JOURNAL PUNJAB ACADEMY OF SCIENCES (Peer Reviewed Open Access Journal)
JPAS, 23: 269-279 (January-December, 2023)
Available online at www.jpas.in
ISSN 2229-7014 (P)

REDUCTION OF BLOCKING PROBABILITY IN GMPLS OPTICAL NETWORKS USING NOVEL HYBRID OPTIMIZATION ALGORITHM

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ABSTRACT

In this paper, an optimized algorithm hybridizing Minimum Execution Time (MET), Weighted Round Robin (WRR) and Particle Swarm Optimization (PSO) is presented to minimize the blocking probability in Generalized Multi-Protocol Label Switched (GMPLS) optical networks to improve Quality of Service (QoS). MET is used for distributing the bandwidth in a well-organized approach to further reduce the latency in the network. The deviation in blocking probability is calculated depending on demanding traffic load and number of wavelengths accessible at the instant when user demand occurs in the GMPLS optical network. WRR is used to increase the flexibility in computing the path between the nodes. The overheads are also optimized using PSO with increasing number of iterations. The consequences exposed that the blocking probability reduces with growing number of accessible wavelengths. The value of blocking probability obtained is <1% by using the proposed hybrid optimization technique for bandwidth allocation and path computation.
Keywords: Blocking Probability; Weighted Round Robin; Generalized Multi-Protocol Label Switching; Minimum Execution Time; Particle Swarm Optimization

INTRODUCTION AND MOTIVATION

Now adays, the main confront is to attain the quickly rising bandwidth requirements and diverse Quality of Service (QoS) necessities (Mir 2014). These requirements need to be sustained beside the protection of data. Optical fibers are capable of achieving these targets for telecommunication purpose (Jerram, 2001). The fiber bandwidth can be utilized efficiently by considering dense wavelength modulation technology as an alternative to increase the capacity by transmitting many channels through the single fiber (Singh 2016, Singh 2017). In addition to providing enormous capacities in the network, an optical network provides a common infrastructure over which a variety of services can be delivered. For enhancing safety and data rate, Multi-Protocol Label Switched (MPLS) optical networks came into account in late 1990's. The MPLS network helps the device to handle the traffic efficiently as prescribed by each subscriber's network policy. It provides mechanism for faster transmission of packets through Internet Protocol (IP) routers but the process took a lot of time and process became slow, therefore, labels present in the packet were made generalized and GMPLS optical networks came into existence (Singh 2014).

In present world, researchers are working on blocking probability in GMPLS optical networks. Bouzid et al. studied a fusion of techniques from both QoS and MPLS-TE known as DiffServ-aware MPLS-TE (DS-TE) (Bouzid 2015). The authors evaluated the building blocks of QoS-DS, MPLS-TE and DS-TE in comparison toeach other and analyzed the fundamental divergence and relationship between them for improved assimilation. The comparison demonstrated that DS-TE worked as MPLS-TE with an understanding to QoS-DS and assisted in enhancing the eminence of traffic communicationin terms of waiting period. Dallaglio et al. surveyed the inconsistent multiflow bandwidth transponders sustaining slice ability (Dallaglio 2015). The observations revealed that node and spectrum resources were efficiently utilized by these transponders in elastic optical networks and were capable of creating subcarriers which could be aggregated or routed independently as per the traffic requirements. Hemamalini et al. showed the performance of Balanced Minimum Execution Time task scheduling algorithm with other algorithms such as Min-Min, Load Balanced Min-Min (LBMM), Minimum Execution Time based on execution time, make span, completion time and load balancing (Hemamalini 2016). The survey revealed that Balanced Minimum Execution Time outperforms the Min-Min, LBMM and Minimum Execution Time task scheduling algorithms. Ge et al. proposed a rough calculation method of path requirements for blocking probability in flexi-grid networks (Ge 2016). A group of birth–death procedures were modeled with collection of adjoining carrier distribution and gave a conjectural investigation to the blocking probability under inconsistent bandwidth interchange. The mathematical results illustrated the consequence of traffic constraints to the blocking probability of path requirements. Saidu et al. proposed a packet-scheduling regulation for downlink interchange in 802.16 networks to enhance performance (Sabiya 2016). The weight of every queue in different classes was dynamically determined on the basis of present traffic parameters using the fixed WRR weight at the commencement of every base station round. Simulations evaluated presentation of load-aware weighted round robin (LAWRR) algorithm and explained average delay and packet failure reduced and average throughput improved in comparison to WRR. Demir et al. presented a PSO based resource distribution and mobility organization algorithm for enclosed visible light communication networks (Demir 2018). The authors formulated the resource distribution trouble as a forced nonlinear integer programming difficulty and explained it using meta-heuristic PSO. Wason et al. proposed a statistical model to diminish the blocking probability for wavelength-convertible networks in WDM optical network (Wason 2011). The simulation results illustrated that blocking probability can be decreased to small value using the proposed model.

Till now, work has been done in the area of blocking probability for MPLS networks and WDM optical networks. In this paper, the work is based on analysis of blocking probability in GMPLS optical networks which is the novelty of our presented work. The significance of the work is that the proposed model is linked with GMPLS optical networks for the dynamic bandwidth allocation and path computation which has not been done in literature. The major advantage of the projected model is that only minor modifications are essential in the construction of existing optical network as it can be employed with little changes. We have contributed in the existing technology in the way that the number of users that can be accommodated in the network increases by using the proposed hybrid optimization algorithm.

The paper is divided into four sections. The first section includes the introduction of GMPLS optical networks and motivation behind the proposed work. The second section discusses about the proposed work. Then the results are discussed in third section and finally the paper is concluded in the fourth section.

A. Generalized Multi-Protocol Label Switching

GMPLS has introduced a great revolution in optical networks for end-to-end transmission with its engineering capacities. The continuously increasing demand of optical communication has significantly increased the problem of interference and bandwidth scarcity (Singh 2016). GMPLS decreases the signaling and switching costs than packet switched networks (Jerram 2001, Anjali 2004). The Routing and Wavelength Assignment (RWA) is the major task which needs to be monitored in optical networks (Ho 2008, Xiao 1999). In GMPLS, the label includes the implicit values defined by the medium used (Ramaswami 1995) as indicated in Fig. 1. No switch is required to examine label in the header of each packet. The switch fabric contains the label asits intrinsic part and the switching procedure depends on wavelength and timeslot etc. The physical property of the received data stream is being used to identify the LSP. In GMPLS, label stacking is done to reduce the node complexity by appending multiple labels to a single packet. During the packet propagation, the previous node identifies the label of the received packet and determines the node for setting up the next connection. Instead of analyzing the whole network, the intermediate nodes switch the packets by simply performing label recognition, which effectively saves processing time. As the complex routing algorithm is only calculated at the terminal nodes, the switching delay for an entire end-to-end route is greatly reduced.

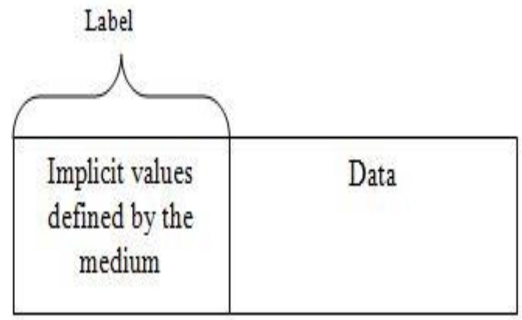

Fig. 1: Packet format for GMPLS

Blocking probability

Probability is the ratio of the constructive cases to the whole number of achievable cases. It is computed as a numeral between 0 and 1, where 0 specifies impracticality and 1 signifies assurance (Papadimitriou 2006).

Blocking probabilities come between the key performance measures in communications networks. Systems need be reproduced as complex set of queues in Erlang loss process for their investigation beside common capability restrictions stated by frequencies circulation to system cells (Berde, 2005). The capability of communication networks is rigorously constrained causing service deprivation due to blocking or disturbance of calls (Papadimitriou 2006). The Engset formula is applied in theory of queuing to verify the probability of call blocking of M/M/c/c/N queue (Berde, 2005). Assume call holding times are exponentially disseminated with mean $1/\mu$ and time in anticipation of an unoccupied resource tries to generate a call is exponentially dispersed with mean $1/\gamma$. The holding times and the idle periods of the sources are considered independent. Consider c as the number of clients, k as the number of routes, j as the number of active routes and P_be as blocking probability.

T The equation (1.1) corresponds to the Engset loss formula (Boucherie 2011, Kaur 2014) and provides the blocking probability for process whenc >k as follows:

the blocking probability for process when$c > k$ as follows:

$$P_{be} = \frac{\binom{c-1}{k}\gamma^k}{\sum_{j=0}^{k}\binom{c-1}{j}\gamma^j} \qquad (1)$$

PROPOSED NETWORK AND ALGORITHM

A new hybrid optimization algorithm including Minimum Execution Time technique to allocate bandwidth efficiently, Weighted Round Robin algorithm to find the path between different nodes and Particle Swarm Optimization is developed for dropping the blocking probability in GMPLS optical network. A dynamic bandwidth allocation technique named MET is used for assigning the bandwidth in proficient approach for appropriate employment of existing possessions and also to further reduce latency in the set of connections which further progresses the quality of service.

In this section, the complete GMPLS optical network having different users placed at their positions is presented. It also shows the location of servers placed in the network. The graphs represent the scenarios of GMPLS optical network showing the users generating requests to other users and the establishment of connections between these users.

The graph in Fig. 2 shows the users and servers in GMPLS optical network at their specified positions. Further, it portrays demands beginning from one client to nearby clients in the system. The red stars in the arrangement signify the situation of demand creating clients whereas the squares in blue color on the right side symbolizes the arrangement of servers that give out wavelength and link rates to the demand creating clients and maintain the routing table and link stability.

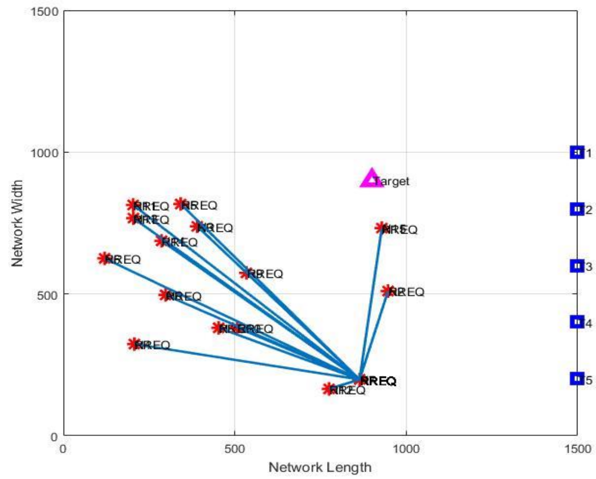

Fig.2: Scenario of GMPLS optical network showing the requests generated

Fig. 3 corresponds to the development of GMPLS optical network with users and servers at their individual arrangement that illustrates the obligation of server with least execution time to the challenging clients in GMPLS optical network. When the consumers demand to propel their data, the group servers are evaluated on basis of least completion time i.e. instant to finish the demand by each server is projected and the server with minimum execution time is chosen. Then the preferred server distributes the wavelengths and link rates to the clients and data transfer takes place. The red lines demonstrate the association between the users and the server. In this specific consequence, fifth server is found to finish the assignment first among all and is chosen for the link formation. The choice of server changes each case the user demand occurs; based upon its completion time. The MET algorithm is used to find the resource having smallest execution time to finish the entire assignment. The first comes first service is opted for assigning job to the resources i.e. the first user demanding for the channel is given server consuming least time at priority (Madni 2017). The algorithm is not worried about the amount of records to be transported.

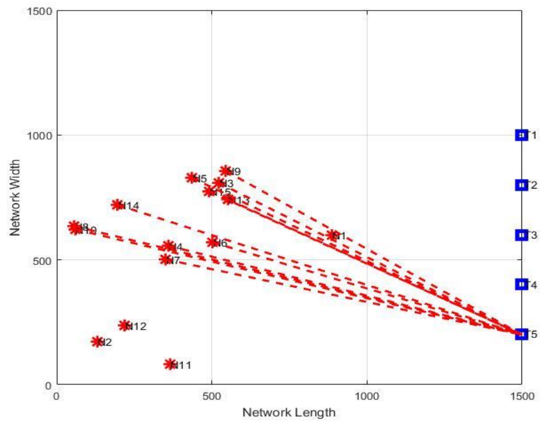

Fig. 3: Scenario of GMPLS optical network showing connection establishment

The next demand is not waited before considering the priority of server. Then the wavelength and link rates are made available by server, bearing in mind their routing table and link stability. Further, the reporting area involving the nearby consumers is intended and the routing table is preserved. The estimation of distance between all the users is done. The distance< zero illustrates that the consumer is locating itself so the routing table is required to be restructured. But if the distance >zero, then the analysis of servers based on execution time is performed. At this instant, when the consumers demand for data transfer, the execution time of each server is anticipated and the server performing the whole task in least predictable execution time period is owed to the particular consumers on first come first service. That is why the algorithm is known as Minimum Execution Time algorithm (Tadapaneni. 2020). When the servers get distributed to the respective consumers, the existing wavelengths are consigned to the challenging consumers. The link rates are estimated to sustain the link stabilities and are supplied to the clients. The algorithm can be represented in the form of flowchart in Fig. 4 as follows:

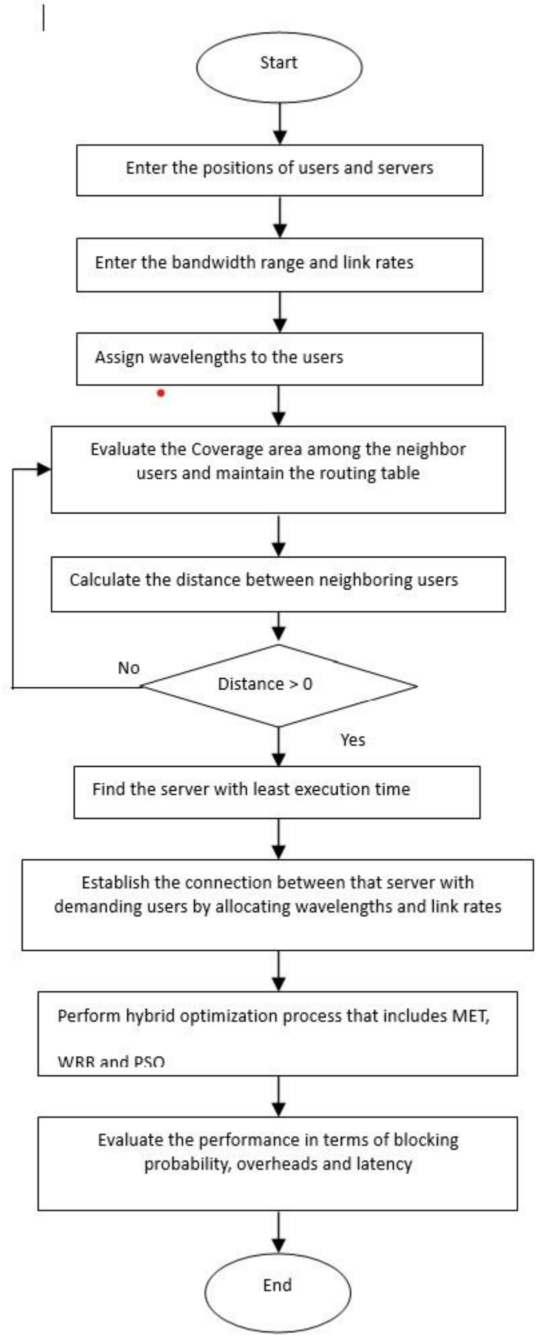

Fig. 4: Flowchart for proposed algorithm

After the allocation of bandwidth, the process of hybrid optimization is performed that includes WRR to compute the paths between different users and PSO for reducing the overheads. The overheads are analyzed by applying iterations. For optimizing the routing overheads, the fitness function is compared with the mean energy in the network in equation 2.1 as:

$$If\ F(x) < E_M\ then\ O_x(i) = \frac{E_x(i)}{I} \times U_L\ (route) \quad (2.1)$$

where EM is the mean of total energy in the network (i)is the energy of the particular node,O_x (i)is the optimized overheads at that particular user,$U_L$is the total number of users in the particular route,I is the total inertia in the network. The flowchart for PSO can be represented in Fig. 5 as follows:

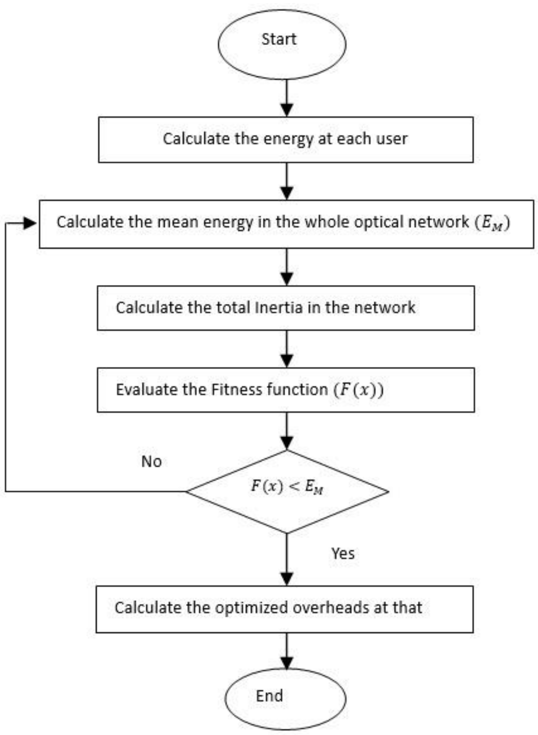

Fig. 5: Flowchart for the PSO used

The WRR technique is basically used for load balancing scheduling which helps in calculating the minimum energy consuming path. The energy consumption at the transmitter side must be equal to the energy consumption at receiver side for proper link stability. If this varies then the link stability decreases due to which proper bandwidth allocation is not possible. Therefore, data gets dropped at that particular node only where this mismatch in the energy occurs. Further, PSO is being used for reducing the overheads which in turn decreases congestion in the GMPLS optical networks. Thus, an optimized path gets selected and data gets transferred efficiently which increases the throughput. The fitness function F(x) used for the proposed algorithm is given in equation 2.2 as:

$$F(x) = \sqrt{\frac{(E_x(i) - E_M)^2}{I}} \quad (2.2)$$

where E_x (i)is the energy of the particular node, where E_M is the mean of total energy in the network, I is the total inertia in the network.

After optimizing the overheads, the performance is evaluated in terms of blocking probability, latency and optimized overheads in the GMPLS optical network.

RESULTS AND DISCUSSIONS

In this particular segment, the consequences are represented for blocking probability based on the number of wavelengths accessible at the instant of consumer demand. Diverse plots are characterized for assorted factors like traffic load, latency and reduced overheads.

The correlation of blocking probability with the number of wavelengths existing at the moment of demand in different Wavelength Bands (WB) is portrayed in Fig. 6. The small value of blocking probability indicates minimum chances of call dropping during hectic hours. The proposed technique incorporates the perception of smallest execution time which allows the persistent accessibility of wavelengths as adequate& shared bandwidths become accessible on the path link to transport the packets between the demanding consumers. This enhances the number of offered wavelengths and thus, the rate of call drop dwindles which in turn reduces the blocking probability. The plot confirms that the projected approach achieves small blocking probability with rising number of wavelengths. Therefore, the QoS for the whole GMPLS network enhances. Fig. 7 corresponds to the deviation of blocking probability based on the escalating traffic load in GMPLS optical network after implementing hybrid optimization. In general, the wavelengths get engaged with augment in the traffic load due to which the consumer demands are blocked but by incorporating the proposed algorithm, the recurrent accessibility of wavelengths is provided because smallest execution time perception is utilized. Thus, additional traffic load can be gripped without blocking by using hybrid algorithm.

The chart explains that the blocking probability rises with rising traffic load but its assessment remains < 1% which is bearable to accomplish elevated link stabilities using the proposed algorithm.

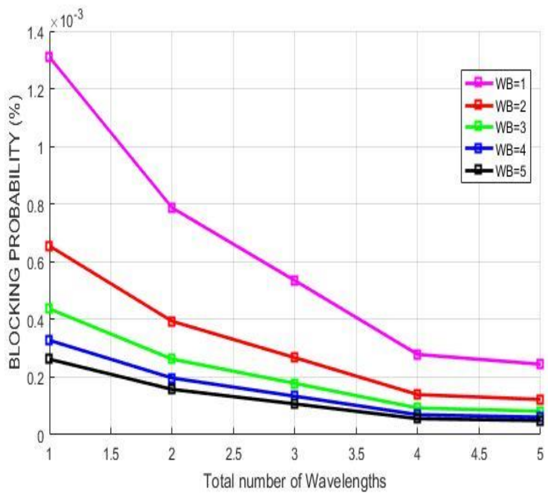

Fig. 6: Blocking Probability as a function of number of available wavelengths in different wavelength bands

Further, the latency in the transmission of data from the source to the destination consumer is plotted with respect to the simulation time in Fig. 8. The latency signifies the time needed to transport the packets to destination consumer. The plot reveals that the latency decreases with increase in the simulation time. The graph shows that the time taken to transmit the data

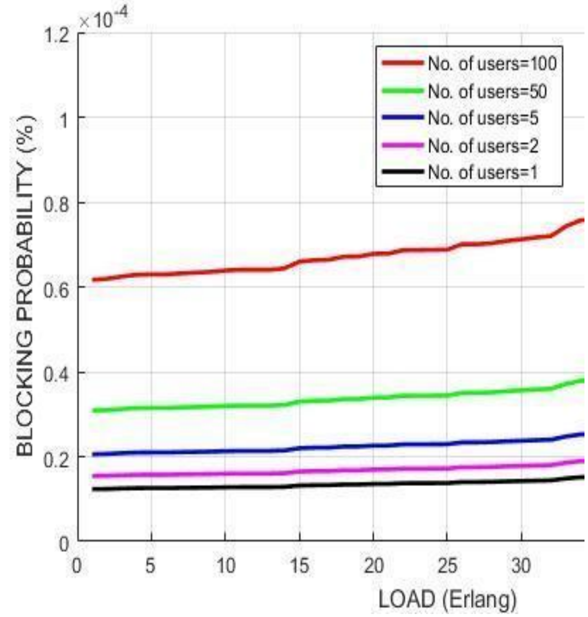

Fig. 7: Blocking probability as a function of load

from the source to the destination user is very less even if the simulation time of the whole process is more by using the proposed algorithm. Thus, the proposed approach is able to achieve high packet deliveries and high throughput which in turn decreases the path delays and packet drops. Therefore, the network becomes more stable with high responses as the packet drops are less.

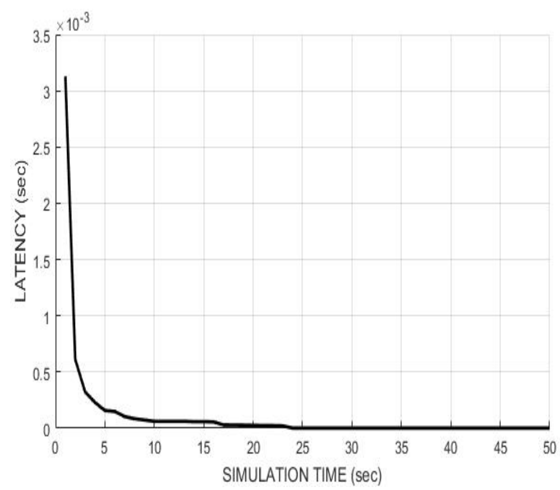

Fig. 8: Latency as a function of Simulation Time

The overheads after optimization are plotted as a function of number of iterations in Fig. 9. The overheads are linked with loss of packets. The route overhead must be low for high packet deliveries and less packet losses. If the route overhead increases, then the path delay increases and the load on the nodes through which packets are broadcasting also increases. So the route overhead must be low as much as possible. The plot reveals that as the number of iterations performed increases, the overheads get optimized which in turn improves the quality of service of GMPLS optical networks.

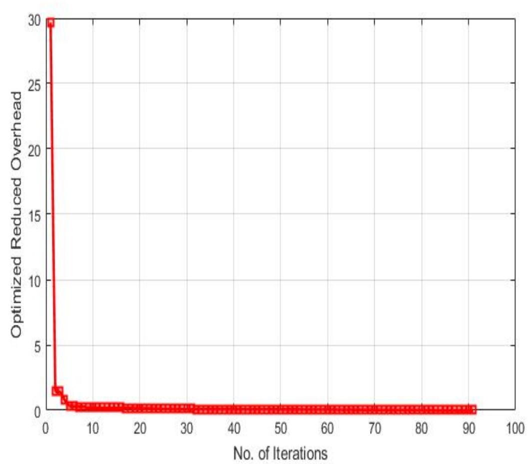

Fig. 9: Optimized reduced overheads as a function of number of Iterations

COMPARISON OF PROPOSED ALGORITHM OVER NETWORK IMPLEMENTING METWITH AND WITHOUT OPTIMIZATION

The performance of GMPLS network implementing proposed hybrid optimization algorithm is then compared with the network implementing MET technique without optimization and another network implementing MET technique with optimization using PSO.

Fig. 10 compares the performance of GMPLS optical networks under different scenarios (a) when MET is implemented (b) PSO is used for optimization after implementing MET (c) when proposed hybrid optimization algorithm involving WRR and PSO is used. The variation of blocking probability with increasing number of available wavelengths is plotted. The plot reveals that the proposed approach is able to achieve lowest blocking probability with increasing number of wavelengths.

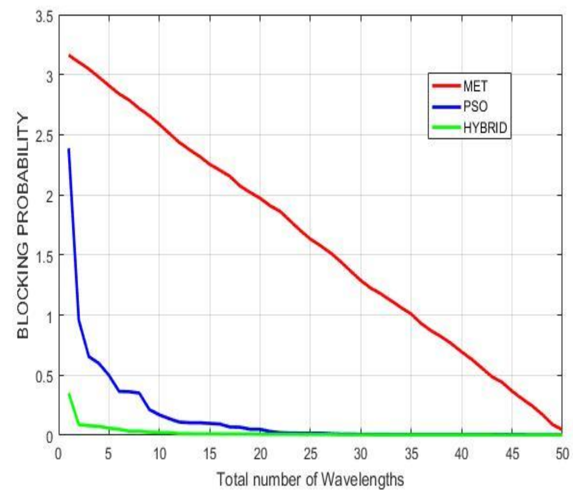

Fig.10: Blocking Probability as a function of number of available wavelengths

The performance comparison of GMPLS optical networks with respect to traffic load under the above mentioned three different scenarios is shown in Fig. 11. The graph exposes that the proposed method attains nominal blocking probability with escalating traffic load. It is so because the proposed algorithm makes the accessibility of wavelengths recurrent by incorporating the thought of MET due to which additional traffic load can be gripped without blocking. The adequate and shared bandwidths get available at path links to transfer the packets from source to destination consumer. Thus, the rate of call drops decreases which in turn decreases the blocking probability with increasing traffic load.

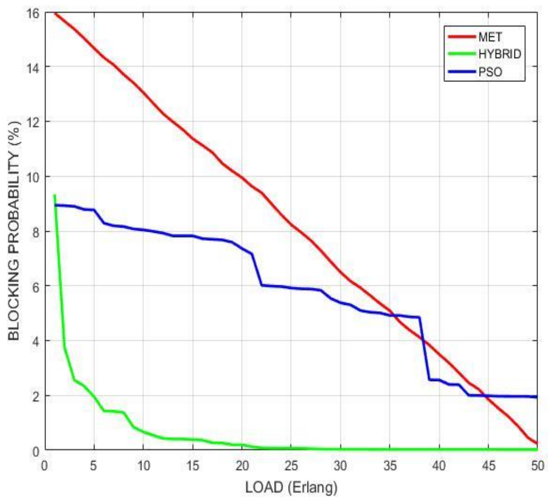

Fig. 11: Blocking probability as a function of load comparing different scenarios

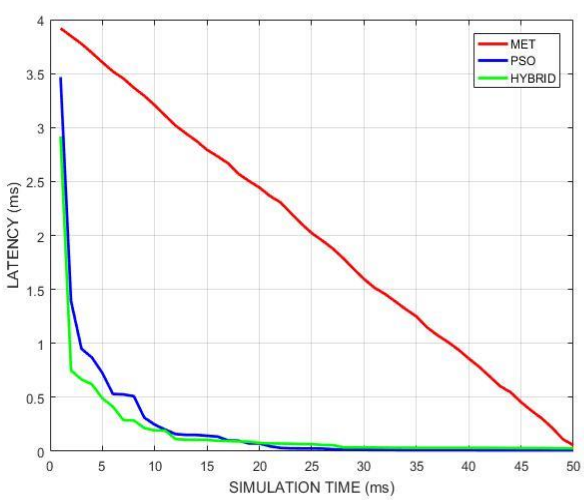

Fig. 12: Latency as a function of Simulation Time under different scenarios

The performance of GMPLS optical networks in terms of latency and simulation time under these three different scenarios is compared in Fig. 12. The variation of latency with increasing simulation time is plotted. Simulation time is an approximate imitation of the process. The latency shows the actual time taken in delivering the packets from source to destination. Lower the latency less is the computation time. The graph shows that the time taken to transmit the data from the source to the destination user is very less even if the simulation time of the whole process is more by using the proposed algorithm as compared to the other scenarios. Thus, the proposed approach is able to achieve lower path delays and reduced packet drops. Therefore, the network becomes more stable.

CONCLUSION

A new algorithm is proposed for optimizing the bandwidth allocation and path computation in an efficient manner for proper utilization of available resources and also for reducing the blocking probability in the GMPLS optical network which in turn improves the quality of service. The proposed algorithm hybridizes the functioning of MET, WRR and PSO. The WRR technique is used for load balancing scheduling which helps in calculating the minimum energy consuming path. PSO is being used for reducing the overheads which in turn decreases congestion in the optical networks. It involves scheduling in which the task (data transfer) completion time at each server is predicted and the server with least execution time is assigned to the respective user. The proposed technique controls the load imbalances on the destination users to transmit requests in the GMPLS optical network. Thus, the availability of wavelengths increases as the task gets completed in minimum time which decreases the latency in the network. Due to the availability of more wavelengths at the time of new requests, the rate of call drops decreases and more number of calls get handled in the network which in turn decreases the network blocking probability. The value of blocking probability remains below 1% which is acceptable in the GMPLS optical network by using the proposed hybrid optimization algorithm. The latency and overheads also decreases in the network.

Acknowledgement

The work has been supported by Visvesvaraya Ph.D Scheme for Electronics and IT, Ministry of Electronics and Information Technology, Government of India. The unique awardee number is VISPHD-MEITY-1669.

REFERENCES

Anjali, T. 2004. Threshold based policy for LSP and lightpath setup in GMPLS networks. IEEE Conf. on Comm. 4:1927-1931.

Berde, B. 2005. Improving network performance through policy-based management applied to generalized multi-protocol label switching ISCC. 739-745.

Boucherie. 2011. Queueing Networks-A Fundamental Approach. Int. Series in Oper. Research & Mgmt Sci. 54:121- 140.

Bouzid, A. 2015. Proof of concept of DiffServ-aware MPLS traffic engineering: A VoIP-based approach. IJIRS, 4(3): 801-806.

Dallaglio, M. 2015. Provisioning and restoration with slice ability in GMPLS based elastic optical networks. J. Opt. Comm. Netw. 7(2):309-317.

Demir, M. 2018. Unified Resource Allocation and MobilityManagement Technique Using ParticleSwarm Optimization for VLC Networks. IEEE Photonics Journal. 10(4):1-10.

Ge, F. 2016. Blocking performance approximation in flexi-grid networks. OFT. 32:58-65.

Ho, P. 2008. Spare capacity reprovisioning for shared backup path protection in dynamic generalized multi protocol label switched networks. IEEE Trans. on reliability. 57(4):551-563.

Hemamalini, M. 2016. Performance Analysis of Balanced Minimum Execution Time Grid Task scheduling Algorithm. Int. J. Comm. & Netw. Sys. 5(2):96-100.

Jerram, N. 2001. MPLS in Optical Networks. Metaswitch Netw. White paper.

Kaur, M. 2014. Performance optimization of GMPLS networks with finite number of sources. Int. J. Light & Elect. Opt. 125(3):1271-1274.

Mir, U. 2014. Diffserv-aware multi protocol label switching based quality of service in next generation networks. IACC, 233-238.

Madni, SHH. 2017. Performance comparison of heuristic algorithms for task scheduling in IaaS cloud computing environment. PLoS ONE. 12(5):1-26.

Papadimitriou, D.2006. Generalized Multi-Protocol Label Switching (GMPLS) Unified control plane validation. IEEE Int. Conf. on Comm. 6:2717-2724.

Ramaswami, R. 1995. Routing and wavelength assignment in All Optical Networks. IEEE/ACM Trans. on Netw. 3(5): 489-500.

Singh, S. 2014. Novel Optical Flat Gain Hybrid Amplifier for Dense Wavelength Division Multiplexed System. IEEE Photonics Tech. Lett. 26(2):173-176.

Singh, S. 2016. Security enhancement in optical code division multiplexed system using anti jamming technique. OAMRC, 10(9-10):680-684.

Singh, S. 2016. Performance enhancement of recycling residual pumped hybrid Raman-EDFA in bi-directional wavelength division multiplexed- passive optical network. OAMRC. 11(12-13).

Sabiya. 2016. Weighted Round-Robin Load Balancing Using Software Defined Networking. IJARCS. 6(6):621-625.

Singh, S. 2017. Bandwidth Efficient Hybrid Modulation Technique in the Scenario of 3.5 Tb/S Dense Wavelength Division Multiplexed System. OAMRC, 11(1-2):51-53.

Tadapaneni. 2020. A Survey Of Various Load Balancing Algorithms in Cloud Computing. IJSAR. 6:1-3.

Wason, A. 2011. Blocking in wavelength-routed all-optical WDM network with wavelength conversion. Optik. 122: 631–634.

Xiao, G. 1999. Algorithms for allocating wavelength converters in All Optical Networks. IEEE/ACM Trans. on Netw. 7(4):545-557.