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Provide a Dynamic Routing Algorithm for MPLS Networks Using Fuzzy Filtering Approach

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Abstract— The advent of Multiprotocol Label Switching (MPLS) technology is the basis of the next generation network to improve multimedia applications. One of the most basic traffic engineering concepts in MPLS is routing for Layered Service Provider (LSP). The purpose of providing routing algorithms is to maximize the number of routed requests according to QoS satisfaction. Most research in this area focuses solely on bandwidth, and relatively few studies consider both bandwidth limits and delay. In this paper, a dynamic routing algorithm based on a fuzzy filtering method is proposed which considers both bandwidth limits and end to end delay for route search. The fuzzy system is a prediction model based on fuzzy weighting rules for filtering high-resource requests. The proposed method tries to postpone requests with high bandwidth and maximum end to end delay. Various scenarios have been used to simulate and evaluate the efficiency of the proposed method, and criteria such as the number of requests accepted, average path length and load balance have been measured. The simulation results prove that the proposed method provides optimal routing performance for MPLS networks.

Keywords— Routing algorithm, MLPS networks, Quality of service, Fuzzy filtering.

I. INTRODUCTION

Due to the advancement and development of technology and increasing the quality of the information sent, a suitable platform with bandwidth and high speed is needed to establish this connection. Communication requires the provision of an IP network platform. This platform can be via Internet, Intranet, MPLS, etc., depending on the amount of bandwidth consumed [1]. The goal of next-generation networks is to increase the performance of audio, video and data-based networks in the form of a multi-service network, where it has the ability to provide services for the future. This has led to a significant increase in the flow of traffic in the network core. The main reason for implementing traffic engineering (TE) in MPLS network is route control and packet routing in network routes. The MPLS platform can provide fast packet transport and TE. Because packet paths are fixed on MPLS networks, these paths may be subject to TE [2]. In MPLS, which uses a driven control model to assign and distribute tags, Layered Service Providers (LSPs) are themselves one-way, and two different LSPs must be defined between source and destination to send two-way traffic.

The benefits of MPLS include scalability, performance, better bandwidth utilization, reduced network congestion, and a better end-user experience. MPLS does not provide encryption itself, but is a virtual private network and is thus disconnected from the public Internet. Therefore, MPLS is a secure transfer mode. The most sensible lead strategy is to load more MPLS traffic into the public Internet, however, MPLS is still used for time-sensitive applications that require guaranteed delivery [3].

Video conferencing technology is very important in distance learning and communication is possible and is one of the most popular features to express features online that allows people to be established in different places. It provides audio and video online at various intervals, which saves time and facilities for sharing documents, exchanging documents, and receiving graphic information during a video conference. The reason for the speed of data transmission and routing in this technology is important [4]. In this study, we identify critical links to ensure latency and bandwidth. The goal here is to assign a path to a new request that does not contain critical links. This will increase the demand for future routing with less interference. The main idea of the proposed algorithm in choosing the path for an input-output pair is to select a path that does not have the maximum interference compared to other input-output pairs [5]. The dynamic routing algorithm suggested in this research is a bandwidth and delay guarantee algorithm based on a fuzzy filtering approach. This algorithm guarantees end to end bandwidth and delay and is configured based on the Minimum Delay and Maximum Flow (MDMF) method [6]. It also objective to load distribute evenly across the network to total requests and to postpone high-bandwidth requests with maximum end to end delay. In addition, the proposed method optimizes the use of resources and intends to maximize the number of requests accepted. In the proposed method, path delay is measured using the delay rate (LR-servers), which makes the algorithm dynamic.

The remaining of the paper is organized as follows: Section II is dedicated to related works. The details of the proposed approach are given in Section III and the discussion and simulation analysis is described in Section IV. Finally, conclusions and future work are presented in Section V.

II. RELATED WORKS

In recent years, many algorithms for service-based routing based on MPLS networks have been proposed, some of which we will study in this section [7-10].

In [11], a method was proposed to increase the impact of Dynamic Multipoint Virtual Private Network (DMVPN) on the quality of video conferencing services. This algorithm is the maximum requested to connect a set of networks securely and automatically. In this paper, video conferencing performance is evaluated based on the impact of sites in a DMVPN on MPLS platform. The comparison focuses on the impact of network number, number of users per network, and routing algorithms, with this method reporting a data loss rate of 3.5%.

In [12], different routing protocols for video conferencing on MPLS VPN network were compared and analyzed. The authors examined the performance of video traffic between the EIGRP and OSPF protocols. This review is based on criteria such as jitter, end to end latency, and Mean Opinion Score (MOS). Experimental results show that OSPF and BGP-MPLS VPNs perform best for video conferencing.

In [13], the Multiprotocol Label Switching-Traffic Engineering (MPLS-TE) algorithm is proposed. This algorithm improves the performance of multimedia services in MPLS wireless networks based on bandwidth guarantee. MPLS-TE also ensures connection reliability and increases QoS. Therefore, this algorithm provides the ability to increase the speed of packet transmission in the network. The most important advantage of MPLS-TE is the increase in the number of requests that are routed.

In [14] the Optimized Network Engineering Tool (OPNET) algorithm is introduced. This algorithm analyzes the performance of real-time video conferencing on MPLS-enabled networks as well as non-MPLS-enabled networks. Here OPNET is used as the most appropriate tool to evaluate performance and compare throughput and end to end latency. Simulations and experiments prove better performance of video conferencing in MPLS environment than IP networks.

In addition, we review previous related work such as WSP [16], MHA [15], BCRA [18], MIRA [17], MIRAD [19], BGLC [21], BGDG [20], SAMCRA [22] and we use MDMF [23] for comparison. In MHA algorithm, the route is selected with the minimum links between number the router input and output. WSP uses the shortest possible path with the most remaining bandwidth capacity. MIRA uses input-output pair information to find usable paths. BCRA creates compromises to reduce route length, route network load balancing, and minimize path cost. MIRAD uses minimal interference for delay, in which paths are calculated by the MIRA algorithm to prevent the selection of critical links. BGDG is a guaranteed delay and bandwidth routing algorithm. The BGLC provides LSP setup requests for the input and output pairs of routers, as well as their bandwidth requirements. SAMCRA is a self-adaptive constraint routing algorithm for the multi-constraint routing problem. MDMF is an algorithm based on minimum delay and maximum current that guarantees end to end bandwidth and delay.

III. THE PROPOSED METHOD

For routing on assumed MPLS networks, all SLSPs are specified and fixed. The requests were received in order and there is no information about the information of the next requests. In the routing process, it is possible that the bandwidth of some LSPs will be zero, as it is not possible to delete requests for subsequent LSPs, so the routing algorithm must be dynamic to be able to route requests optimally and online. Be. In the proposed method, similar to the MDMF algorithm, the path setup requests are defined as $(s, d, TS_{pec}, RS_{pec})$, where s is the input (source node) and d is the output (destination node). TS_{pec} network traffic specifications include parameters (M, r, t, b) . RS_{pec} QoS specifications such as minimum bandwidth and maximum end to end delay are required and are shown as (D, BW). Here, D refers to the end to end delay and BW refers to the minimum bandwidth required.

In the first stage of the proposed method, we temporarily postpone requests with high resources (high bandwidth and maximum end to end delay) in order to increase the number of requests accepted. This is done with a filter system modeled by a fuzzy system based on weighted rules. In the second step, the weight of all links is calculated and based on this weight, a path is assigned to the input request. In the third step, after routing for a certain number of requests, we use a re-chance approach to assign the route to the delayed (filtered) requests. Fig. 1 offers the flowchart of the proposed algorithm.

A. Fuzzy filtering system

In order for the routing process to work better on the MPLS network, it is best to prioritize requests with high end to end delay and lower bandwidth. Due to the dynamic routing policy, this section presents a fuzzy algorithm with an online approach to filtering requests with highly demanded resources. Here the form of fuzzy rules is used as the following Eq. (1).

$$R_j: If\ (x_1\ is\ A_1)\ and\ (x_2\ is\ A_2)\ and\ (x_3\ is\ A_3)\ Then\ Class\ T\ with\ CF_j \quad (1)$$

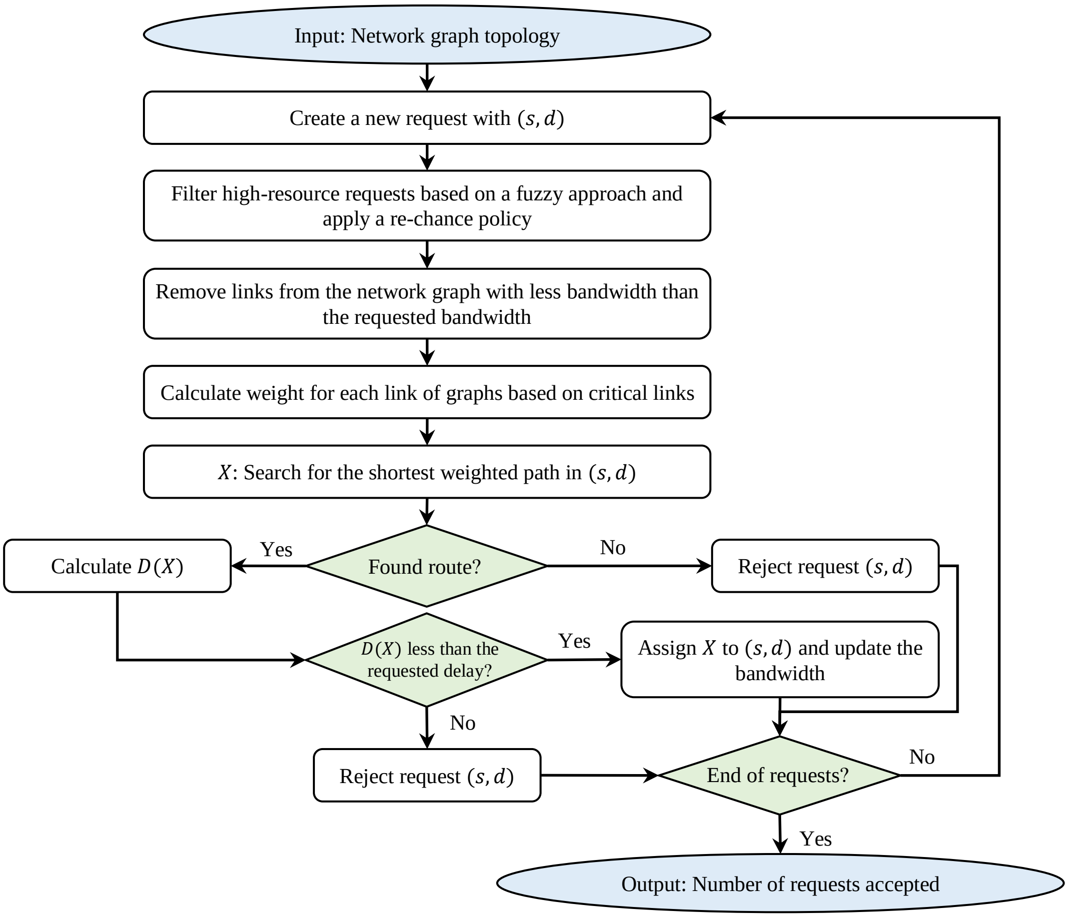

Figure 1. Flowchart of the proposed method

Here a rule database with M fuzzy law is used where CF_j is the weight of the j-th law. T refers to the prediction (output) label by law, where $T \in \{C_1, C_2\}$ and C_1 refers to the Filter class, and C_2 refers to the non-Filter class. In addition, x_1, x_2 and x_3 are the values of the request bandwidth (BW) parameters, the maximum end to end delay (D), and the number of requests in the queue (QL), respectively. These parameters are the inputs of the fuzzy system for filtering work. A_i is also the degree of fuzzy membership assigned to these three parameters, which is done as shown in Fig. 2.

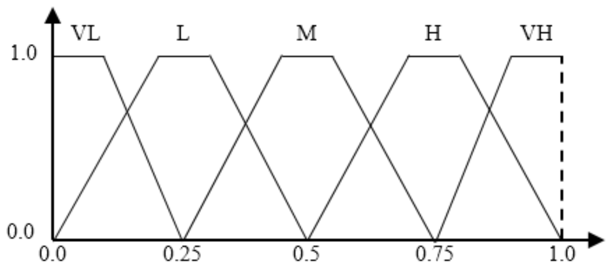

Figure 2. Membership function

The detection of a request delay is determined based on the fuzzy rule database. Fuzzy rules are created offline by a weighted rule learning method and are used online to manage requests in the MPLS network. Due to the small number of input parameters, all different combinations of rules are created. The degree of compatibility of each input request $X(BW, D, QL)$ with the introduction section of the rule $A_j = (A_1, A_2, A_3)$ is calculated using the multiplication operator (Mamdani method) as follows.

$$\mu_j(X) = \mu_{A_1(BW)} \times \mu_{A_2(D)} \times \mu_{A_3(QL)} \quad (2)$$

Where, $\mu_{A_i(.)}$ indicates the degree of compatibility of the i-th input parameter to the fuzzy sets. In addition, the final degree of certainty of the law is $\mu_j(X) \times CF_j$.

Here K is assumed to be a training request to create a database as $X_i: i = 1,2, \dots, K$. A sample label (Filter or non-Filter) is also specified for each request. The process for determining the optimal weight for the R_j rule is described below and is similar for other rules of the process. Initially, the weight of all rules is $CF_j = 1$.

1. Put all training requests in S.
2. The requests in S are categorized by the R_j rule and the accuracy of the model is calculated.
3. Delete requests from S that are not covered by R_j. The reason for this is that the weight of this law does not affect the total number of applications whose label has been correctly identified.
4. Set the weight of the rule R_j to zero ($CF_j = 0$). This makes the law irrelevant to filtering requests. With this

weight, the requests in S are reclassified by the R_j rule and accuracy of the method is computed.

5. If the set S is empty, it means that the R_j rule has no effect on increasing the accuracy of the classification model and can be removed from the rules database.
6. If set S is not empty, each request in this set is weighted. $W(X_t)$ is the weight assigned to the t-th request of set S and is calculated by the following Eq. (3).

$$W(X_t) = \frac{CF_q \cdot \mu_q(X_t)}{\mu_j(X_t)} \quad (3)$$

Where, $\mu_j(X_t)$ is the degree of compatibility of X_t request with R_j rule. CF_q and $\mu_q(X_t)$ are the weight and degree of compatibility of R_q, respectively. R_q is the law with the highest degree of certainty ($CF_q \times \mu_q(X_t)$) among all laws labeled contrary to R_j.

7. The stated steps are repeated consecutively to set the optimal weight for the rule. Here the total number of iterations is constant and is denoted by the symbol G.

The Single Winner of rule in the rules database is used to specify the class tag of each entry request. The winning rule (R_w) is the law with the highest degree of certainty.

B. Re-chance approach

Once routing has been done for a certain number of requests, we use a re-chance approach to assign the route to the delayed (filtered) requests. If the all number of requests in network is N_{req}, then re-chance process request will be applied for each P_{req} request after route allocation. Here, ρ percent of the filtered requests after each P_{req} request are given a chance to redirect. Selection of requests for re-chance is based on “requests with less bandwidth and maximum end to end delay”.

Providing a real and fast connection is a basic requirement of new online technologies that enable multi-protocol tagged switching. The NGN network is one of the things that organizations and businesses are looking to achieve today. There are many reasons to move in this direction, including reducing costs, increasing profits and revenues, increasing productivity, increasing customer satisfaction, and increasing innovation. Today, technology is rapidly making changes in the daily lives and infrastructures of businesses and businesses. The technologies development such as MPLS is the basis of NGN’s work to support multimedia applications. The most basic concept in MPLS network TE is LSR. The purpose of routing algorithms maximize the number of routed requests with respect to QoS satisfaction. In this section, we propose a new routing method with a fuzzy rule approach that simultaneously considers both bandwidth and end to end delay for route search. The fuzzy system is a prediction model based on fuzzy weighting rules for filtering high-resource requests. A combination of MPLS and traditional routing can improve the scalability and overall efficiency of the network. The proposed method tries to postpone requests with high bandwidth and maximum end to end delay.

IV. RESULTS AND DISCUSSION

In this paper, extensive simulations are presented to show the superiority of the proposed approach. All simulations and comparisons are done with the 3.0GHz Intel Corei7 processor and 16GB of RAM. Meanwhile, MATLAB software R2019a is used for simulations.

Finally, we will show that the proposed routing algorithm increases the number of requests accepted and the quality of service satisfaction in MPLS networks. In all experiments, an average of 15 distinct implementations of the algorithms were reported to ensure results.

We use different evaluation criteria to evaluate the performance of the proposed method and compare it with other algorithms. These criteria are the number of applications accepted and the average route length. In addition, the values set for the parameters of the proposed method are as shown in Table I. Most of these parameters are based on research done in [23] and other parameters are adjusted by trial and error.

Table 1. Parameters of the proposed method in the simulation

Parameters	Parameter description	Adjusted value
P_{req}	Section of requests	100
ρ	Threshold of chance again	0.3
$TS_{pec}.M$	Maximum package size	2KB
$TS_{pec}.r$	Request rate	1
$TS_{pec}.t$	Maximum rate	5
$TS_{pec}.b$	Invasion rate	100
μ_{flow}	Flow priority factor	0.5
μ_{delay}	Delay priority factor	0.5
γ_{sd} and λ_{sd}	Input-output pair weight	1
K	Number of training requests	150
α	Weight adjustment coefficient	0.35
G	Number of repetitions to set weights	35

Here, the evaluation of the efficiency of the proposed method based on different conditions in the form of four scenarios is reviewed. These scenarios include bandwidth and maximum end to end delay. These scenarios are as shown in Table II.

Table 2. Defined scenarios for evaluating the proposed method

Scenarios	Bandwidth (units)	Maximum end to end delay (milliseconds)
Scenario 1	{1, 2, 3, 4}	{95, 96, 97, 98, 99, 100}
Scenario 2	{1, 2, 3, 4}	{60, 61, 62, 63, 64, 65}
Scenario 3	{1, 2, 7.5, 9.5}	{95, 96, 97, 98, 99, 100}
Scenario 4	{1, 2, 7.5, 9.5}	{60, 61, 62, 63, 64, 65}

In addition, we use the MIRA network topology to compare the proposed routing algorithm with other algorithms [23]. This topology consists of 15 nodes and 28 links as shown in Fig. 3. The network topology under study includes two types of links with thin links (bandwidth of 12 units) and thick links (bandwidth of 48 units). In MIRA (4 → 2), (5 → 9), (1 → 13) and (5 → 15) are input-output pairs. In this article, all link capacity is multiplied by 100 units. This allows thousands of different LSPs to be examined. Also, the total number of applications reviewed is estimated at 3000.

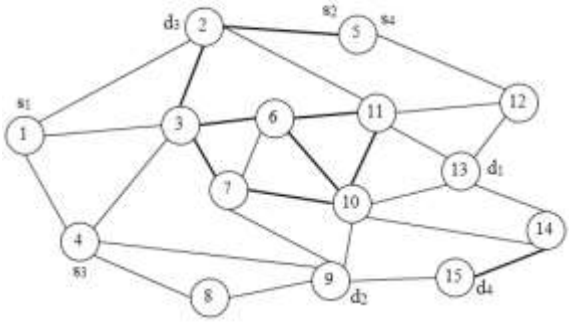

Figure 3. MIRA network topology

In the following, the simulation results of the proposed method are presented and compared with other methods. First, the performance of the proposed method in different load conditions is evaluated by the criterion of the number of accepted requests. For this purpose, this criterion has been analyzed for the proposed method and other methods in different defined scenarios. Fig. 4 shows the details of the requests routed by each method.

In Scenario 1, the performance of all algorithms is almost the same. But in Scenario 2, as the end to end delay decreases, the efficiency of the MIRAD, BGDG, SAMCRA, MDMF, and proposed methods decreases, because these algorithms guarantee end to end delay and cannot delay. Provide the requested end to end according to the remaining routes in the network. The MHA, WSP, MIRA, BCRA and BGLC algorithms do not ensures end to end delay.

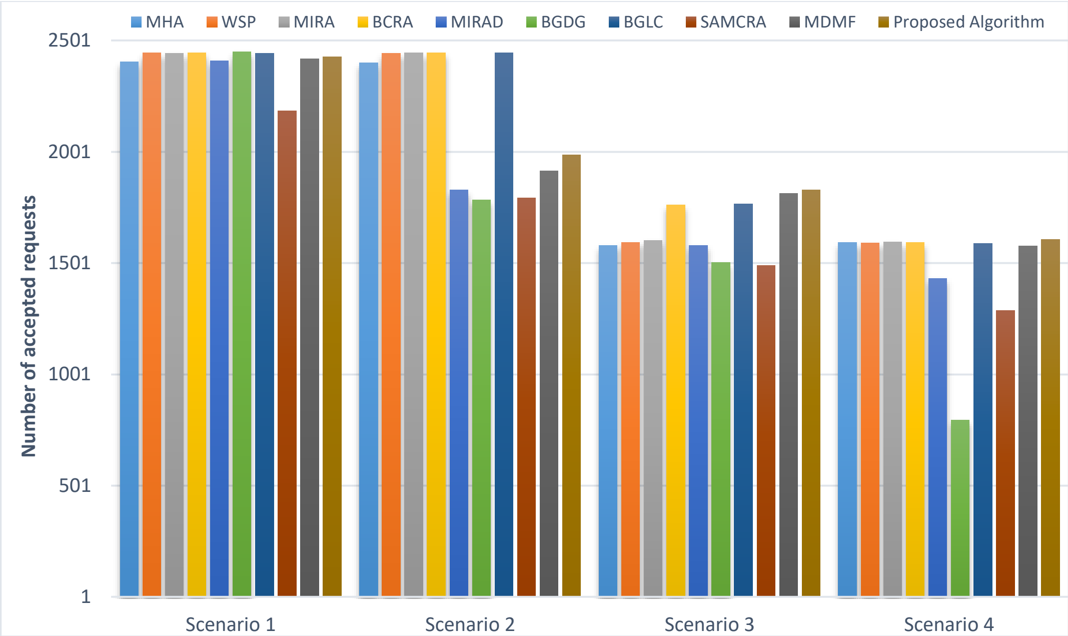

Figure 4. Comparison based on the number of applications accepted

In Scenario 3, the bandwidth associated with requests is increased. In this case, algorithms that guarantee both bandwidth limits and end to end delay accept fewer requests than Scenario 1. The proposed method and MDMF report better performance here, and these results are not comparable to the BCRA and BGLC algorithms, as they only guarantee bandwidth. We will also go on to show that the BCRA allocates longer paths to requests, and as a result the paths launched in the BCRA have longer end to end latencies than the proposed method and MDMF. In Scenario 4, the bandwidth of requests is increased and the delay is reduced to the end. In this case, the proposed method and MDMF perform better than other methods except BCRA and BGLC. In addition, the proposed method provides more requests in all scenarios than MDMF. These algorithms guarantee both bandwidth limits and end to end delay, but the proposed method has been able to accept more requests by delaying high-resource requests.

The following comparisons are made based on the criteria of average route length and load balance. Here, results are reported on average for four scenarios. The results of comparing the algorithms in factors of average route length criterion are shown in Fig. 5. In general, the MHA, SAMCRA, and WSP methods offer superior average path lengths than other methods because they search for the shortest paths only due to bandwidth limitations, which can cause to interference and congestion. The proposed methods and MDMF provide longer routes than other methods except BCRA. This is because the proposed method and MDMF, in order to guarantee bandwidth limits and end to end delay, provide network load as distributed by weight to the links. Therefore, these algorithms can accept more requests. Compared to MDMF and the proposed method, only the MIRAD algorithm offers less path length, but MIRAD has accepted fewer requests. In particular, MIRA has a lower average path length than the proposed method and MDMF, but this algorithm just assurance network bandwidth in routing and ignores end to end delay. In addition, proposed method offers relatively short path length compared to MDMF. According to all the experiments performed, the proposed method is significantly superior to other methods in most criteria.

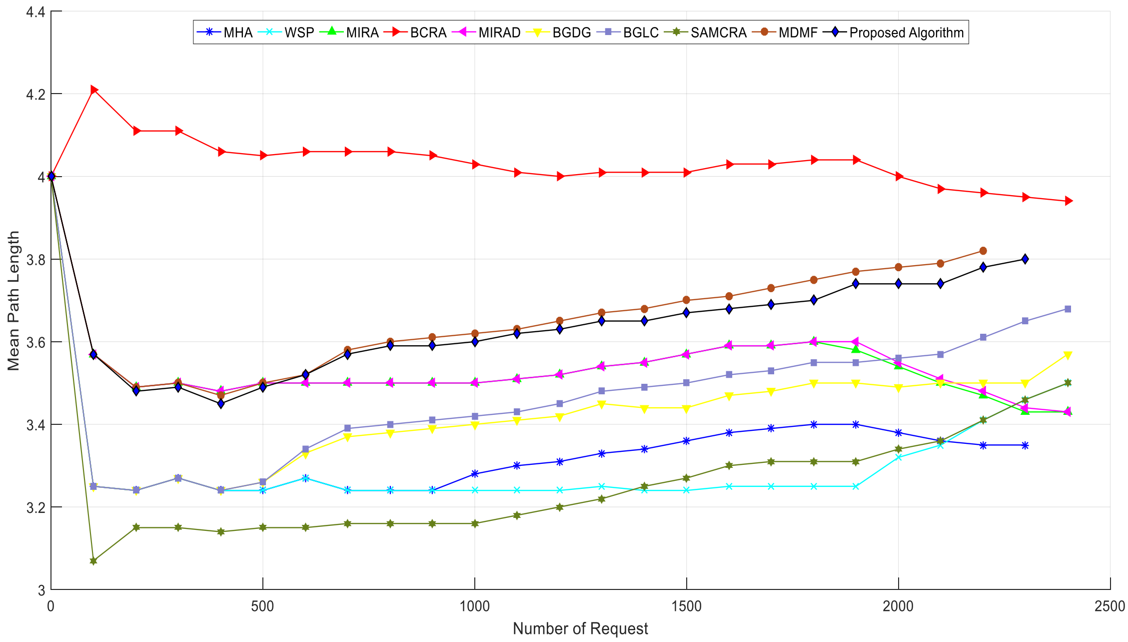

Figure 5. Comparison based on average route length

V. CONCLUSIONS AND SUGGESTIONS

One of the most important TE challenges in the Multiprotocol Label Switching (MPLS) networks is routing labeled routers. This routing should be done in such a way that in addition to estimating service quality criteria, network facilities are also used optimally. In this paper, increasing the quality of video conferencing services through a routing method for the MPLS network TE was studied. The proposed method with max-flow and min-delay capability ensures bandwidth and end to end delay of route requests together and online. Here a dynamic routing method for routing in the MPLS is suggested. The purpose of the proposed method is to save network resources in order to maximize the number of routed requests for connection in the MPLS platform. This algorithm manages and maintains not only the importance of vital links but also importance of network resources for future requests. On the other hand, the proposed method first routes requests with smaller required resources so that it can accept more requests for connection.

In addition, an innovative method such as binary search is proposed to determine the exact amount of bandwidth to ensure maximum end to end delay for future work.

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