Annotating the elemental notions in network model of Optical burst switching Network

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Abstract**—**Optical Burst Switching(OBS) is receiving so much attention by the academic research community mostly because it is a promising technique for next-generation optical switching networks which attempts to address the problem of efficiently allocating resources ofbursty traffic and also provides solution to bandwidth-hungry applications and services of optical networks. This paper analyses an OBS simulation model for a discrete event simulator using scalar, vector graphs and sequence charts since it is the most frequently used instrument for comparing network performance and studying its behaviour. It studies the implementation of optical burst switching network architecture in OMNeT++. The significant part of this network model are necessarily core and edge nodes. Finally, the possibilities of extending the model in future research and development are discussed.

Keywords—*Optical burst switching, optical networks, core node, edge node, modelling,discrete event simulation.*

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I. INTRODUCTION

With advancement of technology the need of bandwidth has increased manifold within this decade and continues to increase because of magnified rise in numbers of users. This provides us key basis for our future research in the field of optical networks. By far the best quality of optical wavelength division multiplexing (WDM) is that it allows the partitioning of large available bandwidth into number of smaller channels which can be efficiently used according to the requirement. The escalation of IP traffic and demand of bandwidth are prevalent factors driving research towards the development of new network architectures and techniques for an effective switching. Though there has been all of improvement and progress in this field there are still so many issues which are yet to be addressed in order to meet the needs of users.

In first generation optical networks optical fiber acts as transmission medium. The process of switching, processing and routing are done at electronic level which creates a problem of electronic bottleneck. When looking for all-optical transmission of data, Optical burst switching (OBS) gives us a promising solution therefore it has managed to garner attention by researchers. This has lead to a significant increase in the number of implementations and testbeds of OBS over these years. Total transmission capacity of upto 400 Gb/s was achieved in the early 2000s with 80-120 wavelengths per fiber by D-WDM technology [9]. So it is easily expected to exceed the capacity of 1 Tb/s or beyond in near future with a potential of creating new network services. Though huge amount of capacity for transmission was made available using wavelength division multiplexing (WDM), the switching techniques like circuit switching and packet switching could not efficiently use it in optical domain owing to their own limitations. Optical circuit switching seldom utilizes the bandwidth and optical packet switching suffers the problem of optical buffering, synchronization etc. These techniques are not matured enough to lead their way into the real world. To resolve this issue, more emphasis is being laid on optical burst switching because it merges the merits of bothcircuit switching and packet switching. It is predicted that in the future, the networks will be based on Internet Protocol (IP) which makes the evolution of all-optical packet switches even more important [10]. Though commendable advancements are made in developing high speed IP routers, the major issue lies in the mismatch of switching capacity of IP routers and transmission capacity of WDM fibers. In optical domain, IP packets processing is still not practical and hence done electronically. Taking an example of a single link where number of WDM channels is 32 each with a capacity of 10Gb/s, the total transmission capacity will be simply 320 Gb/s. The main constraint of switching the IP packets directly in optical router will be its processing. This leads us to burst switching which combines similar IP packets to be forwarded through the networkthus reducing the burden [1]. Optical packet switching and optical burst switching sounds confusing similar to many. The basic difference would be that the length of the burst is arbitrarily long which are transmitted only at channel speed of aoptical WDM link. Data burst is a term used for burst payload while the header of burst is conveniently termed as burst header packet (BHP), both of them using different wavelength for their transmission which as also be seen as an intrinsic feature of OBS. It can beinsighted as two coupled networks with one transmitting control information via BHPs and other transmitting the databursts. This dissociation is a mature approach for advanced optical technology leading to better synergy.

The relevant question which rises is about the effectiveness and advantage of Optical burst switching network over electrical switching networks. Many papers have emphasized on the modeling of OBS network, others have focused on the synthesis of traffic. Considerable research activity is needed to overcome the limitations and achieve optimal working of optical burst switching. If this OBS technology is discussed, understood and developed in a strategic manner it can be the most striking technology than other existing mechanisms of data transfer. This paper discusses the network model of OBS that can be used for performance evaluation. It is done using a discrete event simulator which in this case is OMNeT++. We explain and support our discussion using scalar files, vector graphs and sequence charts obtained after simulations.

II. ARCHITECTURE OF OBS

The network architecture of OBS can be classified into three basic types, Conventional OBS (C-OBS), Emulated OBS (E-OBS) and Labeled OBS (L-OBS) [10]. They differ from one another by the way they send packet and the way of treating burst control packet (BCP). The very first basic concept to be known is that OBS network consists of two types of nodes: Edge node and Core node. We will go into details of these two nodes to a have a better understanding of them. The optical fiber can be thought as data and control channel together [5].

A. Edge Node

The edge node consists of a dispatcher, assembler, scheduler and control packet generator. The first type is Ingress edge node which assembles all the TCP/IP packets into burstsby taking into account some factors like service quality etc. which are transmitted in the form of optical signals inside the network. Several criteria are taken into consideration while assembling IP packets and creating them into bursts. Bursts are assembled on the basis of Forward equivalence classes (FECs). A set of packet with identical characterstics which may be forwarded in a similar manner is termed as Forward equivalence classes (FECs) [3]. The most commonly classified burst assembly schemes are: Time based and Threshold based. In time based scheme, a timer is started at the initialization of the burst assembly. A data burst containing all the packets in the buffer are generated when timer exceeds the burst assembly period. In threshold based scheme, a burst is created & sent into the OBS network when total size of the packets in the queue reaches the threshold value. While time based scheme is suitable for real time/ time constrained application, threshold based scheme is preffered for time insensitive application [4][5].A burst control packet (BCP) is a packet created by Ingress node which contains all the relevant information like size of burst, arrival time of burst, destination etc. which helps backbone nodes to determine the suitable forwarding path of burst between ingress and egress node. Apart from data transport, a separate wavelength is reserved for the transmission of burst control packet (BCP) [3]. The control packet generator has the authority of determining the output port, time of transmission and wavelength on the basis of information acquired from scheduler. The scheduling of bursts itself is done on the basis of burst scheduling algorithms which mainly fall into two categories of with void filling and without void filling. Void can be thought as an duration between two successive data bursts where the channel is unused.The second type is Egress node which can be thought as exactly opposite of Ingress node, performing the operations of diassembling of bursts into packets and forwarding the packet to higher layer network.

B. Core Node

This node manages processing of control packet and routing of bursts and control packets. The task of reserving resources for transmission of bursts and control packets is also done by this node. The main functionality also includes signaling and resolving contention. “OBS uses out-of-band signaling where the control packet contains routing and scheduling information, and it is converted from optical level to electronic for processing and converted from electronic to optical level for delivering. The corresponding data burst goes with some delay (the offset time) and passes through the core nodes, previously configured, until the destination node. The network intelligence is concentrated at the edge of the network and the core nodes only have the responsibility to process the control packet (setup message), send it to the next node and configure the optical cross-connect (OXC) to switch the burst [8].” Maintenance and creation of routing table is done by core node using the control packet information. Information about the burst is extracted by converting the received control packet into electronic form thus updating the routing table and then converted back to optical form for next hop [5]. A control packet is set to core node whenever an edge node intends to transmit a data burst. The control fields are extracted by converting it into electronic form. The next outgoing fiber for a corresponding payload is determined by using the control fields. Here scheduler gets into play to maintain a control packet queue and buffer it until the scheduled time.

III. NETWORK SIMULATION SOFTWARE

The most cost effective method to study and compare the behavior of proposed models and architectures are simulators. Carrying experiments without actual hardware makes it economical and within the reach of researchers and academic engineers to reflect upon the possibilities of a system and its influence. The performance under various conditions can be analyzed by modeling the studied system using simulation techniques. The results thus obtained are repeatable which gives them an advantage over experimental results. “Lack of single uniform simulation platform for optical WDM networks makes it very difficult for researchers and engineers to compare results, since model specifics of different simulators can lead to significant differences in results. Furthermore, disparate sets of feature provided by different simulators and lack of integration usually limit research possibilities [2].” Numerous fields of optical network research can be extended by using a simulation tool but a single simulator does not necessarily covers the required feature functionality of optical networks. Most of the simulators come with a license cost that also limit the researchers and engineers.

Even if that is resolved, extensibility can be another major issue.

OMNeT++ is a eclipse based simulation IDE supporting all major operating systems providing an graphical runtime environment.The architecture of OMNeT++ is bilingual which means that it subsists in both NED and C.OMNeT++ facilitates ease of learning and also makes it simple to modify and change already implemented modules. Model frameworks for various types of network like photonic network, adhoc network, sensor networks etc. can be developed as independent projects to provide domain specific functionality. An open-source communication networks simulation package is provided in the form of INET framework for the simulation environment which contains models for both wired and wireless networking protocols including IP, IPv6, 802.11, Ethernet, TCP, UDP, SCTP, MPLS and many more [5].It has a graphical network editor (GNED) which allows creation of files in Network description (NED) language. One can make simple modules and then assemble them together to form a compound module. These modules exchange messages which may represent for instance, packets in communication network. Event by event execution and graphical display of simulation results can be monitored. The major limitation of OMNeT++ is that it prohibits commercial use that means companies cannot use it to develop or extend the model for any further use.It does not have HLA support but it allows documentation generation.The service releases are informal. It also provides support for GCC compiler but not for Microsoft Visual C++. Another superior version of OMNeT++ is OMNEST which overcomes all the shortcomings of OMNeT++ discussed above and also allows commercial use.

IV. OBS NETWORK MODEL

The modeling is based on conventional optical burst switching architecture which allows sufficient time for the processing of burst control packet (BCP).We explain three NED design files with the help of generated vector file, scalar file and sequence chart respectively so as to have an insight of OMNeT++ as well. The first network design under consideration shown in Fig.1 shows the working of burst-maker section of OBS.

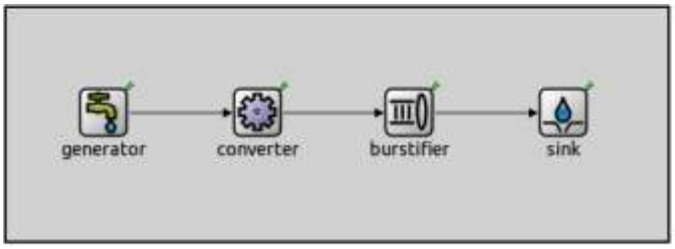

Fig 1. Burst-making section of OBS.

The first block generator simply sends the IP datagrams to a given address while the converter converts them into an entity which is readable by OBS packet dispatcher. The packets are converted into optical bursts by burstifier. The sink is added so as to silently discard all the packets received maintaining the flow of the network. Fig. 2 shows the vector graph for burstifier. The average packet size was 1000 bytes of all 16 packets.

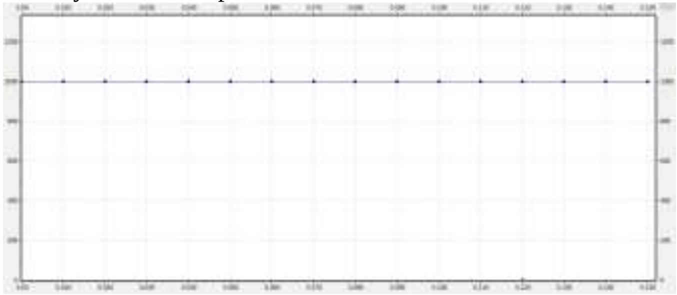

Fig 2. Vector graph for burstfier

The next design under consideration shows the edge node in OBS network as shown in Fig. 3. The edge node of this network is included with OBS interface otherwise it is simply a router from INET framework. IP forwarding is disabled for the host but full duplex connections are supported. It is a standard host with withTCP, UDP, SCTP layers and applications. The monitor transparently lets all the data pass through it. It receives both burst control packet (BCP) and data burst information.

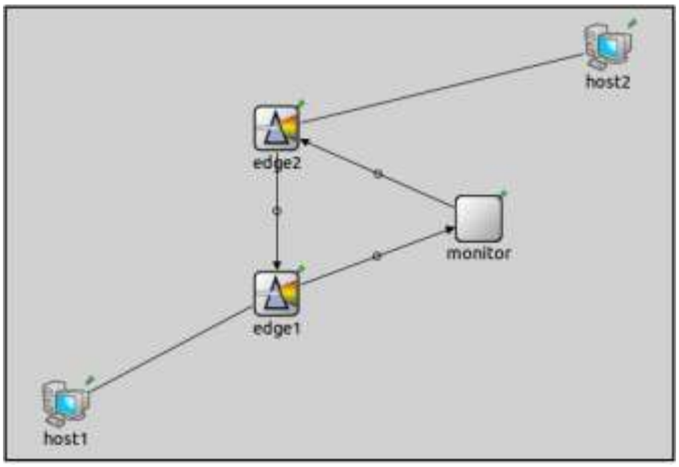

Fig 3. Edge node in OBS

The vector files has a extension of .vec while scalar file has a extension of .sca. Both these files are generated after simulation.This graph as seen in Fig. 4 is based on the scalar data recorded at the end of the simulation. The simulated time for this simulation was close to 19.6 while the receiver channel idle percentage was 100 since there was no traffic.

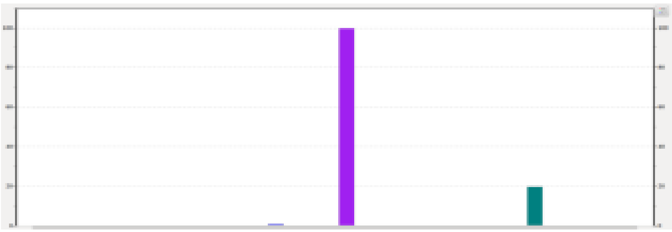

Fig 4. Scalar graph for edge node

The NED design in Fig. 5 shows a simple OBS network model consisting of both edge and core nodes. The core node here is merely a switching device in the OBS architecture maintaining a routing table. The elucidation of edge node and host is same as in previous design discussed above.The host can be linkedvia Ethernet interface to other nodes.

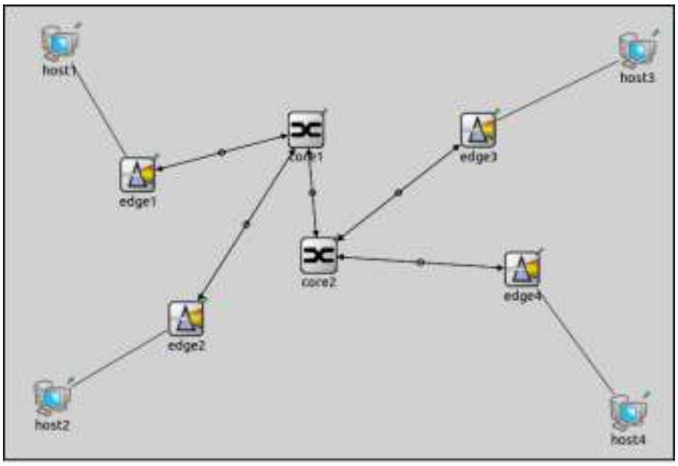

Fig 5. OBS network model

During simulation, the message exchanges are recorded in the form of event log file. The event recording can be manually switched on in the graphical runtime environment giving a .elog file after the simulation is donewhich can be analyzed in the form of a sequence chart as shown in Fig. 6. This figure shows how the message is routed between different nodes in the network. These sequence charts can be very valuable in documenting, debugging and exploringthe model's behaviour.

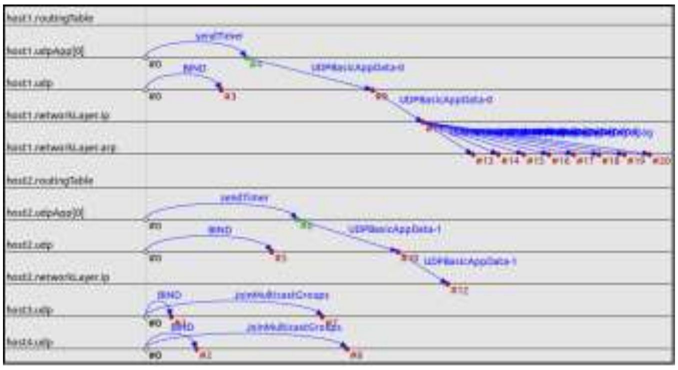
Fig 6. Sequence chart for OBS model

V. CONCLUSION

In this paper,we presented our initial work on optical burst switching network. We discussed OBS model designed in OMNeT++ discrete event simulator framework. We provided some insight on this effective underlying technology. We focused on the basic operations and general architecture of OBS to allow the contribution of future proposals in this emerging technology.

We plan to validate the existing model in future by comparing them to other published simulation results. In addition, we also plan to design more NED files to support and extend our study on a wider set. It will be particularly interesting to evaluate further possibilities from this model.

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