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Optical Burst Switching (OBS): The Future Switching Technology

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***Abstract*—** Optical Burst Switching (OBS) is a potential switching mechanism for future backbone networks, as it can perform fast switching and also data processing time is considerably reduced. It aims to achieve balance between deficiencies found in optical circuit switching and optical packet switching, which makes it an obvious choice for deployment. This future technology meets the user's requirements by removing the Optical to Electrical and Electrical to Optical (O/E/O) conversions.

Keywords: Optical Burst Switching, Burst Assembly, Burst Reservation

1. INTRODUCTION

Due to broadband internet access and shifting of paradigm from voice to data services, the internet traffic has doubled every year [1]. Increasing demand for multimedia live streaming and other bandwidth hungry services is on its great pace. The Cisco census in Figure 1 shows that these bandwidth hungry applications like IPTV, video chat, VOD, video conferencing, e-commerce, online banking etc are sharing 80% of total annual generated internet traffic that is still increasing with passage of time. The generated traffic in the access network is more or less concentrated in the backbone (core) network. As a result traffic load increases on the metro and core (backbone) transport networks. The next generation future networks should provide high transmission (bandwidth) and fast switching technologies in order to fulfill the requirements of increasing traffic demanding applications [2].

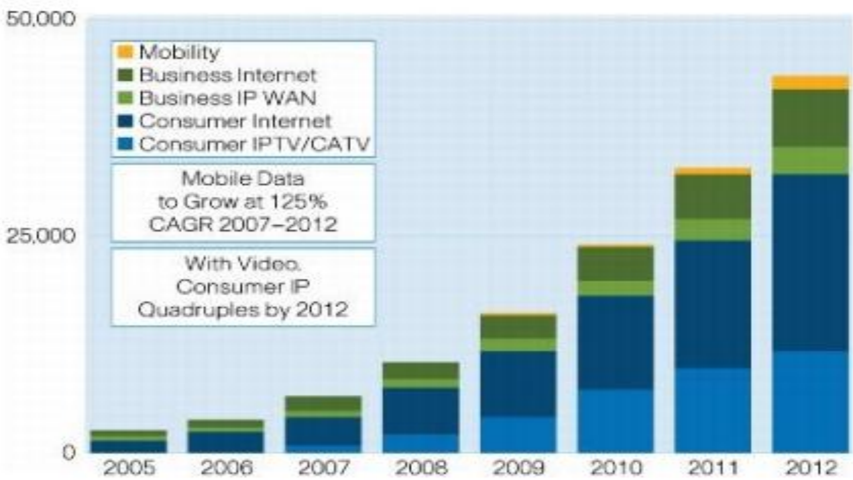

Fig. 1: Multimedia Traffic Distribution (Cisco CNI, 2010)

Recently, Wavelength Division Multiplexing (WDM) optical networks supporting beyond 100 Gbits/s of bandwidth are becoming the technology of choice in nextgeneration networks [3, 4]. Optical circuit switching (OCS) and Optical packet switching (OPS) are main paradigm used for data switching in the optical core networks [5, 6, 7]. However these schemes have some limitations such as round trip delay, bandwidth under-utilization, unavailability of optical RAM and output port contention. To support highly dynamic and burstified traffic on the internet efficiently, optical burst switching (OBS) was proposed [8].

2. OPTICAL BURST SWITCHING

OBS aims to achieve a practical balance between circuit switching and packet switching, and a better utilization of the available bandwidth. Below is a pictorial description of OBS network architecture in Figure 2.

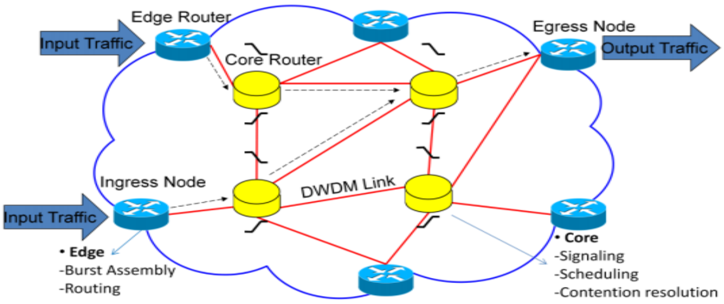

Fig. 2: Architecture of OBS Network

In OBS network, incoming traffic (IP, ATM, SONET/SDH, etc.) from clients at the access networks of same OBS destination node is aggregated at the ingress node in a large unit called optical burst. Each burst has its own control packet (CP) that selects the route and reserves the necessary wavelengths in advance time called "offset time" before burst transmission. This offset time is compensation for the propagation and electronic processing delay of CP at each intermediate hop, whereas the optical burst is transmitted all optically without O/E/O conversion. At the egress node, the optical burst is disassembled into original IP packets, and is sent to their respective access networks [4, 8]. In general the function of edge node is burst assembly and making routing decision. While the main function of core node is signaling, scheduling of incoming burst and contention detection and its resolution.

3. BURST AGGREGATION

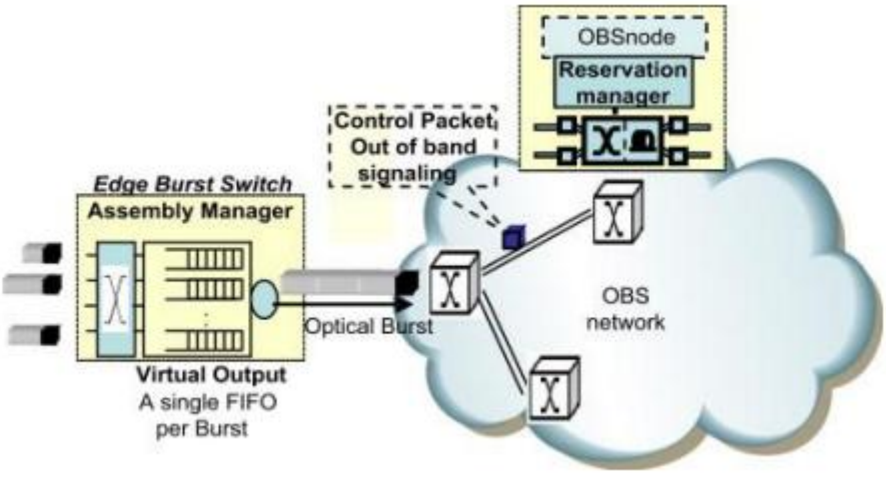

Fig. 3: Burst Aggregations in OBS

Figure 3 explains Burst Aggregation or burst assembly being a process in OBS where different arriving IP packets at source edge node are put into queue on the basis of their destination node. Later these same destination packets are combined to form a larger data unit called burst [9]. Mostly the burst assembly algorithms focus on achieving following two main goals [7, 9].

- Minimize the burst assembly delays
- To increase the burst size

By increasing the burst size, the less number of bursts are injected into the networks, so the overhead can be significantly reduced at the core nodes. Following are the main types of burst assembly algorithm:

Timer Based Algorithm: In this algorithm [10], time is the threshold for burst assembly. A predefined timer when reaches its maximum values within set time frame, arrived packets are combined to form burst. Timer value is very critical in burst assembly. Setting timer value short would result into more overheads in the network. On the other hand large timer value will generate more delay that is not good for streaming applications.

Burst-Length Based algorithm:In this algorithm burst is formed when packets in a destination queue of edge node are reached to a certain threshold value for burst length [11]. The performance of burst length based assembly algorithm depends on the chosen optimal value of the threshold for length. As small value of threshold results in larger number of burst assembled and forwarded. It produces more overheads in terms of control packets. If threshold value is set too large then large amount of data can be lost in case of burst loss.

Hybrid Approach: To overcome inefficiencies of above two techniques hybrid approach is proposed [12]. It is a combination of both timer and length based schemes. In this technique, the burst is formed when any one of the threshold condition is satisfied, i.e., threshold value for burst length is reached or timer is finished.

Adaptive Assembly based algorithm:In this algorithm, parameters of both time and threshold length is dynamically adjusted on the basis of real time traffic characteristics [13]. Adaptive algorithm outclasses the other traditional assembly algorithms in terms of burstifciation delay.

4. BURST RESERVATION PROTOCOLS

Burst reservation protocols are of two types [8].

- Two way signaling
- One way signaling

4.1 Two way signaling

Two way signaling protocols are also called Tell and Wait signaling protocols as shown in Figure 4. These protocols are implemented in such a way that initially source node generates control packet (CP) for every occurring burst. CP reserves the wavelength in advance time for its corresponding burst on hop by hop basis up to destination node. If the resources are reserved successfully all the way up to destination node, then the transmission of burst starts immediately after receiving positive acknowledgement from destination node. In case of non-availability of resources at any node, a negative acknowledgment (NAK) is sent to the source node. Control packet is sent again after back off time.

Advantage:

- These algorithms focus on minimal burst losses

Disadvantage:

- Less efficient because of complete round trip delay

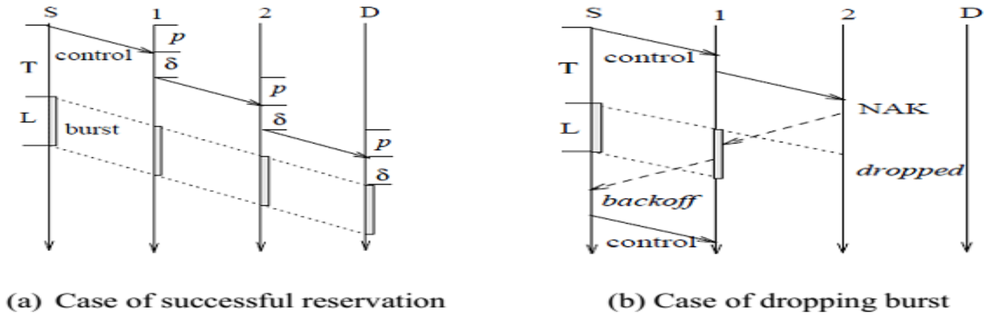

Fig. 4: Two way signaling

4.2 One way signaling

These types of protocols are also called Tell and Go signaling protocols. The conventional OBS is based on one way signaling protocol. Burst is transmitted without waiting for acknowledgement after an offset time of Control Packet (CP).

Disadvantage:
• Higher burst loss probability due to blocking of resources at any switch.

Following are the two main protocols for practical implementation of OBS. All other mechanisms are more or less derived from these basic protocols:

• Just in Time (JIT)

• Just enough Time (JET)

4.3 Just in Time (JIT)

Just-In-Time (JIT) was proposed in [14]. It is based on tell-and-wait technique with slight variations. In JIT protocol as shown in Figure 5, control packet is sent to a central node which is responsible for scheduling purposes. The central node then notifies all the respective nodes the exact time of the burst transmission. In JIT, the bandwidth reservation starts from the arrival time of control packet. Once the bandwidth is reserved by switching the element in router for incoming burst, it is not available to route the other burst. JIT protocol focuses on achieving guarantees allocation of resources to a burst. However the expenses are the less utilization of resources.

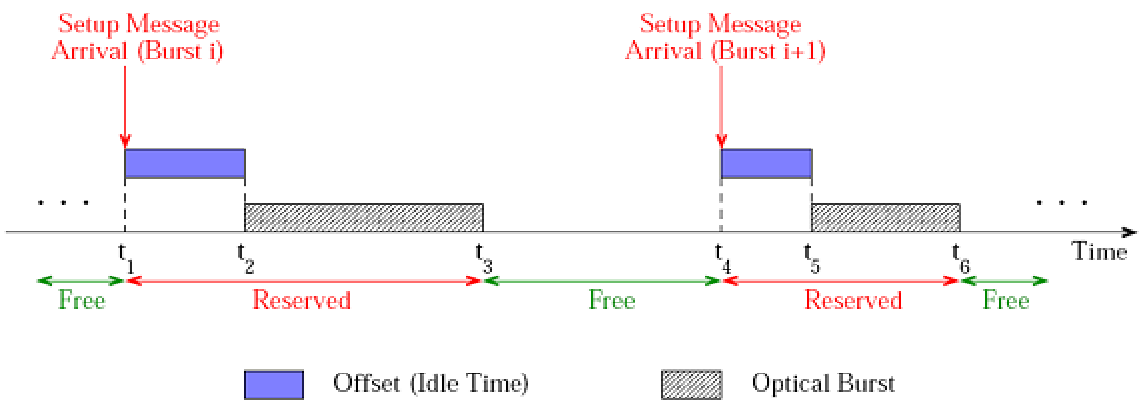

Fig. 5: JIT Protocol

4.4 Just Enough Time (JET)

Just-Enough-Time (JET) was proposed in [15]. In JET, the bandwidth is reserved from the burst's incoming time. Control packet (CP) carries burst occurrence and all other information. This information is conveyed hop by hop through CP up to destination node. CP information is used to predict the start and end time of burst at a node and thus resources are reserved for only the burst occurrence time. JET protocol focuses on utilizing resources more optimally. It comes at a price of increasing complexity at the switch. Below in Figure 6 is the illustration of JET protocol. The source node S has a burst b to transmit, send the control packet CP (that carries the path information, burst occurrence time, etc) signal in the channel towards the D. CP is processed at each node, the node chooses the appropriate wavelength and reserve thebandwidth for burst on the output port of switch, and then burst is transmitted after predefined offset time T(i) .

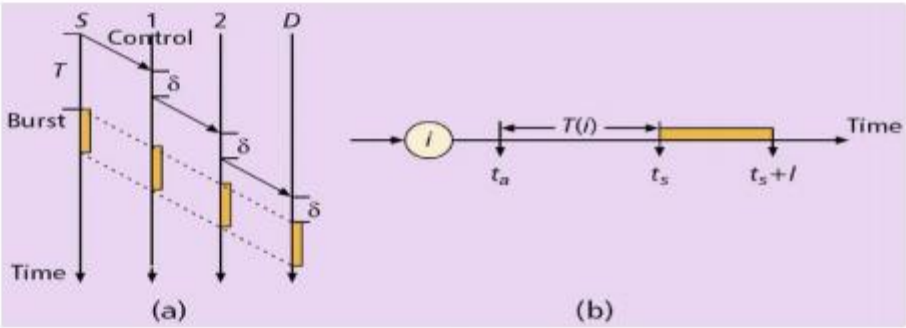

Fig. 6: JET Protocol

5. CONCLUSION

This paper discusses the Optical Burst Switching in detail giving a clear view of what OBS is and what is Burst Aggregation. Later on, the proposed burst assembly mechanisms are discussed. Burst Reservation Protocols are discussed at the end in which the one way signaling is more often used. These are the hot topics of research in OBS.

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