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An Advanced Practice for Congestion Control, Routing and Security Issues in Multi Protocol Label Switching (Mpls)

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Abstract

In recent decades, IP networks have been subjected to different types of Internet applications with different quality of service (QoS) requirements. Traffic engineering enables routed traffic to be altered from standard to alternative routes to improve network reliability and avoid network congestions. However the best effort characteristic of IP makes it inadequate to support traffic engineering and QoS. To support QoS over IP networks, traffic engineering (TE) has introduced Multi-Protocol Label Switching (MPLS). Network traffic delays are often the result of congestions. Internet service providers (ISP) have to minimize congestions because it causes packet delays and consume network resources resulting in low QoS. In MPLS network edge router has complete routing information in its control plane which is obtained through reliable links, bandwidth, efficient path etc. In this paper, we propose a robust framework for MPLS-based network survivability against congestion that occurs in LSPs and redundancy in case of any link failure by making the MPLS control plane routing information stored in a static agent. The static agent selects best paths from OSPF routing table and divide the traffic as defined by traffic engineering formula. In case, any path is down during data transmission, agent will shift the traffic over next best available path. This proposed schema covers not only Congestion Avoidance & Congestion detection but also provides reliability of data transmission over LSPs.

Keywords: ***Multi-Protocol Label Switching (MPLS), Congestion Contro (CC), quality of service (QOS), Constraint-Based Routing (CBR)***

1. Introduction

Multi Protocol Label Switching (MPLS) is a new forwarding mechanism in which packets are forwarded based on labels. Labels may correspond to IP destination networks (equal to traditional IP forwarding). Labels can also correspond to other parameters such as quality of service (QOS) or source address. Only edge routers must perform a routing lookup and are called Edge Label Switch Routers (ELSRs). Core routers switch packets based on simple label lookups and swap labels and are called Label Switch Routers (LSRs). MPLS was designed to support forwarding of other protocols as well.

In internet world, communication is carried out in the form of frames, which travel from source to destination of hop by hop in a store and forward manner. As the frames arrive at each router, it determines the next hop in order to make sure that the frames manage their way towards intended destinations by performing a route table lookup. MPLS is a versatile solution for many problems being faced nowadays on a conventional IP network. MPLS provides connection oriented service for variable length frame and has emerged as a standard for next-generation internet .MPLS is highly scalable data caring mechanism where labels are assigned to data packets and forwarded based on the contents of those labels without checking the originals' packets itself allowing flexibility in using protocols and to route packet across any type of transport medium. MPLS is an emerging technology that is overcoming the existing technology.

MPLS is a protocol for carrier-based core networks that runs over MPLS-enabled IP routers and ATM switches. Such devices are called MPLS LSRs (label switch routers). An MPLS network permits the definition of explicit paths, which are predefined routes through networks in contrast to routes that are selected at each router on a hop-by-hop fashion. Routing protocols such as OSPF and BGP determine these explicit routes in advance, and then build tables to define the routes. Packets carry labels to indicate which explicit route they should be taking. Thus, labeled packets follow LSPs (Label Switched Paths). The preceding procedure of using standard routing protocols to define explicit paths is really the default procedure, and it can take place without operator intervention. In addition, MPLS is flexible enough to define paths based on various constraints such as available bandwidth, the priority setting

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of packets, the whims of an operator, or the directives of a policy-based server, as a result; MPLS also supports CBR (Constraint-Based Routing). An MPLS has two major components control plane and data plane. Control plane contains complex mechanism to exchange routing information such as Open Shortest Path First (OSPF), Enhanced Interior Gateway Routing Protocol (EIGRP), Intermediate System-to-Intermediate System (IS-IS), and BGP, and to exchange labels, such as Tag Distribution Protocol (TDP), Label Distribution Protocol (LDP) and Resources Reservation Protocol (RSVP). Control Plane maintains contents of the label-switching table i.e. Label Information Base or LIB. Only Edge routers consult the control plane because the incoming packet is IP based so must consult the routing table for its destination.

Data plane has a simple forwarding engine that manage a cache memory in which packets are forwarded without checking the IP address and forwarding is performed just like switching. Intermediate or label switch routers only consult the data plane in MPLS domain. There is no need to consult control plane and consult the routing information about the particular data. This reduces the overhead of consulting the routing table hop by hop for incoming traffic.

2. Architecture of MPLS Network Topologies:

A label distribution protocol is used between nodes in an MPLS network to establish and maintain the label bindings. The routers in MPLS domain are categorized into following two major responsibilities according to their working.

2.1 Label Switch Routers (LSRs):

Label switch router (LSR) as shown in Figure 1 receives a labeled packet, swaps it with an outgoing one, and forwards the new packet to an appropriate interface. Depending on its location in MPLS domain, this router performs label disposition (removal, POP), label imposition (addition, PUSH) or labels swapping (replacing the top label in a stack with a new outgoing label value). These are intermediates nodes in MPLS domain and these nodes just perform label swapping and ford data forwarding on labels.

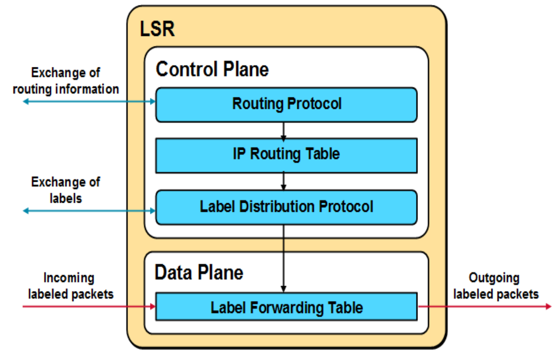

Figure 1: Label Switch Router (LSR)

2.2 Edge Label Switch Routers (ELSRs)

It exists on the perimeter of an MPLS network and is an exit point where the data packet reaches its destination. This edge router as shown in Figure 2 performs label disposition or removal (POP) and forwards IP packet to destination. It disposes label from the arrived packet only when the bottom-of-stack indicator identifies if the encountered label is the bottom label of the stack or not. Both label switch routers and edge label switch routers work simultaneously.

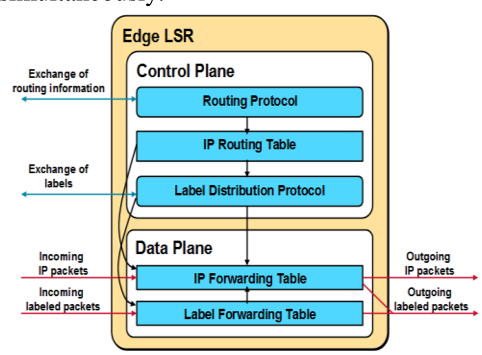

Figure 2: Edge Label Switch Router (LSR)

3 Label Distribution

Label Distribution Protocol (LDP) enables peer label switch Routers in an MPLS network to exchange label binding information for supporting hop-by-hop forwarding in an MPLS network. This module explains the concepts related to MPLS LDP and describes how to configure MPLS LDP in a network. MPLS LDP provides the means for LSRs to request distribute and release label prefix binding Information to peer routers in a network. LDP enables LSRs to discover potential peers and to establish LDP sessions with those peers for the purpose of exchanging label binding information. In label distribution process labels are assigned downstream to upstream as normal traffic flows from upstream to downstream. After

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the routing protocol working the label distribution protocol starts to establish labels in MPLS domain.

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4 Literature Review

Iwan et al., (2003) elaborated network management systems that Client/Server model is used by these protocols. In this model the management station acts as a client which provides a user interface to the network manager and interacts with agents. These agents are in fact the servers which manage remote access to the Management Info Base (MIB). The main focus of this study is to explore the effect of using a mobile agent as compared to a static agent but this result still needs improvement, in particular on response time using the mobile agents and network operations in which several managed nodes are used. Rana Rahim-Amoud et al., (2008) focused on Multi-Agent System (MAS) within the MPLS network to improve its performance and also proposed an intelligent framework for network as well as architecture of agent in order to improve the efficiency of the Quality of Service (QoS) within MPLS. One of the step consisted of finding the decision points into MPLS which are especially identified on the entry of the domain on the I-LSR routers. The MAS is then situated into these decision points. The MAS has a role to set up multiple LSPs between an ingress-egress pair, and to distribute dynamically the incoming traffics to these LSPs. Traffics are distributed based on type and they require QoS. Basically two-layer's architecture of MAS is also proposed in this paper. Dario Pompili et al., (2007) paper discussed IP traffic engineering (TE) for multipath selection in MPLS networks. A centralized and a distributed routing algorithms are proposed, which aggregate IP flows entering the MPLS domain, and optimally partition them among virtual flows that are forwarded on multiple paths according to their quality of service (QoS) requirements. The virtual-flow multipath routing problem was formulated as a Multi Commodity Network Flow (MCNF) problem, and was solved by implementing the Dantzig-Wolfe decomposition method. The main advantages and drawbacks of IP routing are underlines in the study paper of Georgi Kirov et al., (2002). In the OTN the routing is mainly linked to wavelength allocation. The matrices and constraints also differ from the IP/MPLS case. This would affect the CBR process of an Optical RMA furthermore, as the same signaling protocols are being standardized for the RSVP-TE/CR-LDP, therefore the communication with network devices shall be of similar nature. Salah et al., (2010) builds an adaptive, robust, and reliable traffic engineering scheme for better performance and operation of communication networks. This will also provides Quality Of Service (QoS) and protection of traffic engineering to maximize network efficiency. The proposed scheme can be built to secure core networks such as optical and IP networks. Their assumption is based on the fact that core network nodes share multiple edge disjoint paths from the sender to the receiver. S-MATE can secure network traffic against single link attacks/failures by adding redundancy in one of the operational paths. Furthermore the proposed scheme can be built to secure operational networks including optical and multipath adaptive networks. But in case of any link failure or re ordering is not clear in it. Andrzej et al., (2007) discussed potential uses of mobile agents in network Management in this paper. Furthermore software agents and a navigation model which determines agent mobility have also been defined. The description of several actual and potential applications of mobile agents in the five OSI functional areas of network Management is the core of the paper. It is different from classical client/server systems the reason is that there is no clear distinction between a client and a server. In this area most of the research is in its initial stages, so there is a shortage of available resources. For performing various tasks there is an extensive use of agent mobility which would otherwise require extensive attention spans available on the internet. However a lot of effort is still required for controlling congestion and load balancing. Rami Langar et al., (2008) discussed a new mobility management scheme designed to track host mobility efficiently so as to minimize both handoff latency and signaling cost. Building on and enhancing Mobile IP and taking advantage of MPLS traffic engineering capability, three mechanisms and also described a new micro-mobility management scheme called Micro Mobile MPLS. Mingui et al., (2008) has proposed and formulated that the traffic engineering problem is a multi commodity. Most of the traffic is routed by the regular OSPF and the number of MPLS tunnels needed is small. The network can be represented by a directed graph. The traffic volume that flows from the ingress router's' to the egress router't' is represented by G= (N, A) and D(s, t). Only four LSP's are required by MCFTE and the output of MCFTE is the LSP's that are to be configured and the traffic amount that these LSP's will carry. Whenever the changes are required by the traffic, MCFTE can quickly recompute the optimal solution.

While concerning the all dynamic routing is required to handle congestion and link failure problems. Due to dynamic routing load balancing is also achieved and in Constrained based routing in MPLS traffic engineering can be introduced as its some advantages.

5. PROPOSED METHODOLOGY

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The proposed way of handling the congestion control and maintain the reliability in data delivery based on the best selected paths which will be driven by the OSPF routing protocol. Our technique will take the decisions of load balancing on basis of best three paths that are available to one destination by using OSPF protocol and the data transmitted through these paths will be managed by our designed static agent who will reside at the Edge LSR in the MPLS network domain.

Moreover the agent will be playing its role in case of any link or LSP failure and will maintain the reliability of data delivery. The static agent selects best paths from OSPF routing table and divides the traffic as defined by traffic engineering formula. In case, any path is down during data transmission, agent will shift the traffic over next best available path. The static agent is an algorithm which controls data transmission by using maximum utilization of LSPs. This proposed schema covers not only Congestion Avoidance & load balancing; also reliability of data transmission over LSPs is increased.

6. RESULTS AND DISCUSSION

The following algorithm is to calculate the shortest path from the paths array and it returns a path which is the shortest path.

```
Path getshortestpath (array [ ] paths)
{
// to determine the max metrics for path selection
maxmetrics = 0;
// to determine that at which place path resides in the array
index = 0;
// where n is the length of the path array
for i=1 -> n
If (maxmetrics < paths[i].metrics) && (paths[i].used==false)
Then
maxmetrics = paths[i].metrics;
index = i;
path[i].used = true;
break;
if ends
for ends
return paths [index];
}
```

Figure 3: Calculate Paths

In the above figure 3, we have used keyword of path metrics. in order to calculate the path metrics, the following formula can be used to calculate the path metrics.

To calculate the path metrics,

$$\text{Metrics} = 10^8 \ / \ \text{bandwidth}$$

```
Void calculatepathmetrics(array[ ] paths)
{
// where n is the length of paths array
For i = 1 -> n
bandwidth = 0;   // to store the bandwidth
For j = 1 -> m     // where m is the number of edges in a path
bandwidth = bandwidth + paths [i].edges[j].bandwidth
for end,
paths[i].bandwidth = bandwidth;
paths[i].metrics = 10^8 / bandwidth;
for ends.
}
```

Figure 4: Select Paths

The following algorithm in figure 4 is to calculate the path metrics.

```
void sendtodown(data)
{
// send data on the path
path = getshortestpath(array [ ] paths)
while (sendinginprogress)
if  (pathgetdown)
sendtodown(remainingdata);  // iteration
break;
end if;
end while;
}
```

Figure 5: Link Failure

In case of link failure during the data delivery the next available path is utilized algorithm in figure 5 is to send the data on a path when a path gets down. The keyword data is the data to send on a path.

7. SIMULATIONS

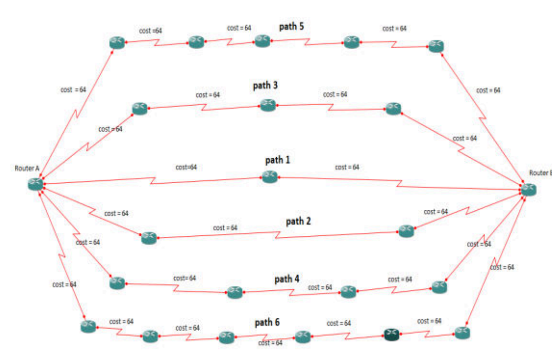

Figure 6: MPLS LSPs (paths)

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Figure 6 is represents the MPLS domain in which Router A is ingress or Edge LSR router and Router B is egress or Edge LSR router and remaining the LSR's routers which just forwarding the packets based on the assigning labels. Router A has six different paths available so as to transmit data to Router B. But out of all these paths or LSPs it will select the best path which is path1 or LSP according to figure and this is the normal routine of selection or utilization of path or LSP in MPLS.

Parameters	Values
Network size	300 x 300
Number of nodes	23
Packet size	512 byte
Packet Transmission Rate	5 and 10
Routing Protocol	OSPF
Simulation time	15 min
Channel Capacity	2 MB

The proposed algorithm is based on the Maximum LSP utilization, rather than best LSP select or best path choose. The algorithm is based on mathematical formula which assigns 50% weight of utilization of first path or LSP, 35% utilization of second path and 15% utilization of third path. These best paths are stored in an array which is derived from OSPF routing protocols. Out of all these paths to a specific destination only best three paths are utilized according to above mentioned percentage. In case of any path or LSP failure the next path will be selected from array which stores information of all short listed paths.

Scenario I: Normal Utilization of LSPs In MPLS Network

In Multi protocol label switching network generally best path or LSP is use during data transmission as shown in Table 1 from one edge node to another edge node in constrained based routing. This can occur due to all incoming traffic has same destination point. In case if it happens frequently in the MPLS network domain than only one best path or LSP is utilized. The other remaining paths or LSP's become idle. It means that other LSP's or paths have no contribution of data transmitting from one node to another. In fact other resources and links have not been utilized and also no load balancing has been achieved. In this scenario in case of maximum traffic load so there are lot of chances have been created to occur congestion on that particular link or LSP.

Steps	Time utilization	Link utilization %	LSP's
1)	85.82 ms	100%	1st path
2)	------	Free	Free
3)	-----	Free	Free

Table 1: Normal Utilization of LSP in MPLS Network

Scenario 2: Data Forwarding By Utilization of Multiple Lsp's

While implementing our approach max m imum utilization of paths or LSP's can be achieved as shown in Table 2. This can be done by using our proposed mathematical formula of link utilization. Now if the incoming traffic belongs to same destination it will utilize the best three paths instead of one path or LSP. This percentage of link or LSP's utilization is pre calculated by agent using mathematical formula. So according to LSP's calculation formula first path or LSP utilizes 50% of data delivery, second path or LSP utilizes 35% and third path utilizes remaining 15%. So the remaining two ideal paths are now utilized by using our approach according to predefined calculation of each path bandwidth utilization and this can be achieved by static agent.

Steps	Time utilization	Link utilization %	Lsp's
1)	53.2 ms	50%	1st path
2)	76.48 ms	50- 85 %	2nd path
3)	85.88 ms	85 – 100 %	3rd path

Table 1: Data Forwarding by Utilization of LSP's

In Figure 4 we have shown the utilization of best three paths or lsp's according to our proposed pre calculated percentage using a mathematical proposed formula so as to utilize each link or lsp. On vertical scale we assumed the utilization each path or lsp during data transmission i.e time in minutes. On the horizontal scale the amount of

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traffic transmitted on each lsp. In Graph 1 page 49 first path or lsp utilizes 50% of traffic forwarding in 52.31ms and second lsp or path forwarding 35 % of data in 25.91ms. similarly the third path or lsp forwarding the 15 % data in 84.47 ms.

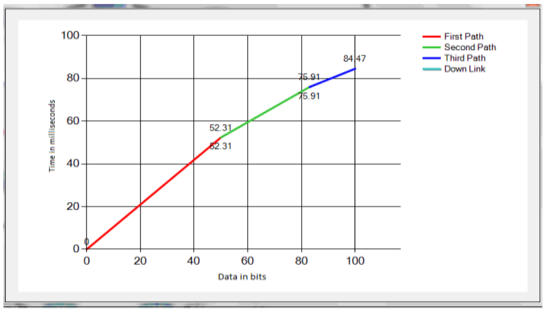

Figure 4: Utilization Of Best Three LSP's (50%, 35%, and 15%)

Scenario 3: Data Forwarding In Case Of Third Lsp Down

In above scenario if we have utilized best three Lsp's according to pre calculated percentage for each path or LSP. Although maximum utilization of Lsp's have been achieved in above scenario. But still chance exists to have lack of reliability of data delivery in case of any path or LSP failure. So in this scenario we have focused and highlighted the problem of third LSP link failure as shown in Table 3. we made an assumption such as if third path or LSP utilizes 5% only and then fails to carry further data so our agent play a vital role in this situation and will guide the remaining traffic to utilize alternative path. So remaining 10% out of 15% traffic will shift to alternative path or LSP.

Steps	Time utilization	Link utilization %	LSP's
1)	53.2 ms	50%	1st path
2)	76.48 ms	50- 85 %	2nd path
3)	78.88 ms	85 – 90 %	3rd path
4)	85.88 ms	90 – 100 %	Alternative path

Table 3 : Data Forwarding In Case Of Third LSP Down

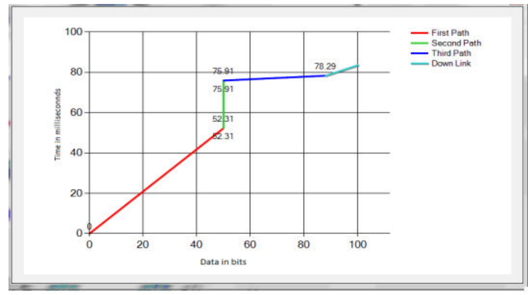

Figure 5: Case Of Failure In Third Lsp (50% , 35% ,5%,10%)

Scenario 4 : Data Forwarding In Case Of Second Lsp Down

In our fourth scenario we made an assumption that in case of 2nd path or LSP in constrained based routing after transmitting 10% of data comes down due to any reason than the remaining 25% data delivery will be accomplished by the alternative link as shown in Table 4. This is achieved efficiently by our proposed agent which retains the multiple path or LSP's information regarding single destination. So 50% of overall data is transmitting by using 1st LSP and 10% is transmitted by using 2nd LSP remaining 25% due to case of failure in 2nd LSP is shifted through alternative path and finally 15% is transmitted by using 3rd LSP

Steps	Time utilization	Link utilization %	LSP's
1)	53.2 ms	50%	1st path
2)	60.9 ms	50- 60 %	2nd path
3)	73.06 ms	60- 85 %	Alternative path
4)	80.21 ms	85 – 100 %	3rd path

Table 4: Data Forwarding In Case Of Second LSP Down

In figure 6 both vertical and horizontal values are same as the figure 5 assigned but in this graph we have shown the failure condition of second path or lsp and the traffic is shifted to another alternate path. In Graph 3 shows that in case of second lsp failure or down the traffic is shifted to an alternate path. In this graph it has been shown that in after 59.31 ms the second lsp or path failed to forward the

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traffic so traffic as be shifted to down or alternate link up to 71.81 ms. Then remaining traffic is forwarded on the third link as it is decided by our normal proposed routine.

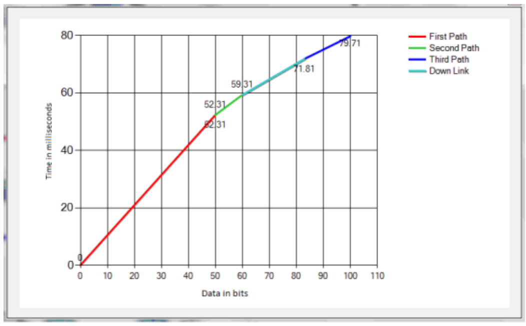

Figure 6: Case Of Failure In Second LSP (50% , 10% ,25%,10%)

In all these simulations results we explain different scenarios in which maximum utilization of lsp's shown and also discussed different scenarios in which path or lsp down due to any reason and the traffic is shifted to alternate path or lsp which is pre calculated by our agent using OSPF routing protocol and set these path or lsp. Due to utilization of more than on lsp's the chances of congestion occurrence in one particular is much more less and the role of agent is to make sure that the data delivery is reliable and efficient in case of any link or LSP failure . Each path or lsp is utilizing according to its pre calculated percentage

Figure 7 shows the comparison between the standard MPLS approach and proposed MPLS approch and ther efficences in case of congestion.

It shows that how many packets lost due to congection in normal scenario and in proposed approach there is less chances of packets dropped due to congestion. Conjestion is one of the major issue of packets lost on a link . once conjestion occurs it is much mor difficult to reduce it at run time so proposed approch provids a better way of utilization of maximum links or paths to overcome the chance of congestion and provide the reliability in data transmittion . its clearly shows that as no of packets increase the rate of packets lost is much more increase and at one stage the link become stuck or down due to overload traffic on that particular path so the best way to split the traffic into multiple paths and reduce the chance of overloading on a particular path.

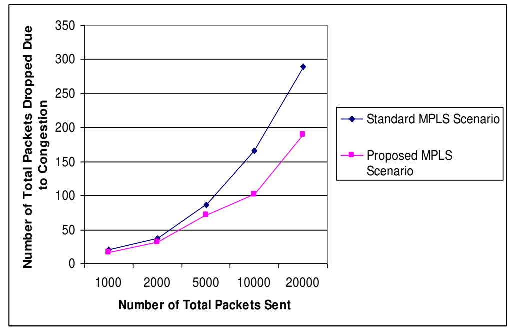

Figure 7:Comparison

Figure 8 clearly shows that proposed approach packet delivery ratio is much more grater then the standard MPLS data delivery and in case of congestion proposed approach provides much more reliability in data delivery as compare to traditional apprach.

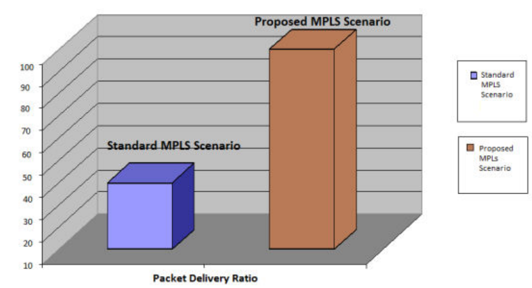

Figure 8: Packet Delivery Ratio

8. CONCLUSION

In this proposed technique we have present a flexible and efficient way to utilize the maximum Lsp's in MPLS domain. In MPLS Lsp's an efficient load balancing have been achieved where congestion on Lsp's in MPLS domain is tried to avoid or overcome during transmitting the data. We have focused on best three available Lsp's first according to our proposed formula of link utilization in data transmitting. We have developed a static agent (algorithm) that performs the specific tasks to handle the avoidances of congestion on Lsp's and also provides the reliability of data delivery. It guides the MPLS forwarding mechanism as to perform different actions in different scenarios to minimize the problems. Agent main role is to avoid human intervention in taking decisions in critical situations and ability to handle the difficult situations .Our research work has been implemented in prototype simulation based approach to obtain results and comparisons in different scenarios.

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