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# OPTICAL BURST SWITCHING PROTOCOLS IN ALL-OPTICAL NETWORKS

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## *ABSTRACT*

*In this paper, all optical network's general structure is briefly described and all optical network's optical switching methods is concantrated on. All optical network's classification is presented according to switching methods and burst switching methods studied carefully.The protocols which are defined for burst switching are studied. One of these protocols JET (Just-Enough-Time) which is mostly studied, is introduced. And the other protocol JIT (Just-In-Time) is presented detailly. The main aim of this study is explaining the all optical network's working mechanism generally, and examine the processing structure of JIT protocol.*

***Keywords:*** *Optical Burst Switching, Optical Packet Switching, JIT Protocol.*

## 1. INTRODUCTION

The demand on the high bandwidth, speed in computer networks and also the great development in fiber technology shows us that in the future fiber will be used instead of copper wires in computer networks. But for efficiently using the infrastructure of the network, the network hardware should be developed in the same rate. And also the network should process the data not in the electronic domain. For these reasons in recent years most of the researchers work on all optical networks.

In an all optical network data is carried in optical form from its source to destination. The data is not conversioned from optical to electrical form along its way. Ideally, this kind of networks would be fully transparent (Data transparency requires that the data layer and the signal layer must be independent from eachother. In the transparent domains the data is completely processed in optical form). By the way, all–optical networks are limited by many parameters of the physical layer in their scope. These parameters are bandwith, signal and noise ratios. For instance: analog signals require higher signal to noise ratios than digital signals. The requirements depend on both the used modulation format and the bit rate[1].

An optical packet network is consist of the fiber cables that works with WDM and the packet switches which are connected to eachother. The switches may be adjacent or connected with lightpaths . The user data is transmitted as optical packets. These optical packets are switched during the optical domain by all of the optical packet switches. By this way, the user data remains as an optical signal from the source to the destination. So there is no need an optical to electrical to optical (OEO) conversion[2].

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The invention of WDM technology affect the improvement of all-optical networks. WDM technology is developed for transmitting more data over fiber. There are different methods in WDM. These are Broadcast and Select, Wavelength Routing, Optical Packet Switching and Optical Burst Switching techniques. Broadcast and Select technique is studied widely. Wavelength Routing technique is stil in use. Optical packet Switching and Optical Burst Switching techniques are still examined. For these reasons, in our study optical packet Switching and Optical Burst Switching techniques are examined .

In our study, we focus on the optical burst switching protocols. Different protocols which are used in this technique are analyzed and explained briefly. Specifically, the optical burst switching technique which is called as Jumpstart is analyzed. The Jumpstart technique is developed by the Microchip Center of North Carolina Research Development Institute (MCNC-RDI). In section two, two of the optical switching techniques which are told before are presented. In this section the general structures of the optical packet switching and optical burst switching are told. In section three, the Jumpstart Protocol and the Just-in– time protocol are examined. Finally, section four concludes this paper.

## 2. THE TYPES OF OPTICAL SWITCHING

### 2.1 Optical Packet Switching

The optical networks that can perform packet switching can provide virtual circuit services or datagram services. These provided services mostly like the networks that are provided by ATM and IP. By the virtual circuit connection the network provides a kind of connection between two nodes. This kind of connection resembles the circuit switched connection. But the bandwith which is provided during the connection would be less than the full bandwith on a link or wavelength.

In figure 1. the structure of an optical packet switching node is presented. The main aim is to create packet switching nodes that have higher capacities than electronic packet switching nodes.That kind of nodes reads the header of incoming packet and switches it to the appropriate output port. And also the node controls the congestions for output ports.

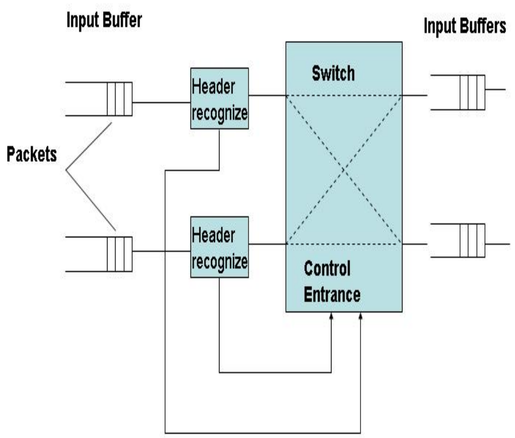


***Figure 1. A Optical Packet Switching node***

The node in which all the functions would be performed in the optical domain is ideal . But in our daily life, specific functions such as processing the header and controlling the switch is performed in the electronic domain. The main reason of this fact is the limited processing capabilities in the optical domain.The loss in transformation from optic to electronic and electronic to optic causes us not to fully benefit from the high bandwith and speed of fiber wires.

The main duty of the optical packet switching is to increase the packet switching capabilities to the rates that can not be thought for electronic packet switching . For this reason most of the packets are processed in optical domain. But there are many limitations about signal processing in optical domain. One of them is the lack of optical random access memory for buffering. Optical buffers are performed by using a length of fiber and delay lines. So these are not efficient memories.
Packet switches include a high amount of intelligent real-time software and hardware to control the network. And also packet switches provide quality of service guarantee. But performing all of these functions in the optical domain is a difficult fact. Because of the

limitations which are mentioned before. The other limitation is the primitive state of fast optical-switching technology compared to electronics[1].

WDM optical packet switching is consist of four parts. Input interface, switching fabric, output interface and control unit. Input interface is basically used in defining the packet header information and transmitting the packet header for packet determination and registration. Switching fabric is the core of the switch and used for switching the packets optically. Output interface is used for forming the optical signals again and placing the packet header. Optical Packet switches are designed for the fixed dimensional packets because of the synchronization need.

When a packet arrives at a WDM optical packet switch, it is processed by input interface at first. The header and the data of the packet is seperated from eachother and the header is transformed to the electrical domain. Then the packet is routed to the suitable port in optical domain by the control unit which processes over the header. At last the packet header is transformed from electrical to optical and transmitted to the next node of the optical domain with the optical packet. So, during the transmission at the switch the data remains as an optical signal whereas the packet header is transformed from optical-electrical-optical. The data is connected with its header after the switch. The header is transformed to the optical domain again at the output interface.

## 2.2 Burst Switching

Burst switching is a kind of (PhotonicPacket Switching) PPS. In burst switching, the source node deliver a header which is followed by a packet burst. In general, the header is transmitted at a lower speed on an out-of-band control channel. An intermediate node reads the header of the incoming packet at first. Then the intermediate node activates its switch to connect the burst stream to the suitable output port . If there is not an available output port, then the burst is either dropped or buffered. If the burst switching and photonic packet switching is compared. The main difference between them is the burst duration in the burst switching is longer than the packet duration in packet switching.

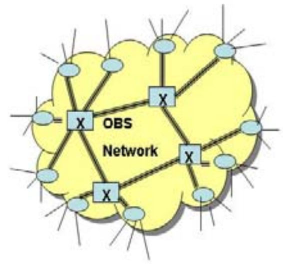


***Figure 2. An OBS network***

In figure 2 an OBS schema is presented. An OBS network is composed of the optical burst switches which are connected with WDM links. An OBS transmits a burst which comes to the input port to the output port. According to its switch structure it may have buffer or may not have. A burst is appointed to a wavelength dynamically. A burst may be transmitted over a wavelength or a network which is not an optical network. The burst may contain one or more IP packets.

In burst switching if the bursts are long enough, then its possible to demand or reserve bandwith in the network before sending the burst. To provide this, there are many protocols proposed. Such as, Just-in-time or Just-enough-time.

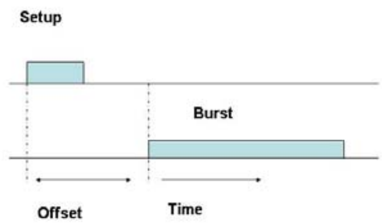


***Figure 3. Sending of an optical burst***

In burst switching, packets may have changeable and large sizes. And also burst switching is a kind of PPS where little or no buffering is used at the nodes. As in the packet switching , the most important issue in burst switching is to determine the buffer sizes needed at the nodes to achieve reasonable burst drop probabilities when there is a contention [1].

OBS is a standard for the burst switching in Asynchronous Transfer Mode (ATM) networks and it is known as ATM block transmission (ABT). There are two types of ABT. These are Delayed Transmission ABT and Immediate Transmission ABT. In Delayed Transmission ABT, the source sends a packet to confirm that it wants to transmit a burst to the ATM switches on the connection path when it wants to transmit a burst. If all of the switches would accept the coming burst, then the request is accepted and the source is allowed to transmit its burst. If the request is rejected, then after a while the source needs to send another request. In Immediate Transmission ABT, as soon as the source sends the request packet, it sends the burst without receiving an acknowledgement. During the path, if a switch can not transmit a burst by the effect of a congestion, then the burst is dropped. Two of these techniques are adapted to the optical networks as Tell and Go (TAG) and Tell and Wait (TAW).

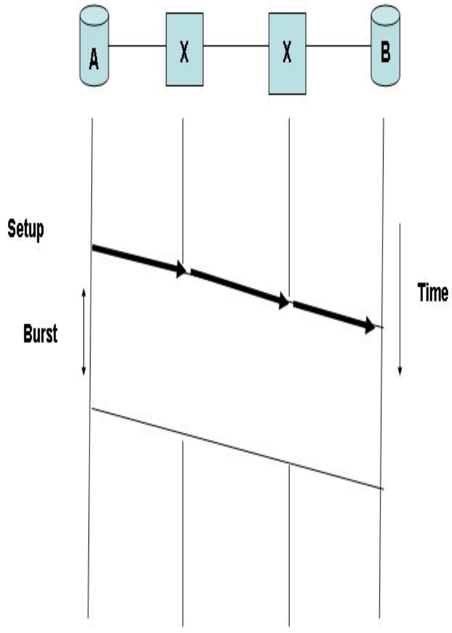


***Figure 4. The Tell-and-Go schema***

In figure 4 the TAG schema is presented. In TAG, the source transmits the control packet and then waits for an ack message. The data is transmitted after receiving an ack message. As told before, with today's technology it is not possible to use TAG protocol. The main reason of this is the processing of the control packets are not in the optical domain but in the electrical domain. For this reason the control processing consumes too much time.

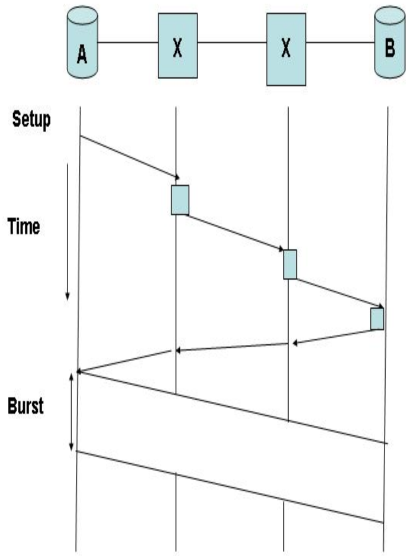


***Figure 5. The Tell-and-Wait schema***

If data packet is sent immediately after sending the control packet then the data packet may have been dropped. Because, before processing the control packet completely the data packet would arrive at the switch. For this reason, this protocol can not be applied. On the other hand, TAW can not benefit from the speed of the optical networks efficiently. In figure 5. the TAW schema is presented. As a result, both of these protocols are not efficient for optical networks. For this reason, there are many new protocols are developed which are JIT and JET protocols.

In figure 6 the process of JET is presented. In JET the source, buffers the optical burst until the control packet is processed. It transmits the burst after waiting enough time which is needed for processing the control packet. So, there is a delay between the transmission of the control packet and the optical burst. This delay, may be determined as longer than all of the processing times of the control packet during the path. In this way, when the burst arrives at every intermediate node, the control packet would be processed and the wavelength would be reserved at the output port. So, there is no need for buffering the burst at the nodes. This is the most important feature of JET protocol.

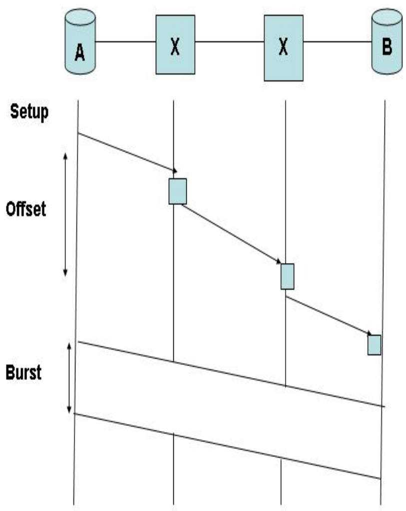


***Figure 6. The JET schema***

There are two traffic types in JET. As real time and non-real time. A burst that belongs to a real time has a priority than the burst that belongs the non-real time.This is provided by the delay between the control packet transmission and the burst transmission.The effect of this extra delay decrease the blocking probability of the real time burst at the OBS.

## 3. JUST-IN-TIME SIGNALLING PROTOCOL

Jumpstart is developed by the MCNC-RDI. It is based on OBS. This protocol uses JIT protocol. For this reason, JIT protocol will be examined, especially the signal transmission part will be studied in this section which is used by the Jumpstart protocol. The main reason of this fact is providing the data transparency is completely possible in JIT protocol.

In jumpstart signalling for each message a link – unique identifier (or label) is used . The main reason of using a label is upon emergence on the other end of the link can be cached and mapped to a new identifier on the exit link. The first message in a signalling flow (session declaration or Set up) serves the purpose of setting up a label-switched path. So, all of the messages would follow in forward and reverse direction.

Signalling Protocol Functions

*Session Declaration:* Declare the connection to the entire network.
*Path Setup:* Preapare the needed resources to setup an all optical path.
*Data Transmission:* Inform intermediate switches about the arrival time and length of the burst.
*State maintenance:* Keep up the necessary state information to maintain the connection.
*Path Teardown:* Leave the resources taken up to maintain the lightpath for the connection.

There are many functions which should be performed by the signalling protocol depending on the type of the connection being set up. All of these functions are described above. These phases can be accomplished by the signalling protocol in a different fashion, depending on the assumptions made about the network: the reliability of individual links ,scheduling capabilities of the switches and other factors.

Every connection setup can be seperated into many logical phases[5]. In multicast connections all of these phases should be classified because multicast path tree must be formed before sending any data.

Relasing of the multicast session is more complex than unicast session. Any leaf may leave the tree at any point by using the Drop Party message. Every multicast connection maintain the data transmission and path assignment. Adding new members or removing from the multicasting tree would not affect the data transmission state [6].

In figure 7,8,9,10 the main differences of JIT schemes are presented.

In figure 7 Explicit setup and Explicit release is presented. In this transmission the switching elements inside the switch are configurd for the incoming burst immediately after the arrival of the Setup message and remain in that configuration until a release message arrives[5]. In this structure the switches are reserved for the releated burst from the arrival of the setup message to the arrival of the release message.

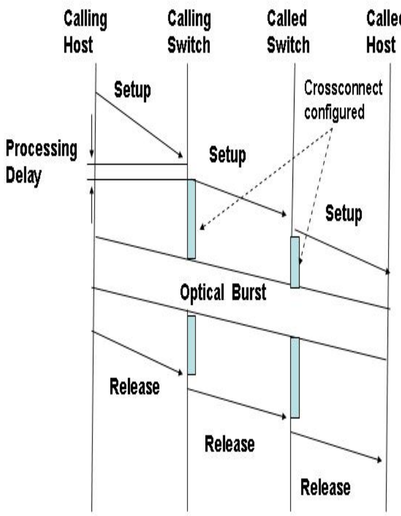


*Figure 7. Explicit setup and Explicit release*

In figure 8 Explicit setup and Estimated release is presented. In this transmission the setup message carries information about the duration of the burst so that, unlike schema 7, no release message is needed to mark the end of the burst. This information is determined by the switch from the arrival time of the setup message and the information about the length of the burst contained in it. So, the reservation of the switch is determined according to the length of the burst.

In figure 9 Estimated setup and Explicit release is presented. This schema is opposite of the schema 8: instead of estimating the end of the burst, the start of it is estimated based on the information contained in the setup message. But in this situation a definite release message is needed for releasing the switching elements for other bursts [5].

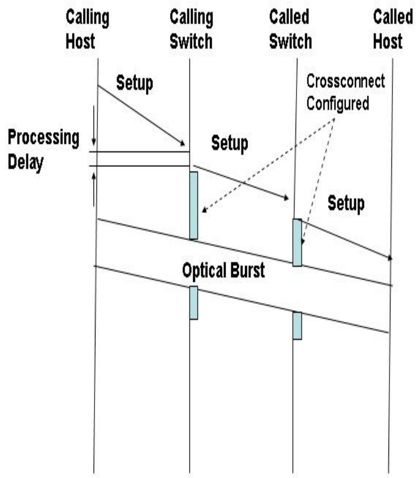


*Figure 8. Explicit setup and Estimated release*

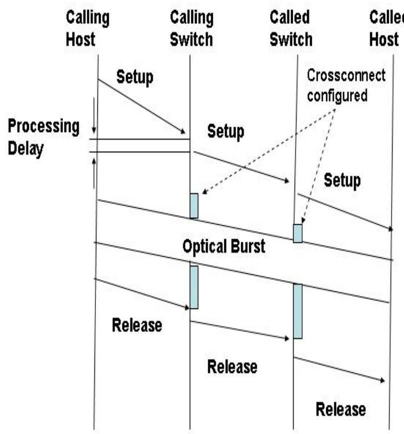


*Figure 9. Estimated setup and Explicit release*

In figure 10 Estimated setup and Estimated release is presented. Here both the start and the end of the burst are predicted based on information contained in the setup message. And the switch is reserved exactly at the predicted arrival time of the burst. Also the switches are released at the predicted end of data transmission. In that way, the switches can be used more efficiently.

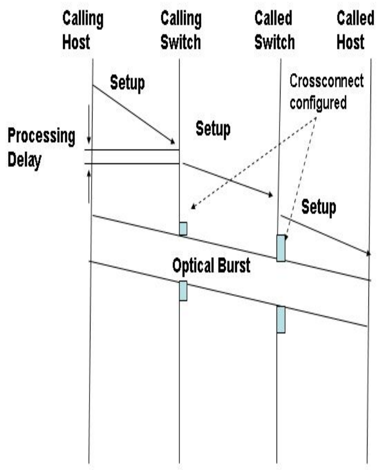


***Figure 10. Estimated setup and Estimated release***

From the figures 7, 8, 9, 10 we can see that these schemas differ in the amount of time the same burst would occupy the switching elements inside a switch. The better the estimate of the start and the end of the burst, the smaller the overhead of keeping the switching elements configured, and the lower the overall burst blocking probability in the network.While explicit schemes gives the worst results, the estimated schemes gives best results[5].

## 4. CONCLUSION

In this article, we present a formal description of OBS in all-optical networks and OPS. We defined the working principles of the JIT and JET protocols which are suggested to the burst switching according to the length of the burst.

In the future if the development of the optical equipments continue, then packet switching and burst switching technologies improve too. If burst switching can be designed without using optical buffer, then in the future obs will be the most prefered technology.

But there are not enough studies about this topic. Especially, about the application part there is too much to do. The main study areas about these topics are: developing more suitable protocols for optical networks, improving the hardwares of optical networks and developing the optical control mechanisms and rearranging the higher level protocols of optical networks.

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