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A New Routing Algorithm: MIRAD

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Abstract**—**LSP routing is among the prominent issues in MPLS networks traffic engineering. The objective of this routing is to increase number of the accepted requests while guaranteeing the quality of service (QoS). Requested bandwidth is the most important QoS criterion that is considered in literatures, and a various number of heuristic algorithms have been presented with that regards. Many of these algorithms prevent flows through bottlenecks of the network in order to perform load balancing, which impedes optimum operation of the network. Here, a modern routing algorithm is proposed as MIRAD: having a little information of the network topology, links residual bandwidth, and any knowledge of the prospective requests it provides every request with a maximum bandwidth as well as minimum end-to-end delay via uniform load distribution across the network. Simulation results of the proposed algorithm show a better efficiency in comparison with similar algorithms.

Keywords**—**new generation networks, QoS, traffic engineering, MPLS, QoS based routing, LSP

I. Introduction

EMERGENCE of multimedia and real-time applications in communication networks a long with proliferation of IP networks brings about new generation networks. Capitalizing on the common kernel of the new generation networks, which are IP based, various traffics, say, conversation service, video images, audio and information files are exchanged. So, in the new generation network, Real-time traffics like voice, so sensitive to end-to-end delay, as well as best- effort, which merely considers bandwidth, are exchanged. Meanwhile the increase of network traffics and diverse QoS requirements inspired the service providers to apply traffic engineering in order to satisfy their clients, increase their productivity and profits, and meet the requested QoS of nowadays networks [1]. Mapping of traffic flows onto physical topology of a network is called traffic engineering, where it tries to increase network throughput through appropriate distribution of the traffic in the network. The primitive consequence of that is avoiding traffic congestion. Considering the inherent characteristics of IP protocol, which are best- effort oriented, there is no feasibility of traffic engineering application.

The principle of routing in IP protocol, which is the main routing protocol in internet, is based on destination address. Each router of the network directs a package to the next router according to the routing table and package destination address. IP protocol does not guarantee the delivery of the package to the destination. The criterion it considers in routing is the minimum number of jitters, which causes collision in the network and inappropriate traffic distribution, on its own. Moreover, shared usage of data flows in peak-time results in insufficient allocation of resources for desirable QoS [1]. There have been proposed some solution such as MPLS, which relays on label switched path (LSP) [2], where an explicit LSP identifies packet passage path. This path is sometimes called tunnel and its resources are reserved by signaling protocols such as RSVP or CR-LDP [3]. Using explicit LSP in MPLS, it is possible to allocate a specific path for every data flow in the network, and reserve its required resources there.

As the paths of packets are distinct in MPLS networks, it is possible to employ traffic engineering on these paths, and guarantee various requirements of QoS such as: delay, delay variations, number of jitters, bandwidth and so forth.

Routing algorithms are categorized as offline and online in [4]. In the offline, all the information of label paths are given at the outset of the path computation and the aim is the optimal usage of the resources. While in the online, every request is routed independently and regardless of prior and subsequent path’s information. In this algorithm the aim is to maximize number of the accepted requests.

There are also combined algorithms, which comprise both the mentioned algorithms’ procedures. In the offline parts, there is no need of precise information of the paths, but a holistic scheme including total sending traffic from on router to another will suffice [4]. These kinds of issues are considered as NP-compete issues in [4] and [5]. But, in this paper, we focus on QoS-oriented routing, which categorized as constrict based routing, and in the proposed algorithm the maximum end-to-end delay, as QoS criterion, is guaranteed.

The rest of this paper is organized as follow: in section 2, a literature survey will be given. In section 3, main ideas of the proposed algorithm will be presented. In section 4, topology and simulation of the algorithm will be dealt. Sections 5 will presents simulation results in comparison with other algorithms’ results, and section 6 will conclude the paper.

II. Literature Survey

The purpose of QoS-oriented routing is to determine a path for the flow according to the available amount of resources and required QoS. It is also a dynamic routing which involves many various routing criteria [5]. In other words, it is a

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dynamic routing pattern which considers QoS criteria. The first and simplest algorithm which was used for LSP routing was Min-Hop algorithm (MHA) [6]. Here, LSP is routed with a minimum number of jitters. This algorithm results in unsymmetrical load distribution in the network, where some links turn to be bottlenecks.

Widest Shortest Path (WSP) was proposed as an improvement for MHA in [7]. This algorithm will select the route of more capacity in case there are several routes with the same number of hops. This means that: WSP distributes loads among all the routs when there are several routes between the desired nodes. However, this algorithm suffers from the same drawbacks as MHA does, and lacks high efficiency.

There has been proposed Minimum Interference Routing Algorithm (MIRA) in [4], which aims to reduce number of the blocked requests. It especially considers those network nodes which have the capability of being ingress or egress, and identifies them as P set. Those links which might be requested frequently are called critical links. There is a specific property with these links: when there is a flow through this links, total flows of the network decreases. So it's tried to avoid any flow through these links as far as possible. If there is a flow through this kind of link, the maximum flow of other ingress-egress pairs is reduced. This reduction is called interference. It is always tried to reduce this interference. The magnitude of the interference is computed using the maximum transferred flow. Each label switched path with (s_i, d_i, b) characteristic is routed using the following objective function.

$$\max \sum \max flow(s_i, d_i) \tag{1}$$

Where $\max flow(s, d)$ is the maximum transferable flow from node s to node d. So routing is performed in a way that: a minimum reduction occurs in the maximum transferable flow among nodes of set P.

But this method suffers from inability of guaranteeing the criteria such as number of jitters, delays and so forth. The other shortcoming of this algorithm is that it selects a longer path in order to shun flow through critical links which results in excess consumption of resources, and leads to further delay. This consequence is undesirable. The last but not least defect of the algorithm is that it might reject those kinds of requests for them there are sufficient resources in the network.

Bandwidth Constrain Routing Algorithm (BCRA) was proposed in [8], where load distribution is performed by means of path shortening. A defect of this method is neglecting information of the ingress and egress routers and network topology.

All the proposed algorithms in literature consider just the bandwidth of the request. Some doesn't operate optimally because of label path lengthening. And in others there are lots of blocked requests. While, in our proposed algorithm, not only is the performance of the network optimized through appropriate load distribution but bandwidth and end-to-end delay is guaranteed for real-time traffics as well.

III. Proposed Algorithm

In this algorithm, requests are taken one by one, and there is no information of previous and prospective requests. The only available information is the status of communication links considering the traffic engineering criteria. It is assumed, here, that all the paths are in service and there is no discontinuity.

The algorithm is modeled as $G(N, A)$ graph in which N represents nodes set and A represents its link set, n and m are the numbers of nodes and links respectively. Any link $l \in A$, connecting node u to node v, is represented with (u, v) pair and, for any criterion I, has its own weight as W_{ij}. Here links are categorized according to their roles, the ingress-egress nodes are identified as P-set nodes, and other routers perform as intermediate routers.

A. End-to-End Delay

According to LR server equation, end-to-end delay is the summation of all delays of the links in the path [9, 10]. For a typical path P, magnitude of end-to-end delay, D_m is computed as follow:

$$D_m = \frac{t-R}{t-r}.\frac{b}{R} + \sum_{(i,j)\in P} \left(\frac{M}{R} + \frac{M_{ij}^m}{C_{ij}} + prop_{ij}\right) \tag{2}$$

Where r is the request rate, t is maximum rate, b is volcanic rate, M is the maximum length of packet, M_{ij}^m is the maximum length of the label paths passage link (*i,j*). *Cij* is the link capacity. $prop_{ij}$ is the delay of link *(i,j)*, R is the minimum bandwidth allocated to LSP. Accordingly, the first term identifies wave shaping delay in ingress nodes and the second indentifies the amount of delay in the buffer queue of the path nodes and their propagation delay. Propagation delay is a physical characteristic of a link.

B. MIRAD Algorithm

Here, acuteness of critical ingress and egress links is obtained using MIRA algorithm in between inputs and outputs. Then, upper limit of the delay in the path is computed with (1). Should the computed value is greater than the desired one, the bandwidth of the link in the path which holds maximum value of the residual bandwidth will be increase by one unit. Delay of the path will be computed once more, and then the same procedure will iterate until the desired value of delay achieved. If the goal is not fulfilled, it means that the links are operating full-capacity. In this case the link which has the minimum bandwidth is identified as bottleneck and will be dismissed. Again with the new configuration, the shortest path will be selected and the delay computation will be performed. This procedure will continue until the desired path is obtained or the request is rejected. The scheme of the algorithm is given below as pseudo code.

TABLE I
MIRAD ALGORITHM

Input: *G(N,L)*, a LSP Request *(s,d,TSpec,RSpec)*, distance matrix
Output: route X_i with desire QoS metric or reject request

1. Find path X_i according algorithm MIRA
2. If path X_i not found go step 5
Else
Go next step
3. Compute the end-to-end delay for path X_i
4. If $D(X_i) \leq RSpec$
Go step end
Else
Find link l_m with maximum residual capacity a long path X_i
If l_m not found
Delete link with minimum bandwidth a long path X_i and go step 1
Else
Increment bandwidth l_m 1 unit and go step 3
5. end

IV. SIMULATION SETUP

In this section, the topology for the simulations along with comparison parameters will be discussed. This topology is adopted from [4], which is known as MIRA. It is a plane topology and consists of fifteen nodes, routers. Two different kinds of links are used in this topology: 12 thin links and 48 thick links. A subset of nodes which operate as ingress-egress nodes is {(1,13),(5,9),(4,2),(5,15)}.

In the course of simulation the capacity of links is multiplied by 100. There is an equivalent probability for each of the pairs to be selected in the subset. Requested bandwidth of each label path can be 1, 2, 3 or 4. These values are selected with the same probability. The maximum value of end-to-end delay for requests of the same probability lays in-between 95 and 100 milliseconds.

The first parameter, which is considered, is the number of the rejected requests. Its low value shows that the number of the accepted request is high. This value is abstained as:

$$Call\ Blocking\ Ratio = \frac{number\ of\ request\ rejected}{total\ number\ of\ request} \quad (3)$$

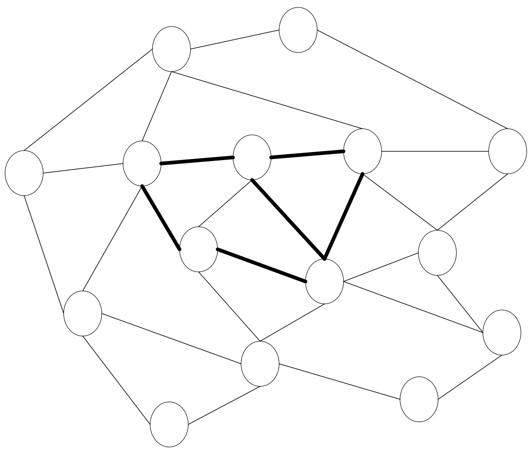

Fig.1 MIRA topology [4]

The second parameter is mean value of label path length, it lower value shows that the shorter path has been selected, which is obtained as:

$$Mean\ Length = \frac{\sum_{i=1}^{NLSPs} lenght(LSP_i)}{NLSPs} \quad (4)$$

Where *NLSPs* and length (*LSPi*) represent the number of the connected paths and the number of links respectively. Fewer links in the selected path needs less resource which increases the potential of network to handle more requests.

The third parameter is the mean value of the maximum flow in-between inputs and outputs and, obtained as follow:

$$Max\ flow_{ave} = \frac{\sum_{i \in P} \max flow(i)}{n} \quad (5)$$

V. SIMULATION RESULTS

Simulation results of the proposed algorithm are given in Fig. 2 which represents the rate of the rejected requests. Comparison of the results with the results of the other discussed algorithms show that the rejected requested of MIRAD is higher than that of the others. The reason is: through this measure MIRAD guarantees the needed bandwidth of the request. Sometimes there is a need for higher bandwidth or longer path, and more resources utilized in order to meet the delay criterion of the network. This algorithm uses a few of its critical links at the outset, and distributes its load evenly which helps it to reserve a sufficient capacity for future requests. The algorithm meets both the criteria: bandwidth and end-to-end delay, so its operation is satisfactory.

Fig. 3 shows another simulation result of MIRAD: mean length for the path which is applied to MIRA topology. As Figures show, at the outset, the algorithm selects a longer path since it is not busy. Doing so, the algorithm meets the QoS, and reserves shorter paths for future requests.

As the working paths get saturated, the algorithm uses shorter paths in order to balance the load, so mean length of the paths will have uniform trend. In the course of time, for reduction of the links residual bandwidth, the algorithm is no longer capable of meeting the network QoS in short paths; hence, it should use longer paths. Non- smoothness and fluctuations which are observed in the mean length is due variation in path length and the flow switched in different paths of network. The diagram will have increasing trend in case of longer path, and decreasing in shorter paths.

Fig. 4 shows mean of the maximum flows in MIRAD along with other algorithms. As it is evident, the value of MIRAD is close to that of BCRA and MIRA, but it outperforms WSP and MHA. The performance of MIRA, in this respect, is better than MIRAD; of course its main goal is to maximize the flow.

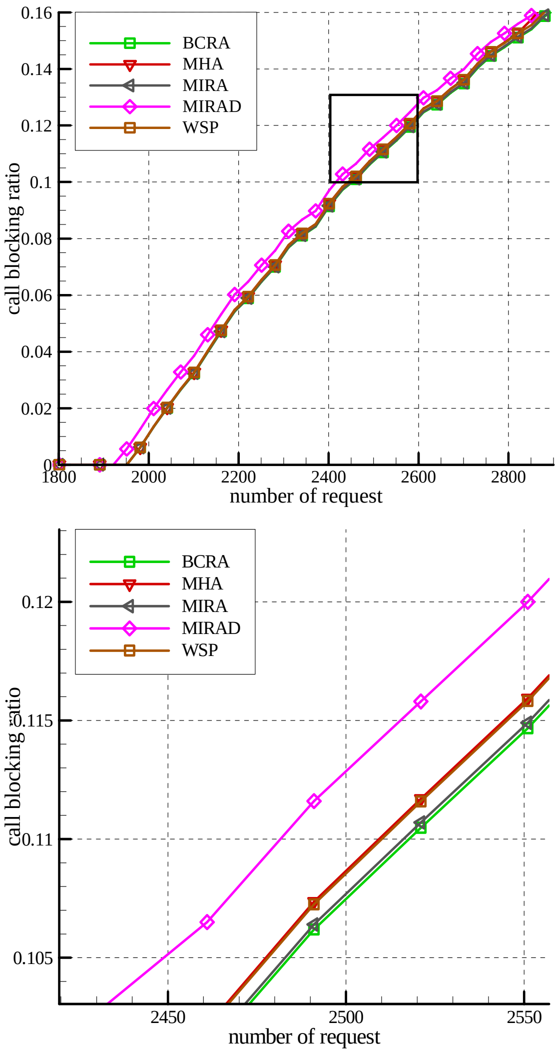

Fig. 2 Rate of reject request of MIRAD algorithm conducted on MIRA topology

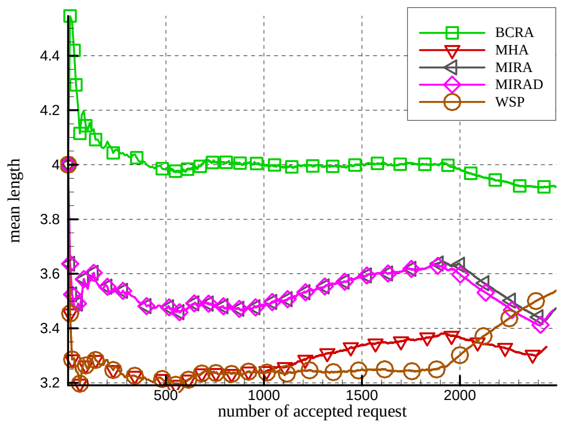

Fig. 3 Mean value of path length of MIRAD algorithm conducted on MIRA topology

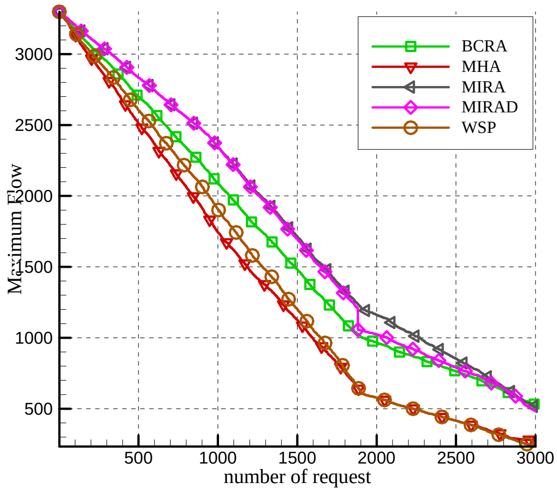

Fig. 4 Maximum flow of MIRAD algorithm conducted on MIRA topology

VI. Conclusion

In this paper, the proposed algorithm, MIRAD, was applied to MIRA topology, and the results compared with that of MHA, WSP, MIRA and BCRA, those how meet bandwidth criterion merely, in operation. Considering the fact that, MIRAD algorithm meets both the criteria of bandwidth and maximum end-to-end delay, at the same time it needs more resources with respect to other aforementioned algorithms in order to guarantee the delay issue. Hence, it produces different results. Rate of the rejected requests in MIRAD is more than that of the other algorithms. The maximum flow of this algorithm on MIRA topology exceeds that of the WAP and MHA, for their lower responds in comparison with that of MIRAD.

References

[1] A. Elwalid, S. H. L. C. Jin, and I. Widjaja, *MATE: MPLS adaptive traffic engineering,* INFOCOM, 2001.

[2] E. Rosen, A. Viswanathan and R. Callon, *Multi-protocol label switching architecture,* RFC 3031. 2001.

[3] Luc De Ghein, *MPLS Fundamentals*, First edition, Indianapolis, IN 46240 USA, 2007.

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

[5] D. Awduche, A. Chiu, A. Elwalid, I. Widjaja, and X. Xiao, *"Overview and Principles of Internet Traffic Engineering",* RFC 3272, May 2002.

[6] D.O. Awduche, L. Berger, D. Gan, T. Li, V. Srinivasan, G.Swallow, *RSVP-TE: Extensions to RSVP for LSP tunnels,IETF RFC 3209*, December 2001.

[7] R. Guerin, D. Williams, A. Orda, *"oS routing Mechanisms and OSPF extensions",* OBECOM, 1997.

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

[9] Stiliadis, D. A. and Varma, "Latency-rate servers: A general model for analysis of traffic scheduling algorithms", *Proceeding INFOCOM*, San Francisco, CA, pp. 111–119, April 1996.

[10] Cruz, R. L., "A calculus for network delay, Part I: Network elements in isolation", *IEEE Trans. Inform. Theory*, Vol. 37, pp. 114-131, 1991.