An Analysis of WDM Network With Different Optimization Techniques

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Abstract- *The so called WDM network (STWN) store and the transfer will store data in source storage or provide light paths at the optimal time as wavelengths are free from clashes. Such a network consists of wavelength communication linked by optical fibers (or routing nodes). Some nodes (called cross-connections). Consequently, User blocking can be reduced and network resource use can be improved. Wavelength multiplexing channel (WDM) is an important technology used in telecommunication systems today. In this paper, we present a view of an optical network with wdm in terms of wavelength allocation of all-optical transportation networks and different optimization techniques are defined. A wide range of applied mathematics is used to generalize theory and techniques of optimization in other formulations which anticipated different criteria for WDM Optimization.*

Keywords- Optical fiber WDM, Multiwavelength optical networking (MONET),optimization techniques.

I. INTRODUCTION

The public's appetite for information continues to increase in an ever-increasing way, starting with a ubiquitous mobile phone & offering voice, images, messages more to an Internet & World Wide Web and providing bandwidth-hungry applications like interactive games, music and file sharing. The optical fiber-based global communication infrastructure – the basis of the superhighway for information is underneath all this, essentially unseen by the users. Multi-wavelength optical networking (MONET),is a digital information communication method using optical fiber lasers. The method provides the next level of SONET optical communication networks. Optical MONET networks provide even more bandwidth. This new method uses wave division multiplexing (WDM) technology to transport big amounts of telephone and data traffic or allow the interoperability of equipment from various vendors.[1].

WDM is a method to combine laser beam multiple signals at various infarct (IR) wavelengths for fiber optic media transmission. A set of independent signals modulates each laser. Wavelength sensitive filters, The IR analog is used at the receiving end for visible-light color filters. FDM is like WDM (Frequency Division Multiplexing). Instead of (RF) radio frequencies, however, WDM is produced in the IR portion of the electromagnetic spectrum. A multi-RF signal combined with FDM & TDM (time-division multiplexing) is received on each IR channel. In the original signal at the destination, each IR multiplex channel is separated and dismissed. At different speeds and on a single fiber, data in combination with WDM and a type of IR channels can be transmitted simultaneously in different formats and at different speeds. [2].Two IR channels have been provided per fiber for early WDM systems. The dichroic (two-wavelength) wave filter was demultiplexed approximately at a mid distance with the wavelength between the wavelengths of the two channels. More than two IR multiplex channels were soon evident that cascading dichroic filters could be demultiplexed, CWDM and DWDM (dense multiplexing wavelength division)-(coarse wavelength division). In CWDM 8 different IR channels are usually available but up to 18 can be used. Docens in DWDM can occur. Since every IR channel has a set of multiplexed RF signals, Combined fiber data can be transmitted at a theory of several hundred Gbps (gigabits per second) of total efficient speed [3].

II. OPTICAL NETWORK

An optical network links computers with optical fibers (OF) (or any other system that can electronically produce or store data). An optical network is a type of fiber optic communication network. The primary means for the transfer and transfer of data are OF cable networks as light waves between sender and receiver nodes. An optical network is also known as the OF network or photonic network. [4].

A. Scaling Optical Fiber Networks: Challenges And Solutions

Increase in consumer demand & network traffic between machine and machine create great challenges for the continued cost-effectiveness of optical communications. More types of optical parallelism will be needed to meet these

requirements. Today we make each phone, Send each text message, The movie we download application and service we use will eventually be converted into photons through an extensive OF network. [5]. OF are also used for the connection of the Variety of cell towers, If billions of mobile users become photons of radiofrequency instantly converted into infrared photons to efficiently backhaul fiber optical systems into metropolitan & regional long & sous-marine networks linking cities & span-countries & bridge continents. To make efficient use of the embedded system, WDM systems try to pack the maximum number of the optical signal in the OF, expensive fiber infrastructure — or more precisely in the small optical amplifier bandwidth placed regularly along with the transmission link. Spectral density of information (spectral efficiency), which can be transmitted through the certain fiber length and however the faces tough limits Basic restrictions associated with Enhancement noise & Kerr nonlinearities which guide to Different kinds of distortion of signal, practical limitations due to technological imperfection &catastrophic damage by fiber fuse to transponders and optical amplifiers.

III. WAVELENGTH DIVISION MULTIPLEXING

WDM optical networks [6] Potential candidates are known to use wavelength routing for the next generation of wide-area backbone networks. The large bandwidth available in OF is a WDM all-optical Network, which builds many channels, Each channel can be operated at a various optical wavelength and is moderately bitrate. In the next few years, networks with 20-100 wavelengths will be feasible. The purpose of this document is to attempt to dene the framework of the architecture for WDM optical networks. It attempts to determine the terminology and bring up the issues to be standardized to ensure the seamless operation of network equipment from different vendors as well as interconnected subnetworks.

A. Benefits of WDM

Wavelength multiplexing channel (WDM) is an important technology used in telecommunication systems today. This works better than other types of customer satisfaction interaction.

1. Transparency

WDM Networks allow the transmission of data at varying bit rates. A number of protocols are supported as well. Thus the way we want to send the data is not too much restricted.

2. Capacity Upgrade

Optical fiber networking has extremely large bandwidth. The data channel carrier is light here. As a norm, a single beam of light is used. Nevertheless, in WDM lights are added to a single optical fiber of different wavelengths

3. Wavelength Reuse

Routing the wavelength is necessary for WDM networks. The same wavelength can be used twice in various fiber connections. This permits reuse of the wavelength and helps to increase the capacity [7]

B. Challenges of Wavelength division multiplexing

The RWA (routing & wavelength assignment) problem in wavelength-routed optical WDM networks with Converting wavelengths at various network nodes. WDM raises new issues with wavelength coordination in the optical network[8]. The independent communication channel known as light path serves each wavelength and carries the information with data rates up to 40 Gb / s. When a light path between two network nodes is needed, a path must be chosen and the wavelength assigned. The RWA is known as this problem. If the conversion of wavelength in Network Nodes is not available, The light path should be set with the same physical connection assigning the same wavelength. This is called the constraint of wavelength. Conversion of wavelength into a node allows the light paths to be determined using the wavelengths between end nodes along the route sections. The problem with the layout of the wave network is to select the link graph and to split the flow to accommodate each dimension of the traffic force matrix node by node between the connection charts generated. The performance measurements of interest are average network delay &network performance[9].

IV. OPTIMIZATION TECHNIQUES

Optimization (O)The method discovers the alternative under a certain constraint, with mainly cost-effective and maximum possible performance. Therefore, optimizing implies trying to achieve the best or highest results of cost. O is constrained by the lack of complete information and a time to decide which data is required to improve the O process. The O method is used to achieve them. The best can be a single organization and objective process which models a similar entity. The process of O shall be applied to factors that determine the best varies with the situation. Several examples are optimized costs used raw materials and time. O can be done for local and global optimal achievement. Several major optimization algorithms are available in each field. [10].

A. Classification of Optimization Algorithm(COA)

COA is useful to find an optimal solution or unconstrained maximum & minimum features. In practical usage some have an objective function classical optimization has a limited scope that is not continuous and differentiable.

B. Numerical Optimization

The case of the linear objective function is linear programming. Set A is defined only on the basis of linear equality & linear inequalities.

Integer programming (IP) – IP studies that restrict certainly and all of the variables. Cases where certain constraints are focused on random variables stochastic programming.

Combinatory programming-concerns the problem when the solution set is discrete [10].

C. Advanced Optimization

Hill Climbing- Hill climbing(HC) is an algorithm for the graphic search where the current path extends to a subsequent node – A solution is closer than the end of the path. HC is popular in the AI field, in order to reach from the target state to the starting node.

D. Simulated Annealing(SA)

SA is the name or inspiration for processes in metallurgy involving the heating and cooling of crystal material to reduce effects of crystals- Search point is comparable with the state of some physical system with The simulated annealing method and minimization function are interpreted as the internal system energy. The aim is to provide the minimum energy available for an arbitrary initial condition.

E. Genetic Algorithm

GAis the local explore method for solving the problem approximately and optimizing search terms. GA is an evolutionary class of algorithm which uses techniques inspired by crossover& inheritance, and selection of evolutionary biology. GA is mainly performed like computer simulation in that the abstract populace of candidate solutions develops to improve solutions to the O issue.Most people in the current population are stochastically selected and changed to form a new population in each generation for the health determination of the whole population.

F. Ant Colony Optimization

ACO is the inspiring method that works together for a common goal, Use the plurality wisdom, like common insect through the ants. Ants (initially) wander randomly or, when they have found food, go back to their colony when they are laying down pheromone paths.They would possibly not maintain the path by chance, instead, follow the path that previous fourth lay down, return and reinforce, when they find food. The longer it takes for you to walk, the more time it takes for the pheromone to evaporate. Overtime, however, the more time the pheromone evaporates. [10].

G. Teacher Learning-Based Optimization

TLBO may classify the big number of applications in the various fields, including electrical & mechanical& civil electronic, thermal and biotechnological applications, of the engineering and sciences sector. TLBO used to resolve the problem of constraints & unconstrain. [10]

Table I: Routing and Wavelength Assignment Methods

Load	Fixed Alternate (FA)	Old-Genetic based RWA (Old-GRWA)	New-Genetic based RWA (New-GRWA)	Ant Colony Optimization(ACO)	Shortest path First (SPF)	Load Balancing SPF (LB-SPF)
40	0.06	0.001	0.001	0.02	0.23	0.08
50	0.013	0.004	0.003	0.04	0.32	0.082
60	0.030	0.008	0.006	0.05	0.38	0.13
70	0.048	0.016	0.013	0.058	0.42	0.14
80	0.060	0.028	0.024	0.063	0.41	0.16

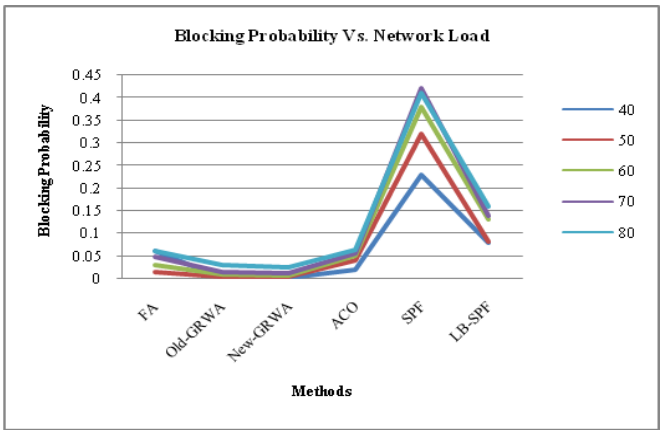

Fig.1. Blocking Probability vs. Network Load for Routing and Wavelength Assignment on Various Methods NSF Network

Now that we have observed the performance improvement of the various algorithms in terms of blocking

probability, it might also be interesting to check other network parameters. Fig. 1 shows the blocking probability over different values of Load (i.e., possible paths per destination). New-GRWA performs outstanding for different values of Load. This method has minimum blocking probability for each load. The blocking probability with 8 wavelengths in the network is in this case, 50%, 18%, and 9% for SPF, LB-SPF, and ACO, respectively. The relative improvement in blocking probability for ACO when compared to SPF is 82% and that of LBSPF is 50%.

V. APPLICATION OF OPTIMIZATION ALGORITHM

Industrial Application - The industry is divided into all its parts by the disassembly method in this process to optimize the separation of the product characteristics. The genetic algorithm for disassembly evaluation & generation.

1) **Network Security**: In the detection system for safety, the computer network is indivisible from events and attacks. This proposed system like classification method the concept of multiple criteria linear programming. The optimization of the particle swarm is a robust & simple classification method for detecting the wrong alarm rate, detection rate and runtime by the IDS & KDD cup with the O algorithm.
2) **Computer Vision and Image Processing**: recreation regularization and computer vision problems are used in different fields.The application of O tothe description of shape is defined as the O method and this is an especially important problem.
3) **Transition Probabilities for Radio System**: Particle swarm optimization is used in this field of application to estimate The Wireless Communication Channel State Probabilities.
4) **Nature Inspired Field**: Nature algorithms are based on the biological system and the intelligence system for the physical and chemical swarm. Such algorithms are known as physics and chemistry-based swarm intelligence, according to inspiration.[11].

VII. LITERATURE SURVEY

D. Wang etal.[2019] the theoretical model applications and the WDM device's basic principles are studied with coherent optical OFDM. The consistent, optical OFDM was derived from a 160-Gb / s simulation experiment with the WDM 80-channel transmission system. The simulation indicated that the Q system of the 12.8Tb / s WDM can be more than 15.0dB in standard single-mode fiber with no nonlinear &optical dispersion correction to 1000 km. [12].

Y. Cao et al.[2019]set how the cost of deploying the backbone networks of QKD-over-WDM is minimized. In general architecture, we present QKD over WDM backbone networks. Build the lowest cost issue, defining the new cost-oriented model; QKD auxiliary devices provide various components of QKD's network, including QKD transceiver and QKD backbone nodes and trustable TRN & QKD links. The TRN layout was also included in the definite model, for example, secret key rate & physical distance. The developed(CEQN) novel cost-efficient QKD networking &ILP (integer linear programming model) Cost Minimize issue heuristic algorithm [13].

J. M. D. Mendinueta etal. [2019]The proposed results confirm the capability for record switching 53.3 Tb / s / port or network defense of MFC failure in less than 10 ms in an event of a (multi-core fiber). (Datacenter) DC traffic in the next few years is expected to increase at a staggering annual rate. But, Current DC Networks, Using point by point optical links & electronic system switching. Cannot meet this traffic request with reasonable energy consumption. Furthermore, A further challenge for DC network designers is the traffic in the DC Network, Dense matrices and bursty hot spots characterize. Addressing capacity & energy bottlenecks in future DC networks and meeting traffic requirements, The novel high-capacity optical switching system employing this paper, packet spatial super-channels (pSSCs), &(SDM) space division multiplexing to realize coherently modulated (wavelength division multiplexing) WDM, time-division multiplexing(TDM)[14].

N. I. Smirnov and S. M. Trukhin [2018]Network Technology Defined Software, Network Virtualization Function Transmission with Control the Automated Parameter Monitoring, will be used by the presented future generation telecommunications systems. In distributed WDM control systems, it is very important to have high time stability synchronization. Two methods will be provided for this time synchronization cam: central sync scheme & distributed sync scheme. This article described monitoring & time synchronization of WDM network parameters [15].

H. Wu et al.[2018]Proposed quasi-lossless fiber-optic transmission over a long distance (100 km) will be experimentally carried out using a 3rd-order amplification Raman pumped by a novel 1280 nm cascading Raman Random Laser, The longest almost lossless transmission system to date reported. [16].

W. Wang **et.al.[2018]**The time-scale of passive optical networks based on lots were investigated to maintain different network services. They conclude that low latency services

require critical slicingfor little latency. Different booming networks & services require networks of optical access, which not only provide immense bandwidth but also support ubiquitous access. [17].

L. Triveniet al. [2017]The problem of WDM (wavelength division multiplexed) systems link failure And recovery was analyzed. Algorithms namely(converter shared wavelength routing) CSWR & CFR (conversion free routing),Dedicated routing algorithms are used. Three methods are used to analyze the efficiency of these systems. A WDM mesh network with various topologies is a network for execution. In the simulator, The proposed CSWR requirements lead to a better performance in terms of costs & relatively cut possible protection with enhanced wavelengths.[18]

Fenget al. [2017]STWN dimensioning investigate and proposes the two-step technique to establish together number & storage size of wavelength necessary to meet the order, This is given like deadline, blocking rate or use of the wavelength matrix. The method model the STWN like TDM network and first achieves a needed storage size by maximizing the fixed time period for every period, then calculates the amount of wavelength required with the number of time frames.
Numerical results demonstrate a significant impact on the wavelengths and available capacity on high load between distant sources & destination nodes. For instance, the predictive load matrix of a 24-knot topology needs 20% more storage than the randomly generated wavelength. [19].

Z. Zhong et al.[2016]the concept of stateful rooming was proposed and implemented to implement differentiated supply Network node state-based policies. The problem of node state O that we formulate & solve, in view of the trade-off in the energy efficiency and performance block (MOILP) Multi-objective Linear Integer Programme, can assess the specific state of network nodes when a given traffic profile is given. Then, we propose an online path traffic-aware intelligent differentiated allocation of light (TIDAL) algorithm, to accommodate stateful grooming And MOILP dynamic mare traffic. The growing popularity of high speed, cloud and the Internet of Things (IoT) has increased the tidal traffic phenomenon. That creates a disparity in network loads for space-time. The proposed method will achieve a significant increase in efficiency through our illustrated numerical results[20].

Table II: Shows the ideas of literature & related Overview

S No.	Author	Title	Idea in Paper
1	Muhammad & R. Forchheimer[2013]	Effective strategies for the proven delay tolerance of dynamic WDM networks.	A novel scheduling of connections to exploit the setup tolerance and keep time efficiently [21]
2	X. Zhaoet *al.[2014]*	IP overclock frequency energy-efficient design adaptive router cards through WDM networks	(MILP) Mixed-integer linear programming model & efficient heuristic algorithm. [22].
3	M. Filer *et al. [2016]*	Microsoft cloud's elastic optical networking.	Discuss the network infrastructure deployed by Microsoft and discuss how elasticity affects network capacity and flexibility. [23].
4	J. Wang et.al.[2017]	A ground simulation method for arbitrary optical distance transmission of the space-free laser communication system using a nanoprobe optical fiber	A method called "relay transmission" is proposed based on an optical fiber nanoprobe[24].
5	X. Pan et.al.[2019]	Integration of heterogeneous traffic prediction data sources through an extreme learning machine	A novel (FBG) fiber Bragg grating temperature sensor based on lead sulfide (PbS)-doped silica optical fiber

VIII. CONCLUSION

WDM is the fiber optic transmission process that allows data to be transmitted through the same medium through multiple light wavelengths (or colors).In this paper, we presented the optical network and a view of the WDM concept because a network consists of wavelength communication linked by optical fibers (or routing nodes).The rapid advances in the application of industrial processes of optimization have mainly been motivated by an increase in environmental regulations and global competitiveness forcing companies to optimize resources. This paper aimed to provide an overview of the various popular techniques for optimization. This knowledge will lead to the choice of one of the techniques used to optimize the WDM model.

REFERENCES

[1] Y. Luo et al., "Physical layer aspects of NG-PON2 standards–Part 2: System design and technology feasibility [Invited]," in IEEE/OSA Journal of Optical Communications and Networking, vol. 8, no. 1, pp. 43-52, 1 January 2016.

[2] C. S. K. Vadrevu, M. Tornatore, C. P. Guok and I. Monga, "A heuristic for combined protection of IP services and wavelength services in optical WDM networks," 2010 IEEE 4th International Symposium on Advanced Networks and Telecommunication Systems, Mumbai, 2010, pp. 19-21.

[3] D. Bulira and K. Walkowiak, "Performance of dynamic many-to-many routing in WDM and Elastic Optical Networks," 2015 17th International Conference on Transparent Optical Networks (ICTON), Budapest, 2015, pp. 1-4.

[4] J. Wen et al., "Spun-Related Effects on Optical Properties of Spun Silica Optical Fibers," in Journal of Lightwave Technology, vol. 33, no. 12, pp. 2674-2678, 15 June15, 2015.
DOI: 10.1109/JLT.2014.2374839.

[5] L. Chen, S. O'Keeffe, P. Woulfe, and E. Lewis, "A comparison of clinic-based dosimeters based on silica optical fiber and plastic optical fiber for in-vivo dosimetry," 2017 25th Optical Fiber Sensors Conference (OFS), Jeju, 2017, pp. 1-4.

[6] P. E. Green, Fiber-Optic Networks. Prentice-Hall, 1992

[7] H. Harai, M. Murata and H. Miyahara, "Performance of Alternate Routing methods in All-optical Switching Networks," Proceedings, IEEE INFOCOM 97, pp. 516-524

[8] C. S. Ram Murthy, M.Gurusamy, WDM Optical Networks - Concepts, Design and Algorithms, Prentice-Hall, 2002.

[9] A. Girard, "Routing and wavelength assignment in all-optical networks," IEEE/ACM Transactions on Networking, vol.3 pp 489-500, Oct. 1995.

[10] Pinto, Vivek D., and William M. Pottenger. "A survey of optimization techniques being used in the field" In the Proceedings of the Third International Meeting on Research in Logistics (IMRL. 2000).

[11] NidhiTomar Prof. Amit Kumar Manjhvar," A Survey on Data Mining Optimization Techniques", IJSTE - International Journal of Science Technology & Engineering | Volume 2 | Issue 06 | December 2015

[12] Wang, S. Zhang and Q. Li, "WDM transmission system based on coherent optical OFDM and its performance analysis," 2019 IEEE 3rd Information Technology, Networking, Electronic and Automation Control Conference (ITNEC), Chengdu, China, 2019, pp. 2157-2161.doi: 10.1109/ITNEC.2019.8729044

[13] Y. Cao, Y. Zhao, J. Wang, X. Yu, Z. Ma and J. Zhang, "Cost-efficient quantum key distribution (QKD) over WDM networks," in IEEE/OSA Journal of Optical Communications and Networking, vol. 11, no. 6, pp. 285-298, June 2019. DOI: 10.1364/JOCN.11.000285

[14] J. M. D. Mendinueta, S. Shinada, Y. Hirota, R. S. Luís, H. Furukawa and N. Wada, "Wavelength and Space Division Packet Super-Channel Switching System for Future Data Center Optical Networks with a Switching Capacity of 53.3 Tb/s/port," 2018 20th International Conference on Transparent Optical Networks (ICTON), Bucharest, 2018, pp. 1-4doi: 10.1109/ICTON.2018.8473497

[15] N. I. Smirnov and S. M. Trukhin, "Time and Frequency Synchronization for WDM Transmission System Parameters Monitoring," 2018Systems of Signal Synchronization, Generating and Processing in Telecommunications (SYNCHROINFO), Minsk, 2018, pp. 1-4.doi: 10.1109/SYNCHROINFO.2018.8456932

[16] H. Wu, B. Han, and Y. J. Rao, "100km Quasi-lossless Fiber-optic Transmission with a Novel Cascaded Random Raman Fiber Laser," 2018 Optical Fiber Communications Conference and Exposition (OFC), San Diego, CA, 2018, pp. 1-3.

[17] W. Wang, W. Guo, and W. Hu, "Network Service Slicing Supporting Ubiquitous Access in Passive Optical Networks," 2018 20th International Conference on Transparent Optical Networks (ICTON), Bucharest, 2018, pp. 1-3.

[18] L. Triveni, P. C. Srikanth and T. Srinivas, "Least resource consumption for optical WDM networks," 2016 International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT), Chennai, 2016, pp. 3868-3872.doi:10.1109/ICEEOT.2016.7755437

[19] Feng, W. Sun, X. Zhang and W. Hu, "Dimensioning of the store-and-transfer WDM network with limited node storage under the sliding scheduled traffic model," in IEEE/OSA Journal of Optical Communications and Networking, vol. 9, no. 4, pp. 275-290, April 2017.doi: 10.1364/JOCN.9.000275

[20] Zhong et al., "Energy efficiency and blocking reduction for tidal traffic via stateful grooming in IP-over-optical networks," in IEEE/OSA Journal of Optical Communications and Networking, vol. 8, no. 3, pp. 175-189, March 2016.doi: 10.1364/JOCN.8.000175

[21] Muhammad and R. Forchheimer, "Efficient scheduling strategies for dynamic WDM networks with set-up delay tolerance," *2013 15th International Conference on Transparent Optical Networks (ICTON)*, Cartagena, 2013, pp. 1-4.doi: 10.1109/ICTON.2013.6602883

[22] X. Zhao, W. Shao and G. Shen, "Energy-efficient design for IP over WDM networks with clock frequency adaptive router cards," *2014 13th International Conference on Optical Communications and Networks (ICOCN)*, Suzhou, 2014, pp. 1-5. DOI: 10.1109/ICOCN.2014.6987145

[23] M. Filer *et al.*, "Elastic optical networking in the Microsoft cloud [Invited]," in *IEEE/OSA Journal of Optical Communications and Networking*, vol. 8, no. 7, pp. A45-A54, July 2016.doi: 10.1364/JOCN.8.000A45

[24] J. Wang, G. Wang, R. Bai, B. Li, and Y. Zhou, "Ground simulation method for arbitrary distance optical transmission of a free-space laser communication system based on an optical fiber nanoprobe," in *IEEE/OSA Journal of Optical Communications and Networking*, vol. 9, no. 12, pp. 1136-1144, Dec. 2017.doi: 10.1364/JOCN.9.001136

[25] X. Pan *et al.*, "Enhanced FBG Temperature Sensitivity in PbS-Doped Silica Optical Fiber," in *Journal of Lightwave Technology*, vol. 37, no. 18, pp. 4902-4907, 15 Sept.15, 2019.doi: 10.1109/JLT.2019.