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SDSFLF: fault localization framework for optical communication using software digital switching network

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ABSTRACT

Optical network is an emerging technology for data communication inworldwide. The information is transmitted from the source to destination through the fiber optics. All optical network (AON) provides good transmission transparency, good expandability, large bandwidth, lower bit error rate (BER), and high processing speed. Link failure and node failure haveconsistently occurred in the traditional methods. In order to overcome the above mentioned issues, this paper proposes a robust software defined switching enabled fault localization framework (SDSFLF) to monitor the node and link failure in an AON. In this work, a novel faulty node localization (FNL) algorithm is exploited to locate the faulty node. Then, the software defined faulty link detection (SDFLD) algorithm that addresses the problem of link failure. The failures are localized in multi traffic stream (MTS) and multi agent system (MAS). Thus, the throughput is improved in SDSFLF compared than other existing methods like traditional routing and wavelength assignment (RWA), simulated annealing (SA) algorithm, attack-aware RWA (A-RWA) convex, longest path first (LPF) ordering, and biggest source-destination node degree (BND) ordering. The performance of the proposed algorithm is evaluated in terms of network load, wavelength utilization, packet loss rate, and burst loss rate. Hence, proposed SDSFLF assures that high performance is achieved than other traditional techniques.

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1. INTRODUCTION

In worldwide, the communication network is the inevitable portion of human life for running an efficient way of life. In spite of spending much more time for searching a good communication bandwidth network for transmitting the information, an optical network is the solution to accommodate a large number of users with available frequency and satisfied the user demands. In the optical network, there are two way for communicating processes such as optical electrical optical (OEO) network and all optical network (AON) conversion. The OEO network prompts from the traffic increases in accordance with it using excessive power (optical to electrical conversion and electrical to optical conversion process takes more time and more power). The AON takes less time for converting process while the input source is a light signal. Hence, choose an AON for communication. The optical interconnection networks in the data centers [1] are introduced for maximizing throughput and consumptive less power. Hence, the interconnection to be accomplished is processed via the ultra-high capacity. But in case of encountering some link failure, the localization must be ensured in prior. The distributed attack localization algorithm of all optical network (AON) is used to locate the attack in multichannel television sound and multi agent system [2]. By using the communication scheme such as mail-slot and multi-thread to predict the attacks. The abnormal nodes and the attacks are located effectively in this algorithm.

Hence, the major improvement requires detecting the abnormal state in the neighboring node. Because it's caused due to the attack propagation or node itself. Therefore, the estimation of node delay and the link are the major aspects of the problem in undirected networks [3]. The end-to-end measurements are used to estimate the delay time of transmission and to pre-specify the delay paths. The network tomography problem and the compressive sensing are enhanced by a fast reference-based algorithm for network tomography via compressive sensing (FRANTIC). The key issue prevailing within the network is SHO-FA algorithm from the compressive sensing rather than drawn the unlike the matrix entries commencing from the set of integers. Finally, the Steiner trees is accomplished by constructing the measurement operations. The major problem in this specified approach is to fail the transmission while transmitting large scale of data packets. Hence, the network engineering task needs the required traffic information for transformation.

The compressive sampling approach [4] is utilized for effective recovery of the missing internet traffic information. The reconstruction of the missing traffic information is based on the six missing patterns on the performance of the traffic matrix reconstruction algorithm, the link sensitivity is traced, and detect the time sensitivity of the network. These are the performance done in the internet traffic monitoring system. Due to their high transmission capacities, the optical networks play an important role in modern information technology. Therefore, the comprehensive survey software defined optical networks (SDOPs) [5] is studied and examined the software defined networking (SDN) paradigm in the optical network. This survey broadly insurances the flexibility of SDN control for supporting networking applications with an underlying optical network infrastructure. And also investigate the Software defined optical networks (SDON) related mechanisms fornetwork virtualization, an orchestration of multilayer and multi-domain networking in the optical networks. The novel technical contributions of the proposed approach are listed as: i) the faulty node localization (FNL) algorithm is exploited to detect the failure nodes which minimizes the transmission delay time and ii) the software defined faulty link detection (SDFLD) algorithm that addresses the problem of link failure in multi agent system (MAS) and multichannel television sound (MTS) and also maximize throughput value.

2. RELATED WORK

In this section, the review of various data dissemination, communication strategies and the security in optical networking schemes are presented with their merits and demerits. Zhao *et al*. [6] viewed the inter-data-center optical network architecture for detecting the traffic and the capacity. The Google's network was achieved due to traffic growth trends and the capacity demands. A proficient review of flex grid dense wavelength-division multiplexed channel plan and the digital coherent detection was achieved by means of both capacity and operational scaling of the proposed practical implementations such as C+L-band transmission, packet and optical layer integration, and a software-defined networking enabled network architecture. Even though the endorsed network was capable to concentrate on the critical areas such as data rate mismatch between Ethernet and optical transport, real-time optical performance monitoring, and the optical regeneration with assurance towards the cost, the energy consumption was mitigated owing to this network.

Mello *et al*. [7] analyzed the variable-code-rate transceivers impact of cost, survivability of wavelength, and the capacity through optical networks. The comprehensive operations of wavelength routing network transmission were quantified the transmission rate and reach trade off into two hypothetical coded such as aggressive and conservative modulation. Three representative networks were utilized to evaluate the performance of the two modulation technologies. The power and modulation format were the major drawbacks in this network. Ives *et al*. [8] adapted transmitter power and modulation format to improve the performance of the optical network. It described a simplified Gaussian noise model approach to estimate the signal quality. Hence, studied the benefits and strategies for the channel allocation of a wavelength routed transparent optical mesh network and the power optimization technique.

Tornatore *et al*. [9] introduced the special issues on the optical network design and modelling (ONDM). However, it was realized that the network virtualization, dynamic optical networks, spatial division multiplexing networking, multi-layer design, and the next-generation optical access networks inferred a traffic issue in addition to it. Saleh and Simmons [10] envisaged an evolution, benefits, challenges, and future visions within the AON through the formulation of an analytical model. The early vision of present vibrant state was utilized to review the evolution of AON. The impervious such as relative merits, demerits, and the numerous benefits was afforded by an optical transmission and all-optical switching technologies.

Finally, discussed the challenges and future directions of AON. Chow *et al*. [11] proposed the convergent optical wired and wireless access networks and validated the feasibility of using all-optical orthogonal frequency division multiplexing (AO-OFDM). Achieved high data rate (>100 Gb/s) and without beating the speed limit of electronic digital-to-analog and analog-to-digital converters (DAC/ADC) due to the AO-OFDM was depended on the all optically generated orthogonal subcarriers. Though it was capable of realizing an AO-OFDM super-channel (SC) the proof-of-concept convergent access network was significantly considerable. Then, established 40-100 Gb/s wired and gigabit/s 100 GHz millimeter-wave (MMW) ROF transmissions. Lazzez [12] presented a deep analysis of the security issues of AONs. The physical infrastructure of AONs was directly affected and that significantly differed the electro-optic and electronic networks. Therefore, the proper functioning of the network and the infrastructure vulnerabilities have to be analyzed.

Additionally, the service disruption or a tapping attack to be performed based on the set of scenarios. The detailed description of the challenging issues and the security attacks were revealed in this section. Khodashenas *et al*. [13] estimated the benefits through an optical traffic grooming (AOTG) from the flexi gridsuper-channels to/ from the all optical add/drop of low rate signals. The thorough and holistic techno-economic evaluation was achieved in this research field. The optically transparent and OTN-based solutions in a planning scenario were the existing networks compared with the proposed AOTG technique. Hence, the consuming cost was the major issues in this research. Jedidi *et al*. [14] evaluated an optical performance monitoring and optical network management in order to omit low capacity in AON and also to mitigate the transmission delay.

The intra-crosstalk in AON was effectively detected and localized the value by a policy monitoring (PMI) system. Therefore, the new demand was to accept or blocked. Through the quality of service (QoS) was proficient enough to pass a light path of PMI, it was using supervising performance degradation for reducing the high cost and complexity of signal quality monitoring. In order to avoid the link failure, high cost, and complex problem to provide security in AON. Xuan *et al*. [15] established a novel theoretical solution framework for discovering the multi-link failure localization. A tree- decomposition based algorithm was accomplished on employing these small dense networks. On the other hand, it was random walk based localized algorithm on a large scale sparse networks in accordance with coping three practical constraints. The link and node delay was the major issue in the undirected networks. Rahman and Arozullah [16] dealt with the security attacks at the physical level to protect all optical networks were capable of accomplishing three major steps in a light paths security.

The overall high level protocol for the establishment, management and on-the-fly restoration of optimal secure light paths established by applying constraint-based open shortest path first (OSPF) source routing. Then, a protocol utilized in fiber diversity between adjacent nodes to protect against attacks on fiber links. Finally, analytical models of propagation of security attacks on optical amplifiers and switches were presented. In case of an attack, the security indices and on-the-fly real-time restoration of components were estimated based on these models exploited to develop the security envelopes. Mukherjee *et al.* [17] prepared a review against disaster disruptions and cascading failures on the cloud services and adapt them to network. The defense treat reduction agency (DTRA) was supported the recent project of light findings. Tapolcai *et al*. [18] explored a global neighborhood failure localization (G-NFL) for sharing the protection scheme.

A novel monitoring trail (m-trail) scenario involved in G-NFL which includes failure dependent protection (FDP). Thus, achieved ultra-fast failure restoration in all-optical networks. Jiang, *et al*. [19] recovered the missing traffic data from the traffic matrix. Suggested the spatio-temporal Kronecker compressive sensing method from the base of Kronecker compressive sensing. The sparse form of traffic matrix constructed that exploited from the spatial and temporal properties. Hence, proposed the novel recovery model to consider the low-rank property of the traffic matrix. The link failure, low throughput, accuracy were considered as the major aspects to accomplish the great approval performance [20]-[26].

3. SOFTWARE DEFINED SWITCHING ENABLED FAULT LOCALIZATION FRAMEWORK

This section discusses the implementation details of the proposed software defined switching enabled fault localization framework (SDSFLF) in the MAS and MTS for accomplishing a robust data transformation network through the implication of optical fiber communication network. The workflow of the proposed SDSFLF is shown in Figure 1. The proposed work formulation initially prompts for network deployment with the nodes and link for communicating over the country by means of detecting faulty node and faulty link in prior. Then, discover the router location for transmitting the data. During communication, the whole data is optical and thus does not modify the data and its traveled path. Therefore, construct the directed graph that depends on the discovered route information. Then, each light path cost is calculated and evaluate the routing metrics for each path. If not evaluated then process the light path cost calculation again. Otherwise, determine the utilization cost of each path and classify the faulty node and the corresponding links respectively. Finally, update the failure information in local route entry table for providing uninterrupted communication service.

Formulated a network of the devised AON is organized with an inclusion of link congestion probabilities and the faulty node. Therefore, design a well efficient network for transmitting an information. Then, determine the best route to exchange the information without any interruption. Based on the packets (bits per second) capacity the routes are assigned to transmit. If transmit the data packets through routers to send a request and accept the corresponding reply. The hop occurs due to a number of packets passed to the next network device at a particular time.

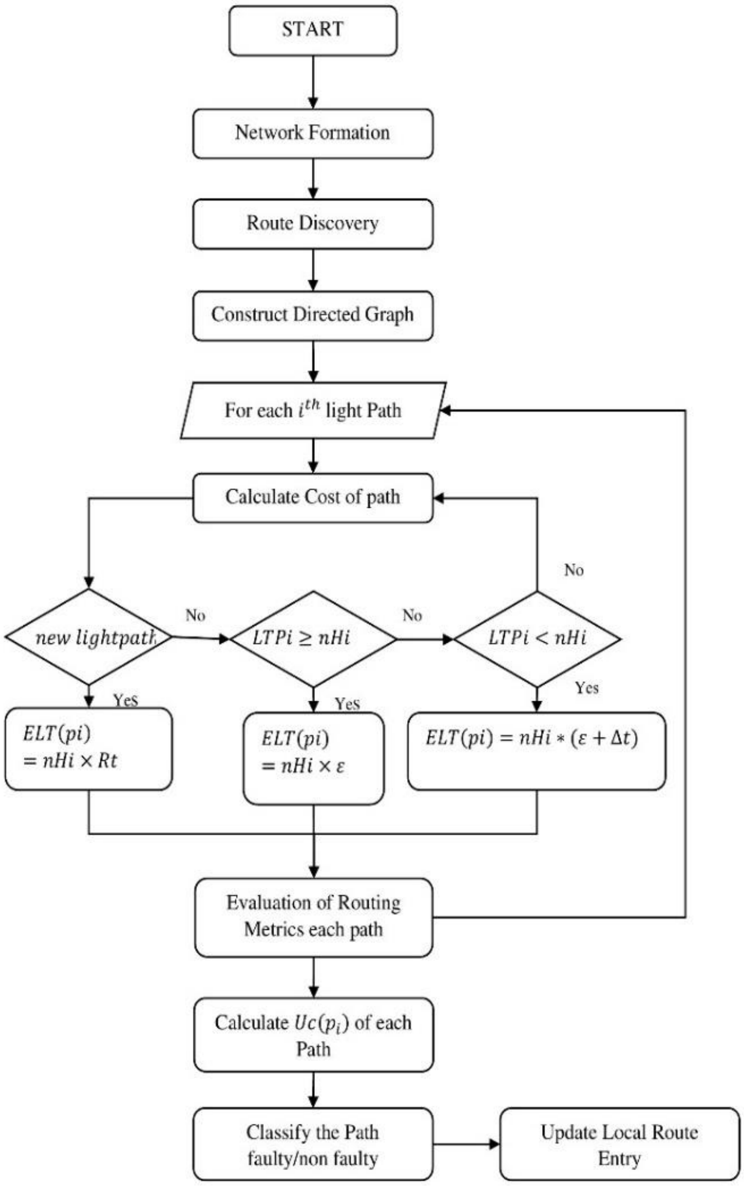


Figure 1. Proposed SDSFLF framework

If the hop count denotes the number of devices through which data must pass between source and destination. It takes the count at least 15 to the maximum number of hops is 255. Therefore, discovered the route which is the required source to construct the directed graph. Then, the network is represented in a directed graph structure also named as a diagraph. It shows an ordered pairs of edges and the vertices N and E are called the endpoints of the edge. Therefore, the network designed the directed graph:

$$G = (N, E) \tag{1}$$

where,
N represents the vertices of nodes or points in a set of elements
E represent directed edges or directed links connected between the nodes in a set of ordered pair's
let consider the number of edges or size of the graph,

$$n = |E| \tag{2}$$

randomly, select the vertex on the directed graph. If moves along the edges and marks that path for reducing the number of repetitions. Therefore, select the source to destination path based on the same wavelength to all of its link. If there is no variance occurs on its path, then select the minimum number of wavelengths utilized path. A set of requests comprises in instances. Therefore, assigning the wavelength to the corresponding request and not assigned the same wavelength for more than one path. For considering R, a set of end-to-end measurements paths. Thus, shows the number of measurement path as,

$$|R| = n_p \tag{3}$$

where, R represents the measurement paths of the source to destination, and n_p represents the number of times to determine the correct path for transmitting the data packets.

Assume that, in each path there are no loops and the length of a path represents $l_i < s$. The $p = \{p_i\}$ represents the states of paths, which is named as congested mean passes at least one congested link or else passes all links called as non-congested. Therefore, consider directed graph G, and the measurement path Rto construct the binary routing matrix M_{n_pXs}, where the entry $M_{ij} = 1$ represent the i^{th} path pass through j^{th} edge or else $M_{ij} = 0$. An end-to-end measurement path $R_i(R_i \in R)$ represents each row of M and the link of a network represents each column. If passes each link by at least one path without loss of generality or else link states are independent due to the measurement.

In this work, several notations are used to derive the link failure which shows that, $V = [V_1 V_2 \dots\dots. V_n]^T$: the states of a link represented by a random binary variable vector. Assume that V_j is independent of each other. T represents the transposition. $P = [p_1\, p_2 \dots\dots. p_{np}]^T$: the state of paths represented by a random binary variable vector. T represents the transposition state.

Then, determine the cost of each i^{th} light path. The dissimilar probability distribution of noticeable variables is generated based on the diverseparameter values which are equivalent to the mathematical notation. Hence, pi is the statistical model of the established path, which shows that the model's fundamental parameter and dimensionprints are the surveillanceinformation. By utilizing a light path, the ending time of a connection is determined based on the duration of a connection information and the last ending time of the connections is used to find the lifetime of a light-path. The main objection of hop time is to use the least possible number of new light-paths that involves a reduction in the length of the lifetime of existing light-paths. Therefore, calculates the cost of the trained number of light-path connection that related to the light-paths of the extended lifetime.

Then, shows the mathematical evaluation of the light-paths lifetime and the duration of the connection. The new path identified based on some conditions which are satisfied to predict the congested links. If founded the new path that shows as,

$$ELT(pi) = nHi \times Rt \tag{4}$$

where, $ELT(pi)$ represents the extension usage or the lifetime cost of i^{th} light-path, nHi represents the number of hops in i^{th} light-path, Rt represents the request holding period, and $LTPi$ represents the lifetime of the i^{th} light-path. Therefore, the request holding period denotes,

$$Rt - LTPi \rightarrow \Delta t \tag{5}$$

where, Δt represents adjustment constant variable. If (4) satisfies the following conditions such as, if $LTPi \geq Rti$.
Then,

$$ELT(pi) = nHi \times \varepsilon \quad (6)$$

if $LTPi < Rti$.
Then,

$$ELT(pi) = nHi * (\varepsilon + \Delta t) \quad (7)$$

where, ε represents exponential constant factor is 10^{-5}(a small constant factor).

Here, the extensive usage of light path lifetime satisfies the above mentioned condition. If not satisfied, then move to (7). Therefore, calculate the light path life time which is used to determine the build the routing matrix. This shows that the effective route path and eliminate the high traffic intensity path. If eliminate the high traffic route based on the weight calculation which shows the maximum weighted routes. In order to avoid, list the low traffic intensity nodes to transfer the information. The bandwidth availability and the extension of the lifetime of the tight-paths are derived from the cost function between the known duration. Therefore, derive the utilization cost of the established light path p_i as,

$$Uc(p_i) = (ELT(p_i) \times \sigma) + \left(\frac{BW(p_i) - bw(p_i)}{BW(p_i)} \times (1 - \sigma)\right) \quad (8)$$

where, $Uc(p_i)$ represents the utilization cost of light path p_i, σ represents the weight which is applied to the extension factor of a lifetime of the light-path, bw represents the available bandwidth inp_i, BW represents the total bandwidth of p_i, and $1 - \sigma$ represents the weight of bandwidth utilization. If p_i is a new light-path mean then satisfy the bandwidth value as, $\frac{BW(p_i) - bw(p_i)}{BW(p_i)} = 1$. Then, determine the utilization cost of new light path using (8) as,

$$Uc(p_i) = (ELT(p_i) \times \sigma) + (1 - \sigma) \quad (9)$$

These are the expectation condition which utilizes to maximize the throughput value. If examine whether the links are congested or not due to one of the measurement path. The concrete Internet application depends on the path packet loss rate threshold β valuesimilar with an individual link. If path p_i exceed the packet loss rate β is said to be congested. Then, determine the congested path probability that introduces a new term of measurement snapshot. In a fixed length time slotderives the *np* path measurements which exist from the snapshot. Hence, the similar n_p path measurements consists in each snapshot that takes SS snapshots as,

$$x = \{x_1, x_2, x_3, \dots \dots \dots .., x_{ss}\} \quad (10)$$

Consider, the random binary variable as x_i thenderive the congestion path expectation can be calculated. The congested links are recovered from the compressive sensing algorithm. To meetnecessities adapt some more conditions which are essential for routing matrix. Usually, the term identifiable is derived from a statistical model. Hence, the infinite number of observations obtaining from the derived model that learn the true value. The route matrix value is updated in the local route entry. Hence, identified the failure link which shows that the effective results. The proposed algorithm is used to locate the faulty node in a network is listed as Algorithm 1.

Algorithm 1. Faulty node localization
```
Input: T single sourced Graph topology, S states of each node in T at time t
Find the each node states {St}
If each node states T[i].s ∈ St[i] is normal
T[i] is not a faulty node
Else
For every node statesT[i].s ∈ St[i] then
IF T[i].s is normal then continue;
Send abnormal status information to downstream nodes
IF the node is the first node of the traffic stream
        It's the faulty node (suspected)
ELSE
IF receiving abnormal information from upstream nodes
        It isn't the faulty node (suspected)
ELSE
It is the faulty source
```

Initializing the variables T, S, and t to represent the single sourced Graph topology, states of each node, and time. The subset of each node state represents the {St}. In this novelty, performed under two states of the network model such as faulty and not faulty node respectively. If suspect the faulty node, send the abnormal status information to downstream nodes or else receive the abnormal information from upstream nodes due to a not faulty node. In this way, the failure nodes are localized successively. If the variation is possible, then go to link detection. The algorithm to detect the faulty link is listed as Algorithm 2.

Algorithm 2. Software defined faulty link detection
Input: *suspected faulty node set* $Fn[i]$, *suspected faulty link set* $Fl[i]$, *and the set of congested faulty path set Cp*
Output: *The set of most possible congested links Lc*
Initialize Lc *to the empty set and* $P(i,j) = Cp, x = 0$
For all i,j *until* $P(i,j) \neq 0 +$
Find a link $l \in Lc$ *that maximizes* $l_k = log \frac{1}{Cp}$
Add l_k *to the solution* $Lc = Lc \cup \{l_k\}, set\, x_k = 1$ *using (10)*
$Ti = Ti \backslash l_k$,
$Fn[i] = Fn[i] \backslash l_k$
$P(i,j) = P(i,j) \backslash C(l_k)$
$C(l_j) = C(l_j) \backslash C(l_k) for\ all\ l_j \in Fl(i)$
End For

Initializing, the variablessuspected faulty node set F n[i], suspected faulty link set Fl[i], and the set of a congested faulty path set Cp. Then, assign the set of the possible congested links L_C to be empty and $P(i,j) = Cp, x = 0$. After that, select the maximum value (suppose l_k) from Ti,which is equivalent to select one suspected congested link $l_k$from Cp and place it to L_C, meanwhile delete $l_k(1)$ and the paths combined with l_k(named by $C(l_j)$) from Ti and $Fl[i]$respectively. Where k denotes the number of congested links. Finally, identified the congested link and select the suitable link to transmit the information without any interruption.

4. RESULTS AND DISCUSSION

This section illustrates the effectiveness of the proposed system by comparing with the existing methods such as traditional routing and wavelength assignment (RWA), simulated annealing, attack-aware RWA (A-RWA) convex, longest path first (LPF), and biggest source-destination node degree (BND) [20]. Proficiency is considered by analyzing various parameters given as network load, wavelength, packet loss rate, and the burst loss. The delay variance, in-band cross talks, out-of-band cross-talks, and the burst loss rate of the proposed system is lower than the existing method when compared the results.

4.1. Performance metrics

A number of basic challenges, including architectural ones like whether control should be distributed or centralised and whether the control and data planes should be distinct, are brought up by the rise of SDN. There are many unsolved difficulties in the SDN field, from implementation concerns like how we create dispersed "logically centralised" control planes to architectural questions that are essential to how networks extend and develop. Furthermore, there is a chance to integrate fault tracking framework more deeply into the overall design process because SDN is still in its early stages.

The proportion of complete number of requested connections to the single number of requested connections among all probable source-destination pairs and it represented in terms of ρ as,

$$\rho = \sum \frac{\Lambda_{sd}}{N^2 - N} \tag{11}$$

where,
Λ_{sd}representsquantity of requested connection for the source destination pair s-d,
$\Sigma\Lambda_{sd}$ represents the summation of total demanded network connections,
N represent the total number of network nodes,
$N^2 - N$ representsthe single demanded network connection among all the source-destination pairs.

4.2. Wavelength

The wavelength is the process of estimating the distance between source and destination in a path and it is inversely proportional to frequency. The mathematical formula as,

$$W = {}^{v}/_{f} \quad (12)$$

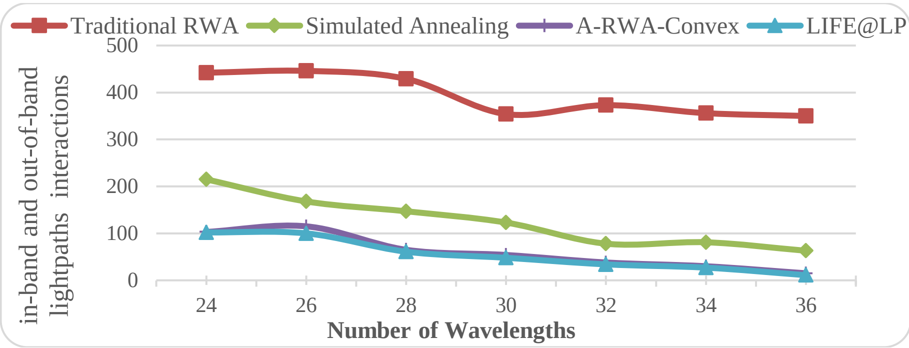
where, v represents the speed of the light signal, and f represents the frequency.

If the same wavelength between the intra-channel, crosstalk generates the in-band jamming attack in which the optical cross connects on the network that produceshigh power signal injection rate. Based on the non-ideal isolation switching, cause the power leakage between light paths. Therefore, the high-power jamming signal occurs due to high leakage which occurs similar wavelength on the attacking signal. Otherwise, the out-band crosstalk attacks generate owed to high power outflow among the adjacent channels. It is due to inter-channel crosstalk, and nonlinearities which affect the wavelengths on the same fiber. Hence, the proposed technique reduces the attacks effectively.

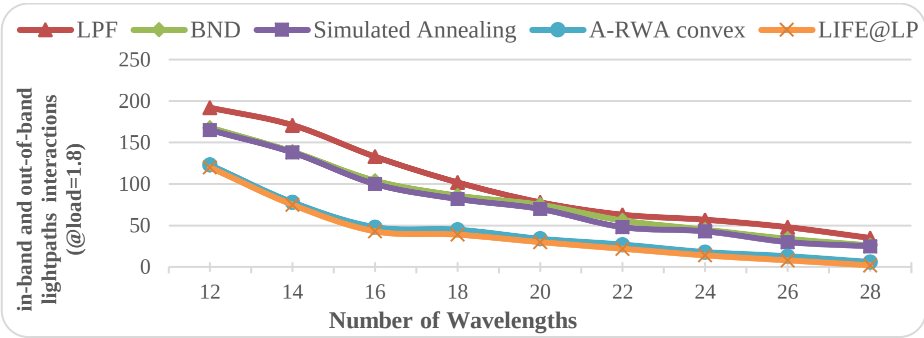
4.3. Utilized wavelength

The network node topology produces the numeral of light paths which is the required source to interact the nodes. This account is consideredinto continuity constraints and the distinct wavelength assignment. The network load is assumed to 0.6 and 1.8 for minimizing the number of the wavelengths usage. The proposed SDSFLF method devised that, minimize the number of wavelengths used and also reduce the effect of light path interactions due to the in-band and out-of-band crosstalk. Figure 2 represents the number of light paths that interact through in-band and out-of-band crosstalk versus a number of available wavelengths for load 06 and 1.8.

Figure 2(a) illustrates that the existing RWA, A-RWA convex, and the simulated annealing approaches, the number of interactions decreases significantly with increasing the number of available wavelengths. Number of light paths that interact through in-band and out-of-band crosstalk for load=1.8 is shown in Figure 2(b). Thus, the proposed SDSFLF method performance significantly reduces the jamming attack than the existing techniques.



(a)

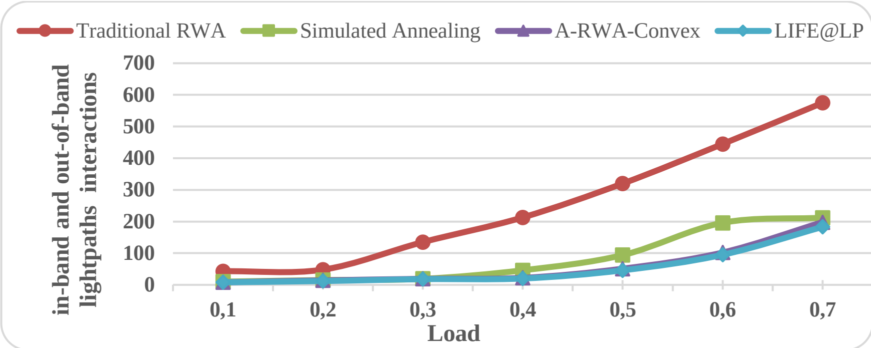


(b)

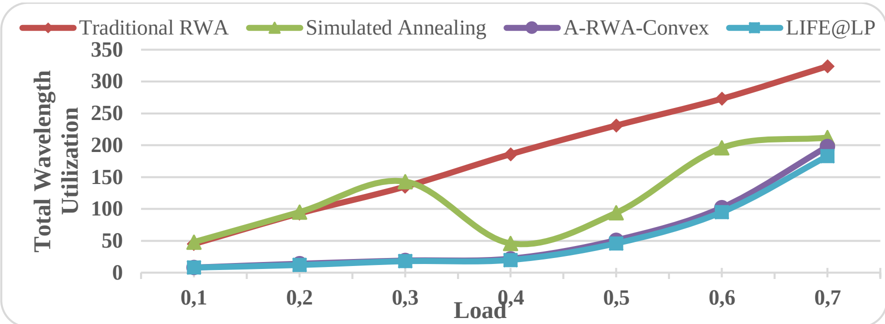
Figure 2. Wavelengths under the light paths in-band and out-of-band crosstalk for (a) load=0.6 and (b) load=1.8

From the figure, shows that the existing LPF, BND, simulated annealing, and the A-RWA-convex approaches, the number of interactions decreases significantly with increasing the number of available wavelength. The proposed SDSFLF algorithm improves the wavelength usage than other existing algorithms. Hence, the SDSFLF framework achieves the greatest performance over numerous collections during execution.

The number of available wavelengths per fiber is assumed to be W=24. Figure 3 shows that load with wavelength utilization with Figure 3(a) represent the number of light path interaction through in-band and out-of-band crosstalk with respect to network load at constant wavelength 24 is shown in Figure 3(b). From the figure shows, the SDSFLF framework exhibits a considerable changes in some cases. The existing RWA, simulated annealing, and the A-RWA-convex performance are compared with the proposed algorithm. The proposed SDSFLF is highly reduced the in-band and out-of-band crosstalk and produce the un-interrupt communication. Hence, the proposed algorithm is expressively better than existing.



(a)



(b)

Figure 3. Load with wavelength utilization (a) in-band and out-of-band crosstalk at W=24 and (b) utilized Wavelength at W=24

Figure 3(b) represents the total number of utilized wavelength through all the light path. In general, the proposed SDSFLF technique is the best choice for utilizing minimum wavelength and effectively using the network resources. Therefore, the proposed algorithm achieves high network security in contradiction of high-power jamming attackdue to increase in the number of utilized wavelength. Hence, the SDSFLF meets the lower bound of the wavelength utilization for most of the network load.

The packet loss rate is calculated by the delay occurrs in the transmission during high traffic intensity range. It is used to estimate the total delay variance in between source node to the destination node of packet transmission’s rate while the packet loss rate of a good link is around zero. Figure 4 represents the packet loss rate.

From the Figure 4, clearly shows that the packet loss rate delay variance of the link under various intensities of cross traffic. The x-axis represents the increasing traffic intensities which are an increasing number of flows loaded on the link and the y-axis represents the delay variances of the link. Hence, the increased data packets transmitted at the specific time is varied randomly. The existing technique delay variance of the link is higher than the proposed technique. Therefore, the minimum number of delay variance is produced in this proposed SDSFLF framework.

The burst loss rate is defined as the average ratio of packets both lost packets and the discard packets over high traffic intensity. Figure 5 represents the burst loss rate. The burst loss rate is ratio of packet under the wavelength of the traffc intensity wity delay variance of the link.

From the Figure 5, shows that the proposed SDSFLF method is compared with the traditional RWA, simulated annealing, and the ARWA-convex methods. The proposed SDSFLF method achieves lower burst rate such as 0.040, 0.043, 0.044, 0.250, 0.570, 0.790, 0.843, 1.001, 1.160, and 1.318 due to the high traffic intensity range from 1 to 10 ms respectively. Hence, it's proven, that the proposed SDSFLF assures that minimum burst loss rate than the existing technique.

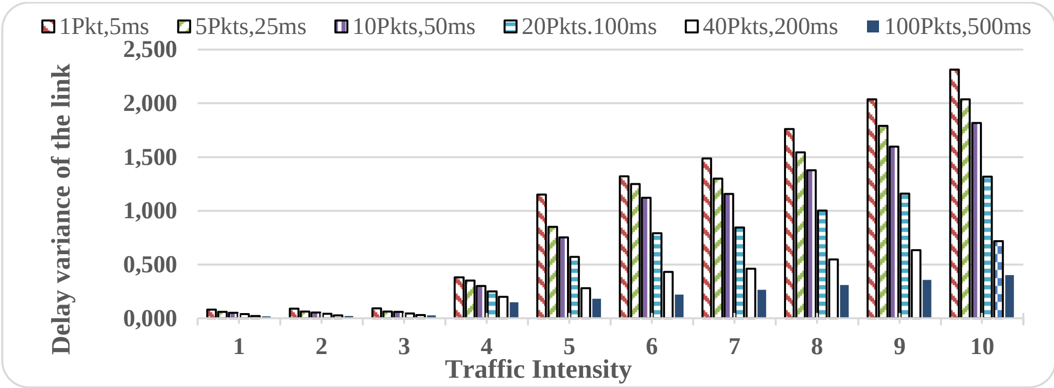


Figure 4. Packet loss rate

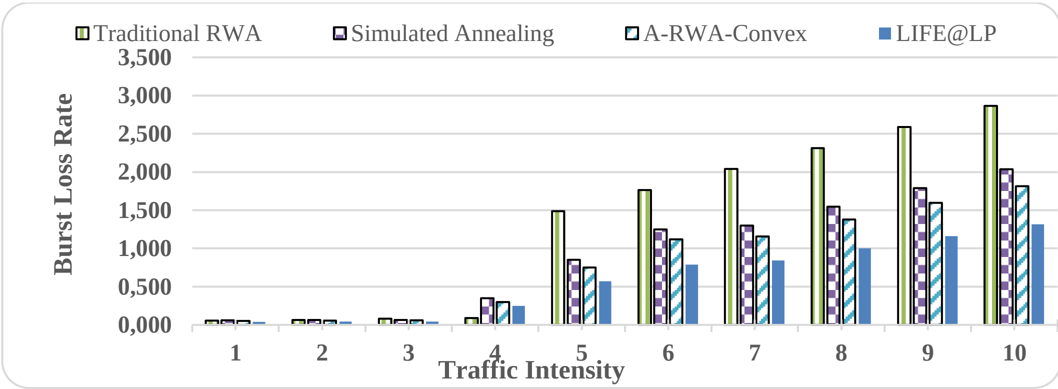


Figure 5. Burst loss rate

5. CONCLUSION

This paper developed a software defined switching enabled fault localization framework (SDSFLF) for link failure localization and improves throughput in the all opticalnetwork. It will deliver good transmission transparency, minimum bit error rate (BER), massive bandwidth, and the good expandability. The proposed faulty node localization (FNL) and the software defined faulty link detection (SDFLD) algorithm is to monitor and localize the faulty nodes and links in an AON. The FNL is processed for locating the failure node which is the required source of link failure estimation and the SDFLD algorithm is used detect the faulty link. Hence, the devised SDSFLF framework improves its throughput than other prevailing methodologies like traditional RWA, simulated annealing, A-RWA-convex, LPF, and BND. The various performance measures such as network load, wavelength utilization, packet loss rate and the burst loss rate are evaluated. Therefore, the proposed SDSFLF framework is achieved high performance than the other traditional techniques.

REFERENCES

[1] C. Kachris, K. Kanonakis, and I. Tomkos, "Optical interconnection networks in data centers: recent trends and future challenges," *IEEE Communications Magazine*, vol. 51, no. 9, pp. 39-45, September 2013, doi: 10.1109/MCOM.2013.6588648.
[2] L. Liu and Y. Jin, "An attack localization algorithm in multi-traffic-stream and multi-attack-source in all-optical networks," *Communications and Networking in China (CHINACOM), 2013 8th International ICST Conference on*, 2013, pp. 761-764, doi: 10.1109/ChinaCom.2013.6694696.

[3] S. Cai, M. Bakshi, S. Jaggi, and M. Chen, "Frantic: a fast reference-based algorithm for network tomography via compressive sensing," *Communication Systems and Networks (COMSNETS), 2014 Sixth International Conference on*, 2014, pp. 1-7, doi: 10.1109/COMSNETS.2014.6734865.
[4] I. D. Irawati, A. B. Suksmono, and I. I. Y. M. Edward, "Missing internet traffic reconstruction using compressive sampling," *International Journal of Communication Networks and Information Security (IJCNIS),* vol. 9, no. 1, 2017, doi: 10.17762/ijcnis.v9i1.2249.
[5] A. S. Thyagaturu, A. Mercian, M. P. McGarry, M. Reisslein, and W. Kellerer, "Software defined optical networks (SDONs): A comprehensive survey," *IEEE Communications Surveys & Tutorials,* vol. 18, no. 4, pp. 2738-2786, 2016, doi: 10.1109/COMST.2016.2586999.
[6] X. Zhao, V. Vusirikala, B. Koley, V. Kamalov, and T. Hofmeister, "The prospect of inter-data-center optical networks," *IEEE Communications Magazine,* vol. 51, no. 9, pp. 32-38, 2013, doi: 10.1109/MCOM.2013.6588647.
[7] D. A. Mello, A. N. Barreto, T. C. de Lima, T. F. Portela, L. Beygi, and J. M. Kahn, "Optical networking with variable-code-rate transceivers," *Journal of Lightwave Technology,* vol. 32, no. 2, pp. 257-266, 2014, doi: 10.1109/JLT.2013.2292298.
[8] D. J. Ives, P. Bayvel, and S. J. Savory, "Adapting transmitter power and modulation format to improve optical network performance utilizing the Gaussian noise model of nonlinear impairments," *Journal of Lightwave Technology,* vol. 32, no. 21, pp. 4087-4096, 2014, doi: 10.1109/JLT.2014.2346582.
[9] M. Tornatore, N. Skorin-Kapov, and P. P. Mariño, "Introduction to the special issue on optical network design and modeling," *Journal of Optical Communications and Networking,* vol. 9, no. 3, 2017, doi: 10.1364/JOCN.9.00ODM1.
[10] A. A. Saleh and J. M. Simmons, "All-optical networking—Evolution, benefits, challenges, and future vision," *Proceedings of the IEEE,* vol. 100, no. 5, pp. 1105-1117, 2012, doi: 10.1109/JPROC.2011.2182589.
[11] C. Chow, C. Yeh, J. Sung, and C. Hsu, "Wired and wireless convergent extended-reach optical access network using direct-detection of all-optical OFDM super-channel signal," *Optics express,* vol. 22, no. 25, pp. 30719-30724, 2014, doi: 10.1364/OE.22.030719.
[12] A. Lazzez, "Notice of Violation of IEEE Publication Principles All-optical networks: Security issues analysis," *IEEE/OSA Journal of Optical Communications and Networking,* vol. 7, no. 3, pp. 136-145, 2015, doi: 10.1364/JOCN.7.000136.
[13] P. Khodashenas *et al.*, "Benefit evaluation of all-optical subchannel add–drop in flexible optical networks," *IEEE Photonics Journal,* vol. 8, no. 2, pp. 1-9, 2016, doi: 10.1109/JPHOT.2016.2541860.
[14] A. Jedidi, M. M. Alshamrani, and A. M. A. Bamhdi, "Monitoring and prediction of intra-crosstalk in all-optical network," *World Academy of Science, Engineering and Technology, International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering,* vol. 10, pp. 167-171, 2016.
[15] Y. Xuan, Y. Shen, N. P. Nguyen, and M. T. Thai, "Efficient multi-link failure localization schemes in all-optical networks," *IEEE Transactions on Communications,* vol. 61, no. 3, pp. 1144-1151, 2013, doi: 10.1109/TCOMM.2013.012313.110645.
[16] F. Rahman and M. Arozullah, "Real time securing of all-optical networks against security attacks at the physical level," *International Journal of Network Security & Its Applications,* vol. 5, no. 4, pp. 1-21, 2013.
[17] B. Mukherjee, M. Habib, and F. Dikbiyik, "Network adaptability from disaster disruptions and cascading failures," *IEEE Communications Magazine,* vol. 52, no. 5, pp. 230-238, 2014, doi: 10.1109/MCOM.2014.6815917.
[18] J. Tapolcai, P.-H. Ho, P. Babarczi, and L. Rónyai, "Neighborhood failure localization in all-optical networks via monitoring trails," *IEEE/ACM Transactions on Networking (TON),* vol. 23, no. 6, pp. 1719-1728, Dec. 2015, doi: 10.1109/TNET.2014.2342222.
[19] D. Jiang, L. Nie, Z. Lv, and H. Song, "Spatio-temporal Kronecker compressive sensing for traffic matrix recovery," *IEEE Access,* vol. 4, pp. 3046-3053, 2016, doi: 10.1109/ACCESS.2016.2573264.
[20] K. Manousakis and G. Ellinas, "Attack-aware planning of transparent optical networks," *Optical Switching and Networking,* vol. 19, pp. 97-109, 2016, doi: 10.1016/j.osn.2015.03.005.
[21] X. Liu and F. Effenberger, "Evolution of mobile fronthaul towards 5G wireless and its impact on time-sensitive optical networking," *2017 Optical Fiber Communications Conference and Exhibition (OFC)*, 2017, pp. 1-2.
[22] D. Hisano, K. Maruta and Y. Nakayama, "Low cost C-RAN and fronthaul design with WDM-PON and multi-hopping wireless link," *2020 IEEE 17th Annual Consumer Communications & Networking Conference (CCNC)*, 2020, pp. 1-6, doi: 10.1109/CCNC46108.2020.9045249.
[23] D. Konstantinou *et al*., "5G RAN architecture based on analog radio-over-fiber fronthaul over UDWDM-PON and phased array fed reflector antennas," *Optics Communications*, vol. 454, 2020, doi: 10.1016/j.optcom.2019.124464.
[24] K. Wang, A. Nirmalathas, C. Lim and E. Skafidas, "High-speed optical wireless communication system for indoor applications," *IEEE Photonics Technology Letters*, vol. 23, no. 8, pp. 519-521, April15, 2011, doi: 10.1109/LPT.2011.2113331..
[25] M. Kavehrad, "Sustainable energy-efficient wireless applications using light," *IEEE Communications Magazine*, vol. 48, no. 12, pp. 66-73, 2010, doi: 10.1109/MCOM.2010.5673074..
[26] H. Manor and S. Arnon, "Performance of an optical wireless communication system as a function of wavelength," *Applied Optics*, vol. 42, no. 21, 2003, doi: 10.1364/AO.42.004285.

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