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New QOS Routing Algorithm for MPLS Networks Using Delay and Bandwidth Constraints

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ABSTRACT

Multi- Protocol Label Switching (MPLS) has been proposed as a new approach which combines the benefits of interworking and routing in layer 3 and layer 2 i.e Network layer and Data Link Layer. But its major technological significance lies in implementing Traffic Engineering. The most important requirement of TE is that the characteristics, as well as resource availability, on links on the network (in addition to bandwidth that would be used for cost computations) be propagated across the network to allow efficient choice of possible TE LSP paths. In this paper we propose a new constraint based routing algorithm for MPLS networks. The proposed algorithm uses both bandwidth and delay constraints. It means that the delay of the path which is computed by the algorithm is less than or equal to the delay constraint value and the residual bandwidth of all the links along the computed path must be equal to or greater than the bandwidth constraint value. In the proposed algorithm best path is computed based on avoiding critical links to reduce call blocking rate, deleting the paths which are not satisfying the bandwidth and delay constraints to reduce complexity of the algorithm and using shortest path algorithm to reduce path length. The proposed algorithm also compares two different topologies to study the performance of our proposed algorithm.

Keywords: *MPLS Networks, QOS Routing Protocols, Traffic Engineering, Path Selection, Constraint Based Routing*

I. INTRODUCTION

Internet has become an integrated carrier gradually, which has multi business such as data, voice, video, multimedia and so on. New multimedia applications require the network to guarantee quality of service. MPLS network has the capability of routing with some specific constraints for supporting desired QOS. Rather than replacing IP routing, MPLS is designed to overlay its functionality on top of existing and future routing technologies and to work across a variety of physical layers to enable efficient data forwarding together with reservation of bandwidth for traffic flows with differing QOS requirements regarding bandwidth, delay, jitter, packet loss and reliability.

MPLS is an efficient encapsulation mechanism which uses labels appended to packets for transport of data. A router supporting MPLS is a label switched router. An edge node is an LSR connected to a non- LSR. An ingress LSR is the one by which a packet enters the MPLS network, an egress LSR is one by which a packet leaves the MPLS network. Labels are small identifiers placed in the traffic. They are inserted by the ingress LSR, and ultimately removed by the egress LSR. As traffic transits the MPLS network, label tables are consulted in each MPLS device. These are known as the Label Information Base or LIB. By looking up the inbound interface and the label in the LIB, the outbound interface and label are determined. The LSR can then substitute the outbound label for the incoming and forward the frame . The labels are locally significant only, meaning that the label is only useful and relevant on a single link , between adjacent LSRs. The adjacent LSR label tables however should end up forming a path through small or all of the MPLS network, a label switched path (LSP) , so that when a label is applied, traffic transits multiple LSRs. If traffic is found to have no label, a routing lookup is done and possibly a new label applied.

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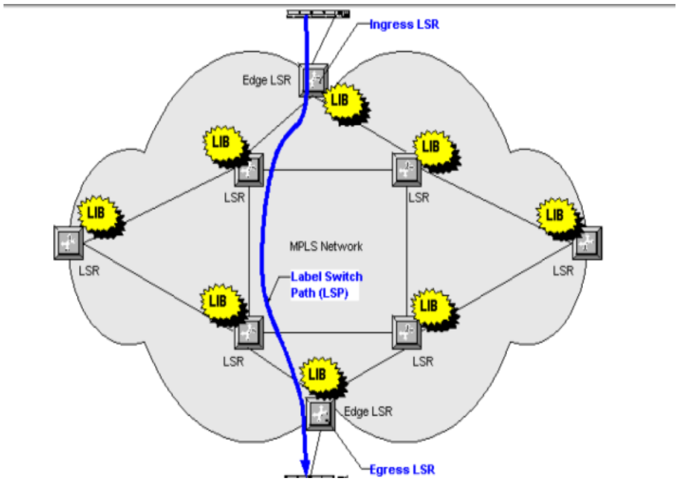

Fig. MPLS Network

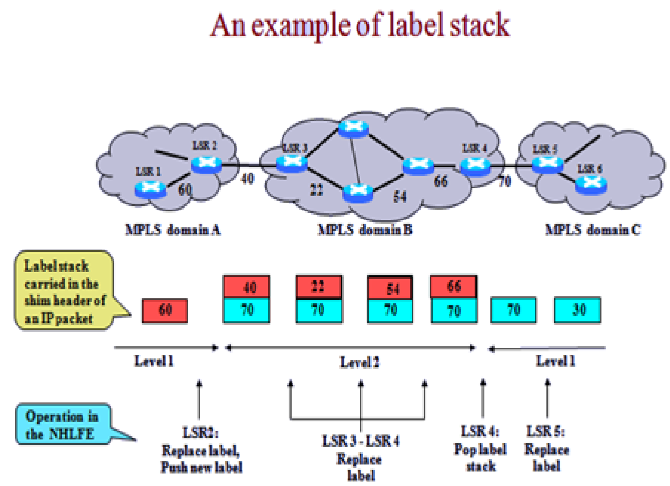

Fig 2 MPLS Label Stack

MPLS Operation

MPLS [10] works by prefixing packets with an MPLS header, containing one or more labels. This is called a label stack. Each label stack entry contains four fields:

- A 20 bit label value.
- A 3-bit Traffic class field for QOS priority(experimental) and ECN(Explicit Congestion Notification)
- A 1 bit bottom of stack flag. If this is set , it signifies that the current label is the last in the stack.
- An 8 bit TTL (Time to Live) field.
-

These MPLS labelled packets are switched after a label lookup/switch instead of a lookup into the IP table. Labels are distributed between LER's and LSR's using the Label Distribution Protocol (LDP). LSR's in an MPLS network regularly exchange label and reachability information with each other using standardized procedures in order to build a complete picture of the network they can then use to forward packets. When an unlabeled packet enters the ingress router and needs to be passed on to an MPLS tunnel, the router first determines the forwarding equivalence class (FEC) the packet should be in and then inserts one or more labels in the packet's newly created MPLS header. The packet is then passed onto the next hop router for this tunnel. When a labelled packet is received by an MPLS Router , the topmost label is examined .

Based on the contents of the Label a swap, push or pop operation can be performed on the packet's label stack. Routers can have prebuilt lookup tables that tell them which kind of operation to do based on the topmost label of the incoming packet so they can process the packet very quickly.

To ensure end to end QOS guarantees [8],[9], QOS routing protocols usually impose a minimum QOS requirement on the path for data transmission . Restricting the hop count of the path being elected can reduce the resource consumption while selecting the least loaded path can balance the network load. There exist many QOS routing protocols in MPLS networks. All of them can find an optimal path by using their path selection algorithms. In this paper we focus on both `bandwidth and delay constraints. It means that the delay of the path which is computed by the algorithm is less than or equal to the delay constraint value and the residual bandwidth of all the links along the computed path must be equal to or greater than the bandwidth constraint value. The proposed MPLS Routing algorithm called New QOS Routing Algorithm for MPLS Networks Using Delay and Bandwidth constraints present performance improvement based on CPU Time, path length, call back ratio and maximum flow. The rest of the paper is organized as follows. In section II , we presents related work. Our proposed routing algorithm is described in section III. Section IV contains the performance evaluation. Conclusions are set out in section V.

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II. RELATED WORK

First we review some of the most popular algorithms, such as the Minimum Hop algorithm (MHA), the widest shortest path algorithm (WSP),the minimum interference routing algorithm (MIRA)[1], and Bandwidth guaranteed MPLS Routing Algorithm (BGMRA). These algorithms take into account the topological layout of the ingress and egress points of the network.

Min-Hop Algorithm

The Min-Hop algorithm chooses the path with the least number of links between source and destination. This scheme based on Dijkstra's algorithm is simple and computationally efficient. However, using MHA can result in heavily loaded bottleneck links in the network, as it tends to overload some links leaving others underutilized.

Widest Shortest path algorithm

The widest shortest path algorithm is an improvement of the Min- Hop algorithm, as it attempts to balance the network load. WSP chooses a feasible path with minimum number of links, and if there are multiple such paths, the one with the largest residual bandwidth, thus discouraging the use of already heavily loaded links. However, WSP still has the same drawbacks as MHA since the path selection is performed among the shortest feasible paths that are used until saturation before switching to longer feasible paths.

Shortest Widest Path Algorithm

The shortest widest path algorithm selects the path with the maximum available bandwidth and if there are more than one such path, the one with the least number of hops is chosen. SWP also create bottlenecks for future LSPs and lead to network underutilization.

Minimum Interference Routing Algorithm

The key idea of MIRA is to route a new connection over a path which least interferes with possible future requests. MIRA exploits the knowledge of ingress-egress pairs in finding a feasible path. The main aim is to route a new connection through a path that does not interfere with a path that may be critical to satisfy a future demand. Here, a critical link, is identified as a link that can decrease the maximum flow (max-flow) value of one or more ingress-egress pair if critical link has been selected in a path. The algorithm attempts to avoid the critical links as much as possible during a path selection procedure. In Fact, MIRA considers the amount of interference on a particular ingress-egress pair (s,d) as the reduction in the maximal available bandwidth between (s,d).[2] With this type of algorithm, the path lengths can become long enough to make path practically unusable.

III. PROPOSED ALGORITHM

This section presents a New QOS Routing Algorithm for MPLS Networks Using Bandwidth and Delay as constraints. To explain proposed algorithm consider a network with n nodes (routers) . To setup the paths a subset of these routers is considered to be the ingress-egress routers. A path setup request arrives at the ingress router in which an explicit route for the request is computed locally. The ingress router set up the path to the egress and reserves resources on each link along the path. For computation of explicit route, ingress router requires to know current network topology, links reserved bandwidth and minimum delay which we are assuming to be known. Our optimization goal is as follows: to determine a feasible path for each request which satisfies the constraints of bandwidth and delay and performs better in terms of call blocking ratio, path length, CPU time and maximum flow[3].

Our proposed algorithm is one of link constrained and path constrained routing. The designing objectives, weight calculation, path selection and the details of the routing algorithm for our proposed algorithm are described here:

Designing Objectives

- Minimize interference levels among source-destination node pairs, in order to reserve more resource for future bandwidth demands.
- Balancing traffic loads through underutilized paths in order to reduce network congestion.
- Optimize the network resource utilization using Dijkstra's algorithm.
- Reduce algorithm complexity.

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Calculation of Critical links

$$C(j) = \frac{Total\ demands\ per\ link}{Length\ of\ all\ possible\ connections} \qquad (1)$$

From (1), critical links directly depends on the value of total demands per link. Higher value of criticality means that numbers of future requests are possible through these ingress-egress routers. So, avoid critical links with higher values to reduce network congestion. It also satisfies the first objective to minimize interference levels among source-destination node pairs.

Calculation of Link Weight

Here weight of link j could be determined by:

$$W(j) = \frac{C(L)}{Residual\ bandwidth\ of\ the\ link} \qquad (2)$$

From (2), Weight of the link is directly proportional to critical links and hence higher the value of criticality, higher will be the weight of that particular link (j). Also, it is inversely proportional to the Residual bandwidth, so when residual bandwidth is less, weight of the link will be more. So in the proposed algorithm ,we are avoiding the link with more weight, so as to balance loads through under utilized paths.

Calculation of path

The weight of path belonging to source destination node pair {S,D} is obtained by (3)

$$W\{S,D\} = \sum W(j) \qquad where\ \{j \in L\{S,D\}\} \qquad (4)$$

This path weight is used to route LSP from ingress node S to egress node D. The constraint is to avoid the path with more path weight. However, if there are many result paths with the same minimum path weight, the algorithm would pick a shortest path between those result paths in order to reserve network bandwidth.

Algorithm steps

The algorithm steps are shown in Fig 3:

Bandwidth and Delay Guaranteed MPLS Routing Algorithm

1.) Compute C(j) i.e the critical links according to formula (1)
2.) Compute weight of link according to formula (2)
3.) Use Minimum Interference routing algorithm to obtain the path with minimum path weight W{S,D}.
4.) Prune the paths to select the best path as follows:
    Suppose (j,k) is the link between nodes j and k
    (i) If Bandwidth(j,k) < bandwidth constraint then delete paths containing link (j,k)
    (ii) If Delay(j,k)> delay constraint then delete paths containing link (j,k).
5.)Use Dijkstra's routing algorithm to obtain the shortest path among the path selected.
6.) Establish the best path with requested bandwidth and delay constraints.
7.) If no path selected the algorithm fails.

Figure. 3 Bandwidth and delay Guaranteed MPLS Routing Algorithm

Simulation Test

For simulation study, we develop extensive routing simulation program on MATLAB 7.12.0 (R2011a). The topology adopted from [4],[5] is called MIRA topology and consists of 15 nodes as shown in Fig. 4(a). There are two different kinds of links in the network: the thin links have the capacity of 1200 units and the thick links have the capacity of 4800 units. A subset of the nodes in the network acts as the ingress- egress pairs. The second topology adopted from [6] which consists of 18 nodes and 30 links and is presented in Fig 4 (b). There are two different kinds of links in the network: the thin links have the capacity of 1200 units and the thick links have the capacity of 4800 units.

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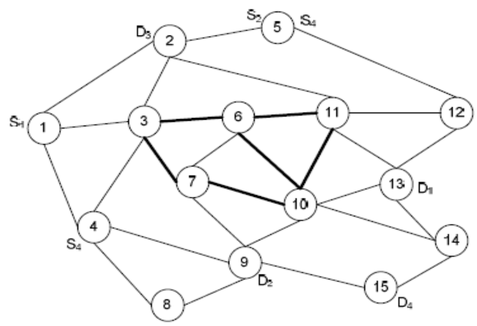


Fig 4(a) MIRA Topology

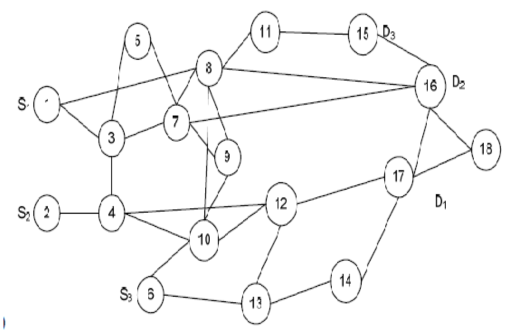


Fig 4 (b) Network Topology 2

IV. PERFORMANCE EVALUATION

From the simulation program, there are 4 measured parameters to test the performance of algorithms, i.e , call back ratio, mean length, maximum flow and CPU calculation time. These parameters can be obtained from(5) to (8). MPLS Routing algorithm must have low call blocking ratio, less mean path length, high maximum flow and low CPU calculation time

$$Call\ back\ Ratio = \frac{Number\ of\ requests\ rejected}{Total\ number\ of\ requests} \quad (5)$$

$$Mean\ Length = \frac{Total\ number\ of\ links}{Total\ number\ of\ requests - Number\ of\ requests\ rejected} \quad (6)$$

$$Maximum\ Flow = mean\ (available\ bandwidth) \quad (7)$$

$$CPU\ Time = Total\ Simulation\ Time \quad (8)$$

Results

We have performed simulations using each of these two topologies and found better results in terms of Call back Ratio and CPU calculation time. Fig 6 and Fig. 7 shows the result of simulation on MIRA Topology with different requirements of user in terms of bandwidth and delay constraints. Fig. 6 (a) show the mean path length for bandwidth requirement of user as 1 unit and delay requirement as 1 unit.

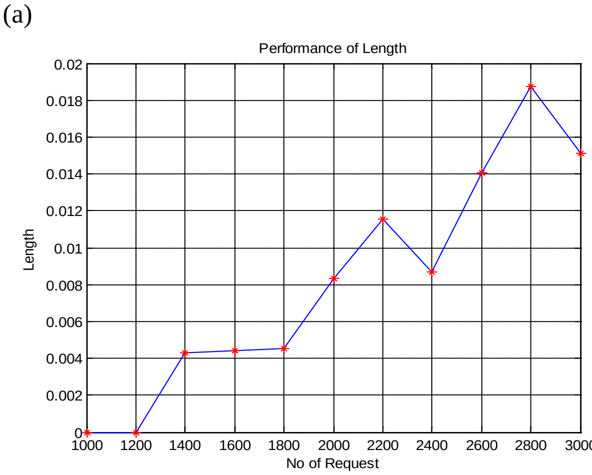
Fig. 7 (a) show the mean path length for user bandwidth requirement as 5 units and delay reduced to half of the previous units. We observed from the graph that the path length increases with the increase in number of requests and it is more when the user bandwidth requirement is increased and delay requirement is reduced.

Fig.6 (b) and 7(b) shows plots for call blocking ratio versus number of requests. We observed that with increasing number of requests, the call blocking ratio increases consistently and when the user bandwidth requirement is increased and delay requirement is reduced , then also the call blocking ratio is almost same.

Fig 6 © and 7 © shows plots for Maximum Flow . Maximum available Flow is decreasing as the number of requests is increasing but in this case also the results are same as the user requirements in terms of bandwidth and delay is changed.

Fig 6 (d) and 7 (d) shows plots for CPU Time versus number of requests. We observed that the performance of CPU Time is increasing as the number of requests are increasing but our proposed algorithm shows almost same performance of CPU Time for the same network with different BW and delay requirements.

(a)



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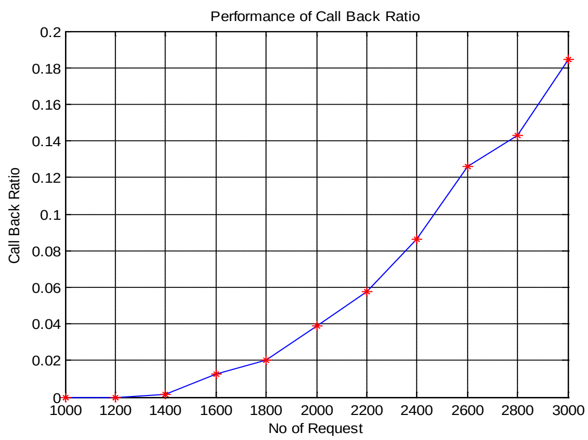
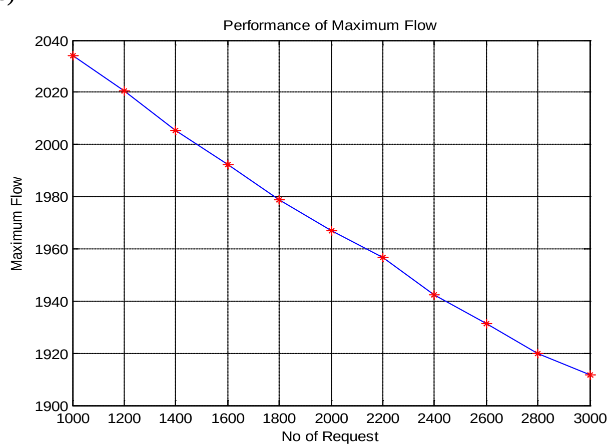
(b)



(c)



(d)

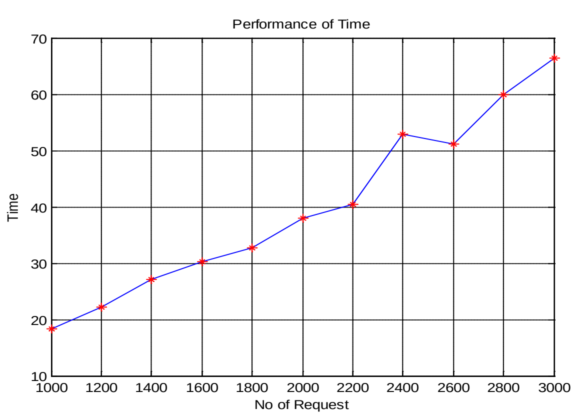
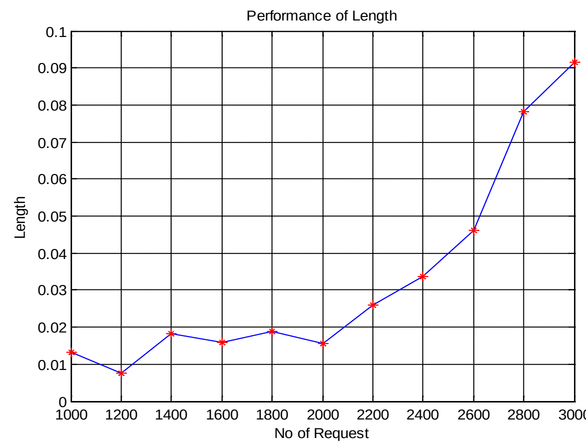


Fig 6: Simulation result about topology 1 (a) performance of mean path length (b) Performance of call back ratio (c) Performance of Maximum Flow (d) performance of CPU Time.

(a)



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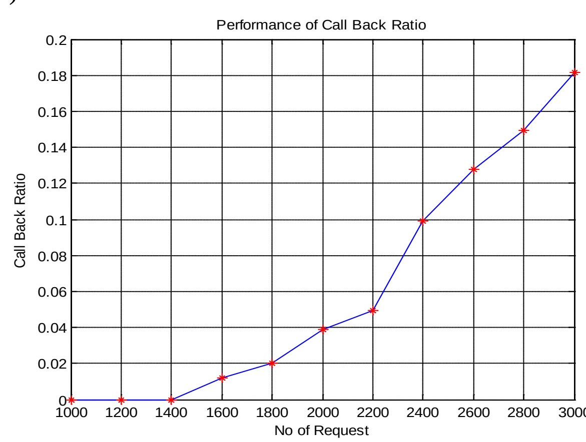

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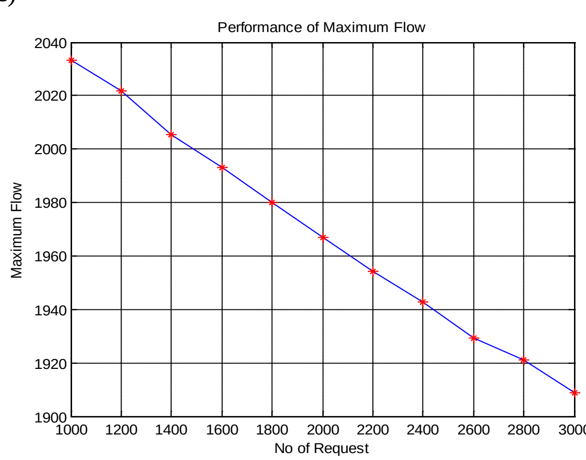

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(d)

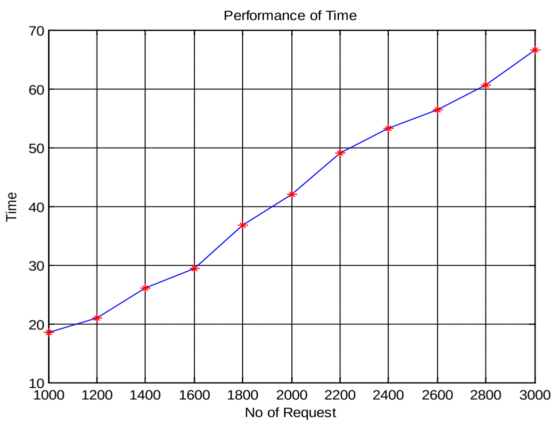


Fig 7: Simulation result about topology 1 with user Bandwidth requirement taken is five times and delay requirement is half of the previous results (a) performance of mean path length (b) Performance of call back ratio (c) Performance of Maximum Flow (d) performance of CPU Time.

Table 1: Comparison table with different user Bandwidth and delay requirement (Topology 1)

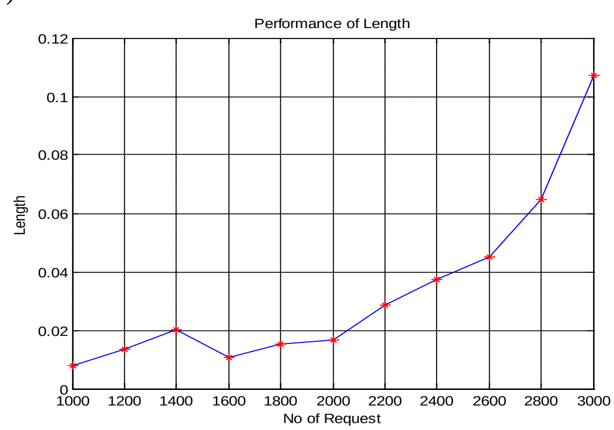
S.No	User Bandwidth 1 Unit and Delay 1 Unit			User Bandwidth 5 Units and Delay 0.5 unit		
No.of Requests	1000	2000	3000	1000	2000	3000
Mean Path Length	0	0.008	0.015	0.015	0.015	0.09
Call Blocking Ratio	0	0.04	0.185	0	0.04	0.18
Maximum Flow	2035	1965	1910	2035	1965	1910
CPU Time	19	38	65	19	42	66

Fig 8 and Fig. 9 shows the result of simulation on second Topology with different requirements of user in terms of bandwidth and delay constraints. Fig. 8 (a) show the mean path length for bandwidth requirement of user as 1 unit and delay requirement as 1 unit. Fig. 9 (a) show the mean path length for user bandwidth requirement as 5 units and delay reduced to half of the previous units. We observed from the graph that the path length increases with the increase in number of requests and it is more when the user bandwidth requirement is increased and delay requirement is reduced. Also as compared to MIRA Topology the performance of our program is better with more number of nodes and complex topology.

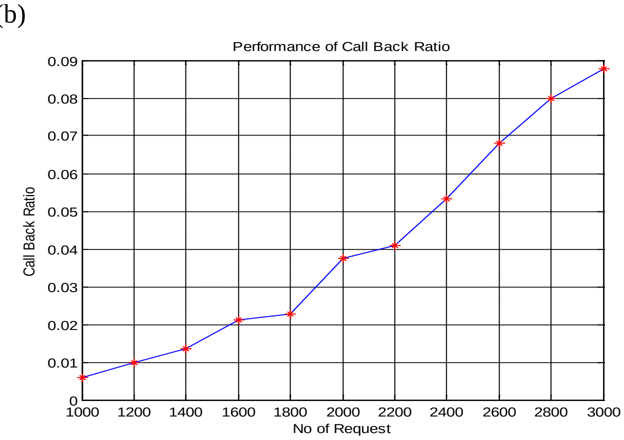
Fig.8 (b) and 9(b) shows plots for call blocking ratio versus number of requests for second topology with different requirements of user in terms of Bandwidth and Delay. In terms of call blocking ratio also our program gives better results with more complex 18 nodes topology. Fig 8 © and 9 © shows plots for Maximum Flow for second topology with different requirements of Bandwidth and delay . Maximum available Flow is decreasing as the number of requests is increasing but in this case the results are better for the MIRA topology.

8 (d) and 9 (d) shows plots for CPU Time versus number of requests with different requirements of user in terms of Bandwidth and delay. We observed that the performance of CPU Time is increasing as the number of requests are increasing but our proposed algorithm shows better results for more complex topology.

(a)



(b)



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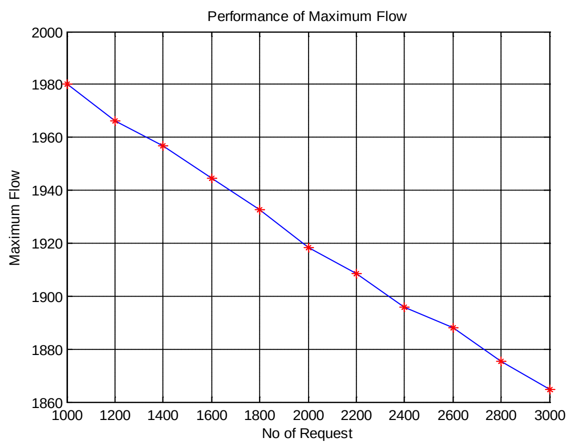
(c)



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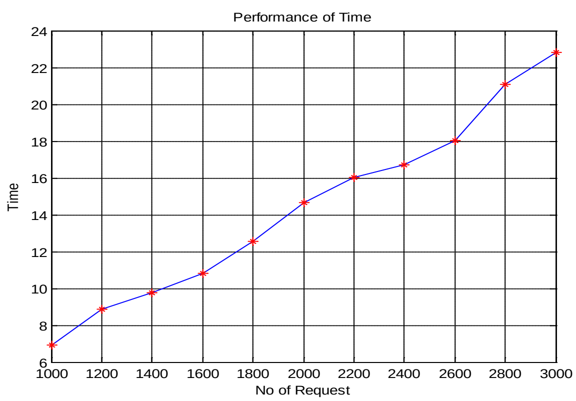
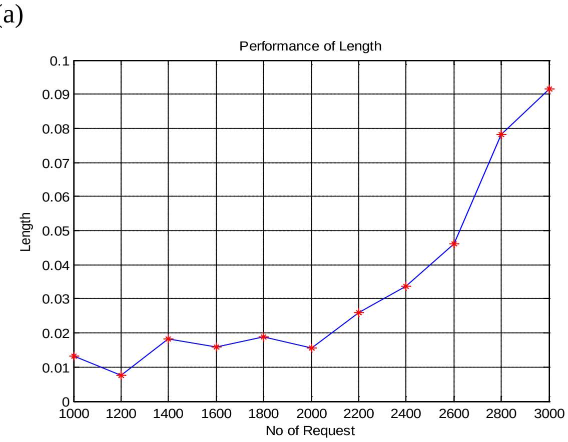
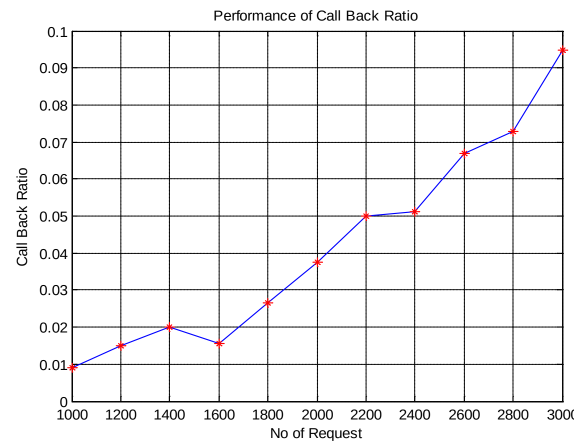


Fig: 8 Simulation Result about Topology 2 (a) Performance of Mean Path length (b) Performance of Call Back Ratio (c)Performance of Maximum Flow (d) Performance of CPU Time.

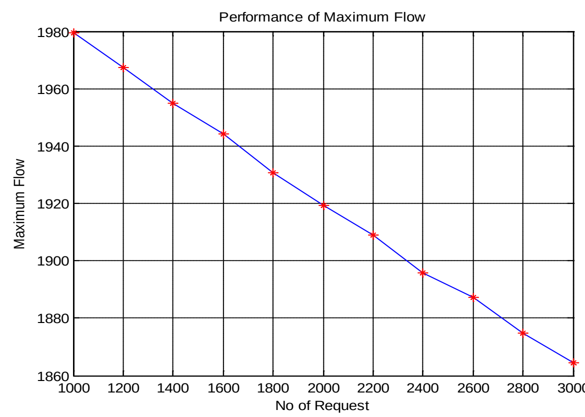
(a)



(b)



(c)



(d)

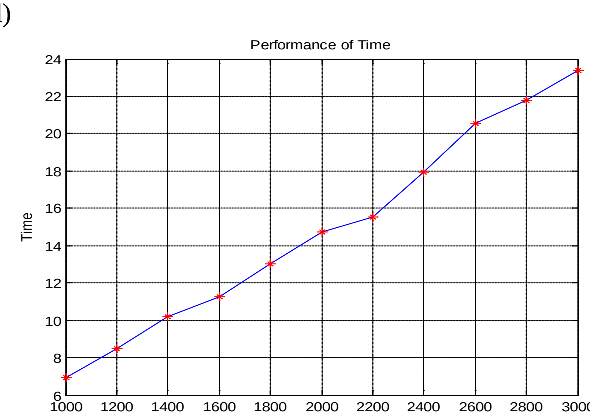


Fig 9: Simulation result about topology 2 with user Bandwidth requirement taken is five times and delay requirement is half of the previous results (a) performance of mean path length (b) Performance of call back ratio (c) Performance of Maximum Flow (d) performance of CPU Time.

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Table 2: Comparison Table with different user Bandwidth and Delay Requirement (Topology 2)

S.No	User Bandwidth 1 Unit and Delay 1 Unit			User Bandwidth 5 Units and Delay 0.5 unit		
No.of Requests	1000	2000	3000	1000	2000	3000
Mean Path Length	0.01	0.016	0.11	0.013	0.016	0.09
Call Blocking Ratio	0.005	0.038	0.088	0.01	0.038	0.095
Maximum Flow	1980	1920	1862	1980	1920	1865
CPU Time	7	15	23	7	15	23

Simulation results show that we have optimized goal with a simple path computation technique. Our algorithm can lead to improved performance and provides better network utilization for Bandwidth and delay guaranteed constrained applications since it selects the uncongested and shortest path to reach the destination node. It also reduces CPU Time by pruning the links from the topology which are not satisfying the Bandwidth and delay constraints[11].

V. CONCLUSION

In this paper, we have proposed a new QOS Routing algorithm for MPLS networks, using Bandwidth and delay as constraints. Paths are selected based on critical links so as to minimize interference with the future requests. Simulation experiments have been conducted to examine the performance of new algorithm using two different network topologies. We observed that our proposed algorithm performs better for complex network in terms of call blocking ratio and CPU Time.

REFERENCES

[1] Antonio Capone, Luigi Fratta, Fabio Martigon, " Dynamic online QOS Routing schemes: Performance and bounds, Article in press, Science Direct, Computer Networks (2005)

[2] Koushik Kar, Murali Kodialam, T. V. Lakshman, "Minimum Interference Routing of Bandwidth Guaranteed Tunnels with MPLS Traffic Engineering Applications", IEEE Journal On Selected Areas In Communications, VOL. 18, No. 12, December 2000.

[3] Alidadi A., Mahdavi M., Hashmi M.R., "A New Low-Complexity QOS Routing Algorithm for MPLS Traffic Engineering", Proceedings of the 2009 IEEE 9th Malaysia International Conference on Communications 15-17 December 2009 Kuala Lumpur Malaysia, Pg 205-210.

[4] M. Kodialam, T.V. Lakshman, Minimum Interference Routing with applications to MPLS traffic engineering, IEEE INFOCOM 2000, March 2000

[5] Kotti, A. Hamza, R. Bouleimen, K,"Bandwidth Constrained Routing Algorithm for MPLS Traffic Engineering", Networking and Services, ICNS, Third International Conference on, 19-25 June 2007

[6] Gopalan, K, and Chiueh, T.C. and Lin, Y.J, "Load balancing routing with bandwidth- delay guarantees", IEEE Commiuiicurionr Magazine, Vol 42, pp 108-113, June 2004.

[7] Piyaporn Krachodnok, "Constrained Based Routing with Maximize Residual Bandwidth and Link Capacity- Minimize Total Flows Routing Algorithm for MPLS Networks, IEEE, ICICS 2005, Pg 1509-1513.

[8] S. Chen, K.Nahrstedt, "An overview of quality of service routing for the next generation high speed networks: problems and solutions, IEEE Network 12 (6)(1988) 64-79.

[9] Bin Wang, Xu Su, C.L.P Chen, A new bandwidth guaranteed routing algorithm for MPLS traffic Engineering, in: IEEE International Conference on Communications, ICC 2002, vol 2 , 2002, pp 1001-1005

[10] E. Rosen, A. Vishwanathan, R. Callon, Multiprotocol Label Switching Architecture, in: IET

[11] Mohammad Hossien Yaghmae, Ali Asghar Safaeei , Quality of Service routing in MPLS Networks Using Delay and Bandwidth Constraints