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Multi Domain Optical Network Routing Using OBGP and OSPF

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Abstract:
Now-a-days the most and fastest growing technology is optical communication. As we know that the future generation requires more and more bandwidth to accommodate a greater number of users, so there is absolute chance of problem when we have the same Non-Optical means of communication in next generation too. So, we need to switch from the legacy network to the better network which can meet the requirements of the future generations. The substitutional networks for legacy systems might be All-Optical-Networks. All-Optical-Networks requires algorithms which are suitable for optical switching. Various routing algorithms like Dijkstra's algorithm can meet the requirement of electrical networks. But All Optical Networks requires similar protocols like OSPF, BGP and so on. The proposal deals with the standardized Border Gateway Protocol (BGP) in an optical network and its implementation by considering the shortest distance and wavelength continuity constraint. Analyzing Routing and Wavelength Assignment (RWA) in an optical network in order to establish an optical route from source to destination. A path computational algorithm for checking the wavelength continuity and Dijkstra's algorithm for checking the shortest path is to be designed.

I. INTRODUCTION

The most popular and rapidly expanding technology today is optical communication. There is definitely a chance of an issue if the same Non-Optical ways of communication are used in the next generation as well, given that we already know that the future generation will need more and more bandwidth to support a larger number of users. Thus, we must replace the outdated network with a new one that can accommodate the needs of coming generations. All- Optical-Networks may be the replacement networks for outdated systems. Algorithms that are appropriate for optical switching are required by All-Optical Networks.

The Internet is a decentralized collection of networks, grouped and interconnected in the form of domains or Autonomous Systems (AS's). Each AS typically represents a pool of networks, managed by a single authority, and under a common routing policy. At present, the Internet has approximately 64,511 ASs, each of which uses one or more Interior Gateway Protocols (IGPs) for routing within the AS. The process that handles the exchange of routes among ASs is referred to as inter-domain routing.

The Border Gateway Protocol (BGP), a path vector protocol, is the "de facto" protocol for inter-domain routing in IP networks for worldwide connectivity. BGP is the foundation to provide a solution for inter-domain routing at the optical layer. The critical aspects Various network simulators used for implementation of optical networks are OMNET++ (Optical Micro Networks plus plus), OPNET (Optical Network Engineering Tool), NS2 & 3 (Network Simulator 2 & 3), JSIM (Java based Simulation) and NETLOGO tool. In this proposal, BGP implementation in multidomain optical network system need to be analyzed. The proposal includes the general frame work of cluster generation, multidomain network generation, Modelling of WDM network characteristics such as multi wavelength links and implementationof border gateway routing protocols for optical links. Parameters such as transmission distance and wavelength continuity are to be compared for various routing techniques. A path computational algorithm for generation of shortest path with a common wavelength need to be implemented. The path calculation algorithm should satisfy the Wavelength Continuity Constraint (WCC) and if the wavelength is not available at a particular node, instead of blocking the packet, it has to search for alternate paths from the node where the link has broken.

(i) Any extension of BGP over optical networks, such as the Optical Border Gateway Protocol (OBGP),

inherits the non-solved problems of BGP.
(ii) Optical networks do not build paths but rather lightpaths, hence adding a new component, the wavelength, in the routing process that is not considered in the traditional BGP.
(iii) BGP does not consider physical impairments, metric that undoubtedly must be considered when selecting a light path.

Therefore, any research effort in providing a solution for inter-domain routing in optical networks must be feed on the long record of research existing for BGP at the IP layer, hence trying to benefit from the lessons learned in the past. To this end, we believe that a solid background on inter-domain routing concepts is radically necessary to position any potential research contribution on multi- domain routing at the optical layer.

Optical networks employing wavelength division multiplexing (WDM) offer the promise of meeting the high bandwidth requirements of emerging communication applications, by dividing the huge transmission bandwidth of an optical fiber (∼50 terabits per second) into multiple communication channels with bandwidths (∼10 gigabits per second) compatible with the electronic processing speeds of the end users. There has been great interest in WDM networks consisting of wavelength routing nodes interconnected by optical fibers.

Such networks carry data between access stations in the optical domain without any intermediate optical to/from electronic conversion. To be able to send data from one access node to another, one needs to establish a connection in the optical layer similar to the one in a circuit-switched network. This can be realized by determining a path in the network between the two nodes and allocating a free wavelength on all of the links on the path. Such an all- optical path is commonly referred to as a lightpath and may span multiple fiber links without any intermediate electronic processing, while using one WDM channel per link. The entire bandwidth on the lightpath is reserved for this connection until it is terminated, at which time the associated wavelengths become available on all the links along the route.

In the absence of wavelength conversion, it is required that the lightpath occupy the continuous wavelength on all fiber links it uses. This requirement is referred to as the wavelength continuity constraint. However, this may result in the inefficient utilization of WDM channels. Alternatively, the routing nodes may have limited or full conversion capability, whereby it is possible to convert an input wavelength to a subset of the available wavelengths in the network.

Since lightpaths are the basic building block of this network architecture, their effective establishment is crucial. It is thus important to provide routes to the lightpath requests and to assign wavelengths on each of the links along this route among the possible choices so as to optimize a certain performance metric. This is known as the routing and wavelength assignment (RWA) problem. The wavelengths assigned must be such that no two lightpaths that share a physical link use the same wavelength on that link. Moreover, in networks without wavelength converters, the same wavelength must be used on all links of the lightpath (wavelength continuity constraint).

The RWA problem is critically important in increasing the efficiency of wavelength- routed optical networks. With a good solution of this problem, more customers can be accommodated by the given system, and fewer customers need to be rejected during periods of congestion.

II. LITERATURE REVIEW

[1] Priority-aware traffic routing and resource allocation mechanism for space-division multiplexing elastic optical network. Propose a RMSCA algorithm for SDM–EON. We present traffic priority-aware protection mechanism which saves optical resources We propose an optical spectrum release mechanism that prioritizes requests based on their priorities. We compare the performance of the QUARANTINE algorithm with existing algorithms to demonstrate its efficacy.

[2] Impairment- and fragmentation-aware dynamic routing, modulation and spectrum allocation in C+L band elastic optical networks using Q- learning. A novel Q-learning based dynamic RMSA algorithm for C+L band elastic optical networks is proposed.. The algorithm considers impairment awareness (XPM, SPM, ASE, ISRS effects) and fragmentation awareness.. The algorithm is tested with different spectrum algorithms, network loads and topologies. The proposed algorithm is simple and can be easily used by the network controllers in real situations.

[3] A Novel Multicast Routing, Spectrum and Modulation-Level Assignment in Elastic Optical Networks.Frequency slot: In the EONs, spectrum is broken to slices called frequency slots. Each frequency slot spectrum width is considered 12.5 GHz in this article.
[4] A novel two-dimensional metric for fragmentation evaluation in elastic optical networks. Related works are presented. Proposed Golden metric and Golden-RSCA are explained. Performance evaluation results are presented. Concludes the paper and compares the positive and negative features of the proposed algorithms.

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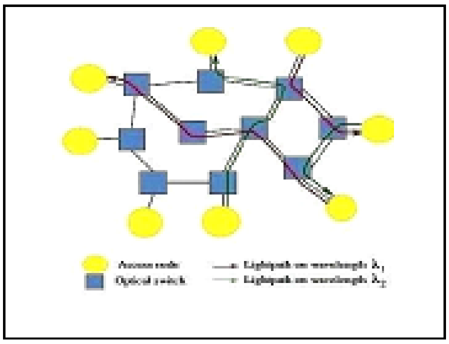
[5] Routing, Modulation, Spectrum Assignment in Programmable Networks Based on Optical White Boxes. Routing, Modulation, and Spectrum Assignment (RMSA) for intra domain network is elaborated in this paper. Used for Elastic optical networks (EONs). Hardware-aware Routing Algorithm (HRA) for routing with less number of Hops. But It is not fit for a Multi-Domain Network. Alternate path computation is not available in case of non- availability of wavelength at a particular node or a cross connector.

[6] Extended Path-finding RWA Algorithm Based on ACO in Optical Satellite Network. Extended pathfinding routing and wavelength assignment (RWA) algorithm based on ant colony optimization (ACO-EP) is proposed. Applied in dynamic network. Best route is identified from Pheromone Table. Wavelength availability is identified from Wavelength Usage Table. But It is not fit for a Multi-Domain Network. Multipath Routing is also not available (Routing between multiple sources and multiple destinations

Numerous research studies have been conducted on the RWA problem. Several RWA schemes have been proposed that differ in the assumptions on the traffic pattern, availability of the wavelength converters, and desired objectives. The traffic assumptions generally fall into one of two categories: static or dynamic. In static RWA models we assume that the demand is fixed and known, i.e., all the lightpaths that are to be set up in the network are known beforehand. The objective is typically to accommodate the demand while minimizing the number of wavelengths used on all links. By contrast, in a stochastic/dynamic setting, we assume that lightpath requests between source-destination pairs arrive one by one at random, and have random terminating times.

Due to computational complexity in obtaining an optimal solution, much of the previous work on the routing and wavelength assignment problem has focused on developing efficient heuristic methods. A common approach is to decouple the routing and wavelength assignment steps by first finding a route from a predetermined set of candidate paths and then search for an appropriate wavelength assignment.



Wavelength-Routed Optical WDM Network with Light PathConnection

Light-path: A light-path is an optical path that is established between each source- node and destination-node in the EONs and light travels through [4]. Non-overlapping spectrum assignment Spectrum contiguity constraint: Allocated frequency slots to a connection request must have a continuous index on each link of a light- path. Spectrum continuity constraint: In order to allocate a frequency slot to a connection request, it must be free in all links of a light-path. Dynamic traffic: When traffic is dynamic, the traffic conditions may be changed at any moment of time. In this type of traffic, connection requests arrive one by one

. III. METHODOLOGY:

i. Wavelength Division Multiplexing

In fiber-optic communication, Wavelength Division Multiplexing (WDM) is a technology which multiplexes a number of optical carrier signals onto a single optical fiber by using different wavelengths (i.e., colours) of laser light. This technique enables bidirectional communications over one strand of fiber, as well as multiplication of capacity. The term wavelength-Division Multiplexing is commonly applied to an optical carrier, which is typically described by its wavelength, whereas frequency-division multiplexing typically applies to a radio carrier which is more often described by frequency. This is purely convention because wavelength and frequency communicate the same information.

In optical communication, wavelength division multiplexing (WDM) is technology that carries a number of optical carrier signals on a single fiber by using different wavelengths of laser light. This allows bidirectional communication over one standard fiber with increased capacity.

Light possess different colours like red, green, yellow, blue, etc. all at once. The colours are transmitted through the air together and may mix, but they can be easily separated using a simple device like a prism, just like separating the "white" light from the sun into a spectrum of colours with the prism. Let us consider Light at 850 nm and 1300 nm

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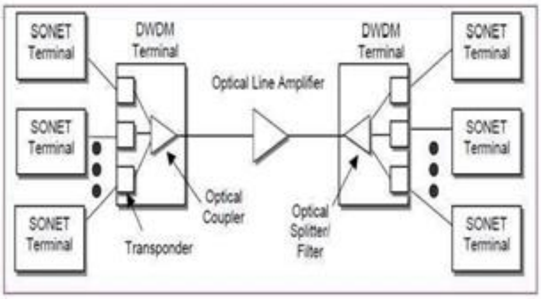
were injected into the fiber at one end using a simple fused coupler. At the far end of the fiber, another coupler split the light into two fibers, one sent to a silicon detector more sensitive to 850 nm and one to a germanium or InGaAs detector more sensitive to 1300 nm. Filters removed the unwanted wavelengths, so each detector then was able to receive only the signal intended for it.

A WDM system uses a multiplexer at the transmitter to join the several signals together and a demultiplexer at the receiver to split them apart. With the right type of fiber it is possible to have a device that does both simultaneously, and can function as an optical add-drop multiplexer. The optical filtering devices used have conventionally been etalons (stable solid-state single-frequency Fabry–Perot interferometers in the form of thin-film- coated optical glass). As there are three different WDM types, whereof one is called "WDM.



WDM with Couplers and Filters

ii. Routing and Wavelength Assignment
The problem of RWA is divided into two parts:

- Routing
- Wavelength Assignment

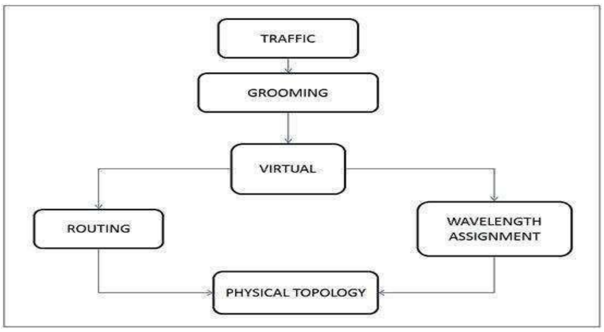
In optical networks, the major goal is to define a way for establishing a light path across multiple domains. Specifying the sequence of physical fibers that each light path can traverses and specifying a specific wavelength channel that it will use on these fibers is called Routing and Wavelength Assignment (RWA). A light path is an end- to-end connection that might span multiple links in the optical DWDM network. In order to establish light paths in all-optical DWDM networks, a signaling protocol is required to request and set up the light path through the optical network. The steps for RWA are present in Fig.

Routing and Wavelength Assignment
RWA involves various steps. Traffic is varied depending on the multiplexing technique used, speed of the traffic whether it is slow or fast etc. Irrespective of the type, the traffic undergoes grooming. The groomed traffic is proceeded for routing and wavelength assignment processes. These two steps are used to find an optimal route from source to destination. This route is linked to the physical network.
To select appropriate routing for operations based on the optimization aims. The following introduces two frequently used algorithm of routing.
Fixed Routing: The network node pair provides fixed optical paths. Though this method is easy, it needs more wavelength resources. In dynamic flow, it is more probable to cause flow blockage.

Fixed-Alternate Routing:Each node in network maintains a routing table which lists a series of routings from the node to others, including the routing of the working optical path and the routing of the alternate optical path. If the working routing is occupied or ineffective, a secondary routing is selected from the alternate routing, so the network is capable of recovering from link fault.

Wavelength Assignment
After selecting a route for the connection request, an appropriate wavelength needs to be assigned to setup a light path from source to destination nodes. For static RWA, optical techniques like graph coloring are used to do wavelength assignments.

Two of the most common methods for wavelength assignment are First Fit and Random Fit. First Fit chooses the available wavelength with the lowest index. Random Fit determines which wavelengths are available and then chooses randomly amongst them.



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An extension to First Fit and Random Fit was proposed to consider signal quality. Quality First Fit and Quality Random Fit eliminate from consideration wavelengths which have an unacceptable signal quality.

For dynamic connection requests, different heuristic algorithms are used for dynamic light path establishments like Random, First-Fit, Least-Used, Most-Used, Min product, Least Loaded, MAX-SUM, Relative Capacity Loss, Wavelength Reservation and Protecting Threshold. Each heuristic algorithm has its own advantages and disadvantages.

There are different types of wavelength assignment algorithms are used in WDM network. It is important task after designing a physical topology upon which whole network quality depends. So the existing wavelength algorithms are follows as:

Random Wavelength Assignment: In this algorithm, first all possible routes between a source-destination node pair is determined. Then all the free wavelengths (which are currently not being used) are found out. Then randomly a wavelength is assigned for data transmission to take place.

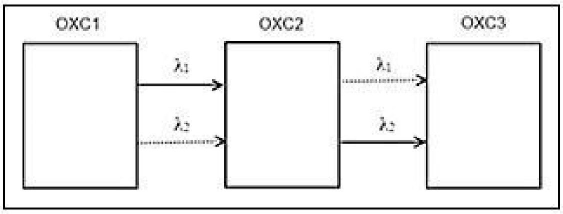
First-fit Wavelength Assignment: Here, each and every wavelength is numbered. When a connection request is made, the wavelength which is having the lowest assigned number is selected from the available wavelength set.

Most-used Wavelength Assignment: The wavelength that is used by the highest number of links in the network is the most used wavelength. The most used wavelength is selected by the most used algorithm from the available wavelength on the path.

To transfer data from one OXC to another OXC, a connection needs to be set up at the optical layer similar to the case in a circuit-switched telephone network. To do this work, we must deal with both routing and wavelength assignment. Finding a suitable light path (route) to go to the destination and determining a common wavelength available on all of the fiber links in this light path for the connection. This problem is known as the routing and wavelength assignment (RWA) problem and is significantly more difficult than the routing problem in electronic networks.

After calculating the Shortest Path, an appropriate wavelength is required to be assigned to establish a light path from source to destination.

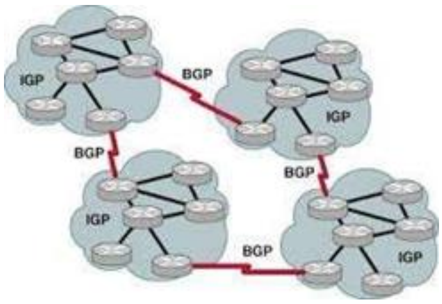
In DWDM different signals have different wavelengths. Wavelength Assignment means a packet of information is carried with a particular wavelength. The wavelength selection should be in such a way that it should satisfy Wavelength Continuity Constraint. The light path should have same wavelength in all the links it traverses from Source to Destination; it is called as Wavelength Continuity Constraint.



The Fig. shows the Wavelength Assignment. Consider three Optical Cross Connectors (OXC1, OXC2 and OXC3) in a network. Optical Cross Connectors are switches in optical networks. If a packet of information has to be transferred from OXC1 to OXC3, a light path has to be established from Source (OXC1) to Destination (OXC3), that light path has to be assigned with a wavelength available in the entire path from source to destination. In the Fig. 3.2, Dark line between the OXCs indicates that particular wavelength is occupied (i.e. another packet of information is carried with that particular wavelength). λ1 wavelength is occupied andλ2 wavelength is available in both the links OXC1 to OXC2 and OXC2 to OXC3. Therefore the light path can be assigned with the wavelength λ2 which satisfies the wavelength continuity.

iii. Border Gateway Protocol:

Border Gateway Protocol (BGP) is a standardized exterior gateway protocol designed to exchange routing and reachability information among autonomous systems (AS) on the Internet.



Multidomain Network

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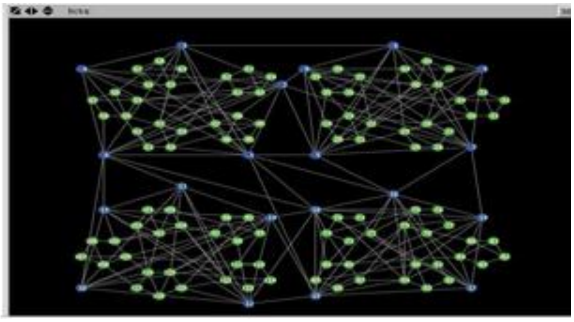
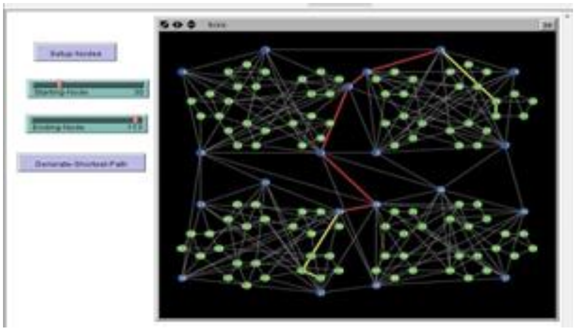
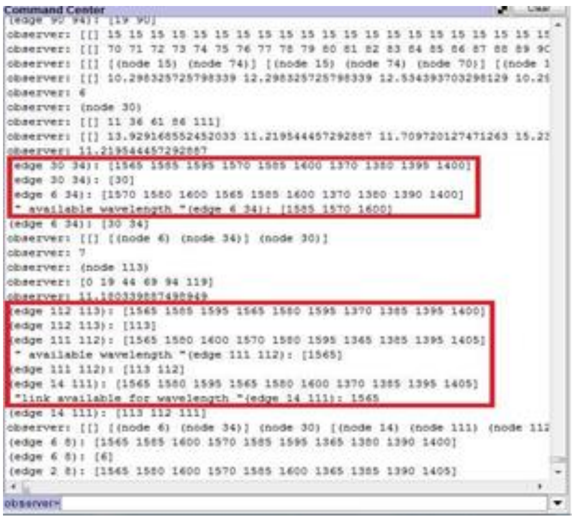
IV. RESULTS

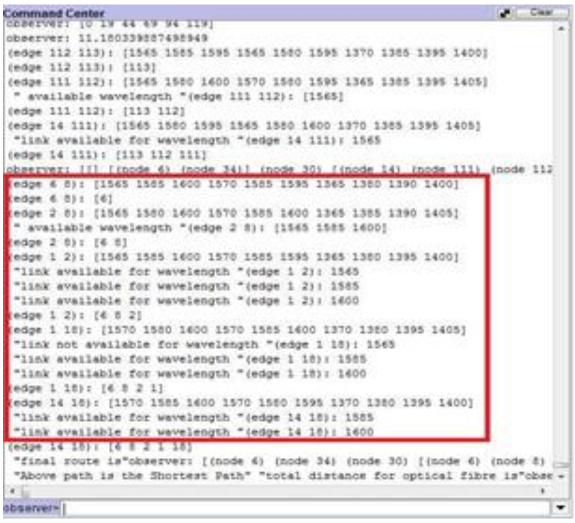




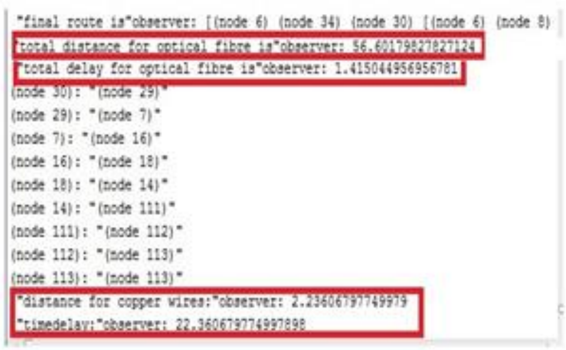
Route between
Source node : node 30 in AS2 Destination node:node 113 in AS3



List showing wavelength availability in source node AS and destination node AS



List showing Wavelength availabilities for routing BG nodes of source and destination AS's



DICUSSION / LIMITATIONS

Parameter	BG-BG Diff AS		BG-BG Same AS		BG-Intra Diff AS	
	Electrical	Optical	Electrical	Optical	Electrical	Optical
Distance	13.4km	43.4km	16.6km	15.6km	3.16km	50.02km
Transmission Time	134.16us	1.08us	156.5us	0.39us	31.6us	1.25us

Parameter	BG-Intra Same AS		Intra-BG Diff AS		Intra-BG Same AS	
	Electrical	Optical	Electrical	Optical	Electrical	Optical
Distance	3.16km	22.2km	4.12km	35.17km	8.06km	20.56km
Transmission Time	31.62us	0.55us	41.23us	0.87us	80.62us	0.51us

Parameter	Intra-Intra Diff AS		Intra-Intra Same AS	
	Electrical	Optical	Electrical	Optical
Distance	2.23km	33.13km	2.23km	26.45km
Transmission Time	22.36us	0.82us	22.23us	0.66us

List showing distance and transmission time for both conventional network and optical network

VI. CONCLUSION

In an all-optic network a light path is to be established from source to the destination which might be followed by a packet of information. For transmission of the packet, a wavelength is assigned which is commonly available in the entire path. This process of finding a route and assigning a wavelength to that route is called as Routing and Wavelength Assignment.

In this project, Border Gateway protocol in Multi-Domain Optical Network with Wavelength Continuity Constraint is analysed. RWA is analysed in a random wavelength environment. Wavelength Assignment for a packet is the main factor affecting the blocking probability. Path Computational Algorithm is developed for generation of the Shortest Path with a common wavelength, with which the packet is traversing. The path computation algorithm is designed such a way that it satisfies the Wavelength Continuity Constraint (WCC). If WCC is failed to satisfy, instead of making the packet blocked, the path computation algorithm searches for an alternate path from the node where the link is broken. If the WCC is very frequent in the network and alternative paths are not available, usage of Wavelength Converters in such phenomena minimizes the blocking probability.

VII. REFERENCES

[1] Rafael Lopes, Denis Rosário, Eduardo Cerqueira, Priority- aware traffic routing and resource allocation mechanism for space-divisionmultiplexing elastic optical networks,Computer Networks, Volume 218, 2022, 109389, ISSN 1389-1286, https://doi.org/10.1016/j.comnet.2022.109389.

[2] Jaya Lakshmi Ravipudi, Maïté Brandt-Pearce, Impairment- and fragmentation-aware dynamic routing, modulation and spectrum allocation in C+L band elastic optical networks using Q-learning, Optical Switching and Networking, Volume 47, 2023, 100717, ISSN 1573- 4277, https://doi.org/10.1016/j.osn.2022.100717.

[3] Sarah Sarraf-Maralaniyan, Akbar Ghaffarpour Rahbar, MT3A : A Novel Multicast Routing, Spectrum and Modulation-Level Assignment in Elastic Optical Networks, Computer Networks, Volume 218, 2022, https://doi.org/10.1016/j.comnet.2022.109388.

[4] Yaghoub Khorasani, Akbar Ghaffarpour Rahbar, Mohammad Jafari-Beyrami, A novel two-dimensional metric for fragmentation evaluation in elastic optical networks, Computer