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Design Criteria of High Speed Optical Packet Switching Network

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--ABSTRACT--
Optical packet switching enables the transfer of packet signals in the optical domain on a packet-by-packet basis. In conventional electronic routers, all input optical packets are converted into electrical signals that are subsequently stored in a memory. Optical packet switching is promising to offer large capacity and data transparency. However, after many years of research, this technology has not yet been applied in actual products, because of the lack of deep and fast optical memories and the poor level of integration. It will be overcome not only through technical breakthroughs but also through clever network design, making optimal use of optics and electronics. Developments in OPS seem to lead integration of optical and electronic networks and the use of optical burst switching (OBS).
Keywords – *Optical Packet Switching (OPS), Optical Burst Switching (OBS),UPDS*

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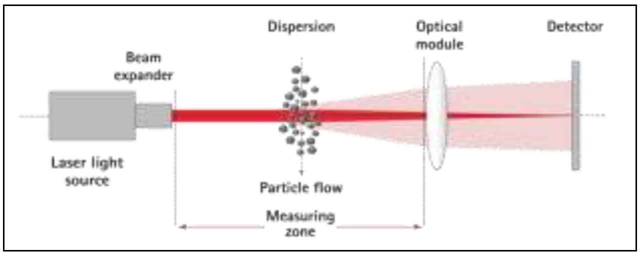
I. BACKGROUND

High-speed digital fiber-optic transmission using subcarrier multiplexing(SCM) is investigated both analytically and numerically. In order to reduce the impact of fiber chromatic dispersion and increase bandwidth efficiency, optical single-sideband (OSSB) modulation was used. Because frequency spacing between adjacent subcarriers can be much narrower than in a conventional. Dense Wavelength Division Multiplexing (DWDM) is an optical multiplexing technology used to increase bandwidth over existing fiber networks system, nonlinear crosstalk must be considered. Although chromatic dispersion is not a limiting factor in SCM systems because the data rate at each subcarrier is low, polarization mode dispersion (PMD) has a big impact on the system performance if radiofrequency (RF) phase detection is used in the receiver. In order to optimize the system performance, tradeoffs must be made between data rate per subcarrier, levels of modulation, channel spacing between subcarriers, optical power, and modulation indexes. A 10-Gb/s SCM test bed has been set up in which 4×2.5 Gb/s data streams are combined into one wavelength that occupies a 20-GHz optical bandwidth. OSSB modulation is used in the experiment. The measured results agree well with the analytical prediction. In the optical domain, the Optical Packet Switching(OPS) paradigm is similar to electronic packet switching, except that the payload of the packets are switched and buffered in the optical domain while the headers, which contain control information, are processed electronically. In this paper, we focus on slotted OPS networks, where optical packets are of a fixed duration, and are aligned at the inputs of the switching node. Slotted OPS with a packet size in the order of 1μs has been concluded as a promising alternative for future OPS backbone networks. The switching architecture (switch fabric) is the node component responsible of the transfer of the optical packets from the input ports to the output ports of the switching node. This requires a packet-by-packet switching operation.

II. CONCEPT ABOUT OPTICAL NETWORK COMPONENTS

Light sources

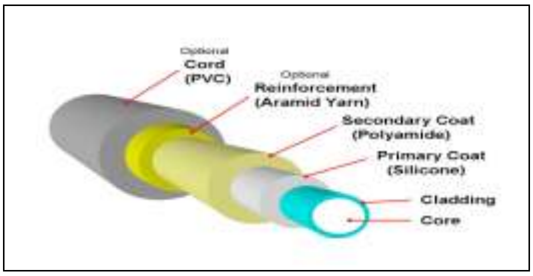
Light sources used in photonics are usually far more sophisticated than light bulbs. Photonics commonly uses semiconductor light sources like light-emitting diodes(LEDs), super luminescent diodes, LASER. Other light sources include single photon sources, fluorescent lamps, cathode ray tubes (CRTs), and plasma screens.



Fig(II-a): Light Sources

Transmission media

Light can be transmitted through any transparent medium. Glass fiber or plastic optical fiber can be used to guide the light along a desired path. In optical communications optical fibers allow for transmission distances of more than 100 km without amplification depending on the bit rate and modulation format used for transmission.

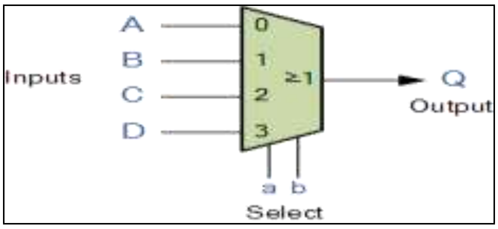


Fig(II-b): Optical Fiber

Multiplexer

A multiplexer (MUX) is a device allowing one or more low-speed analog or digital input signals to be selected, combined and transmitted at a higher speed on a single shared medium or within a single shared device. Thus, several signals may share a single device or transmission conductor such as a copper wire or fiber optic cable.

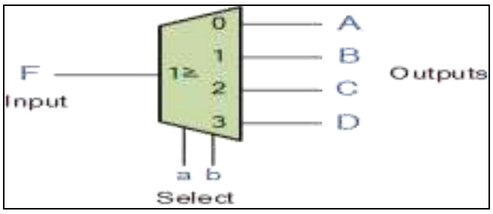
In telecommunications the combined signals, analog or digital, are considered a single-output higher-speed signal transmitted on several communication channels by a particular multiplex method or technique. With two input signals and one output signal, the device is referred to as a 2-to-1 multiplexer; with four input signals it is a 4-to-1 multiplexer etc.



Fig(II-c): Multiplexer

Demultiplexer

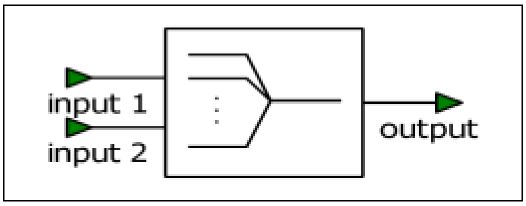
A demultiplexer (or demux) is a device that takes a single input line and routes it to one of several digital output lines. A demultiplexer of 2^n outputs has n select lines, which are used to select which output line to send the input. A demultiplexer is also called a data distributor. Demultiplexers can be used to implement general purpose logic.



Fig(II-d): Demultiplexer

Coupler

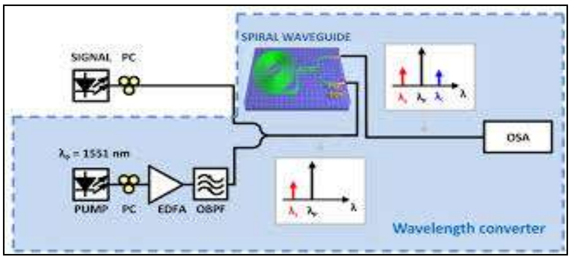
A fiber optic coupler is an optical device capable of connecting one or more fiber ends in order to allow the transmission of light waves in multiple paths. The device is capable of combining two or more inputs into a single output and also dividing a single input into two or more outputs. Compared to a splice or connector, the signal can be more attenuated by fiber optic couplers, as the input signal can be divided amongst the output ports.



Fig(II-e): Coupler

Wavelength Converter

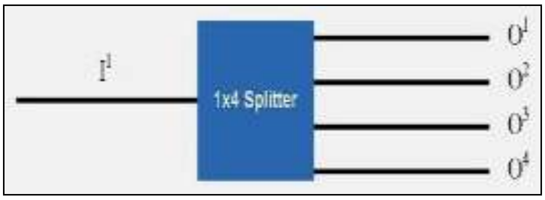
As the name suggests wavelength converter converts optical signal with one wavelength to the other optical signal. These types of converters are widely used in WDM networks. Optical wavelength converters are of four types based on their input and output wavelength handling limits.
They are fixed input fixed output, variable input fixed output, fixed input variable output and variable input variable output.



Fig(II-f): Wavelength Converter

Splitter

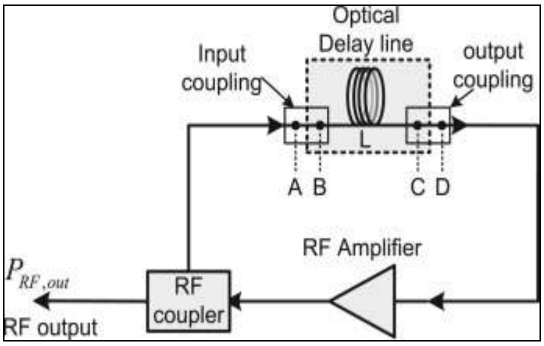
A fiber optic splitter is a device that splits the fiber optic light into several parts by a certain ratio. For example, when a beam of fiber optic light transmitted from a 1X4 equal ratio. Splitter, it will be divided into 4-fiber optic light by equal ratio that is each beam is 1/4 or 25% of the original source one.



Fig(II-g): Splitter

Optical Delay Line

Optical delay line are used to produce defined optical transmission delays and to compensate for delay differences in optical fibers. In fiber sensor technology, optical coherence tomography, and fiber-optic interferometers, the transmission time of the optical signal often has to be adjusted or delayed among the different optical paths. Different optical components and modules are available for such adjustments.

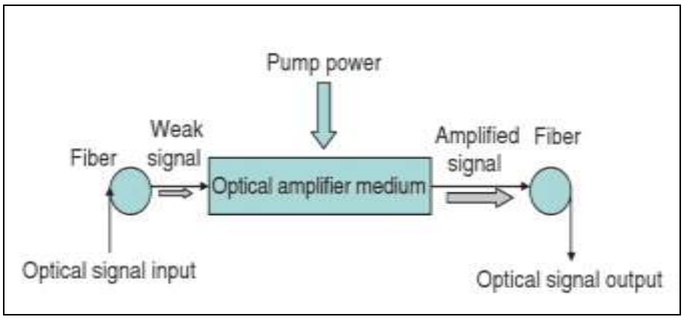


Fig(II-h): Optical Delay Line

Optical Amplifier

An optical fiber amplifier is a fiber optic device used to amplify optical signals directly without conversion into electrical signals. Optical fiber transmission has revolutionized networking and communication systems.

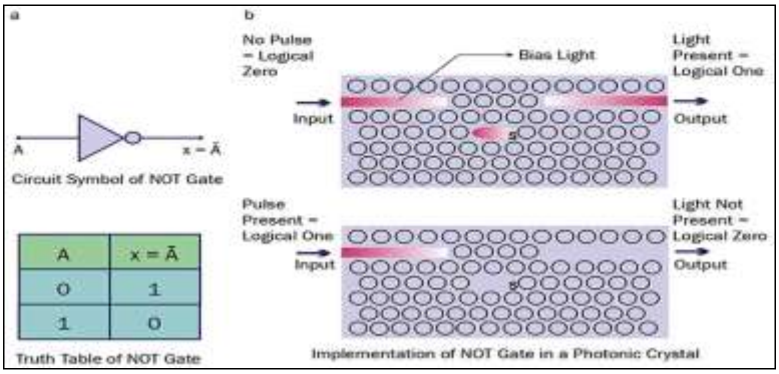
An optical amplifier may be thought of as a laser without an optical cavity, or one in which feedback from the cavity is suppressed



Fig(II-i): Optical Amplifier

Optical Gate

An optical gate amplifies or damps the incoming optical signal in the given wavelength range. It is controlled by the electric signal in nanoseconds. An optical gate can be implemented with a semiconductor optical amplifier (SOA). Nowadays, prototype of all optical logic gates at high bit-rate are coming out from the laboratories. The researches are going forward in this field to make it possible. However, in optical signal processing the digital gates have complicated and cumbersome electro optic conversion. To make all-optical systems, it is necessary that entire components which are used in optical networks such as add-drop multiplexer, packet synchronization, clock recovery, address recognition, and signal regeneration.



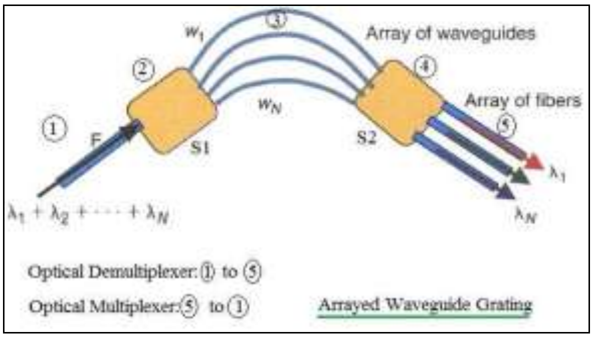
A	x = Ā
0	1
1	0

Fig(II-j): Optical Gate

AWG

An arrayed waveguide grating(AWG) is a typically fiber-coupled device which can separate or combine signals with different wavelengths. It is usually built as a planar lightwave circuit, where the light coming from an input fiber first enters a multimode waveguide section, then propagates through several single-mode

waveguides to a second multimode section, and finally into the output fibers. Wavelength filtering is based on an interference effect and the different optical path lengths in the single-mode waveguides: any frequency component of the input propagates through all single-mode waveguides, and the output in any channel results from the superposition interference of all these contributions.
The wavelength-dependent phase shifts lead to a wavelength-dependent overall throughput for any combination of an input port and an output port.

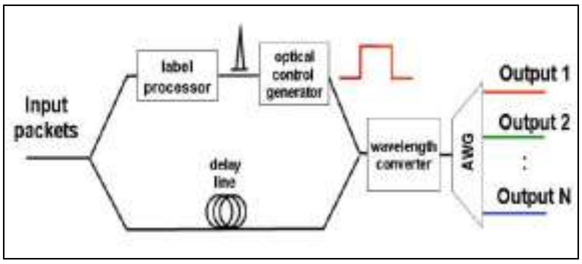


Fig(II-k): An Arrayed Waveguide Grating(AWG)

III. PACKET SWITCHING

Optical Packet Switching(OPS) enables the transfer of packet signals in the optical domain on a packet-by-packet basis. In conventional electronic routers, all input optical packets are converted into electrical signals that are subsequently stored in a memory. The stored signals then undergo switching to reach the intended output ports while being handled as low-speed signals, and finally the switched signals are reassembled into the high-speed packets. To resolve these issues, we have been undergoing research for the hybrid optoelectronic packet router (HOPR) that aims to optimally combine optical and electrical technologies based on novel optical and optoelectronic devices developed in labs.

All-optical packet switching (OPS) is one of the promising technologies for the next generation of optical networks. It realizes the packet switching in optical domain that eliminates optical-electrical and electrical- optical conversions. One of the main components in an OPS network is the optical interconnect that provides the basic functionality of directing packets from input ports to the desired output ports, while maintaining data in the optical domain.

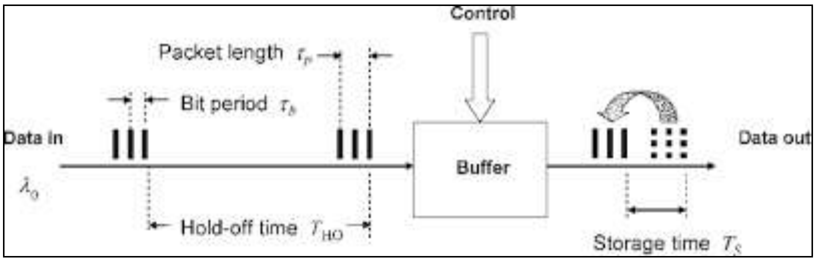


Fig(III): Packet Switching

Optical Packet Switching (OPS) is the simplest and most natural extension of packet switching over optics. It consists of sending IP packets directly over an all-optical backbone. The biggest challenge that packets face in an optical switch is the lack of large buffers for times of contention. As a rule of thumb, routers have RTT×bandwidth worth of buffering, so that TCP congestion control works well. For an OC-192c link and an average packet length of 500 bytes, this is equivalent to a buffer space of 625,000 packets. In contrast, existing optical buffering techniques based on fiber delay lines can accommodate at most a few tens of packets.

IV. BUFFERING

Optical delay lines or buffers have emerged as key components for future optical networks and information processing systems. Applications of optical delay lines and buffers range from optical packet switches (OPSs) to optical delay-line filters and microwave photonic devices such as antenna beam formers using optical delays to achieve the so-called “true time delays” in microwave signals. In OPS applications, buffers are required for synchronization of incoming packets and for collision avoidance on outgoing light paths. The most practical buffer technology for OPS applications is based on fiber delay lines combined with optical switches. This style of buffer has proved satisfactory in limited-scale laboratory-based demon-strations of OPS, but it is bulky and does not scale well to full-size networks, especially in buffering for collision avoidance.



Fig(IV): Buffering

There have been recent suggestions that adequate network performance can be achieved with two orders of magnitude less buffering than this. In addition, wavelength-division multiplexing (WDM) of multiple stored bit streams on each delay line could reduce the total length. However, while these measures may help a little, the required buffers would still be impractically large. At the heart of the buffer scaling problem is the issue of the physical size of a bit of data stored on an optical fiber delay line. At 40 Gb/s 1 bit occupies approximately 5 mm of length on the fiber. Compare this with complementary metal–oxide semiconductor random access memory (CMOS RAM), which can store a single bit in an area of less than $1\mu m^2$. The clear message here is that for OPS to become viable and for OPS networking to become competitive with electronic networking, it will be necessary to find an optical buffering technology that provides many orders of magnitude reduction in size. Many orders of magnitude increase in storage density. As pointed out above, optical signal processing and microwave photonic applications generally require shorter fiber lengths. However, in these applications, there is a need for greatly improved miniaturization and increased storage density.

V. CRITERIA OF A HIGH SPEED OPTICAL NETWORK

V(a): Facilitates of Universal Packet Delivery System(UPDS)

It is important to design network architectures that accommodate a variety of protocols and allow interconnection of heterogeneous networks. The availability of high speed communication technology has already spawned new protocols and new applications. The Multi switch architecture is based on a packet delivery system called Universal Packet Delivery System(UPDS). The delivery system is universal because it does not interpret the contents of packets accepted for delivery and therefore, can deliver packets that belong to multiple transport protocols. UPDS provides sufficient functionality at the network layer so that a variety of transport protocols can use its services. UPDS also allows routers for multiple protocol suites to coexist and thus facilitates interconnection of heterogeneous networks. To support high-performance applications such as image transfers and multimedia communication, UPDS provides a communication abstraction with performance guarantees. It also uses a novel rate-based congestion avoidance and control mechanism to prevent congestion within the network.

V(b): Transmission Rate Calculation

Changing the transmission rate in response to a control message involves either modifying the packet rate(packets per second)or adjusting the inter~packet gap(or inter-packet arrival time). Choosing a correct function for increasing or decreasing transmission rates is extremely important, because the function may determine the stability and fairness of the congestion control scheme. Under one possible scheme, when a node decreases its packet rate in response to congestion or increases it when conditions improve, the node could use a simple additive function (adding or subtracting a fixed amount from the packet rate) to change its transmission rate. However show that an additive function leads to oscillations in delays and throughput, and to unfair sharing of network resources among multiple sources. Instead show that multiplicative decrease(reducing the rate to afraction of its previous value)and additive increase leads to fair sharing of resources. The packet rate and inter-packet gap as follows.

Let,

L=Link capacity reported in the rate control message

P=Effective packet rate=L/Packet size

ω = Current load on the link, $0< \omega<1$

$R_{old=}$ Current packet rate in packets/sec

$G_{old=}$ Current inter-packet gap in sees.

$R_{new=}$ New packet rate

$G_{new=}$ New inter-packet gap

The formulas for decreasing and increasing packet rates or inter-packet gaps are as follows For multiplicative decrease

$R_{new=}min(P,\delta^* R_{old})$ and
$G_{new=}max(G_{old}/ \delta,1/P)$

Where δ=1.5- ω,0.5< $\delta\leq$0.9, and ω>0.5

For additive increase

$R_{new=} R_{old}*(1+\Delta)$ and
$G_{new=} G_{old}/(1+\Delta)$

Where 0< Δ<0.5, Δ=(0.5- ω)/2, and $\omega\leq$0.5

After a node reduces its transmission rate in response to control messages, it may increase the transmission rate again if the node does not receive any rate control message over a long period. 'When the additive increase takes place in the absence of a previous rate control message, value of 0.1 for Δ. to achieve a steady linear increase in the transmission rate to match the capacity of a path.

V(c): Addressing

Within a UPDS each packet switch has a unique identifier called nodeid and each link also has a unique link identifier. A single distinguished node called master node is responsible for assigning node identifiers to individual packet switches and for coordinating changes to the topology when a packet switch or a link is added or deleted. Adding a new packet switch involves obtaining an address(nodeid), acquiring information about the complete topology of the network and establishing links with peers so that the switch becomes a function al part of the network. UPDS contains an auto configuration mechanism that automates entire process.
Provides the details of the Auto configuration mechanism. Packet switches within a UPDS use a link-level protocol called Multi switch Interior Link.

V(d): Congestion Control

The overloading condition that leads to arbitrary increases in delay over a packet switched network is called congestion. Packet switched networks use a congestion control mechanism to detect and recover from congestion. Existing congestion control schemes are based on one of the following two approaches. First the network Itself may control congestion by refusing to accept new traffic until the congestion ceases within the network. Second the network may rely on outside sources to adjust the amount of traffic they send to reduce the congestion. The advantage of the first approach is that a network can act to ensure that the total amount of traffic is within its capacity without relying on outside sources. The disadvantage is that network resources are expended in monitoring and controlling the incoming traffic. The second approach avoids the cost of controlling congestion within the network. However the network sends back warning messages to outside sources and relies on the sources to reduce the traffic. The disadvantage is that it can take along time before the sources receive the warning and reduce the traffic to an appropriate level. A congestion control scheme based on the first approach involves pre-allocating buffer space to incoming and outgoing links at intermediate machines. Each intermediate machine on a path only accepts traffic that can fit in the reserved buffer space and informs its immediate predecessor to reduce the traffic when the incoming traffic exceeds the node's buffer capacity. The scheme is slow in preventing congestion because the congestion notification must trickle back to the source of traffic through all the intermediate machines before the source reduces the input

V(e): Protocol Hierarchy

Network design into layers of protocols to reduce the design complexity to deal with various functions at appropriate layers and to allow us the flexibility of modifying implementation at one level without affecting the over all structure. UPDS also needs an algorithm for routing within the network and a protocol for communication among the packet switches to exchange routing and other control information.

V(f): Auto configuration

A mechanism for automatically configuring a packet switch without any manual intervention whenever a new packet switch or a new link is added to the network, or when a packet switch recovers from a shutdown. Adding a new packet switch involves assigning a nodeid acquiring information about the current topology of the network and establishing connections with peers to make the switch a functional part of the network. The notion of automatic configuration is simple. When one wishes to add a node to a UPDS, it should be possible to physically connect the new node to one or more existing nodes power it up and the node should simply execute a procedure that converts it into a fully functional packet switch. Also a packet switch that recovers from a shut down or a crash should be able to obtain information about the current state of the network and restore itself to its operational status without external intervention. Such a facility is desirable for several reasons. It makes the packet switch hardware simple and maintaining a packet switch require less expertize. Also, network management is simpler because configuring packet switch does not need local or remote intervention by a network manager.

The idea of automatically booting a system is not novel because diskless workstations on a broadcast network such as Ethernet automatically restart by downloading configuration information and binaries from a file server that resides on the same physical network. However, each diskless workstation is manually configured when it is first added to the server. Automatic configuration in this case is straight forward because workstations and the server share a common broadcast medium. In computer networks, configuring a packet switch is not so straight forward because a network typically has an arbitrary topology as opposed to a single LAN. It is important to coordinate changes in topology so that all the nodes in the network still obtain a consistent view of the state of the network at all times. Designing a fault-tolerant distributed algorithm for maintaining consistency is always a difficult problem.

One can accomplish assignment of a nodeid to a new packet switch or addition of a new link to the network through a de centralized algorithm involving all the nodes in a network. Such an algorithm is complex because it should handle node or link failures during its execution. In contrast an algorithm that centralizes all such actions a ta single node is easy to design and leads to simple and efficient implementation. However, such an algorithm suffers from a single point of failure because one can’t add a node or a link when the master node is unavailable or unreachable. Use centralized algorithm because it leads to a simple and efficient implementation. Among all the nodes over a new nodeid requires a larger field for nodeid, because of the possibility of sparse assignment of nodeids in the presence of link or node failures in the midst of a selection of a nodeid.

V(g): Routing

A router addresses the packets it sends to a destination port(address of another router). The packet switch that accepts these packets from the router is responsible for routing each packet to its final destination. For routing datagram’s packet switches use a distributed, adaptive, link-based routing algorithm similar to the network. Each node in the network knows the current topology of the network. Nodes generate and propagate control messages to keep topological information at each node up-to-date. Also each node in the network monitors the status and performance(load, average delay per packet etc.) of out going links and broadcasts that information to all the other nodes. Thus every node in the network has a database of status information on all the links in the network. To keep the database consistent and up to date across all nodes, link status update protocol for reliable and fast propagation of link status updates.

V(h): High Speed Propagation

The multi switch network uses a link status routing algorithm that requires each node to know the complete network topology. The topological information is kept in a data base that also maintains information about the status of each link including the current load, average per-packet delay and error rate. A node uses the topology data base to calculate a set of paths including the shortest path(or the best path according to a particular criterion based on a delay and band width specification)to each destination in the network. To keep the data base at each node up-to date ,every node in the network periodically generates and propagates an update on the current status of every adjacent link. Correct routing under such a scheme requires that all nodes receive all the updates in the correct order and have the same information.

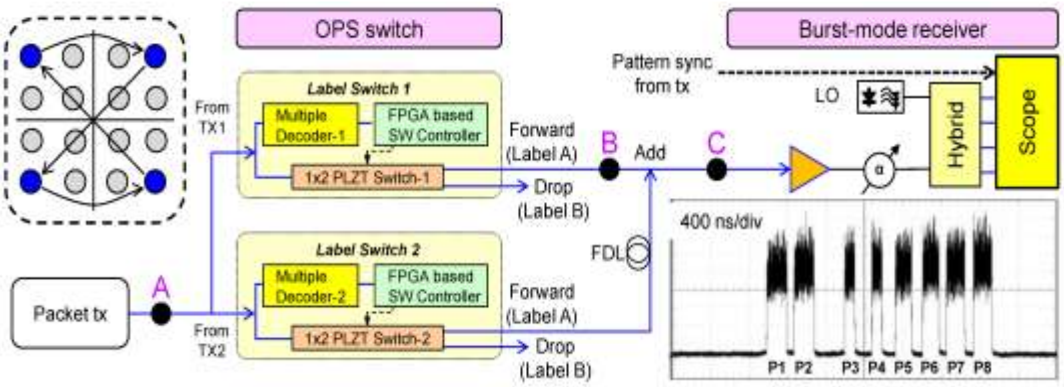
VI. METHOD OF A HIGH SPEED OPTICAL NETWORK DESIGN

Step-1. Survey of Enabling Technology

Optical communications not only increase the capacities of communication system but also improve the system dynamicity and survivability. Various new technologies are invented to increase the bandwidth of individual wavelength channels and the number of wavelengths transmitted per fiber. The switch fabric at an OPS node must be capable of rapid re-configuration on a packet-by-packet basis. At data rates of 40Gbps and beyond, this requirement implies that switching times have to be on the order of a few nanoseconds. Other critical requirements include scalability of the technology to high port counts, low 6 loss and crosstalk and uniform operation across all signals independent of the path from input to output port moreover, issues such as reliability, energy usage and temperature independent operation are also important. Today, most optical switch fabrics, including those based on opto-mechanical, thermo-optic or acousto-optic technologies, are limited to switching speeds in the millisecond or microsecond range. Two promising technologies include semiconductor optical amplifier (SOA) switches and electro-optic lithium niobate (LiNbO3) switches, both capable of switching speeds in the nanosecond rage. However, both technologies have limitations that must be overcome before it becomes possible to build high-performance, reliable and cost-effective optical packet switches. For a recent comprehensive survey of optical switch fabric technologies.

Since this operation must be performed for each incoming packet, the circuit must be able to synchronize the header with its clock within a few bit times. In addition to bit-level synchronization, OPS nodes in slotted net-works must also synchronize incoming fixed-size packets to the local switching slots. This slot-level synchronization is accomplished by passing each incoming packet through a cascade of fiber delay lines and optical switches, in order to delay the packet by a sufficient amount of time for it to align with the beginning of a slot. This scheme introduces losses and crosstalk, resulting in a significant power penalty over long paths. A deferent strategy takes advantage of the fact that the propagation delay in a highly dispersive fiber depends on the signal wavelength. Each incoming packet is therefore passed through such a fiber, after its wavelength is first converted to achieve the desired delay The primary purpose of this paper is to refresh the knowledge and broaden the understanding of advances in optical communications, and to encourage further research in this area and the deployment of new technologies in production networks.

Optical Packet Switching (OPS) presents new avenues for high speed interconnection networks. There is a rapidly growing demand for high-throughput networks to transmit heterogeneous traffic services such as communication of voice, images and data, multimedia interaction and advanced digital service.



Fig(VI): Optical Packet Switching (OPS)

Step-2. Simulation Design of High Speed Optical Network

In the optical domain, the Optical Packet Switching (OPS) paradigm is similar to electronic packet switching, except that the payload of the packets are switched and buffered in the optical domain while the headers, which contain control information, are processed electronically. In this paper, we focus on slotted OPS networks, where optical packets are of a fixed duration, and are aligned at the inputs of the switching node. Slotted OPS with a packet size in the order of 1μs has been concluded as a promising alternative for future OPS backbone networks The switching architecture (switch fabric) is the node component responsible of the transfer of the optical packets from the input ports to the output ports of the switching node. This requires a packet-by-packet switching operation, and potentially, the optical buffering of the packets, a technological challenge under the current state-of-the-art of photonic technology. This is because in the OPS networks, the optical switching function has to be performed in the order of nanoseconds. Two main components fulfill the nanosecond switching speed requirement. Optical gates and Tunable Wavelength Converters (TWC), both of them based on Semiconductor Optical Amplifiers (SOA). Regarding the packet buffering, it is implemented almost exclusively by means of fiber delay lines, which delay the optical signal for a fixed time depending on the fiber physical length and the signal propagation speed. As an example, to implement a N positions queue, for a packet duration of 1μs, N delay lines of lengths 0,...,N-1μs. The simulators built on top of the OMNeT++ framework, are based on the interconnection of simulation modules, implemented as C++ classes, which are able to send and receive events, defined also as C++ classes. The module interconnection topology can be flexibly configured using an own script language.

Step-3. Performance Analysis of The Designed High Speed Optical Network

For several years now, optical fiber communication systems are being extensively used all over the world for telecommunication, video and data transmission purposes. Fiber optics has made a revolutionary change in commercial telecommunications over the past few decades. The demand for transmission over the global telecommunication network will continue to grow at an exponential rate and only fiber optics will be able to meet the challenge. Multimedia optical networks are the demands of today to carry out large information like real time video services. Presently, almost all the trunk lines of existing networks are using optical fiber. This is because the usable transmission bandwidth on an optical fiber is so enormous (as much as 50 THz) as a result of which, it is capable of allowing the transmission of many signals over long distances. However, attenuation is the major limitation imposed by the transmission medium for long-distance high-speed optical systems and networks. So with the growing transmission rates and demands in the field of optical communication the electronic regeneration has become more and more expensive. The powerful optical amplifiers came into existence, which eliminated the costly conversions from optical to electrical signal and vice versa. Due to the need of longer and longer unrepeated transmission distances and ultra fast broadband transmission, the advanced transmission schemes have to be investigated. So, it is imperative to investigate into the feasibility of unrepeated transmission and ultra fast broadband transmission over long distances. In order to achieve these goals i.e. broadband and repeater less transmission of an optical communication system. Real-life performance analysis of the designed high speed optical network. The technical complexities inherent in today's optical components, systems and networks make the use of dedicated software tools for researchers and designers not a luxury, but a bare necessity. One important category of such software tools provides the capability to simulate the physical behavior of optical systems by modeling time-dependent signal propagation, the results allow the user to assess the performance of a design, for instance with respect to the bit error rate to expect under certain conditions. A broad range of applications can benefit from this capability, including naturally research and design, but also product evaluation and technical marketing. Due to the wide range of scales involved from wavelength-sized resonators in lasers and filters, to interactions in global networks, such design tools must employ highly advanced simulation technology. This chapter outlines the status of design software which is commercially available today, covering simulator technology as well as modeling problems. While the availability of accurate and efficient software is a prerequisite for successful modeling of optical systems, its application in a real-world engineering environment still faces many problems. The most dominant problems include a lack of qualified designer, a lack of supper for the design process within the tools, and finally a lack of precise input data as required for an accurate simulation.

Step-4.Finalization a Model of The High Speed Optical Network

The core of a physical level design tool is constituted by its simulation engine, which provides the infrastructure to define, execute and control simulations. The simulator operates according to a model of computation that specifies the laws of physics of a simulation. The most common model for optical system design tools is the dataflow model, where the simulation is made up of models that process and exchange simulation data representing physical signals according to a deterministic schedule. Other models are based on discrete events or continuous time. In addition to the model of computation, the simulator defines a frame work for the representation of signals. While most simulation applications make use of straight-forward representations, usually uniform sampling of the signal, the problems encountered in modeling optical systems require a more sophisticated approach. Section discusses this issue in some detail. Historically, simulation tools targeting the problem domain of optical components, systems and networks have evolved in three phases:

1st. The first generation of tools addressed a dedicated problem configuration, such as the simulation of a certain type of laser. These tools had no graphical user interface and in many of them the problem to simulate was hard-coded, requiring modification of the source code to alter the configuration. Tools of this generation were never released commercially, but were mainly the result of research and as such were only used by researchers.

2nd. The second generation introduced a graphical user interface and the concept of building blocks, allowing the user to construct a design to simulate through point-and-click with the mouse. The first commercial tools were released in 1997. These enabled designers for the first time to make direct use of simulation technology, leading frequently to opposition against the introduction of design tools from research departments.

3rd. The third generation extended the scope of the tools to truly address multiple problem domains, from the simulation of components to entire, albeit simplified networks. The introduction of advanced signal representation concepts played a key role in making this development possible.

VII. CONCLUSION

High speed networks in the evolving technological environment of communications. In the early sections of this work the primary thesis explicitly presents the properties of fiber optics, existing and developing high speed networks, and applications of these high speed networks. The analysis and validation of this thesis leads to two major postulations. The first investigates the possibility of replacing the current communication network for the Aegis real-time combat system aboard Naval ships with a dual optical fiber ring. This network would consolidate all sensors, weapons, electronic equipment, and computers into a single communication network, possessing a simple topology, higher data transfer capability, and enhanced security. The network has also been designed to accommodate the projected requirements of the next generation of surface combatant. The future system is expected to build upon the current Aegis combat system architecture, becoming more complex but remaining a well integrated and easily operable combat system. A high speed network based on OPS can satisfy the demand for more bandwidth, integrating both real-time and other communication services aboard a ship. This paper supports the view that OPS can not only successfully replace the current communications in a ship's combat system, but also provide an enhanced level of operation. There are also several other advantages which are quite significant. These include a significant reduction in weight and volume, and reduced susceptibility to electromagnetic interference. The second major construction is the configuration of a hospital health care system utilizing a high speed network. The intern-hospital network would connect the medical hardware, electronic equipment, and computers into a single network. It is projected that the intern-hospital network will interface with an external network employing emerging telephone transmission capabilities

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