

Recent Research Challenges for Coherent All Optical Networks: A Survey Report

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Abstract: This paper presents a survey report on recent research challenges for all-optical and coherent all-optical networks. The aim is to list the challenges available for further research. This paper gives an overview for finding the way of further development in all optical and coherent all optical networks. The use of coherent optical systems has become popular in designing all optical networks in the recent years. This development can be achieved by the improvement in the transmission capacity of the optical link and the length of the signal reach.

IndexTerms - Coherent network, All optical network, Bit error rate, Multiplexing

I. INTRODUCTION

The bandwidth requirements for high speed networks can be achieved by designing networks in all-optical domain where electrical to optical conversion and vice versa are omitted and signal remain in the form of light only [1]. The exponential growth of availability of bandwidth can be achieved by using all-optical networks in place of traditional optical networks [1, 8]. In today's scenario, it is possible to design various communication components in all-optical domain such as amplifiers, multiplexers, demultiplexers, wavelength convertors and modulators etc. for efficient feasibility of all-optical networks. The use of concept of the coherent optical system in all optical domain makes network designing more fascinating and useful [1, 7]. This combination of coherent and all optical networks gains an importance for different research fields and has many applications in various areas including medicine, military, industry, space exploration and various telecommunications [1, 20]. This combination is termed as the Coherent All-Optical Networks (CAONs). The important advantages of all optical coherent systems lies in achieving electronic equalization of the optical channel [1]. Many parameters like Bit Error rate (BER), Optical Signal to Noise Ratio (OSNR), receiver and transmitter spectral sensitivities etc. for various types of networks can be analyzed and evaluated for coherent networks [20]. BER versus OSNR characteristics decide the level of the performance of transmission for coherent optical transponder. The digital signal processing has also become an important tool to achieve sophistication in CAONs [6, 15, 20]. The coherent optical systems has become popular in designing all optical networks in the recent years because of obtaining better spectral efficiency, data carrying capacity, receiver sensitivity and greater network flexibility. This development can be achieved by the improvement in the transmission capacity of the optical link and the length of the signal reach. This combination of coherent and all optical networks gains an importance for different research fields and has many applications in various areas including medicine, military, industry, space exploration and various telecommunications. The summary of few related works has been presented in section 2 followed by analysis in section 3 and conclusion has been presented in section 4.

II. LITERATURE SURVEY

Bostjan Batagelj et al. [1] have given an overview regarding future research in optical communication. Authors have considered year 2020 a mile-stone. Till year 2020, the optical fiber would be used at its maximum capacity. This maximum capacity is called "fiber-wall". The authors have divided the field of optical communication into three categories: optical devices, communication technologies and optical networks. The challenges existing in these three categories has been discussed.

Amor lazzez [2] has described mainly two things regarding all-optical networks: vulnerabilities and security attacks. In vulnerabilities, two things have been discussed: transparency feature and component vulnerabilities. In security attacks, there are three things: attack method classification, service disruption methods of attack and mapping methods of attack.

Xiaowen Chu et al. [3] have proposed a dynamic RWA (routing and wavelength algorithm) with wavelength converters. Name given to this algorithm is weighted least-congestion routing and first fit wavelength assignment (WLCR-FF). It takes into account both distribution of free wavelengths and route-lengths. A heuristic algorithm for converter placement have also been proposed.

Alton et al. [4] have presented a literature survey on all optical networking. The main reviewed topics are multiplexing techniques, network design, topological features and performance issues. Wavelength Division Multiplexing in optical networks has a great attention in it. Dynamic and Static solutions for the problems of routing and wavelength assignment (RWA) have been considered. There is also a summary of issues regarding current research.

R. Sabella et al. [5] have presented an overview of AONs in concise manner. The main inspiration for all-optical networking come from the capacity of optical fiber technology to attain the increasing demand for protocol transparency, bandwidth per user, simplified management & operation and higher path reliability. In all these fields, already existing approaches implemented via electronic circuitry based on time division multiplexing (TDM) are now insufficient, as they are not able to perform the desired operations as economically as the all-optical techniques.

Muhammad Irfan Anis [6] has given insight about signal processing in all optical domain. This analyses elastic optical networking, optical switching paradigms, need for elastic optical node, important functional basics for future elastic optical networks, all optical converters and survey for signal processing functionalities in all optical domain. It has also been discussed the solution the more optimal transport of heterogeneous type traffic by improving the flexibility in the optical layer for distributing network resources etc.

Samir Chatterjee et al. [7] have given analysis of all optical networks to sufficient depth. Drivers for optical networks, componentry in system for optical transmission, optical networking technology, overall architecture of optical networks and optical services, deployment considerations for WDM, test-bed initiatives and network bottlenecks have been discussed.

Adel et al. [8] have presented an overview for all optical networks in a comprehensive way. These topics have been discussed for example, about electronic bottlenecks, difference between all optical and legacy networks, basics for all optical networks such as transparency etc., early research programs, commercialization in all optical domain, O E O (optical-electrical-optical) strikes back, persistence of all-optical networks, and future directions in all optical domain.

Lida et al. [9] have discussed various hybrid optical networks and an inter comparison is presented in terms of performance criteria. EISM (efficient integration of switching mechanism in all-optical networks") has been discussed. EISM is the combination of OCS, OPS, short-OBS and long-OBS switching mechanisms. Circuit block rate, packet loss rate, OBS loss rate and long-OBS loss rate have been calculated over traffic load and graphs are plotted for comparison.

Ridha Rejeb et al. [10] have discussed all optical networks management regarding attack and fault. In spite of novel approaches for localization and attacks detection given here, no powerful techniques or standards exist till now in order to ensure guarantee for the quality of service in all-optical networks. That is why, robust approaches those can help in managing and accessing the exact working of components of transparent network are greatly required. Therefore, this is an algorithm for identification and localization of multiple attacks that are useful in various tasks for "fault management" of networks in all-optical domain.

Ruth Van Caenegem et al. [11] have discussed label stripping in all-optical domain from the perspective of network recovery. Path recovery, link recovery and comparison of the two has been discussed. The ill-effects to the node or network design are introduced by all recovery schemes, path recovery increases label overhead and does not change the node or network design, link recovery has smallest dimensions for node and it needs some adaptations for network topology or stripping nodes have been explained.

R. Rejeb et al. [12] have discussed fault management for transparent optical. An algorithm has been analyzed and presented for identification and localization of multiple failure in all-optical networks. In comparison to other approaches, in this algorithm the monitoring information is used less in amount. Consequently, this gives the advantages of decreasing the high price and signal complexity in all optical networks management requirements in future for quality monitoring. The mali algorithm, attack scenario, analysis for complexity and cost and schemes for path recovery have been discussed.

R. Rejeb et al. [13] have discussed identification and localization of multiple attacks in all optical networks. Vulnerabilities to attacks in AON, optical type cross-connect nodes, algorithm for identification and localization for attack and scenario of attack propagation have been discussed. To handle all channels for wavelength at various detection points for a node is mostly very costly. The formal specifications for crosstalk in optical communication that can come in cross-connect nodes have been analyzed.

Min Zhang et al. [14] have designed switching based all-optical type on one-dimensional and periodic two-segment joint tetrahedron waveguide network in optical domain. The network generalized eigen value method and equation are utilized for analyzing the switching mechanism and characteristics. The designed switch in all-optical using a tetrahedral waveguide network made by polystyrene has an ultra-high efficiency in switching of about 7×10^{17} have been discussed.

Jianjun Yu et al. [15] have presented the summary of recent progress for optical high-speed transmission. The recently found high baud-rate and high spectral efficiency (SE) for signal transmission are all rooted on digital signal processing (DSP) and coherent optical digital communications. DSP makes the advanced modulation formats reception easier and also facilitates the most of the optical and electrical impairments at the receiver or transmitter side in the digital domain, in which these are compensated.

Ziwei Yan et al. [16] have presented an optical wireless sensor network that establishes a link between optical communication technology and wireless sensor networks. In cooperative communication, the vector quantization is used to track the active nodes and analyses the overall network performance parameters. The mathematical calculations for analysis has been made on the basis of the node placements which depends on energy detection with their sensing outputs.

Fael Leira et al. [17] have given an analysis of current high-performance "packet engines", such as DPDK, and discussion on the issues related to measure latencies in "high-speed optical networks". Depending on these outcomes, a software-based solution to be used to measure latency has been also proposed. Furthermore, an extension that can be used to measure bandwidth and also the novel concept has been explained about convoy of the packet trains.

Sana Tariq [18] has presented the inside story of all optical networks. The detail given includes optical devices, communication techniques and network architectures in all-optical domain. A brief history, drivers, evolution, components, multiplexing techniques, architectural structures of WDM networks, networks types, IP, routing, deployment challenges and simulation in all-optical field have been discussed.

Shweta Bharti et al. [19] have discussed the different types of networks for examples long haul, local area, and metro network. The passive optical networks include all the component passive in nature. Low loss and high-speed has been provided by passive networks in comparison to traditional networks. The important criteria for high speed communication are high-baud-rate in signal transmission and spectral efficiency (SE).

Kazuro Kikuchi [20] has given overview of the background of development and research in the field of coherent optical communications. The basics and quantum-noise characteristics of coherent detection has also been discussed. Also, the significance of DSP ("digital signal processing") in estimating the carrier phase, reducing linear transmission impairments, and finding the state of polarization in coherent detectors have been explained.

Dao Thanh Hai [21] has explained that the coding techniques for network designing is being considered as the new parameter for improving performances of the network. In optical networks, the usage of coding in networks for the kingdom of network failure and recovery attained a big deviation from schemes for conventional protection as this can certainly achieve both capacity improvement and fast recovery, for speed recovery and vice versa, challenging the powerful wisdom of trading capacity efficiency.

Ronald J. Vetter et al. [22] have presented distributed Computing with High-speed Optical Networks. Lightwave (photonic) technology rooted on waveguides of optical fiber has already well set up for voice communication systems for long-distance. Next generation transmission systems for lightwave using wavelength-division multiplexing (WDM) techniques will grant a single fiber cable to hold multiple channels of high speed communication with a joint data rate for the range of tera bits per second (Tbps).

J. Feldmann et al. [23] have discussed all-optical spiking neurosynaptic networks with self-learning capabilities. A neurosynaptic system in an all-optical version, having ability of supervised and unsupervised learning has been explained. Wavelength division multiplexing techniques have been used to realize a scalable architecture of circuit for neural networks for photonic domain, successfully showing pattern recognition directly for optical communication. These neurosynaptic photonic

networks access to the high bandwidth and high speed in optical systems, therefore, allowing the direct signal processing of visual data and optical communication.

Monir Hossena et al. [24] have presented an efficient energy, delay and allocation of dynamic bandwidth for wireless sensor and hybrid optical networks. WSN, PON, FTTH, ALDBA, HOWSNs (hybrid optical and wireless sensor network), architecture of proposed DDE (delay and energy efficient) scheme and simulation results have been discussed. The DDE is to decrease the end-to-end energy consumption and packet delay.

Roshanak Karimi et al. [25] have discussed a thermally-resilient all-optical network-on-chip. An alternative path has been provided for each node to resend the optical data which is misrouted if fault occurrence is there. A new architecture which is Mesh-based in all-optical has been selected for the proposed thermally-resilient optical communication approach, and the famous λ -router, as indirect and direct non-blocking networks in all-optical domain, respectively. Simulation results signify the importance of the proposed architecture based on reliable Mesh, in terms of thermal resilience, network performance and throughput.

III. ANALYSIS AND INTERPRETATION

Design of the network components has to be improved in order to meet challenges in implementation of high-speed networks. Challenges related to implementation of fiber at its maximum capacity have to be primarily dealt with. Enhanced mechanisms to capture vulnerabilities and attacks have to be considered in parallel. Multiplexing techniques, network design, topological features need continuous research and development. There is increasing demand for protocol transparency, bandwidth per user, simplified management and operation and higher path reliability. In all these fields, already existing approaches implemented via electronic circuitry based on time division multiplexing (TDM) are now insufficient. Elastic optical networking, optical switching paradigms, need for elastic optical node, important functional basics for future elastic optical networks, all optical converters and survey for signal processing functionalities in all optical domain need further enhancements. Solutions for more optimal transport of heterogeneous type traffic need to be proposed by improving the flexibility in the optical layer for distributing network resources etc. All optical networks management regarding attack and fault required continuous novel implementations. Less powerful techniques or standards exist till now in order to ensure guarantee for the quality of service in all-optical networks. That is why, robust approaches those can help in managing and accessing the exact working of components of transparent network are greatly required. Novel techniques for identification and localization of multiple failure in all-optical networks have to be in synchronization with enhanced capacity. Dealing with vulnerabilities to attacks in AON, optical type cross-connect nodes, algorithm for identification and localization for attack and scenario of attack propagation require further developments. High baud-rate and high spectral efficiency (SE) for signal transmission are all rooted on digital signal processing (DSP) and coherent optical digital communications. DSP makes the advanced modulation formats reception easier and also facilitates the most of the optical and electrical impairments at the receiver or transmitter side in the digital domain, in which these are compensated. Low loss and high-speed has been provided by passive networks in comparison to traditional networks. The important criteria for high speed communication are high-baud-rate in signal transmission and spectral efficiency (SE) which demands further optimization. The significance of DSP in estimating the carrier phase, reducing linear transmission impairments, and finding the state of polarization in coherent detectors needs to be investigated further.

IV. CONCLUSION

This paper presents most of the research challenges in coherent all-optical communication networks. CAONs are expected of being developed continuously with high speed and sophistication in future. This will lead to cross the old boundaries as well as to define the new boundaries in this field. The challenges for getting higher speed, better quality and large capacity will continuously change to new limits and due to the competition to achieve more development in getting high speed, quality and capacity etc., the achievable limits will continue to grow. The components and the techniques such as multiplexers and de-multiplexers, coherent detection, multilevel modulation, polarization and digital processing etc. will play an important role in further expanding the limits of all-optical communication domain.

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