursts (DBs) through them smoothly. An OBS network can use one of two signaling protocols to establish the connection. Which are 'Tell and Go (TAG)' and 'Tell and Wait (TAW)' connection setups [9]. In the TAG connection setup option, the ingress node can send bursts after an offset time without acknowledgment from the egress node (whether the connection has been created correctly or not). Generally, the BCPs are sent separately on a control channel(s) before its data bursts, while the DBs or (data payloads) will be sent after offset time over the data channel(s) [10]. When the reservation is successful, the bursts will reach their destination. Otherwise, it dropped BCPs, hence dropping their DBs [11]. However, under the TAW setup connection, the ingress node allows for the transmission of the burst only when they receive a confirmation message that a complete connection has already been established successfully. The signaling protocols have been implemented for the OBS network as illustrated below:

2.1. Just In Time (JIT)

The JIT scheme is a reservation protocol based on the TAG strategy. It is proposed by Wei and Mc Farland [12]. his protocol is reserving the resources directly to set up resource switching and their release for data switching at the core node. In this context, the burst can be reservation the wavelength directly after BCP arrival at the core node. However, when it can't make a reservation directly, this burst will be rejected and dropped, as shown in Fig. 3. Additionally, it uses a first-come-first-served (FCFS) that services each wavelength according to its scheduling [13].

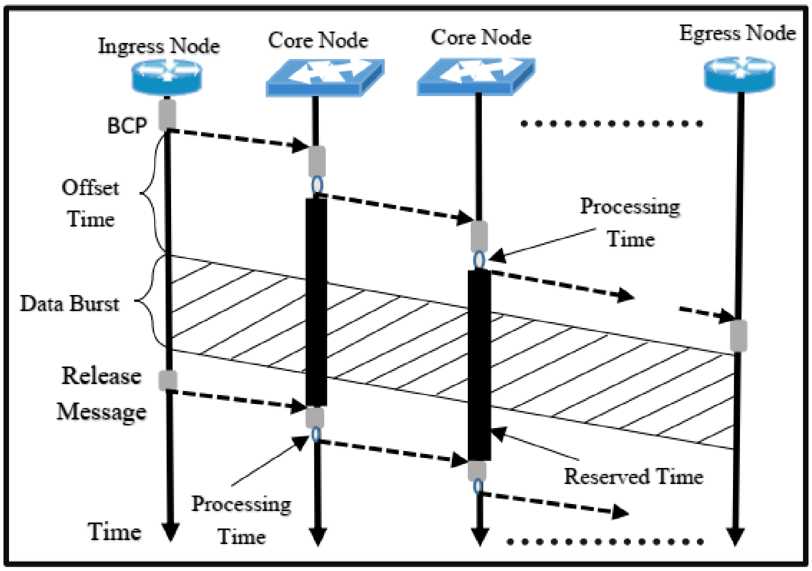

Fig. 3. Just in Time (JIT) scheme

2.2. Just Enough Time (JET)

JET is a reservation protocol based on the TAG strategy [14]. The information about the duration of DB (burst length) and offset time can be found in BCP. This information is about each burst's beginning and ending; it is calculated based on their offset' time' and' burst' length. The reservations by JET begin at the time when the real burst (DB) comes, and it continues without interruption until the conclusion of the burst. The JET known as the void-filling reservation strategy is the most often used for delayed bookings. Where JET depends on estimated release to free up switching resources allocated [15]. Fig. 4., illustrates the JET protocol.

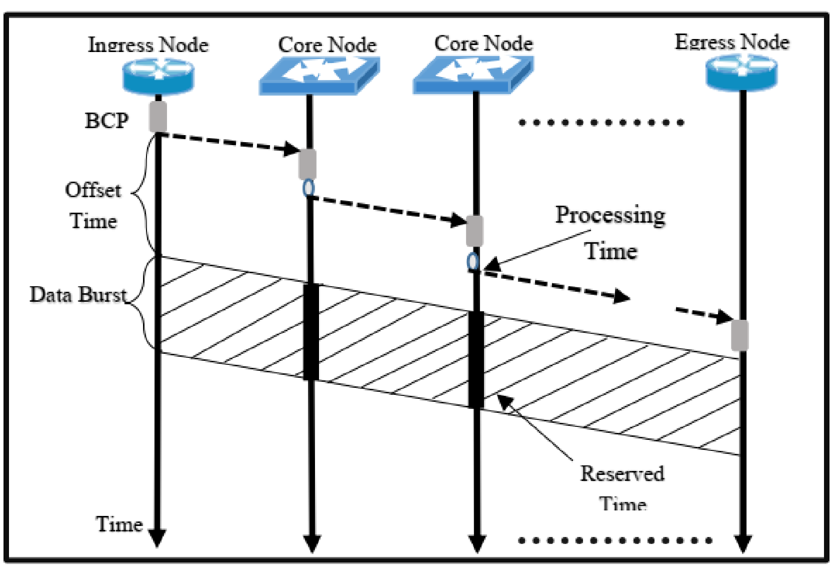

Fig. 4. Just Enough Time (JET) scheme

3. Channel Scheduling

The communication configure method in an OBS network is critical to achieving data bursts (DBs) transfer between a shared pair of source and destination. Every core node must have a channel allocation (DB scheduling) mechanism and a signaling scheme. The channel scheduling purpose is to allocate an unused channel for transferring bursts. Generally, the scheduling algorithm aims to ensure enough process BCP quickly before DB arrives at a core node. Numerous channel scheduling techniques for OBS networks have been presented in the literature. However, there are intervals between consecutive bursts when the channel is unscheduled called "voids". To fill these gaps (voids), the scheduling method must employ information supplied by BCPs, such as burst arrival time (offset time) and burst exit time (burst length). Accordingly, the scheduling algorithm is utilized commonly according to its simplicity. Unlike complex algorithms, simple algorithms aim to locate an available wavelength to accommodate an arriving burst without any additional and complicated bandwidth processing that involves the efficient use of unscheduled voids on the data wavelengths.
In This paper, we used the Latest Available Unscheduled Channel with Void Filling (LAUC-VF) algorithm [16,17] with each of the JIT and JET signaling schemes. This algorithm aims to improve channel utilization by minimizing the voids between bursts. Where it is choosing an appropriate unscheduled data channel for each arrived burst. However, when the bursts don't use the channel at or after time t, this means the wavelength of this channel at time t is unscheduled. Consequently, it doesn't consider the voids between bursts. Therefore, the LAUC-VF algorithm can fill the voids on the wavelength with incoming bursts.

4. Contention Resolution

The main problem in an OBS network is contention, which occurs due to the overlapping in-service time [18]. If cannot resolve the conflict, will drop the incoming burst. Hence, it must address this problem due to its negative impact on the OBS network's performance and Quality of Service (QoS) simultaneously [19]. Usually, an electronic memory known as Random-Access Memory (RAM) is utilized to store the data and place them in a queue where it is sent out as soon as the output port becomes available. However, this solution is not feasible in an all-optical network as a consequence of non-available equivalent optical buffers. Therefore, an OBS network depends on contention resolution mechanisms to achieve an acceptable performance level. Many mechanisms operated on contention resolution in the OBS network. The Deflection Routing mechanism is one of the better methods for dealing with contention problems at the OBS network [20]. In this technique, if two bursts contend for the same output port at the core node, one will be switched to reserve the correct output port, while the other burst will be switched (deflected) to any other available output port. This technique improves the chances of a burst being successfully switched instead of dropped to resolve the contention. However, the bursts not reserved for the correct output ports may take longer paths to their destinations, referred to as "hot-potato" routing [21]. Accordingly, the deflected burst must re-adjust the offset time before sending BCP to the next hop at the core node according to Equation (1):

$$Offset = ((processing\ time + switching\ time) \times number\ of\ hops) \tag{1}$$

5. Proposed Techniques

a. The first proposal is to implement an OBS network with a JIT signaling scheme and Deflection Routing (OBS_JIT_DR) at intermediate nodes. It is done by executing an algorithm at a core node of the OBS network, as illustrated in Table 1. Typically, with JIT signaling, when the BCP reaches the core node, it immediately reserves the resources for the incoming DB. However, if the resource reservation is unavailable for DB, it deflects the BCP to another available port with a different path rather than discarding it entirely. In addition, the core node calculates (re-adjust) its deflected conflict burst's offset time according to equation 1 above because it will travel on a different route.

Table 1. Implementation of (OBS_JIT_DR) algorithm at the core nodes

Input: The Data Burst *DB[i]*, and Burst Control Packet *BCP[i]*.
Output: Send the DB Reservation to the next hop.
Begin
if the received data is *BCP[i]* **then**
    immediate configure the switch for resources reservation to *DB[i]*
    update reservation table
    if *BCP[i]* reservation is not permitted **then** //*The contention occur*//
        if a deflection path is available then
            re-adjust offset time // * according to equation (1) *//
            update *BCP[i]* header
            send *BCP[i]* to next-hop
          forward *DB[i]* to the next hop
        else drop *DB[i]*
        end if
    end if
end if
go to 1
End

b. The second proposal is to implement an OBS network with a JET signaling scheme and Deflection Routing (OBS_JET_DR) at intermediate nodes. It is done by executing the Algorithm at a core node of the OBS network, as illustrated in Table 2. Generally, when the BCP reaches the core node, it waits "0.9 * (Offset time)" and then configures the switch for resource reservation to DB. However, If the resource reservation is unavailable (contention occurs), it deflects the BCP to another available path rather than discarding it entirely. In addition, the core node calculates (re-adjust) its deflected conflict burst's offset time according to equation 1 because it will travel on a different route.

Table 2. Implementation of (OBS_JET_DR) algorithm at the core nodes

Input: The Data Burst *DB[i]*, and Burst Control Packet *BCP[i]*.
Output: Send the *DB* Reservation to the next hop.
Begin
1: **if** the received data is *BCP[i]* **then**
2: **wait for 0.9 * (Offset time)**
3: **configure the switch for resources reservation to *DB[i]***
4: **update** reservation table
5: **if** *BCP[i]* reservation is not permitted **then** //*The contention occur*//
6: **if** a deflection path is available then
7: **re-adjust** offset time // * according to equation (1) *//
8: **update** *BCP[i]* header
9: **send** *BCP[i]* to next-hop
10: **forward** *DB[i]* to the next hop
11: **else** drop segment *DB[i]*
12: **end if**
13: **end if**
14: **end if**
15: **go to 1**
End

6. Setup of Simulation

Fig. 5 illustrates the network simulation that uses the topology of the National Science Foundation Network (NSFNET). The topology of NSFNET consists of 10 computers, 10 edge nodes, 14 core nodes (switches), and 28 WDM links that are interconnected between both core and edge nodes. Table 3 illustrates the simulation parameter requirement.

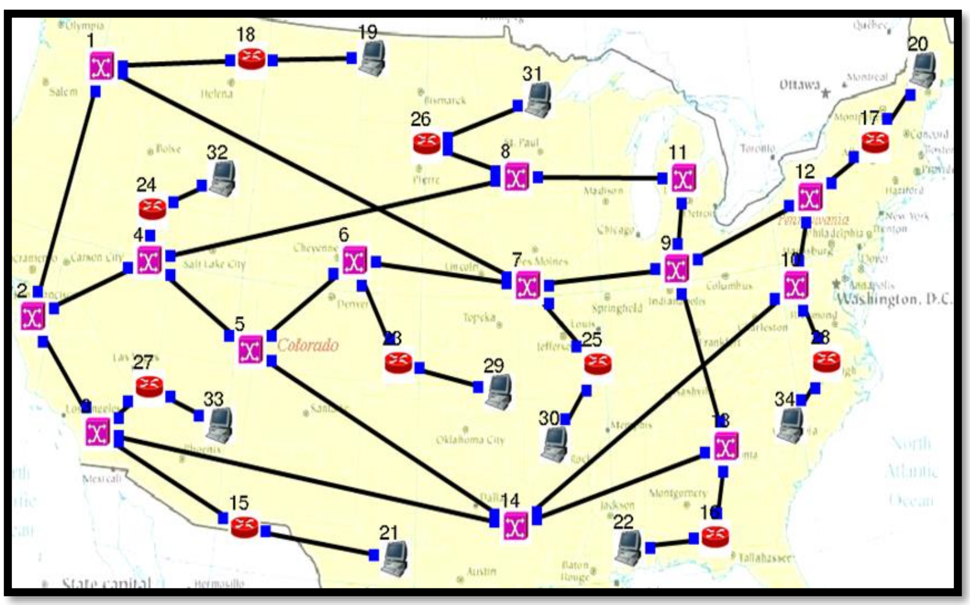

Fig. 5. NSFNET to simulate OBS network (NCTUns 0.6-screenshot)

Table 3. Simulation parameters

Parameter	Value
DB length	15360 KB
Threshold Time	μs 2
BCP Processing time	2 ns
Bandwidth/channel	100 Mbps
Reservation Protocols	JET, JIT
No. of channels/fiber	14
Computers	10
Edge nodes	10
Core nodes	14
WDM links	28

In this paper, there are ten UDP connections, which are from node 19 to node 22, from node 31 to node 21, from node 20 to node 33, from node 32 to node 34, from node 29 to node 19, from node 30 to node 20, from node 33 to node 30, from node 21 to node 31, from node 22 to node 32 and from node 34 to node 29. Hence, each link consists of only 14 channels which are 12 channels for DBs and 2 channels for BCPs. Additionally, the data rate of each channel in the link is 100 Mbps, and the processing time of BCP is set to 2ns. This paper aims to examine the performance of the OBS network with the proposed DR contention resolution in two scenarios: the JIT and JET signaling within core nodes. For performance evaluation of this network, it is used the throughput and number of packets dropping are used. Each personal computer has a packet generator assumed with Poisson's process to generate the DBs. In addition, the routing algorithm is based on the shortest fixed path to the destinations, while all the switching nodes use FIFO queuing strategy for BCPs. Fig. 6 shows the implementation of the OBS network at NCTUns-6.0 by using traffic load.

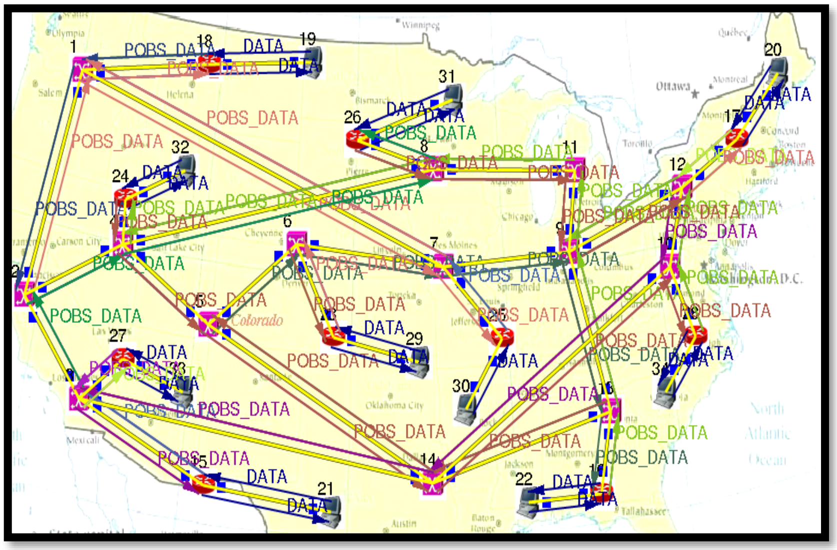

Fig. 6. Implementation of OBS network by using high-traffic load

The first performance parameter is the number of packets dropped in the OBS network. This status occurs when one or more data packets upon its traveling through the network fail to reach their destination. Accordingly, the NCTUns-6.0 simulator records the number of packets dropped in the network during simulation time.
The second performance parameter is the throughput, that defined as the amount of data received at the destination per unit of time. The throughput of the network is calculated as Equation (2):

$$throughput = \frac{\sum Received\ packets \times packet\ size\ in\ bit}{Simulation\ time} \tag{2}$$

7. Result and Discussion

The performance comparison of the OBS-JET-DR with the OBS-JIT-DR method is based on the packets dropped and throughput versus network load. Figs. 7 and 8 depict the simulation results performed by using the network topology in Fig. 5 for each proposed method. Where the first performance parameter is the number of packets dropped versus network load. The results indicate that the number of packets dropped in the OBS-JIT-DR approach is higher than OBS-JET-DR, as shown in Fig. 7. Accordingly, the OBS-JET-DR method is seen as better than the OBS-JIT-DR in reducing the number of packets dropped on OBS network in all network loads. This is because the JET signaling strategy required less time than JIT signaling for the reservation of bandwidth resources at intermediate nodes.

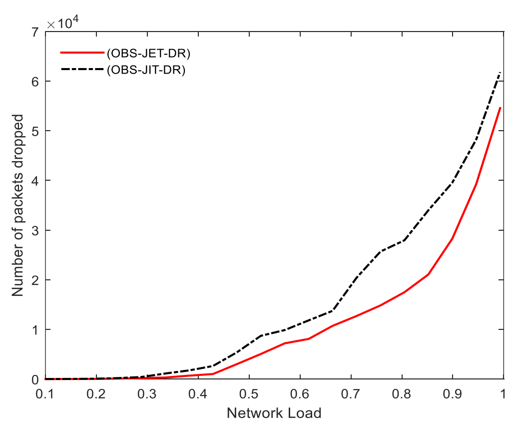

Fig. 7. Number of packets dropped vs Network load

The second performance parameter is throughput versus network load. It is defined as the amount of data received at the destination per unit of time. Fig. 8 shows that the throughput results in the OBS-JET-DR method are higher than the OBS-JIT-DR. This is because of intermediate nodes of The JIT that is reserving bandwidth resources for a longer time than JET.

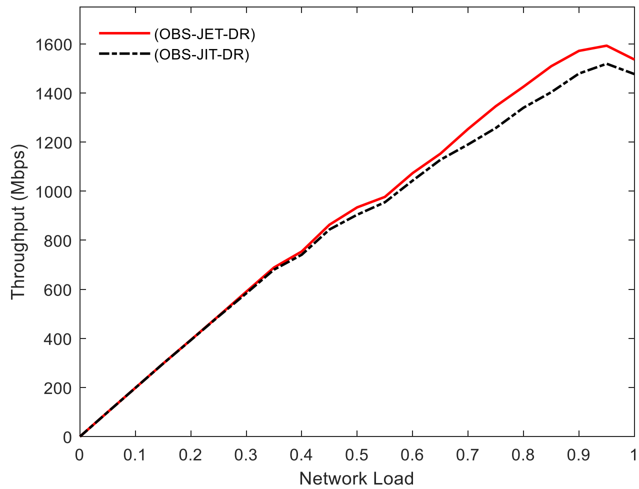

Fig. 8. Throughput (Mbps) vs Network load

8. Conclusion

Optical burst switching (OBS) is considered a viable solution for the next generation of optical Internet. The OBS technique was chosen to increase bandwidth utilization to provide a flexible network that could handle the requirement for traffic rise. One of the most challenging aspects of the OBS network is overcoming performance degradation due to contention issues. One of the most investigated topics is the DR technique of contention resolution in OBS networks. The comparison between OBS-JET-DR and OBS-JIT-DR strategies is described in this paper. The comparison parameters are based on throughput and the number of packets dropped in the network for analyzing the performance of the OBS network. The results depicted that the OBS-JET-DR method is an effective technique for contention resolution in an OBS network. Furthermore, it has been shown that the proposed OBS-JET-DR method not only reduces the packets dropped due to unresolved contention at the core nodes but also provides higher throughput than the OBS-JIT-DR.

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