Application of N jobs M machine Job Sequencing Technique for MPLS Traffic Engineering

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Abstract

This paper discusses Traffic Engineering with Multi-Protocol Label Switching (MPLS) in an Internet Service Provider's (ISP) network. In this paper, we first briefly describe MPLS, Constraint-based Routing, MPLS-TE, N jobs M machine Job sequencing technique and how to implement the job sequencing technique for Multi-Protocol Label Switching Traffic Engineering. And also improve the quality of service of the network, using this technique firstly reduce the congestion for traffic engineering; minimize the packet loss in complex MPLS domain. In small network packet loss is negligible. We used NS2 discrete event simulator for simulate the above work.

Keywords: Traffic Engineering, Multi-Protocol Label Switching, Constraint based routing, N jobs M machine Job Sequencing Technique, Qos, MPLS-TE.

1. INTRODUCTION

Traffic Engineering is the process of controlling how traffic flows through one's network so as to optimize resource utilization and network performance [1, 2, 3]. Traffic Engineering is needed in the Internet mainly because current IGPs always use the shortest paths to forward traffic. Using shortest paths conserves network resources, but it may also cause the following problems.

i) The shortest paths from different sources overlap at some links, causing congestion on those links.
ii) The traffic from a source to a destination exceeds the capacity of the shortest path, while a longer path between these two routers is under-utilized.

There is a debate of whether network capacity will one day become so cheap and abundant that these two problems will be eliminated. This debate is beyond the scope of this paper. Here we simply note that currently all ISPs have the above problems. By performing Traffic Engineering in their networks, ISPs can greatly optimize resource utilization and network performance. Revenue can be increased without large investment in upgrading network infrastructure. In order to do Traffic Engineering effectively, the *Internet Engineering Task Force* (IETF) introduces MPLS [4], Constraint-based Routing [6] and N jobs M machine Sequencing Technique [7]. They are briefly reviewed in this section.

1.1 MPLS

We are now going to discuss the basics of MPLS protocol. This protocol was designed by Internet Engineering Task Force (IETF) and its specifications were given in RFC 3031(Request for Comments). Now we are going to give the basics of this protocol next, in form of points.

a) When MPLS protocol is implemented in any network or subnet then two special routers namely ingress and egress routers are imparted in it. See figure 1 below.

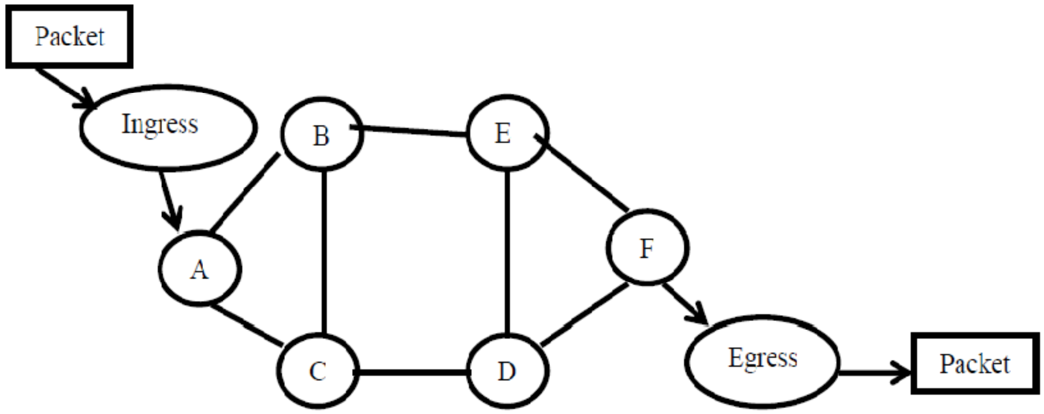
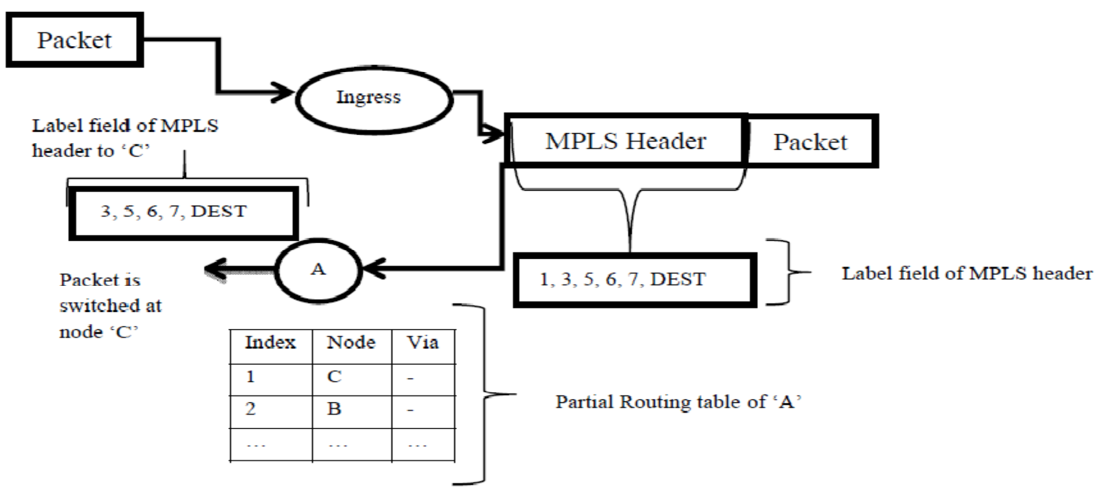


Figure 1.1: showing working of MPLS subnet with Egress and Ingress router attached

b) Then whenever packet has to move inside the MPLS subnet then it enters from the Ingress router and whenever any packet has to move out from the MPLS subnet then it moves out from the egress router.

c) Now whenever any packet has to move from source to destination through MPLS subnet then it is subjected to the ingress router first.

d) Then ingress router adds a tag or label which is known as MPLS label to it and switches it inside the MPLS subnet (see fig1).



Index	Node	Via
1	C	-
2	B	-
...	...	...

Figure 2: Showing the add MPLS header by ingress router and how to move from A to C.

e) Then using this MPLS label (Complete label format is shown in figure 3) this packed moves from one node to another within the MPLS network. Whenever this packet moves from one node to another then the node updates the MPLS header accordingly so it could easily be switched from one node to another until it don't reaches the destination node or egress router. For example see figure 2 in this we have shown Label field of MPLS header according to it packet has to move from ingress router towards destination. Now when packet reaches to ingress router it adds an MPLS tag in it and switches it to node say A. Now this node A has a routing table in it whose partial version is shown in figure 2. Now from label field first digit is read which is index 1. This index is searched in the routing table of node A and packet is switched to node C which is correspondent node at index 1. Moreover MPLS header is also modified by node A as shown in figure 2.

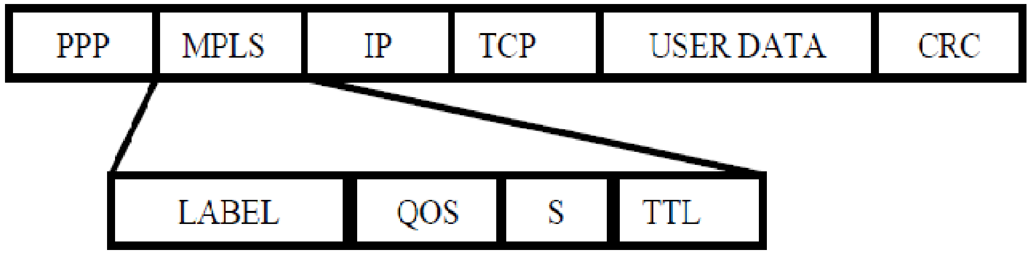


Figure 3: Showing the MPLS header Format

f) If the destination node is present inside the MPLS network then ok. Packet is switched there. But if destination node lies outside the MPLS network then packet reaches the egress router and there egress router removes the MPLS tag from it and routes the packet out of the MPLS network towards the destination.

1.2 Constraint Based Routing:

Constraint-based Routing (CBR) computes routes that are subject to constraints such as bandwidth and administrative policy. Because Constraint-based Routing considers more than network topology in computing routes, it may find a longer but lightly loaded path better than the heavily loaded shortest path. Network traffic is hence distributed more evenly. For example in Fig. 2, the shortest path between router A and router C is through link A-C with IGP metric *m*=1. But because the resolvable bandwidth on the shortest path is only (622-600) = 22 Mbps, when Constraint based Routing tries to find a path for an LSP of 40 Mbps, it will select path A-B-C instead, because the shortest path does not meet the bandwidth constraint.

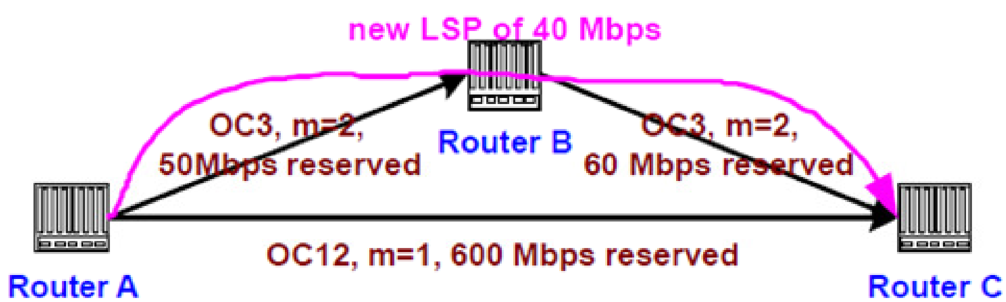


Figure 4: Constraint Based Routing

It should be noted that the reservable bandwidth of a link is equal to the maximum reservable bandwidth set by network administrators minus the total bandwidth reserved by LSPs traversing the link. It does not dependon the actual amount of available bandwidth on that link. For example, if the maximum reservable bandwidth of a link is 155 Mbps, and the total bandwidth reserved by LSPs is 100 Mbps, then the reservable bandwidth of the link is 55 Mbps, regardless of whether the link is actually carrying 100 Mbps of traffic or more or less. In other words, Constraint-based Routing does not compute LSP paths based on instantaneous residual bandwidth of links. This reduces the probability of routing instability [6]. Constraint-based Routing can be online or offline. With online Constraint-based Routing, routers may compute paths for LSPs at any time. With offline Constraint-based Routing, an offline server computes paths for LSPs periodically (hourly/daily). LSPs are then configured to take the computed paths.

1.3 Generic Issues of Designing an MPLS System for Traffic Engineering

To build an MPLS system for Traffic Engineering, the following design parameters must be determined:

1. The geographical scope of the MPLS system;
2. The participating routers;
3. The hierarchy of MPLS system;
4. The bandwidth requirement of the lsps;
5. The path attribute of the lsps;
6. The priority of the lsps;
7. The number of parallel lsps between each endpoint pair;
8. The affinity of the lsps and the links;
9. The adaptability and resilience attributes of the lsps.

The process of deciding the scope of an MPLS system is driven by administrative policy. Specifically, if the network architecture of a region is irregular (as opposed to the regular architecture showed in Fig. 4), or the capacity of a region is tight, then the region should be included in the MPLS system.

The second step is to decide the participating routers in the MPLS system, i.e., the ingress LSRs, the transit LSRs and the egress LSRs. This should also be guided by the administrative policy. Network administrators may want to forbid some routers from participating in the MPLS system for some reason, for example, because those routers cannot be trusted or because those routers do not have enough processing power and/or memory capacity. Another factor for consideration is the tradeoff between the number of LSPs and efficiency of the links. More ingress and egress LSRs mean more LSPs and thus higher LSP-routing complexity. But because the average size (bandwidth requirement) of the LSPs is smaller, Constraint-based Routing has more flexibility in routing the LSPs. Higher link efficiency may be achieved. After the LSRs are decided, network administrators need to decide the hierarchy of the MPLS system. One alternative is to fully mesh all LSRs, resulting in a single layer of LSPs. For large ISPs, there can be hundreds of LSRs. A full mesh will result in a huge MPLS system. Another alternative is to divide one's network into multiple regions. LSRs in each region are meshed. This forms the first layer of LSPs. Some selected LSRs from each region, for example the core routers, are also fully meshed to form the second layer of the LSPs. This hierarchical design can significantly reduce the number of LSPs in the network, and hence the associated processing and managing overhead. Unless an end-to-end traffic matrix is available beforehand, the bandwidth requirement of the LSPs is usually unknown and has to be guessed for the first time LSPs are deployed. Later, the measured rate of the LSPs can be used as the bandwidth requirement of the LSPs.

LSP paths can be manually specified or dynamically computed. Unless offline Constraint-based Routing is used to compute the paths, manually specifying paths for LSPs is difficult. Therefore, LSPs are usually dynamically computed by an online Constraint-based Routing algorithm in the routers.

Important LSPs, such as those carrying large amount of traffic, can be given a higher priority than other LSPs. In this way, these LSPs are more likely to take the optimal paths. This will result in higher routing stability and better resource utilization from a global perspective. Multiple parallel LSPs can be configured between an ingress-egress pair. These LSPs can be placed on different physical paths, so that the traffic load from the source to the destination can be distributed more evenly. By using multiple parallel LSPs, the size of each LSP is also smaller. These LSPs can be routed more flexibly. These are the primary motivations for parallel LSPs. It is recommended that parallel LSPs be used to keep the size of each LSP below 25 Mbps Affinity, or color, can be assigned to LSPs and links to achieve some desired LSP placement. For example, if network administrators want to prevent a regional LSP from traversing routers or links outside the region, color can be used to achieve the goal. All regional links can be colored *green*, and all inter-region links can be colored *red*. Regional LSPs are constrained to take only *green* links. In this way, regional LSPs can never traverse any inter-region link. The process of assigning color to LSPs and links is again guided by administrative policy. Depending on the stability of the network, when better paths become available, network administrators may or may not want to switch LSPs to the more optimal paths. The switching of LSPs to better paths is called LSP *re optimization*. Re optimization is not always desirable because it may introduce routing instability. In the case that re optimization is allowed, it should not occur too frequently. Performing re optimization once per hour may be a good choice. As to the resilience attribute, LSPs are generally allowed to be rerouted when failure occurs along their paths. In the cases of failure, it may even be desirable to reroute LSPs regardless of their bandwidth and other constraints.

1.4 N jobs M machine Job Sequencing Technique

Routing problems in networks are the problem related to sequencing and, of late, they have been receiving increasing attention. Such problems usually occur in the areas of transportations and communication. A network problem involves the determination of a route from source city I to destination city J for there exist a number of alternative paths at various stages of the journey. The cost of journey, which may be function of distance, time or money, is different for different routes and the problem is to find the minimum cost route. The following algorithm is used to find the shortest path of the given complex network. In this technique there are N no. of jobs and M no. of machine. Each job contains constant execution time for each machine. Each job is organized such as that minimum optimal execution time is obtained. For this there is n-1 sequence is obtained by Johnson's rule and now calculates the optimum sequence.

The rest of the paper is organized as follows: In section 2, we mention related works carried out by other researchers. Proposed algorithm to find the shortest path of a given complex network is presented in section 3. In section 4, we present our results and its analysis. Finally, conclusion and future scope have been given under section 5.

2. RELATED WORK

General issues of supporting MPLS Traffic Engineering are identified and discussed in [5]. With Differentiated Services (Diffserv), packets are classified at the edge of the network. The Differentiated Services-fields (DS-fields) [12] of the packets are set accordingly. In the middle of the network, packets are buffered and scheduled in accordance to their DS-fields by Weighted Random Early Detection (WRED) and Weighted Round Robin (WRR). Important traffic such as network control traffic and traffic from premium customers will be forwarded preferably [8]. In addition to the concept of a hybrid of L2 and L3 forwarding, label distribution, and LSP setup trigger mode, the authors have proposed a framework for IP multicasting in MPLS domains. However, they did not address issues related to traffic engineering of multicasting or aggregating label assignment schemes in MPLS domains. The proposed ERM scheme eliminates most of the problems mentioned in [1,2,3] An MPLS Multicast Tree (MMT) scheme was introduced in [7] to remove multicast forwarding state in non-branching nodes by dynamically setting up LSP tunnels between upstream branching nodes and downstream branching nodes. Like ERM, MMT can dramatically reduce forwarding states. However, MMT still needs to set up and update LSPs between edge LSRs and core LSRs (if some core LSRs is branching nodes of multicast trees). As a result, the core LSRs have to support the coexistence of L2/L3 forwarding schemes. Normally LSPs are built between edge LSRs. LSPs produced by MMT may not necessarily be able to aggregate with other unicast LSPs. However, in ERM, there would be no need to set up any LSPs between edge LSRs and core LSRs, which enables ERM to aggregate both multicast and unicast traffic. Another difference between MMT and ERM is that the multicast tree is centrally calculated in MMT, while basic ERM is fully distributed, and the extended ERM (ERM2) is partially distributed. The most popular and widely used routing algorithm in MPLS networks is the shortest-path first algorithm (SPF) based on the number of hops. SPF selects the path that contains the fewest hops between the source and the destination node describe in [9, 10].

One obvious problem with SPF is that it tends to route traffic onto the same set of links until these links' resource are exhausted. This leads to concentration of traffic on certain parts of the network. In addition, SPF typically accepts less path setups into the network than some other more advanced routing algorithms. Amore intelligent routing algorithm the Minimum Interference Routing Algorithm (MIRA) proposed in [13]. The objective of MIRA is to accept as many path setups into the network as possible by using the concept of critical links. Critical links have the property that when their capacity is reduced by 1 bandwidth-unit, the maximum data flow between a given source-destination node is also reduced by 1 bandwidth-unit. The goal of MIRA is accomplished by selecting paths that contain as few critical links as possible. However MIRA suffers from two weaknesses. First, MIRA is computationally expensive.

3. PROPOSED METHODOLOGY

For MPLS traffic engineering there are so many approaches are used to control the congestion of traffic and improve the qos of the network. And for congestion control there are many control policies are used. Fair Queuing is one of them. Fair queuing is a congestion control policy where separate gateway output queues are maintained for individual end-systems on a source-destination-pair basis. When congestion occurs, packets are dropped from the longest queue. At the gateway, the processing and link resources are distributed to the end-systems on a round-robin basis. Round-robin is an arrangement of choosing all elements in a group equally in a circular. Equal allocations of resources are provided to each source-destination pair. Here in this paper we used another algorithm for scheduling instead of Round Robin algorithm. This algorithm is based on N jobs M machine Job sequencing technique [17]. The following algorithm is used to find the optimized sequence. For this, it generates up to n-1 sequences. Sequence generation is accomplished in the following manner: Let t_{ji} where j=1, 2, 3, ………., n and i = 1, 2, 3, ……………, n represent the distance having j^{th} node from the i^{th} node. In this algorithm firstly we make a weighted adjacency matrix using the given network having node and edge having some weight which denotes distance between the two nodes. Now we have divided it (N x N weighted matrix) into N X 2 sub matrix according to the given formula.

$M_{j1}^{k} = \sum^{k}_{i=1} t_{ji}$ = Constructing first column of N x 2 adjacency matrices.

$M_{j2}^{k} = \sum^{n}_{i=n+1-k} t_{ji}$ = Constructing second column of N x 2 adjacency matrices.

After it using Johnson's rule we have sequence the node so that we have obtain n-1 sequences. Then we calculate the cost of each and every sub sequence. Now estimate which sequence cost is minimum that is optimal sequence. And according to the sequence scheduler is worked. And using this technique congestion of the traffic is reduced and packet loss is negligible. The proposed algorithm is described follows:

Step 1: Begin

Step 2: Construct the N x N adjacency matrices Where N is the node of the network.

Step 3: The N x N adjacency matrices split into N x 2 sub matrices. The number of such matrices will b N - 1. Thus a network having 7 nodes then it will involve 7-1=6 sub matrices.

Step 4: Using p, where p<=N-1, auxiliary N-1 sub matrices can be defined as follows. In the K^{th} auxiliary problem.

Step 5: Set k=1, for first auxiliary problem.
$M_{j1}^{k} = \sum^{k}_{i=1} t_{ji}$ = Constructing first column of N x 2 adjacency matrices.
$M_{j2}^{k} = \sum^{n}_{i=n+1-k} t_{ji}$ = Constructing second column of N x 2 adjacency matrices.

Step 6: Apply S.M. Johnson's n-job, 2- machine algorithm to the n-job 2-machine problems established and determine S_k and store.

Step 7: Check k with p; if k < p, set k = k+1 and repeat the **step 4**; if k=p, then proceed

Step 8: Using real N x N matrix of processing distance, compute total processing distance for each of the p sequences generated.

Step 9: Select minimum total processing distance sequence as the optimal sequence. This optimal sequence is determining the shortest path of the given complex network.

Step 10: End

4. RESULT AND PERFORMANCE ANALYSIS

4.1 Simulating Parameter

For simulation topology we used two source nodes, two edge routers one is for Ingress router and other is for Egress router, two core routers and one destination node. Both source node linked with Ingress router by Duplex link. Ingress router is connected with core1 and core2 router by simplex link, core1 and core2 also connected with ingress router by simplex link.core1 and core2 linked with Egress router by simplex link and vice versa. And Egress router is connected with destination node by duplex link.

TABLE 1.a

Cir	1000000
Cbs	3000
Pir	3000
Pbs	3000
Packet size	1000
Simulation time	10.0

Queue limit	3

TABLE 1.b

Link To	Link From	Link Type	Bandwidth	Delay
N0	E0	Duplex	10mb	5ms
N1	E0	Duplex	10mb	5ms
E0	C0	Simplex	10mb	5ms
E0	C1	Simplex	10mb	5ms
C0	E1	Simplex	5mb	5ms
C1	E1	Simplex	5mb	5ms
E1	N3	Duplex	10mb	5ms

4.2 Results

Our simulation shows that on increasing the no. of packets on different nodes shows greater packet loss. Scheduling techniques used in this simulation is Round Robin.

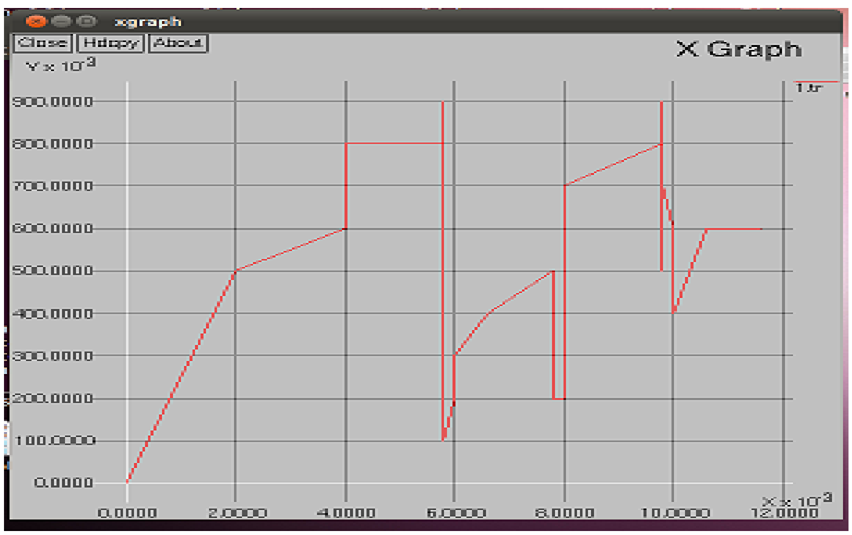


FIGURE 4.1: Lost of the application attached to agent UDP0

Our simulation with the proposed algorithm shows no packet loss has been occurred during the transmission of packets this means it provides greater efficiency than the previous scenarios.

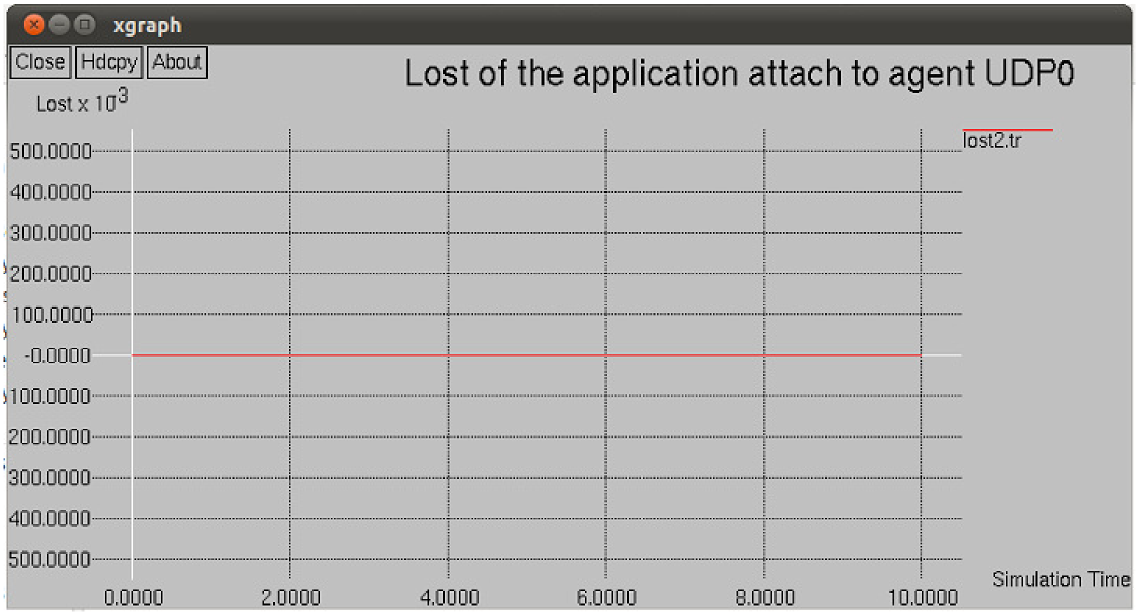


FIGURE 4.2: Lost of the application attach to agent UDP0

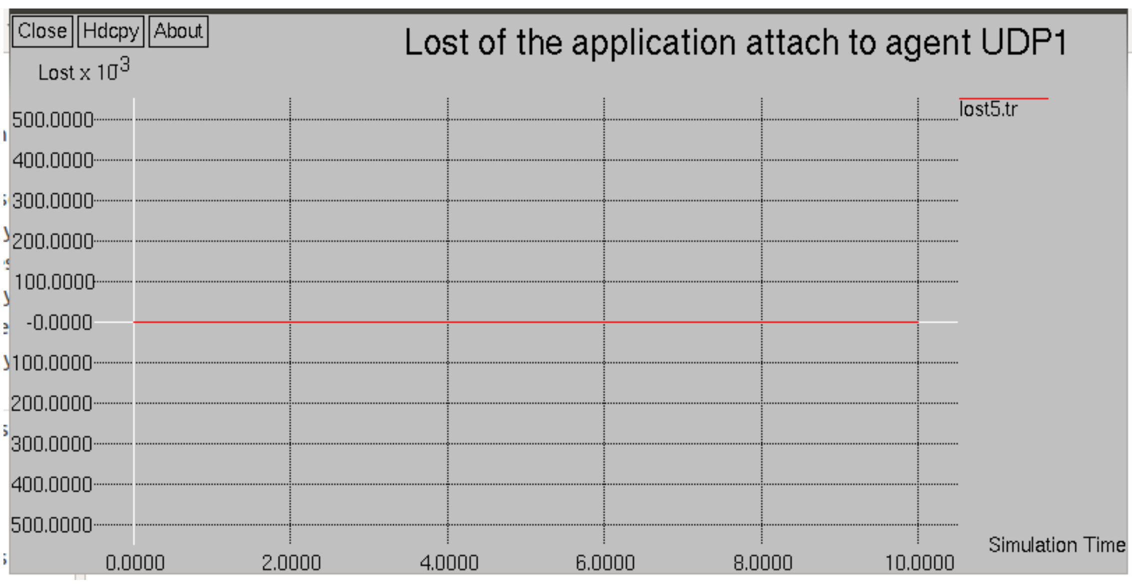


FIGURE 4.3: Lost of the application attach to agent UDP1

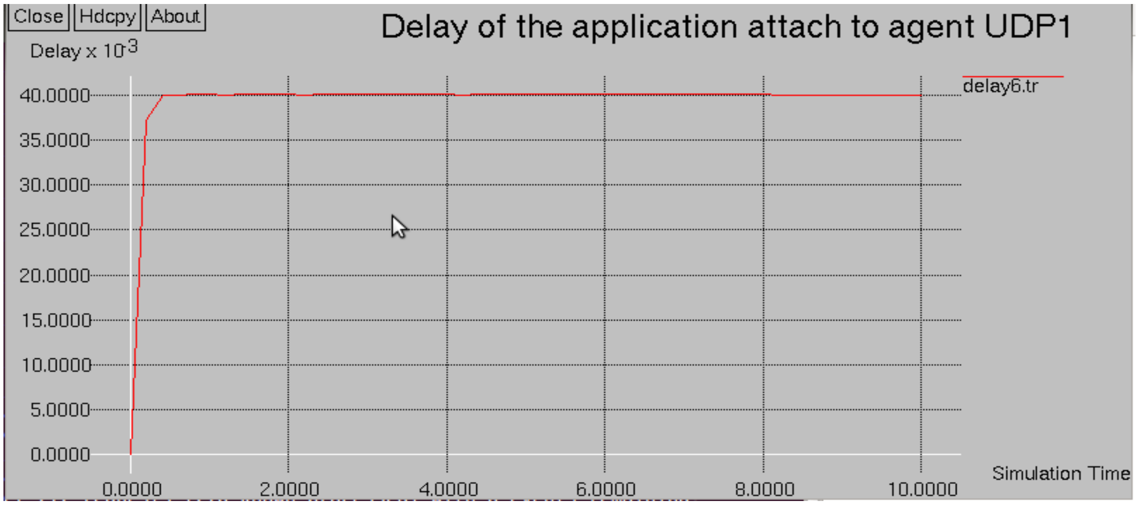


FIGURE 4.4: Delay of the application attach to agent UDP1

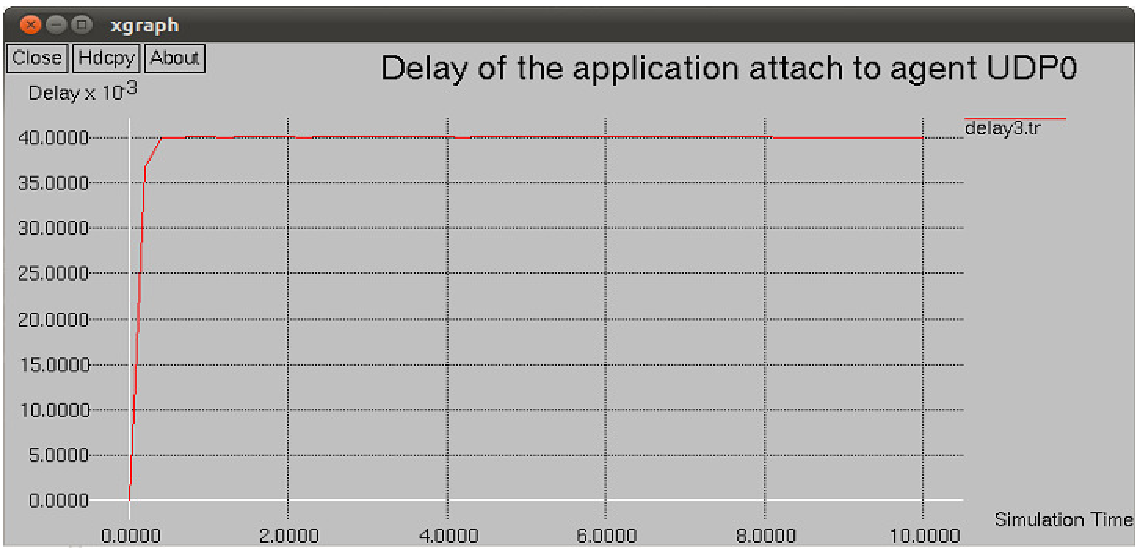


FIGURE 4.5: Delay of the application attach to agent UDP0

The figure below shows the bandwidth utilization of the current scenarios with proposed scheduling policy.

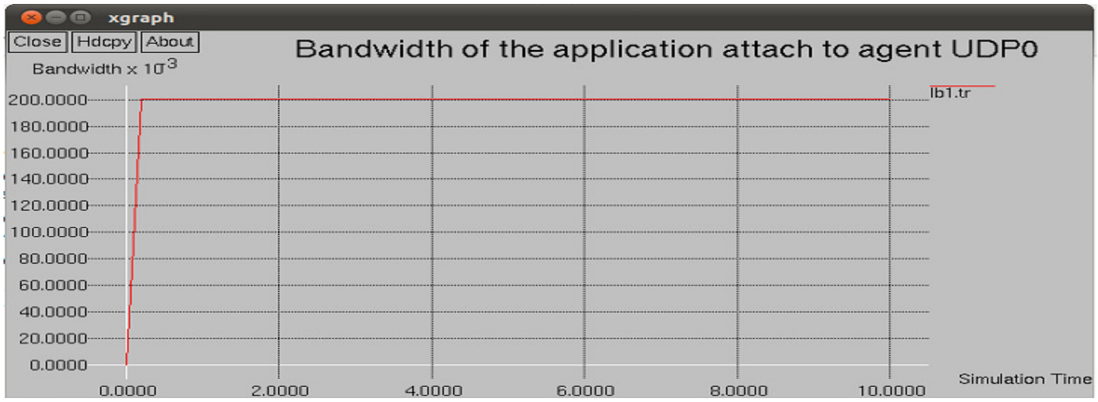


FIGURE 4.5: Bandwidth of the application attach to agent UDP0

5. CONCLUSION AND FUTURE SCOPE

The scheduling policy applied before have very large number of packet loss during the transmission of data packet. Simulation results shows that there occurs great improvement in efficiency in the network for the packet transmission, the loss of packets become nearly null for the proposed scheduling technique and the scheduling policy also maximizes the bandwidth utilization of the network. The simulation supports our scheduling policy and supports its applicability on MPLS Traffic Engineering over the Diffserv network.

In this report, many other issues are still to be resolved and need to be worked upon. Following are some suggestions to extend this work.

This topology is working on wired scenarios not in wireless scenarios. In future there can be further evaluation of our scheme for wireless scenarios or mobile MPLS. Here we work on the congestion control for the traffic engineering this algorithm can be applied for the other qos of the network ex. path optimization.

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