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An Enhanced Proactive Transmission Protocol for Optical Burst Switching Networks

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Abstract: Due to provision of connectionless and tremendous transmission service, Optical Burst Switching Network (OBSN) becomes the most challenging task for enabling a reliable as well as congestion free communication. So, different communication protocols are developed in the traditional works, but it has the following drawbacks: inefficient, reduced throughput, increased delay, and bandwidth consumption. To solve these problems, this new protocol, namely, Multiple Path Transmission Protocol (MPTP) is developed in this work. It integrates the functionalities of multiple-path routing and Transmission Control Protocol (TCP) Vegas. Here, the wavelength reservation is mainly performed for channel reservation during communication. Moreover, the proposed MPTP efficiently avoids the congestion and data retransmission by selecting multiple paths. The conversion path is identified for detecting the node failures, which increases the throughput of the network. During simulation, three different architectures such as National Science Foundation Network (NSFNET), Capacity Optical Transmission Networks (COST239), and Advanced Research Projects Agency Network (ARPANET) are considered for evaluating the performance of the MPTP technique. Furthermore, the superiority of the proposed protocol is analyzed and compared with the existing protocols based on the measures of delay, burst time, In-band and out-of-band light paths.

Keywords: Optical Burst Switching Network (OBSN), Multiple Path Transmission Protocol (MPTP), Transmission Control Protocol (TCP) Vegas, Throughput Maximization, Congestion Avoidance, Wavelength Reservation, and Multiple Path Routing

1 Introduction

Optical Burst Switching Network (OBSN) is a new technology [1] that is mainly developed to handle both the direct and indirect multimedia traffic in an efficient manner. Due to the multimedia applications, such as internet telephony, digital audio, and video conference, there is an increasing demand for bandwidth in optical networks [2, 3]. The structure of OBSN is depicted in Fig. 1, in which the packets are gathered into burst based on its intrinsic features. It separates the operation of burst switching and data transmission based on the payload. The key factors of using OBSN [4, 5] are as follows:

– It efficiently reduces the network overhead
– It has the ability to handle the bulk traffic with low-priority bursts.
– Also, it integrated the benefits of both optical circuit and optical packet switching.
– It does not require any additional hardware.
– Finer contention resolution.
– Easy to deploy

1.1 Problem Identification

The major problem that occurs in an optical network is wavelength conversion. So, the same wavelength is used for all links in the route [6]. Normally, the OBS network is bufferless, where each data can burst based on the process of one way signaling resource reservation protocol [7]. So, the burst loss occurs by high utilization of network resources, and random contention. It leads to TCP false congestion with increased packet loss events,

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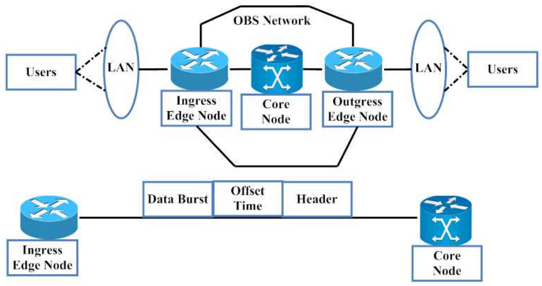

Fig. 1: Structure of optical burst switching network

which reduces the throughput of the entire network [8]. It decreases the overall performance of the network, if a burst contains the packets from various TCP in which each connection is regulated based on an individual flow and congestion control mechanism. The traditional TCP [9] over OBS network lacks with global scheduling and one way signaling, which leads to increased random contention loss [10]. In the previous work, an efficient fault-tolerant path detection mechanism is proposed to perform the scheduling based on reservation. In which, the control plane is isolated with the information sending plane for actualizing the functionalities of control plane. To improve the performance of the entire network with increased throughput, the TCP Vegas-based data communication model is proposed in this work. It uses the multiple path TCP model for avoiding the network congestion with better throughput maximization.

1.2 Objectives

The major objectives of this paper are as follows:

– To attain the maximized throughput, the multiple-path concept is integrated with the Transmission Control Protocol (TCP) Vegas, which is named as MP-TCP Vegas or MPTP.
– To avoid the network congestion, the dynamic wavelength is assigned between the source and destination.
– To reduce the packet retransmission rate, the previously-calculated path is utilized during packet transmission.

1.3 Organization

The rest of the sections present in the paper are as follows: the existing protocols and architectures that are related to optical switching networks are surveyed in Section 2. The motivation behind the proposed work and the clear description with its detailed flow are illustrated in Section 3. The results of existing and proposed methods are simulated and depicted in Section 4. Finally, the paper is summarized and the future work that can be implemented in the next work are stated in Section 5.

2 Related Works

Shihada, et al. [11] implemented a congestion control mechanism for avoiding the packet loss and delay in the Optical Burst Switched Networks (OBS). Fast Transmission Control Protocol (TCP) was utilized to avoid the network failure. Here, the Global stability of the OBS was analyzed for identifying the occurrence of random burst contention, and throughput performance. Zhang, et al. [12] investigated the features of OpenScale network architecture for increasing the scalability, fault tolerance, and maintaining the load balancing. In this environment, the light paths were allocated to the node pairs by simple heuristic algorithm. Here, the performance of the network was improved by efficiently managing the traffic patterns. Also, a proof-of-concept experiment was demonstrated for proving the effectiveness of topology construction. However, it required to analyze the coordination between the upper layer application and optical resource allocation for promoting the performance of the network. Sreenath, et al. [13] investigated the problem of burst in OBS network for enabling a fast retransmission. In this paper, the contention losses were reduced without intervention of Transmission Control Protocol (TCP). Here, a uniform wavelength was established between the source and destination for enabling a reliable data transmission in OBS network. Also, the Adaptation Layer (AL) was utilized to handle sequencing, buffering and burst retransmission. Also, the feasibility and implications were analyzed for investigating the contention losses at varying stages. But, this paper didn't show improvement on the Quality of Service (QoS) during packet transmission.

Liu, et al. [14] suggested a Unified Control Plane (UCP) for validating the feasibility and efficiency of the optical switching network. In this architecture, the link manager and burst scheduler components were used for classifying the packets with the use of burst assembler and disassembler. The suggested technique is to improve its efficacy by enabling a reliable communication. Chen, et al. [15] implemented an Optical Switching Architecture (OSA) for analyzing the traffic patterns of the network. In this paper, different optical networking technologies are discussed, which include the following:

– Wavelength Division Multiplexing (WDM)
– Optical circulators
– Optical Switching Matrix (OSM)
– Wavelength Selective Switch (WSS)

Here, the optimization is concentrated to estimate the optimal topology and network capacity based on bisection bandwidth. The steps involved in the suggested control algorithm are traffic demand estimation, topology computation, routing configuration, and wavelength assignment computation. But, in this paper, the feasibility of the suggested technique is not evaluated. Ives, et al. [16] employed a physical layer optimization technique for solving the problem of static route allocation. The motive of this work is to increase the network throughput with reduced nonlinear interference. Also, the multi-stage optimization technique is implemented to increase the spectral efficiency of network. The required number of transmitters and nonlinear interference are reduced by grouping with interfering signals. But, still it requires to improve the efficiency of routing. Bergman and Rumley [17] suggested some performance metrics used for analyzing the switching performance of the optical networks. It includes switching time, arbitration, scalability, power consumption, and cost. Zhang, et al. [18] introduced a Dual Price-based Congestion Control (DPCC) mechanism for maximizing the network utilization. Here, an optimal reliability tradeoff was attained by increasing the transmission reliability of OBS.

Larhlimi, et al. [19] developed a Neural Best Fit Void Filtering Scheduler (NBFVFS) for improving the computing capacity of OBS. The Neural Network (NN) was utilized to identify the most suitable features of the optical networks for allowing maximum instantaneous reactivity. In this technique, two different types of neurons such as linear and threshold logic were used for adjustable Order Statistic Filter (OSF). The advantages observed from this work were, increased speed, and reduced cost. But, it required to improve the overall efficiency of the network. Patel and Dhabariya [20] analyzed the burst assembly for improving the adaptability, and scalability of the optical burst switching network. Here, the amount of time that a burst occupied the path was computed by using the resource reservation and release mechanisms. Moreover, different resource release schemes that include time and explicit release were used to extract the burst length information. The limitation that is observed from this paper is that computational efficiency is to be improved.

Zhang, et al. [21] introduced a scheduling algorithm for increasing the speed of scheduling in optical burst switching networks. Here, the void filling channel scheduling scheme was utilized for splitting the OBS network into two modules, in which all the data channels were identified by accommodating the incoming packets, then the optimal one from feasible data channels were extracted. From the paper, it is observed that it has the reduced burst loss ratio, and increased throughput, if the load is light. But, it is not able to process multiple BCPs in a parallel manner. Fiorani, et al. [22] designed a Hybrid Optical Switching (HOS) architecture for providing an electronic switching solutions to reduce the network's energy consumption. Here, the control information of various data types were supported for increasing the flexibility and ensuring an efficient resource utilization. Moreover, two parallel switches such as slow and low power were used for reducing the overall energy consumption. In this paper, the energy efficiency of the network is analyzed by increasing the input load and terminating the percentage of fibers at each node. Zannin and Ennser [23] investigated the performance of stabilization for determining the impact of burst length and inter arrival time. Here, the characteristics of the clamped amplifier were validated for asynchronous transmission. The motive of this work is to reduce the transmission error by estimating the overall burst loss probability. Here, the interplay between the bursts was reduced based on the Relaxation Oscillation Frequency (ROF).

Elrasad, et al. [24] analyzed the blocking error probability of burst by using slotted time mode for OBS. Also, tractable model was employed to split the time slots into burst duration and offset time. Here, no-wavelength conversion was performed to evaluate the error probability with the use of Just In Time (JIT) model. Moreover, the congestion of the network was avoided for improving the reliability of transmission by implementing a Dual Price based Congestion Control (DPCC) algorithm. However, this work failed to reduce the overall contention of the network by implementing an efficient routing mechanism. Muhammad Umaru, et al. [25] suggested a fuzzy-based hybrid assembly technique for minimizing the end-to-end delay and maintaining the packet loss ratio of OBS. In this work, the length of thresholds and timer are fixed for generating a burst. It efficiently handles the incoming load and bandwidth capacity of the channel. The suggested technique utilizes the fuzzy rules, inputs and bandwidth of the channel for routing. It includes the following stages:

– Fuzzification
– Fuzzy inferencing
– Defuzzification

However, this system is required to reduce the computational complexity by integrating the concept of service differentiation. Rauniyar, et al. [26] implemented a Best Void Filling Algorithm (BFVF) for reducing the burst loss and efficiently utilizing the channel for a reliable communication. For this purpose, the void utilization factor is calculated for scheduling the data burst. Moreover, various scheduling mechanisms are analyzed for estimating the suitable mechanism in order to efficiently reduce the burst loss. Pedroso, et al. [27] developed a Generalized Multi-Protocol Label Switching (GMPLS)-based architecture for offering guarantee to OBS. Here, the most available resources are identified by the use of mixed integer linear programming model. But, it required to reduce the congestion of the network by implementing an efficient routing mechanism. In this investigation, the benefits and drawbacks of the traditional algorithms are surveyed. From that, it is observed that the existing mechanisms contains the following limitations:

– Increased congestion
– Minimized throughput
– Does not provide transparency
– Long bursts contain more payload
– Complicated route selection

To solve these problems, this work aims to develop a new protocol based on TCP Vegas for enabling a reliable communication in OBS network.

Table 1: Symbols and notations

Notation	Description
K	number of paths
N_k	vector of all nodes on path K
P	priority level of the path
W	maximum number of wavelengths
L	link state matrix
$L_{i,j}$	state of link between the nodes i and j
C_{path}	current path selected
C_{λ}	current wavelength reserved in the path
λ	wavelength

3 Proposed Method

In this unit, the description about the proposed MPTP for an OBSN is presented. The motive of this paper is to avoid the network congestion by incorporating the concept of multiple routing with TCP Vegas protocol. After forming the network, the node gathers the information about their neighboring nodes by sending the RREQ and RREP during route discovery. Then, the dynamic wavelength is assigned between the source and destination nodes by validating the expected wavelength. Here, the minimum conversion path is identified for detecting the network failures. In this work, the conversion path is represented as transferring the data from failure path to best path. The best bandwidth are selected before the transmission of data. This helps to reduce the path conversion during the transmission.

3.1 Multiple Path Routing

Here, the multiple path routing is established between the nodes in optical network with increased bandwidth requirements. It efficiently reduces the resource consumption by ensuring the reliable path. Fig. 2 represents the flow of proposed multiple path routing mechanism. Table 1 describes the symbols and notations that are used in this work.

The flow of the proposed multipath routing is described as follows: initially the link ($L_{i,j}$) between the node i and j is initialized and the average path between them is obtained. From this average path, maximum path is calculated and determined, and the wavelength of the light paths (C_{λ}). Then it checks for whether the wavelength is free or not. If the lightpath wavelength is free, then this wavelength is reserved for the burst. The main intention of establishing the multiple routes are to distribute the traffic for minimizing the overall burst probability of the network. Also, it avoids the congestion by determining the distribution of traffic. Here, the Round Trip Time (RTT) is estimated between the sending time of burst, and receiving time of acknowledgement, which is shown in below:

$$RTT_i = RT_{Prop_t} + \eta_t \tag{1}$$

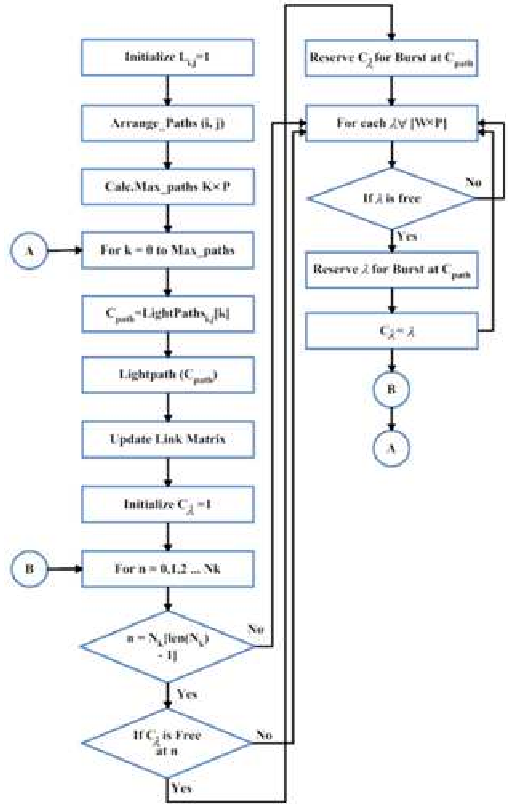

Fig. 2: Flow of the proposed multiple path routing

where, $prop_t$ indicates the propagation time, and η_t denotes the bit error factor. If there is any path changes at the time of routing, an unbiased estimator at time T is calculated as follows:

$$\begin{aligned}(\widetilde{RT\,prop}) &= RT\,prop + \min(\eta_t) \\ &= \min(RTT_t) \forall t \in [T - W_R, T],\end{aligned} \tag{2}$$

where, $RT\,prop$ is round trip propagation time, and W_R is the window size of round trip, and T denotes the overall time. Based on this, the delivery rate of the burst is calculated as follows:

$$\text{Delivery Rate} = \frac{\Delta \text{deliveryRate}}{\Delta t} \tag{3}$$

The delivery rate must be less than bottleneck rate, and the uncertainty in the Δt must be greater than the true arrival interval. So, a delivery rate of this routing is increased with reduced bottleneck bandwidth, which is illustrated as follows:

$$Btl\hat{B}W = \max\left(deliveryRate_t\right) \forall t \varepsilon [T - W_B T] \tag{4}$$

where, W_B denotes the window of bandwidth (i.e. typically 6 to 10 RTTs). Here, the burst assembler records the departure time of each burst for computing the RTT.

3.2 Data Transmission

Here, the major reason of integrating the multiple path routing with TCP Vegas protocol is to attain an improvement in throughput, and bandwidth. The working procedure of TCP Vegas protocol is shown in Fig. 3 in which, each and every packet transmission, the RTT is calculated based on the congestion status and available bandwidth of the network. Here, the congestion status is determined by measuring the throughput of network at a particular time window, which is calculated as follows:

$$ET = \frac{Cw}{BRTT} \tag{5}$$

where, ET indicates an expected throughput, Cw is the current size of the congestion window, and BRTT defines the Base RTT. Similarly, the actual throughput is estimated as follows:

$$AT = \frac{Cw}{RTT} \tag{6}$$

where, AT indicates an actual throughput. Based on the actual and expected throughput, the difference is estimated as follows:

$$Diff = Cwnd\left(1 - \frac{BaseRTT}{RTT}\right) \tag{7}$$

Here, if the value of expected throughput/actual throughput is less than the value of α, the TCP Vegas linearly increases the congestion window at next round of transmission. Similarly, if the obtained value is greater than β, then TCP Vegas linearly decreases the congestion window, and if the value lies between α and β, the congestion window remains unchanged at the next round of transmission. Moreover, the congestion links in the path is identified by using the following equation:

$$Cwnd = \text{Congestion bandwidth} \times \text{Round trip propagation time} \tag{8}$$

The proposed MPTP mainly focuses to reduce the congestion by maintaining the expected number of log packets that lies between α and β in the network. Here, the congestion window is incremented by 1, if the packet is successfully acknowledged; otherwise the window is decreased by 1. Here j—is an indicator of congestion and Th- is limit Moreover, the wavelength reservation is also performed for avoiding the congestion. Typically, the OBSN utilizes the separate wavelengths for transmitting the bursts with control header. In this environment, the wavelength reservation is started at the time of burst transmission, and is reserved until the burst is received by the destination. It efficiently improves the performance by reserving a channel at the time of transmission. It provides the support to transmit multiple classes of services by reserving the resource in advance. The

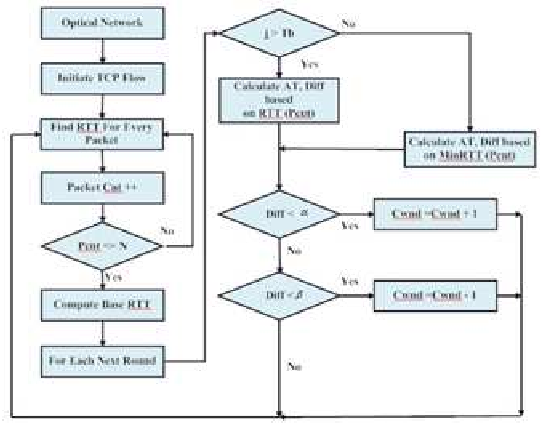

Fig. 3: Flow of the proposed TCP Vegas

wavelength utilization reply is described in Algorithm 1 as follows: the bandwidth for the packet is estimated based on the propagation time for transmitting the packet via selected bottleneck bandwidth. After selecting the bandwidth, the requisition for acknowledgement based on the TCP state variable which obtained from Eq. (8). Then check the burst bandwidth for the data transmission for received acknowledgement. The burst bandwidth characteristics are determined based on the packet size and duration for the packet transmission. The data are transmitted through the selected burst bandwidth in frame by frame manner. For each frame, the transmission and reception time are estimated based on the bottleneck bandwidth speed. The delivery rate are determined for every frame of the packet. By repeating the process until the delivery rate reaches the $burst.app\_limited$, then the process of data transmission gets stopped.

The Vegas is employed to increase the throughput and decrease the losses. TCP offers the ability to anticipate congestion and adjust their transmission rate accordingly. TCP mechanism is utilized to avoid the packet losses while trying to find the available bandwidth during the initial use of slow start. Reno does not suffer from stability problems and it does not adversely affect latency.

4 Performance Analysis

In this sector, the simulation results of existing and proposed protocols are analyzed and evaluated with respect to three different architectures such as National Science Foundation Network (NSFNET), Capacity Optical Transmission Networks (COST239), and Advanced Research Projects Agency Network (ARPANET). In which, the NSFNET is a wide area network that connects the smaller networks with supercomputing sites, which is shown in Fig. 4. It is represented as logical topology with three tiers, which links the networks of different size and running protocols. The ARPANET was built by the U.S. government for ensuring a reliable and robust communication. In

Algorithm 1: Wavelength utilization reply

$bdp =$
$BtlBwFilter.currentMax \times RTpropFiltercurrentMin$
if *(cwnd ≥ cwnd_ gain × bdp)* **then**
  Wait for getting acknowledge or retransmission timeout;
end
return;
if *(now ≥ nextSend)* **then**
  burst=nextBurstToSend ()
end
return;
if *(!burst)* **then**
  $app_{limited\_until} = inflight$
end
return;
$burst.app_{limited} = (app_{limited\_until} > 0)$
$burst.sendtime = now$
$burst.delivered = delivered$
$burst.delivered_{time} = delivered\_time$
$ship(burst)$
$nextSendTime =$
$now + burst.size/(pacing_{gain} \times BtlBwFilterCurrentMax)$
$timeCallbackAt(send, nextSendTime)$
$rtt = now - burst.sendTime$
$updateMinFilter(RTpropFilter, rtt)$
$delivered += burst.size$
$deliveredTime = now$
$deliveryRate = (delivered -$
$burst.delivered)/(deliveredTime - burst.deliveredTime)$
if *(deliveryRate > BtlBwFiltercurrentMax ∥ !burst . app_limited)* **then**
  update_max_ filter(BtlBwFilter, deliveryRate)
end
if *(app_ limited_ until > 0)* **then**
  $app_{limited\_until} = app_{limited\_until} - burst.size$
end
Repeat the steps;

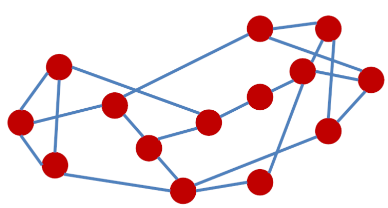

Fig. 4: Architecture of NSFNET

addition, it works based on the concept of packet switching network that contains separate hosts and subnets as shown in Fig. 5. Then, the COST239 interconnects the major cities by analyzing the feasibility of the optical overlay networks, which is depicted in Fig. 6. These networks are considered in this work for evaluating the performance of the proposed technique with respect to delay, in and out of band light paths, and burst loss.

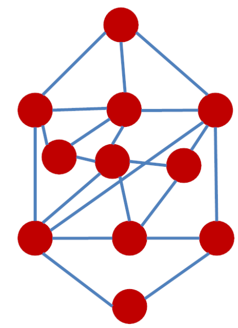

Fig. 5: Architecture of COST239

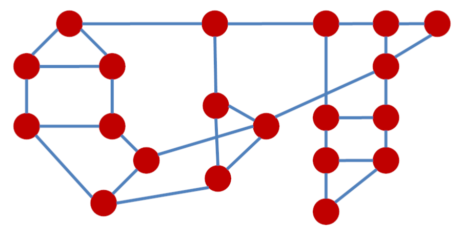

Fig. 6: Architecture of ARPANET

Table 2: Parameters used in this work

Number of burst request	14
Source nodes for each burst request	7
Destination nodes for each burst request	10
Time duration for burst transmission	10 μs
number of multiple paths	3 or 4

Priority level of path:
The priority level can be determined by analyzing the minimal time duration taken for data transmission among the available multiple paths.

4.1 In-band and Out-of-band Light Paths

Here, the in- and out-of-band light paths are evaluated with respect to varying number of wavelengths. Typically, the in-band congestion is defined as the result of intra-channel crosstalk, and out-band congestion is defined as the inter-channel crosstalk. The proposed MPTP performs the wavelength reservation for reducing the interaction between light paths and avoiding the cost of network components. In this work, the impact of high-power signals are reduced by assigning the routes and wavelengths to the nodes based on the traffic demand. Moreover, the transmission of high-power signals from one light path to another light path is minimized by avoiding the channel interactions between different light paths.

The in and out of band light interactions of the existing TCP, TCP Reno, TCP/SACK and proposed

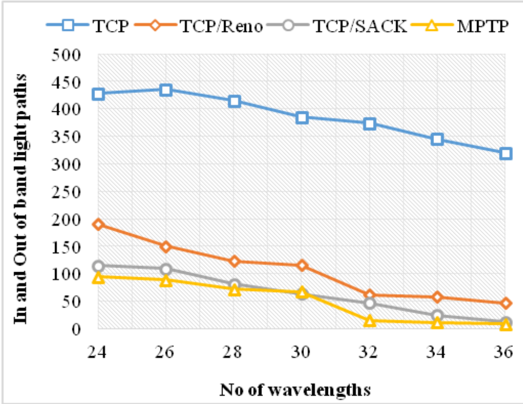

Fig. 7: In- and out-of-band light paths of NSFNET

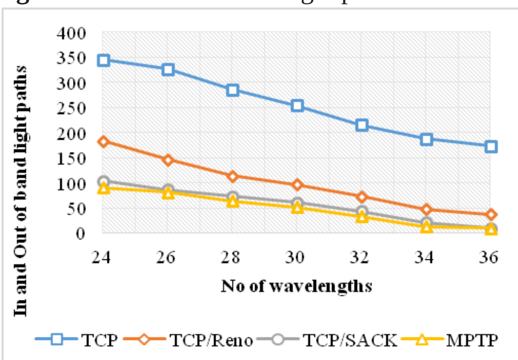

Fig. 8: In- and out-of-band light paths of COST239

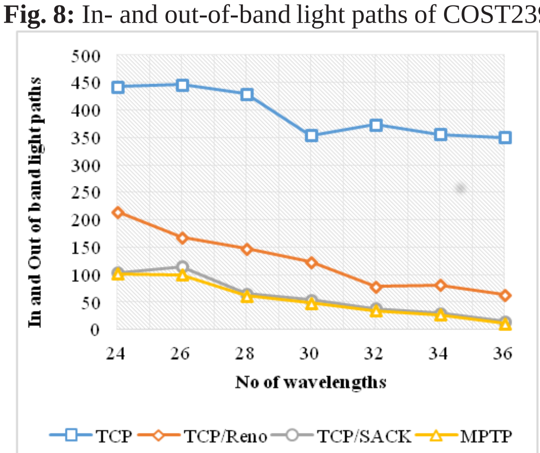

Fig. 9: In- and out-of-band light paths of ARPANET

MPTP protocols are shown in Fig. 7 to Fig. 9 with respect to different architectures. From this analysis, it is observed that the proposed MPTP has a reduced in- and out-of-band light paths for all the architectures, when compared to the other protocols.

4.2 Burst Loss Rate

The burst loss rate is defined as the bursts which are not successfully received by destination that can be increased with their load. The throughput of OBS network highly depends on the burst loss rate and it is estimated based on the period of burst and gap. The parameters are considered during the evaluation of burst loss rate are burst length, gap length, burst density, and gap density. Here, the burst loss is estimated for both existing and proposed protocols with respect to different architectures, which are graphically depicted in Fig. 10 to Fig. 12. In this work, the burst loss is reduced to 1.315 for the NSFNET architecture, 1.313 for the COST239 architecture, and 1.318 for the ARPANET architecture.

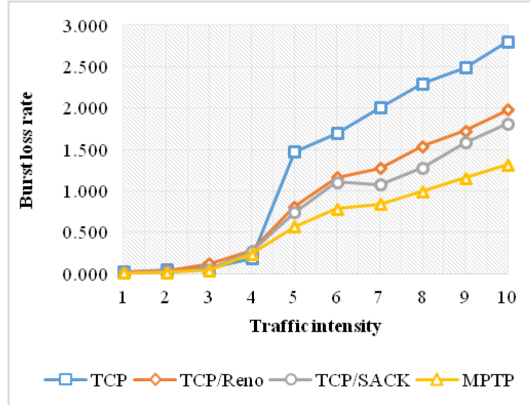

Fig. 10: Burst loss of NSFNET

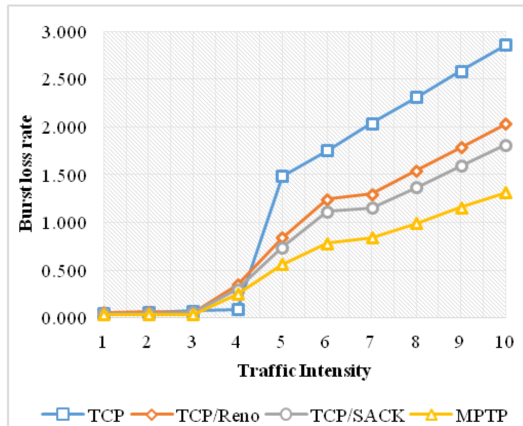

Fig. 11: Burst loss of COST239

From the evaluation, it is stated that the proposed MPTP efficiently reduces the burst loss rate for all the architectures compared to the other protocols. Because, it reduces the congestion and avoids retransmission by selecting multiple paths for ensuring the reliable communication in the network. Moreover, the reduced burst loss results in an increased network throughput.

4.3 Delay

Transmission delay is defined as the required amount of time that a packet takes to travel from the source to

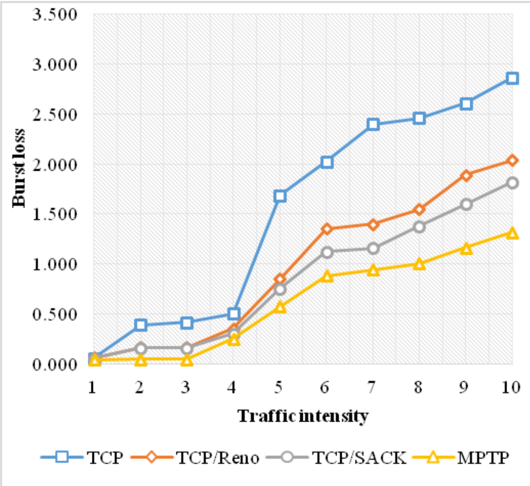

Fig. 12: Burst loss of ARPANET

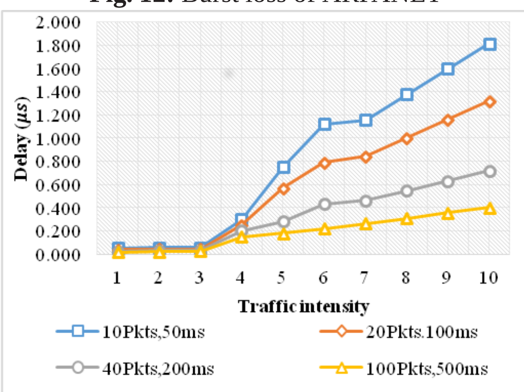

Fig. 13: Delay of NSFNET

destination. It is estimated as follows:

$$T_D = T_R - T_S \quad (9)$$

where, T_D is the transmission delay, T_R indicates the time when the message is received by the destination, and T_S indicates the time when the message is sent by the source. Here, the delay of the proposed MPTP is estimated for three architectures with respect to different traffic intensity.

In this evaluation, the number of packets i.e. 10 packets per 50ms, 20 packets per 100ms, 40 packets per 200ms, and 100 packets per 500ms are considered for estimating the delay time. From these experiments, it is observed that the MPTP provides the minimized delay for all the architectures. Fig. 13 to Fig. 15 shows the delay of the proposed MPTP technique with respect to different traffic intensity values.

The latency and throughput of proposed MPTP is evaluated and compared with the existing ECMP and fission methodologies. Figs. 16 and 17 show the roundtrip latency and throughput as function of load, where the number of bits sent per second to maximum capacity of channel. The load increases, then the latency also increases. Throughput is measured as the volume of data packets effectively directed to the endpoint terminus within the total simulation period. Here the throughput metric plays significant role. The major advantages of the proposed MPTP are as follows:

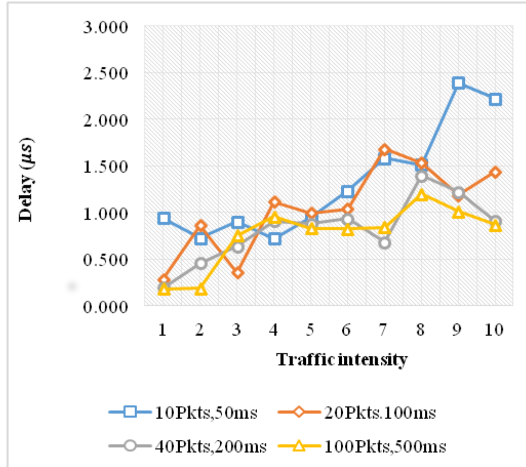

Fig. 14: Delay of COST239

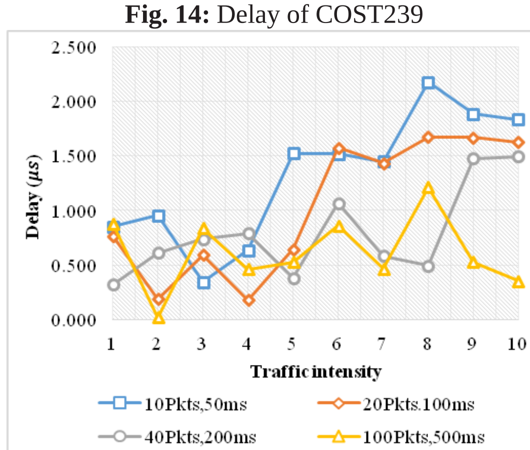

Fig. 15: Delay of ARPANET

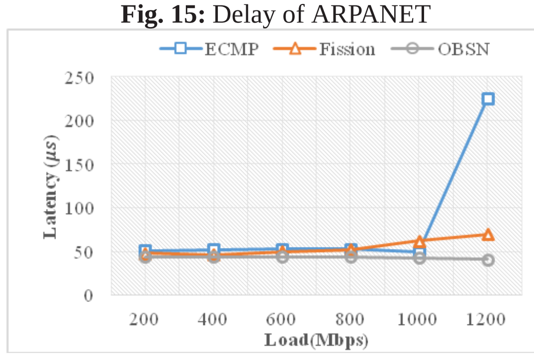

Fig. 16: Latency

–Maximized throughput
–Efficient data transmission
–Reduced delay and congestion
–Highly suitable for different architectures of OBNS
–It avoids the interaction between different light paths

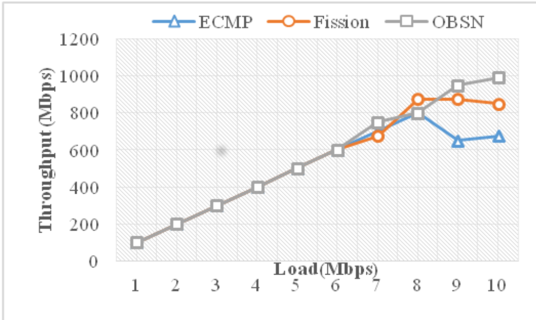

Fig. 17: Throughput

5 Conclusion and Future Work

This paper proposes a new protocol, namely, MPTP by incorporating the functionalities of the multiple-path routing and TCP Vegas for ensuring a reliable communication. Here, the packets are grouped into a burst, which is transmitted from the source to destination. During this transmission, the RTT is estimated for calculating the delivery rate and delay time of the bursts. Also, the failure nodes are detected by establishing the contention path. The wavelength reservation is mainly performed to avoid the congestion by reserving the resources from the starting time of transmission to ending time. The burst sending time and delivered time are calculated with respect to the size of burst. It efficiently detects the congestion by setting a threshold parameter with burst retransmission. Furthermore, the bursts losses are avoided by reducing the in and out lights during transmission. In simulation, three different architectures such as NSFNET, COST239, and ARPANET are implemented to evaluate the effectiveness of the proposed protocol. The measures considered in this analysis are in-path and out-of-band light paths, delay, and burst time. The efficiency of the proposed method is proved by comparing it with the existing TCP, TCP Reno, and TCP SACK protocols. From the evaluation, it is observed that the proposed MPTP outperforms the other techniques.

In future, this work can be enhanced by analyzing the security issues in an OBSN. In addition, the problem of energy consumption in both OBSN and OPS can be considered.

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