CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

At the network edge, a control packet is sent on the control channel ahead of the variable-length data burst to reserve bandwidth resources for each corresponding data burst. At the intermediate nodes, the control packet is electronically processed, while the data channels are switched through transparently. Bursts may be blocked at intermediate nodes due to resource contention, i.e., more than one outgoing burst wants to use the same output port at the same time. In order to reduce burst blocking probability, a contention resolution mechanism is required. Contention resolution is an important research issue in OBS networks.

Optical buffering, wavelength conversion and deflection routing are the technologies used to resolve the contention in OBS networks. These are reactive techniques that try to resolve the contention when it occurs and attempt to minimize the loss based on the local information at the node. An alternative to contention resolution is to avoid contention before it happens. In contention avoidance technique, the contention can be avoided by source policing or by routing the traffic in such a way that the congestion in the network is minimized.

OBS networks are typically connectionless in nature; thus, it is likely that there will be contention for resources in the core network that leads a packet loss. When a contention cannot be resolved, one of the contending
burst will be lost. If the lost burst cannot be recovered at the OBS layer, higher layers (such as Transmission Control Protocol) need to handle the retransmission of the lost data at a later. In order to satisfy the low-loss requirement of higher layer applications and to overcome the lossy nature in OBS networks, a reliable OBS network must be developed.

In an OBS network, the incoming packets with the same destination and/or QoS requirements go through the burst assembly process to form OBS bursts at the ingress node. One control packet is then sent out on the dedicated control channel for each burst prior to the corresponding burst by an offset time. At the intermediate nodes, bandwidth is reserved on the outgoing link according to the information carried in the control packet ahead of the actual burst arrival, so that the burst could remain in the optical domain until reaching the destination. To reserve bandwidth according to the information carried in the control packets, many scheduling algorithms have been proposed.

In this chapter, the literature review of various routing algorithms, loss recovery methods and scheduling/assembly algorithms in OBS networks is presented.

2.2 ROUTING ALGORITHMS IN OBS NETWORKS

Borgonovo et al (1994) introduced the deflection routing as the contention resolution method in optical networks with regular mesh topologies before the emergence of OBS networks. The authors Forghieri et al (1995) and Bononi et al (1999) have shown the improved performance of deflection routing compared to hot-potato routing in a network with high connectivity topology. Hsu et al (2002) considered deflection routing as a practical contention resolution approach and examined the performance with prioritized burst types and JET scheduling through simulation analysis.
Kim et al (2002) demonstrated via simulation study that deflection routing improves the blocking probability as a contention resolution method. Salvadori&Battiti (2003) proposed new load balancing techniques for optical networks based on IP-like routing, where the forwarding mechanism is only driven by the destination address. Li et al (2004) studied the deflection routing in conjunction with the self routing addressing scheme. However these studies do not address how routing to an alternate path should be done.

Based on different alternative path selections, Elbiaze et al (2004) have suggested three new deflection routing strategies to resolve contention at low load. They are Shortest Path (SP), Latest Available Unused Channel with Void Filling (LAUC-VF), and Least Used Wavelength (LUW) deflection strategies. If the wavelength on the primary path is busy, the SP strategy chooses the shortest available path from the Alternate Path Table (APT). LAUC-VF which is a data channel scheduling provides a good performance by choosing the wavelength with the smallest possible available window, leaving larger windows for control packets which arrive later. The burst is inserted within a wavelength so that the gap between bursts is minimized. When a contention occurs on the wavelength \( \lambda \) of the primary path, LUW strategy deflects the burst on the same wavelength \( \lambda \) on alternative links. In this case, the APT is composed of output links wavelengths sorted by the least used \( \lambda \) constraint.

Teng&Rouskas (2005) studied that the routing path optimization strategies have recently received considerable attention using as input the long-term network and traffic information to compute paths for pairs of network nodes. Coutelen et al (2005) discussed adaptive path selection techniques. The Pre-Estimate Burst Scheduling (PEBS) has been introduced by Junghans (2005). By pre-calculating parts of the scheduling decisions for
void-filling algorithms, it reduces the realization complexity. It can be combined with existing wavelength selection schemes like First Fit and LAUC-VF.

Cameron et al (2005) have suggested a new OBS routing protocol Shortest Path Prioritized Random Deflection Routing (SP-PRDR) with an objective of minimizing burst loss probabilities using limited state information from traditional Internet protocol technologies. Through simulation analysis, the authors have proved that the blocking probability is significantly reduced with negligible impact on average delay, and that worst case performance is upper-bounded by the blocking probability of standard OBS, due to the convergence of SP-PRDR to fixed, non-deflection routing at high load.

Lee et al (2003) introduced contention based deflection routing. Through further investigations, Lee et al (2005) have proposed an on-demand Contention-Based Limited Deflection routing (CLDR) protocol in which deflection routing scheme sequentially performs the following i) based on certain performance criteria, it dynamically determines whether the burst should be deflection routed or retransmitted from the source and, ii) If the decision is to deflection route, then the same is done using a path that is based minimization of a performance measure that combines distance and blocking due to contention.

The authors also suggested that the network nodes should periodically re-compute and store optical paths. This allows for deflection routed bursts to traverse the alternate optical paths that are not necessarily shortest path but are optimized for best performance in terms of blocking and delay. This technique calls for monitoring the link and node congestion and updating the same in a periodic manner so that the path computation can be as
optimal as possible. Simulation results have shown that CLDR performs well both in terms of burst loss probability and increased network throughput at low load. It requires more computations and longer response time. In this dissertation, the CLDR protocol is simulated & compared with the proposed work to handle increase in network load.

The behavior of TCP connections in OBS networks with deflection routing has been analyzed by Schlosser et al (2005). Deflection routing can work with limited optical buffering or even no buffering. The aggregation of more packets out of one TCP flow in a burst has a positive impact on TCP performance with deflection routing. The results show that deflection routing leads to a degradation of TCP performance which is however much lower as the case where the deflected bursts are dropped instead. Long et al (2006) discussed the methods for the optimization of the set of alternative routes.

A one-moment reduced-load approximation is used by Zalesky et al (2007) to evaluate the blocking performance with deflection routing protected by either wavelength reservation or preemptive priority. The ill-effects of OBS-layer load-balanced routing are identified by Komatireddy et al (2007). The value of the path delay-differential has a significant impact on the higher-layer TCP performance. They proposed a simple source-ordering approach that maintains the order of the bursts using electronic buffers at the ingress OBS edge node so as to minimize the number of false timeouts and false triple duplicates.

Jun et al (2007) proposed a new load based adaptive routing algorithm to avoid inaccuracy and instability in path selection. The load from local sources is measured by the edge nodes and link state information a certain edge acquired from core nodes is composed of two parts: load from other links and total load in this link. Therefore, the load of each predefined path includes the local load and the load to different destinations is distributed
more uniformly. To minimize contentions in OBS networks, Pedro et al (2007) have introduced a multi-path routing strategy. In their approach, a set of candidate paths is available to route bursts between each node pair. Two Linear Programming (LP) models are used to determine the amount of burst traffic sent through each path. The first model only minimizes the burst traffic load on the most congested links, whereas the second model reduces the average offered traffic load per link. They further suggested combining the contention minimization ability of multi-path routing strategy with contention resolution through deflection routing.

Deflection routing using a reinforcement learning approach is formulated by Belbekkouche et al (2008). Their scheme is a distributed model used to reduce the loss probability when the network endures the congestion. This work also reduced the communication & computation overhead through learning approach to select the route for deflected burst. However, as their routing scheme is a single-path routing, it may prone to more security and reliability issues.

Barradas & Medeiros (2009) considered the problem of routing path selection in OBS networks to minimize the overall burst loss and also suggested to combine the dynamic resolution schemes with load balancing methodology. Klinkowski et al (2009) studied and compared the reactive and proactive routing methods. Wong et al (2009) have demonstrated a new method with deflection routing for the estimation of blocking probabilities in bufferless optical burst or packet switched networks. De Leenheer et al (2009) have proposed enhanced deflection routing in anycast-based OBS grids. In a grid scenario, the essential insight is the successful processing of a job rather than the precise location where the processing takes place. Since deflection implies that congestion has occurred, this seems an opportune time to reschedule the job. Pedrola et al (2009) have presented a recent comparative study of deflection routing strategies.
Rumley et al (2010) have developed a feedback based deflection routing and admission control strategy called Adaptive Deflection Routing (ADR). As this mechanism integrates Admission Control (AC) capabilities, burst might be dropped rather than forwarded, even if the local port is not congested, if the risk of latter contention is high. ADR estimates the risk and quality associated with each forwarding operation using feedback messages exchanged between core nodes. It is not suitable when the network is injected with low load.

Guan et al (2012) have introduced a method to resolve contention in the core node through incorporating prioritized burst segmentation with deflection routing scheme. Guan et al (2013) further developed a contention resolution scheme based on the prioritized burst segmentation and deflection routing in the core node and composite burst assembly scheme at the edge node. A composite burst assembly scheme combines packets of different classes into the same burst, placing the highest priority packets in the middle and low priority packets at the tail and the head of the burst.

Yahaya et al (2013) contributed a review of existing state-of-the-art routing strategies for OBS networks developed by researchers to deal with burst contention before it happens. Patel & Kothani (2013) have proposed a dynamic hybrid retransmission in deflection routing to resolve contention. This approach provides an accurate relationship between impact of network load due to retransmissions or deflection and gain in the end-to-end burst delivery rate.

### 2.3 LOSS RECOVERY SCHEMES IN OBS NETWORKS

Due to lack of optical buffers at the core nodes, bursts are lost during contention among multiple bursts that arrive simultaneously. Since a burst contains several IP packets, burst loss leads to a high packet loss rate at the higher layers. Retransmission also causes more delay. Hence loss recovery
mechanisms have to be developed to get more reliable OBS network performance. This literature presents an overview of loss minimization and loss recovery mechanisms in OBS networks.

Yoo et al (2000) have shown that burst loss rate is high in OBS networks due to wavelength contention at intermediate nodes. Several methods have been proposed to reduce the burst loss rate by recovering blocked bursts by copying traffic. Griffith & Lee (2003) studied that the total traffic load doubles, causing higher overall blocking probability in OBS networks.

Maach et al (2004) have proposed a contention reduction by combining congestion control and bursts retransmission to eliminate the burst loss. The simulation results indicate that this scheme can transform an optical burst switching to a robust burst forwarder. Also the retransmission technique is particularly suitable for metropolitan or local area network where the additional delay incurred by the retransmission is negligible. De Leenheer et al (2004) and Mountrousidou et al (2005) discussed the simultaneous path transmission for grid over OBS where the chances for burst loss are more. Zhang et al (2005) have suggested that it is important to resolve the random burst contentions, a burst loss having multiple TCP segments could adversely affect TCP performance. Overby (2006) has introduced Forward Error Correction (FEC) as one of the contention resolution scheme in OPS.

Vokkarane & Zhang (2005) used FEC for providing loss recovery in OBS networks. In FEC loss recovery mechanism, the packet loss probability can be evaluated using the network level analytical model which combines burst segmentation with FEC. In their proposal, the code packet is generated for a group of data packets and the code packet is assembled with their original data packets into a single burst at the ingress nodes. The authors have assumed that if a burst experiences contention, segmentation is employed so as to drop only the overlapping segments of one of the
contenting bursts. The dropped segments of a burst can be recovered using the FEC code packets at the OBS egress node, resulting in lower packet loss.

Luby et al (2002) studied forward redundancy is particularly well suited for optical transmissions, where bandwidth is reasonable but end-to-end latency across long-haul networks is significant. The authors Vokkarane & Zhang (2006) applied a forward redundancy as loss recovery mechanism for OBS networks. They aimed to eliminate the fundamental limitations of the burst retransmission mechanism, such as requirement of large ingress electronic buffers to store copies of transmitted bursts and additional delay incurred in retransmitting bursts after the original burst has been dropped in the OBS core. Their mechanism can provide a flexible level of reliability for each burst or flow.

Arima et al (2007) have found FEC for consecutive burst transmission for unidirectional ring networks. Here the redundant data are transmitted with multiple bursts. Out-of Burst Generation (OBG) and In-Burst Generation (IBG) are the two burst generation methods. When some bursts are lost at any intermediate node, FEC recovers the lost bursts with the redundant data using correction processing at the destination node. This method cannot eliminate the burst loss completely since it does not use ARQ mechanism.

A new Forward Segment Redundancy (FSR) mechanism is employed by Chandran et al (2008) to minimize segment loss during burst contentions in the core and also recovers from the segment loss in the forward direction using redundant segments placed in each data burst. Redundant TCP segments are added to each burst and assembled at the ingress node before transmission to the destination. Optimal FSR value has to be identified for the best results. Um et al (2008) have proposed a priority-based Duplicate Burst Transmission Mechanism (DBTM) in an OBS network to enhance the probability of successful reception of bursts. Receiving low priority bursts at the egress can increase the probability of successful reception without
complex signaling or higher computational processing. Their results proved that the burst loss rate is improved especially under light traffic loads.

An integrated mechanism of adaptive routing and adaptive burst cloning has been proposed by Sreenath et al (2008). Their mechanism ensures service differentiation in OBS networks. It differs from the conventional burst cloning mechanism in the following ways: The selection of cloning node, the number of cloned bursts for each original burst, and the routing for the original and cloned bursts.

Zhao et al (2008) have presented an algorithm RCO (redundant coding optical) which confirms the correctness and performance of the algorithm. First, RCO uses the idle edge link bandwidth to transfer redundant coding burst, and has little impact on the transmission of the data burst. Second, RCO can guarantee the reliable burst transmission using ARQ. Tsai et al (2011) have introduced FEC with path interleaving for video streaming process in wireless networks and reduced the processing time of FEC encoding and decoding with increased video quality.

Bikram et al (2011) have proposed a coordinated multi-layer loss recovery approach for OBS networks. At the lowest layer, they have implemented ARQ to minimize data loss due to random burst contentions. At the next higher layer, Snoop is implemented to eliminate any False Timeout (FTO). Their approach is a hybrid of both Snoop and ARQ where Snoop performs recovery at the packet-level and ARQ at the burst-level. They have developed the mechanism to coordinate between Snoop and ARQ.

Some other burst loss recovery mechanisms have been discussed by Boobalan et al (2011). The first algorithm is a closed loop feedback technique in which the destination node senses the data traffic and sends feedback to the source node. A second algorithm provides a link protection and restoration
mechanism by providing suitable backup channels by using Label-Stacking and Burst-Multiplexing Techniques.

Charbonneau et al (2012) have proposed FSR which is a proactive technique to prevent data loss during random contentions in the optical core. With FSR, redundant TCP segments are appended to each burst at the edge and Redundant Burst Segmentation (RBS) is implemented in the core so that when a contention occurs, primarily redundant data is dropped. An analytical throughput model for TCP over OBS with FSR is developed, and extensive simulations are performed. FSR is found to improve TCP’s performance by an order of magnitude at high loads and by over two times at lower loads.

FSR is comparable to burst cloning. In burst cloning, a separate duplicate burst is sent into the network. Burst cloning is similar to FSR with 100% redundancy, but instead of appending the redundant data to the same burst, it is sent out as a separate burst. Not only does this involve extra control overhead in terms of BHPs, but it is not as flexible as FSR. Cloning provides only 100% redundancy. Cloning also does not handle out-of-ordering well. This thesis simulated RBS, analyzed this work and also compared with the proposed method.

2.4 SCHEDULING AND BURST ASSEMBLY APPROACHES IN OBS NETWORKS

Sui et al (2005) have proposed a new Dynamic Adaptive Assembly (DAA) mechanism which dynamically adjusts Burst Assembly Time (BAT) at edge node based on load estimate and traffic prediction to reduce assembly delay and estimate real-time network traffic character. The dynamic range of BAT for four traffic classes is introduced to make comparisons among current and previous prediction with different prediction time under QoS based offset time.
Varvarigos et al (2008) have presented several multicast algorithms for routing and time scheduling connections in networks that support advanced reservations. They initially presented an optimal scheme of non-polynomial complexity, and then proposed two heuristic algorithms of polynomial complexity. They also proposed a branch-and-bound mechanism that reduces the search space for the case where the function to be optimized is known and is same for all connections.

Pavon-Marino et al (2009) have proposed Parallel Iterative Optical Burst Scheduler (PI-OBS) for OBS Networks. Their scheduling algorithm has processed all the headers simultaneously in a given time window. Their approach has optimized the delay and output wavelength allocation of operating void filling techniques and permitting traffic differentiation. Further, their approach has the capability to adapt with loss differentiation in accord with the burst header information. However, their approach is much suitable only for fast parallel iterative implementations with algorithm response time, which is independent of the switch size.

Papazoglou et al (2009) have discussed two new techniques. The first proposed technique is based on a triangular estimate that defines a “drop zone”; bursts that fall into this area are considered to have a very low probability of finding a suitable wavelength and as such, no effort is made to schedule them. In the second approach, the drop zone is defined dynamically based on the burst drop history. Their proposed algorithms reduced the number of channels or void checks and thus the overall scheduling complexity.

Cao et al (2009) have proposed novel algorithms for batch scheduling in OBS networks with different optimization criteria. The algorithms effectively consider the strong correlations among the multiple bursts and employ the proposed interval graphs and min-cost circular flow techniques to achieve optimized network performance in terms of data loss rate in the network.
Garg & Kaler (2009) proposed a novel Modified Horizon Scheduling algorithm with Minimum reordering Effects (MHS-MOE) for high speed OBS networks. Simulation results have shown that the proposed algorithm runs much faster and is significantly simpler than Min-SV in terms of complexity. A complete characterization of reordering becomes noteworthy, especially when assessing a protocol’s viability over a given network. This shows an improvement in the wavelength usage of OBS network, which in turn increases the network utilization gain. Nandi et al (2009) have proposed a new approach which has less burst loss and also utilize voids in an efficient way. Their proposed algorithm first selects all possible void channels, on which the data burst can be scheduled. Then, select one of the possible void channels such that the void utilization factor is maximized.

Ramantas et al (2009) have introduced a new multi-class preemptive scheduling scheme. It strengthened the QoS, based on pre-emption, which is controlled by the pre-emption policy. And further their scheme has utilized a variation of the Pre-emption Drop Policy (PDP) for provisioning flexible priorities to different service classes. Without applying any access restriction techniques, any free wavelength of a service class can be reserved by making use of PDP. Even their approach is flexible, it endures more complexity as it considers a more number of parameters for defining preemption probability and preemption policies.

Gao et al (2009) have examined the fairness and burst loss problem owing to cascading constraint when bursts have longer hop count value in OBS networks. Their scheduling technique has considered the impact of cascaded wavelength conversions and has dynamically assigned priority to each burst based on a constraint threshold and the number of already conducted wavelength conversions among other factors for this burst. According to their priorities, newly arriving superior burst may preempt another scheduled one at the time of contention. Fukushima et al (2009) have proposed a burst assembly method that reduces the end-to-end delay. The key
idea of their method is to include IP packets that arrive during offset time into the burst that is currently being assembled. As a result, those packets are transmitted earlier and consequently the end-to-end delay is reduced.

Barradas & Medeiros (2010) suggested four path selection strategies to prevent congestion. The first two addressing contentions on networks assuming total wavelength conversion capability, including the streamline effect in a relaxed way. The last two strategies considering no wavelength conversion, thus, the wavelength continuity constraint is respected and the streamline effect strictly applies. Papazoglou et al (2010) have proposed a new class of burst scheduling algorithms based on a triangular estimator. Their proposed tool reduces the complexity of the scheduling without compromising its performance. The estimator uses a formula based on the burst offset and length in order to immediately discard bursts whose probability of successful resource reservation is low.

Bonald et al (2011) have investigated a modified version of OBS that adapts the size of switched data units to the network load. Specifically, they proposed a two-way reservation scheme in which every active source-destination pair attempts to reserve a light path and for every successful reservation, transmits an optical burst whose size is proportional to the number of active data flows. They have proved that the proposed scheme is optimal in the sense that the network is stable for all traffic intensities in the capacity region. Singh et al (2011) have proposed a random algorithm, first-fit wavelength algorithm and wavelength reservation algorithm. The blocking probability of the optical burst switch was analyzed depending upon the number of channels, loads and the number of links. The number of wavelengths on all the links was kept constant.

Netak et al (2012) have developed a composite scheduling approach, in which at a time, one algorithm is selected based on the information of the current voids interval of data channels. This approach increases the bandwidth utilization and decreases time complexity. The
simulation results show that composite scheduling is more effective and has less burst dropping as compared to individual scheduling algorithm.

Liu & Jiang (2012) have introduced a mixed-threshold burst assembly algorithm based on traffic prediction to solve the extra offset introduced under heavy traffic. This algorithm assembles and sends burst dropping probability in advance by predicting the burst length, which reduces end-to-end delay.

Figueiredo & da Fonseca (2013) presented a novel channel scheduling policy for OBS networks called least reusable channel. This channel decides to which interval of the output channel (void) an incoming burst should be allocated on the basis of reuse of the remaining voids. It is shown that it produces lower blocking probability and distributes losses more uniformly among routes than do other existing scheduling policies.

Udmale et al (2013) explained that in OBS network, key concern is to reduce burst dropping probability and it is depend on different factors like burst size, offset time and scheduling algorithms used to schedule the bursts. On their observation, the burst dropping probability is directly proportional to number of Burst Header Packets (BHPs) dropped in an OBS network. So they introduced a control channel approach to control BHP dropping probability with the help of extensive simulation on ns-2. Simulation result shows that the dropping probability decreases with increase in number of control channel.

2.5 PROPOSED WORK & CONTRIBUTIONS

For the improvement of OBS network performance, the thesis aimed to develop the following modules. The modules are Load Balanced Deflection Routing and Priority Scheduling, Simultaneous Multi-path Transmission for Burst Loss Recovery and New Burst Assembly & Scheduling technique for OBS networks. The operation, performance metrics and the limitations are compared with the existing methods as follows.
2.5.1 Load Balanced Deflection Routing and Priority Scheduling

Algorithm of load balanced deflection routing is given below: Initially, two link-disjoint shortest hop paths are determined for every source-destination pair. The node information is collected by core nodes and the network load information is collected by edge nodes. The information about the network load function is maintained by each node. After every interval time, the ingress node dynamically selects the least-congested path among the two paths and transmits the burst on that path. The least congested paths in the network are selected using the congestion-information about the entire link along the two pre-calculated paths. Using the Networks Simulator (ns-2) simulation results, it is observed that the bursts are deflected only through these paths. Since the bursts traverse only through least congested paths, this work proved that the effect of burst loss is minimized.

Through the inclusion of preemptive priority between non-deflected bursts and deflected bursts in the simulation environment, the destabilization has no effect on the OBS networks. This stabilizing property of trunk reservation is highly reliant on the priority of reservation threshold.

The reservation scheduled for a deflected burst can be preempted by the non-deflected burst using this scheduling approach. Only when a non-deflected burst looks for an appropriate idle wavelength, initially the preemption is taken into account. The preemptive priority scheduling guarantees the stabilization of deflection routing. This method outperforms the deflected burst.

Thus a congestion free load balanced path can be selected by this contention resolution technique. The protection for OBS network has also been analyzed in terms of blocking performance and insensitivity to variation in hop-count with preemptive priority.
The proposed Load Balanced Deflection Routing (LBDR) and the Contention based Limited Deflection Routing (CLDR) protocols are simulated using ns-2 with the following parameters: 1. Burst Size & 2. Load. Simulation results have shown that LBDR outperforms CLDR in terms of Blocking Probability, Burst delay, CBR Delay, Burst received and Delivery ratio.

2.5.2 Simultaneous Multi-path Transmission for Burst Loss Recovery

In the above work, the thesis also considered a simultaneous multi-path transmission along with path interleaving for burst loss recovery. Initially, the data blocks containing redundant bursts are gathered together in Forward Error Correction (FEC) encoding technique. Then, the redundant bursts are separated. When burst loss occurs continuously, this work proposed a technique which combines FEC with path interleaving. This technique can be used to recover the continuous lost bursts. In the path interleaving mechanism, all the FEC blocks send one packet to each path; however, the transmission rate should be maintained as low as the original transmission rate. Then the packet of FEC blocks selects an alternative path, if the first path’s transmission rate exceeds original transmission rate until all packets are transmitted.

Similarly, in the receiver, the average packet loss rate and the number of continuous lost packets are calculated. The values are forwarded to the transmitter. After receiving those values, it performs the block length control by fixing the number of source packets and redundant packets without increasing the FEC redundant information. Using this block length, the data packet containing continuous lost bursts is divided into two Reed Solemn (RS) codes. During packet transmission, the continuously lost bursts can be recovered using the redundant data blocks in each path.
Hence there is no need to increase the FEC redundant information, this scheme reduces the processing time of FEC encoding/decoding. Due to the dispersion of lost packets, the FEC recovery efficiency can be improved.

An extensive simulation study on the performance of Simultaneous Multi-path Transmission (SMT) Scheme for burst loss recovery has been performed by using ns-2. The results of the proposed technique are compared with the FEC method for Reliable Transmission (FECRT). From the simulation results, it is inferred that the SMT scheme decreases the processing time of FEC encoding/decoding hence improved the recovery of blocks and packet delivery ratio.

2.5.3 New Burst Assembly and Scheduling Technique for OBS Networks

From the above considerations, it is observed that OBS network parameters like, CBR Delay, Burst Delay, Burst received and Delivery ratio have been improved. Hence, this work also undertakes the new burst assembly and scheduling technique in simultaneous multi-path transmission for real-time applications. The Redundant Burst Segmentation (RBS) is used for the burst assembly to reduce the losses due to random contentions at core nodes. In this technique, the following algorithm is evolved.

(i) A new field is added to initiate the burst assembly algorithm at the ingress node.

(ii) This algorithm works with four policies: Combined Head and Tail Drop (HTD), Head Drop (HD), Tail Drop (TD) and Drop Contending burst (DC). Due to the four different policies, there is a need of selecting the proper policy. It is chosen
based on the following parameters: the priority of each burst, the length of each burst and the length of the redundant data.

(iii) After assembling, the burst will be scheduled using the scheduler algorithm. This algorithm is responsible for output wavelength and contention-free FDL to switch every burst payload to its target output fiber. This avoids the gap between two consecutive bursts in an output wavelength.

(iv) The algorithm is composed of a set of delay cycles and each delay cycle consists of a sequence of 4 steps: Request, grant, accepts and update.

The performance evaluation of the New Burst Assembly and Scheduling technique (NBAS) is carried out by the ns-2 network simulator. The results of the proposed technique are compared with the Redundant Burst Segmentation (RBS) technique. From the simulation results, it is noticed that the NBAS outperforms the RBS in terms of the Burst delay, CBR Delay, Burst received and Delivery ratio.

In brief, it is proposed to study in this research as

1. Load Balanced Deflection Routing and Priority Scheduling
2. Forward Error Correction Based Loss recovery Technique and
3. New Burst Assembly and Scheduling technique.