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Improved Link Communication and Fast Recovery In MPLS Network

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Abstract

Multi Protocol Label Switching (MPLS) is a technology for fast switching of the packets based on the labels and also superior for Traffic Engineering. In real time network link failure occurs because of the power depletion of a node which may be due to congestion on that node and the communication gets interrupted. To make the network resilient to such interruptions several route recovery models have been proposed like Makam's model, Haskin model, fast reroute one to one back-up model and ASQ model. But all these models do not focus on congestion in the network, so chances of link failure due to congestion in these models are almost remains equivalent. The problem of link failure due to congestion is overcome by the proposed algorithm discussed in this paper. Moreover by the use of proposed algorithm, Packet Delivery Ratio (PDR) and Delay has been improved.

Index Terms: MPLS, Congestion, ASQ, Link Failure, Makam's Model, Fast Route Recovery.

Introduction

Network is a collection of nodes which are linked to each other via wired or wireless medium for the purpose of communication [1]. Different types of networks are available in the field of computer network like IP network, Ethernet network, SONET, ATM network etc [2].These different network requires different environment for their operation .To overcome this problem new field had emerged. The name of that field is MPLS [3]. Multi Protocol Label Switching technology (MPLS) which switches the packets based on the imposed labels [3]. The packets on which the labels are imposed can be of any type like IP packets, Ethernet frames, ATM Cells, etc. This network can carry any type of traffic over the same backbone, so it is known as ATOM (any traffic over MPLS) [3].

There are certain limitations of IP network which are overcome by MPLS network. In IP network packets are forwarded by checking the 32 bit IP address, so switching takes time because at each hop 32 bit destination address of packet is check with all the entries in the routing table of a router [3]. The situation becomes worst as network grows. But in MPLS network switching is based on labels attached to the packets, hence switching is faster [3].

The technology MPLS also helps in Traffic Engineering [4]. The aim of traffic Engineering is to move the traffic from one end to another in the most optimal manner [4]. In real time networks, the link failure occurs due to congestion, power failure etc and communication gets interrupted. But no one like this type of network which gets interrupted by any how so, we reserve the back-up paths to reroute the traffic from faulty paths to the back-up path.

Many models and approaches have been proposed to switch the traffic to back-up paths from the faulty paths. These models are Makam's model [5], Haskin model [6], fast reroute one to one back-up model [7], and ASQ model [8].

Related Work

In route recovery Makam's model completely back-up path is established in advance, so when link failure occurs time taken for computing the back-up is saved. In this model working path is connected with the back-up path only by ingress and egress router of back-up path and if link failure occurs close to destination of longer chain network so, this leads to delay in Fault Indication Signal (FIS) reaching the upstream ingress router. If the rate of production of packets from the source node is high then the numbers of packets that get dropped are also high [5]

Haskin route recovery model is also known by another name called Reverse Back-Up model. In the working path of this model if fault is identified then traffic will be reversed back from the faulty node to the ingress router. Likelihood that back traffic will alter the order of packets is high in this case. Reverse traffic will work as fault indication Model (FIS) in this case. If the rate of production of packets from the source node is high then the number of packets that get dropped is also high [6].

In fast Reroute One to One Back-Up model every node on working path has its own separate back-up called a Detour which is computed in advance and is reserved. Delay is reduced because Fault Indication Signal needs not to move back to the ingress router to take the decision. Since every node has its own back-up so this model requires large amount of bandwidth and routers [7].

Assured Quality of Service (ASQ) model overcome the challenges faced by Makam's model, Haskin Model and Fast Reroute Back-Up model. In this model back-up path is setup for the complete working path. Every node on working path is not have its own back-up but after every 'x' hops routers on working path is connected with back-up path so, this type of topology requires lesser resources and ensures redundancy. In the network of longer chain if fault occurs close to destination the nearest router takes the switchover decision so, delay in Fault Indication Signal is reduced because there is no need to send the Fault Indication Signal to ingress router to take the decision [8].

But in the all four route recovery models that are discussed above have equivalent chances of link failure because they does not check the congestion on the paths that led the traffic to the destination and congestion is one of the important factor of link failure. This problem is solved by proposed algorithm which is discussed in this paper.

Depending upon where recovery path can be located in the model there are two main categories of recovery mechanism. These are Global Repair and Local Repair [5]. In Global Repair mechanism global protection is achieved means protection against any link failure on the path or on a piece or segment of path. In Global Repair point of repair is far-off from the point of breakdown and needs to be notified by the Fault Indication Signal. The main advantage of this method is that all the links on the main working path are protected by a single back-up path so less resources like bandwidth and routers are required in this case. The disadvantage of this method is that if link failure occurs close to destination in a long chain network then Fault Indication signal has to propagate back to the ingress router so, this increases the delay in FIS signal. Makam's model is based on Global Repair. In local Repair local protection is achieved. In this protection is provided against a link failure or a neighbor node failure. In Local Repair method Fault Indication Signal does not have to propagate back to the ingress router for the start of recovery. In this case FIS delay is reduced because recovery can be start by the nearest Label Switch Router that detects the failure. The disadvantage of this approach is that only one segment of the working path is protected. Local Repair is faster than Global Repair. Local Repair can be done in two different ways. These are link Recovery and Node Recovery. In link Recovery mechanism the aim is to provide protection against link failure in the working path and in Node Recovery the aim is to provide protection to node failure in the working path.

Recovery can be done in two different ways. These are Recovery by Rerouting and Recovery by Protection Switching [9]. In the Recovery by Rerouting mechanism recovery path is not computed in advance. In the recovery path is computed on demand when a link failure is detected in the working path. The advantage of this method is that there is no wastage of resources like bandwidth and routers if no failure is detected. The disadvantage of this approach is that it takes longer time in route recovery because back-up path is computed on demand after the link failure occurs. In Recovery by Rerouting the recovery path that is computed on demand is based upon Network Routing, Fault Information and Network Topology Information. In Recovery by Protection switching the recovery path is computed in advance and is pre-established before the failure occurs on the working path in the network. The Recovery by Protection switching is further classified in two forms. These are (1+1) One plus One and the other is (1:1) One for One. In (1+1) One plus One mechanism the resources like bandwidth, buffers and processing capacity on the working path are fully reserved, so this is an expensive model. The advantage of this mechanism is that resume time is fast because back-up paths are pre-computed and pre-established. The disadvantage of this approach is that resources gets waste because recovery path is reserved even when no failure occurs on the working path in the network. In (1:1) One For One approach the resources like bandwidth, buffers and processing capacity is fully available to the low priority traffic until no failure is detected on the working path in the network. The resources like bandwidth, buffers and processing capacity is not available to the any other traffic when link failure is detected because at that time traffic from working path is switched to the back-up path and this traffic is having more priority than any other traffic in the network. As no wastage of resources is there in this network so this is an inexpensive model.

Proposed Algorithm

According to the proposed algorithm if we have ‘n’ number of paths available from source to the destination then, the source router computes the congestion on all the available paths that led the traffic to the destination. After computing the congestion the source router compares the calculated congestion of all the available paths. After that the source router selects the path that is having the lowest congestion. Once the selection is done the traffic is forwarded to the selected path. Since the selected path is having the lowest congestion so chance of link failure due to congestion gets reduced on that path. But failure occurs due to power loss of the node also. If the link failure occurs on the lowest congestion path due to power loss of a node then Fault Indication Signal (FIS) is send back to the immediate upstream router. The delay in sending the FIS is reduced because all the paths are connected to each other after every ‘k’ hops so, we are sending the Fault Indication Signal to the immediate upstream not to the edge label switch router. After that the immediate upstream router computes the congestion on all the other available paths and switches the traffic to the lowest congestion path.

Flow Chart

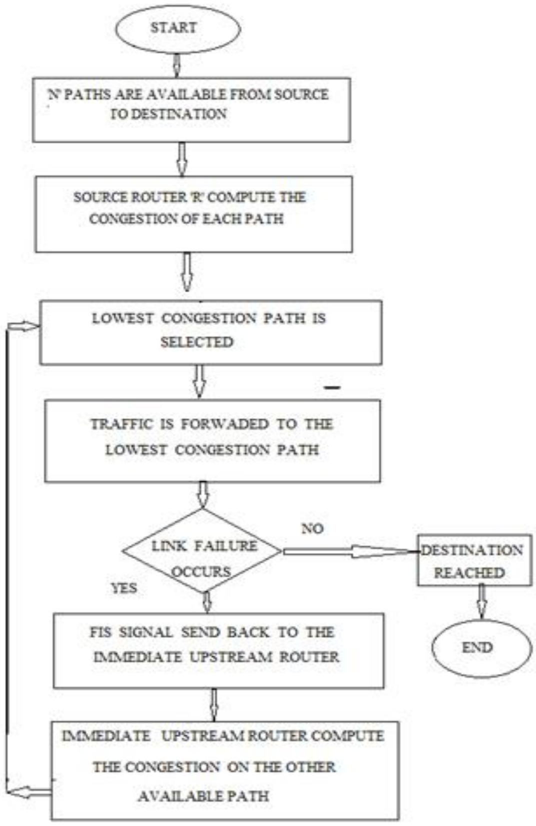

Figure 1: Proposed Algorithm

Simulation

For simulation we use NS2.

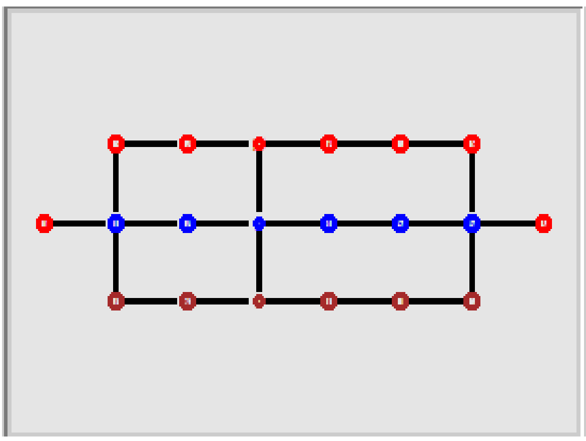

Figure 2: Simulation Scenario

Figure 2 is the topology on which the proposed algorithm discussed in this paper and the Assured Quality of Service (ASQ) approach is tested.

Figure 2 topology consists of three paths. The top path contains 6 nodes [13-14-15-16-17-18] of Red color. The middle path contains 6 nodes [1-2-3-4-5-6] of Blue color and the bottom path also contains 6 nodes [7-8-9-10-11-12] of Brown color. All the nodes of each of the three paths (top, middle and bottom) are MPLS nodes. The Node 0 and the node number 19 of Red color are non-MPLS nodes. Node 0 is the source node and Node 19 is the Destination node. The top path is connected with the middle path as [13--1], [15--3] and [18--6], similarly the middle path is connected with the bottom path as [1--7], [3--9] and [6--12]. Node 0 and Node 19 which are non-MPLS nodes are configured with UDP agent. Agents are attached with CBR traffic generator. Duplex links are there between adjacent nodes. Out of these three paths one path is having the lowest congestion and one have the highest congestion.

Results

Here we compare the proposed algorithm with the Assured Quality of Service (ASQ) approach.

On the basis of two parameters the performance of topology (Figure 2) is analyzed. These two parameters are packet Delivery Ratio (PDR) and Delay. A good network is one that is having high packet Delivery Ratio (PDR) and lesser Delay.

Case 1: ASQ approach

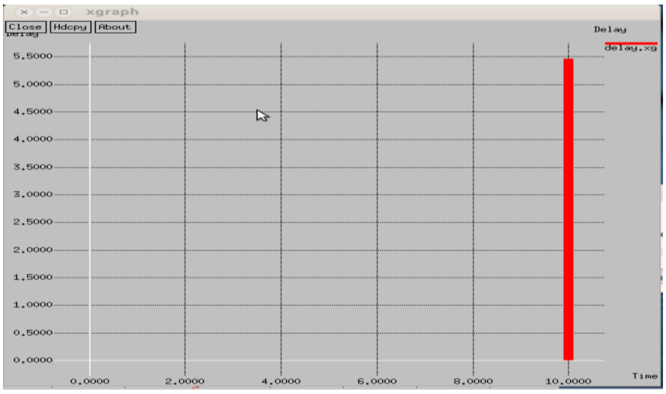

Figure 3: Delay in case of ASQ approach

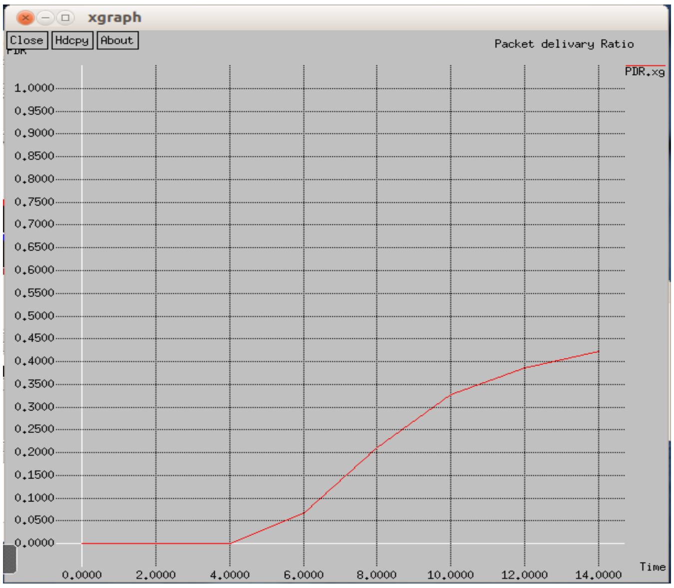

Figure 4: PDR in case of ASQ approach

According to the Assured Quality of Service (ASQ) model there will be no initial computation of congestion. So traffic can be forwarded to any of the path. If the traffic takes the highest congestion path then due to congestion on that path link failure may occur because if path is having the high congestion then the nodes of that path have to process more data packets (traffic-data) and due to more processing battery gets down fast and link failure may occurs. Moreover if highest congestion path gets selected then the data packets have to wait more in the queue for processing by the nodes on that path so, traffic takes more time in reaching from source to the destination as shown in figure 3. Since the highest congestion path gets selected so data packets dropped on that path gets very large in number so number of packets reaching from source to destination by that paths are almost nil as shown in figure 4.

After the link failure occurs on the highest congestion path due to congestion, the immediate upstream router directs the traffic over other path having less congestion than the previous path so more number of packets starts reaching to the destination than earlier path as shown in figure 4.

Case 2: Proposed approach

According to the proposed algorithm there will be an initial computation of congestion. After computation of congestion lowest congestion path is selected and traffic will be forwarded to the lowest congestion path. Due to selection of lowest congestion path chances of link failure on that path then due to congestion gets reduced because if path is having the low congestion then the nodes of that path do not process more data packets (traffic-data) and due to more processing their batteries may not get down fast and link failure does not occur. Moreover due to selection of lowest congestion path, the data packets need not have to wait more in the queue for processing so; traffic takes less time in reaching from source to the destination as shown in figure 5 as compare to the ASQ approach.

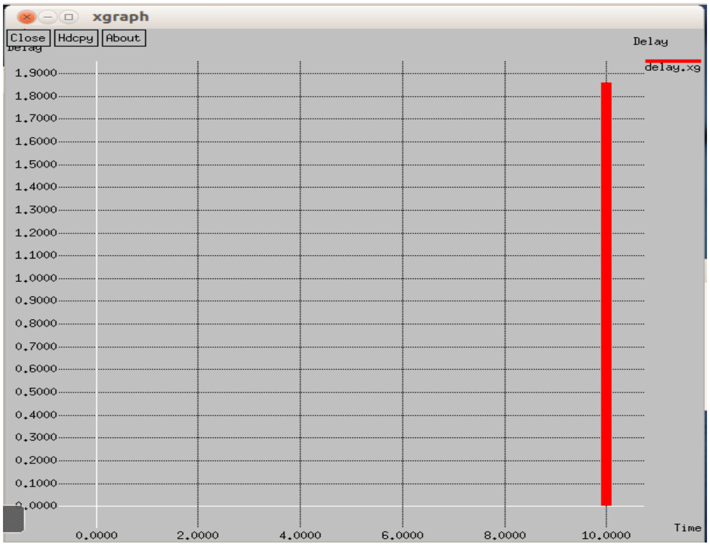

Figure 5: Delay in case of proposed algorithm

As the highest congestion path gets selected so data packets dropped on that path are very few in number as shown in figure 6 as compare to ASQ approach. But the link failure may occurs on the lowest congestion path due to power failure so, the immediate upstream router compute the congestion again on the other available paths directs the traffic over other path having less congestion in the other available.

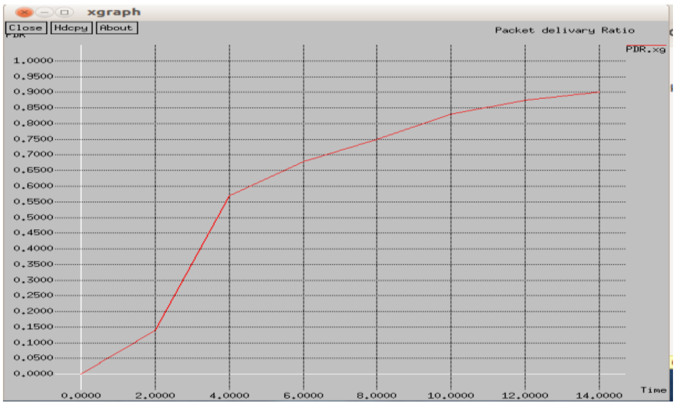

Figure 6: PDR in case of proposed algorithm

Performance comparison of ASQ approach with Proposed Algorithm

Case 1: On the basis of Delay

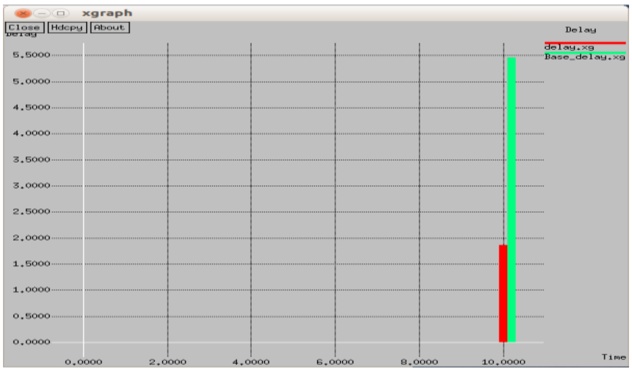

Figure 7: Delay Comparison

The Figure 7 shows that by using the proposed algorithm lesser Delay is obtained as compared to the Assured Quality of Service (ASQ) approach due to the selection of the lowest congestion path in case of proposed algorithm, so by the definition Delay proposed algorithm performs better than ASQ approach.

Case 2: On the basis of Packet Delivery Ratio (PDR)

Case A: Before link Failure occurs.

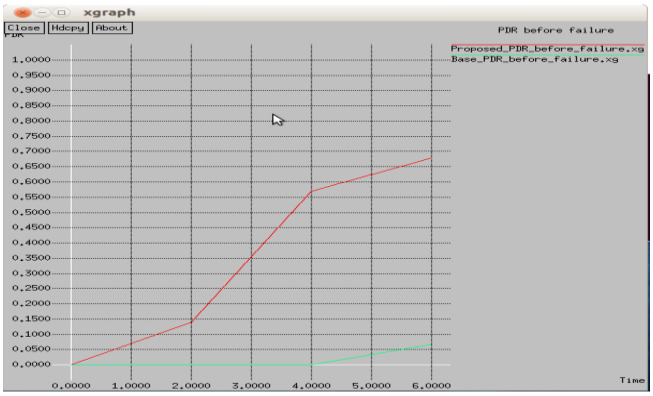

Figure 8: PDR Comparisons before Link Failure

The Figure 8 shows that by using the proposed algorithm higher Packet Delivery Ratio (PDR) is obtained as compared to the Assured Quality of Service (ASQ) approach due to the selection of the lowest congestion path in case of proposed algorithm, so by the definition of PDR proposed algorithm performs better than ASQ approach.

Case B: After link Failure occurs.

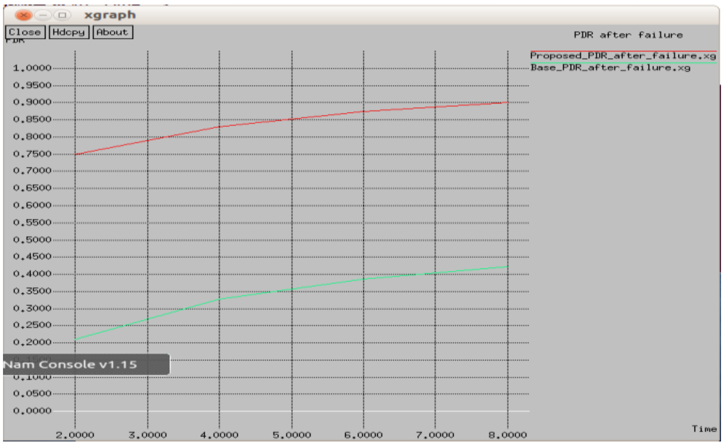

Figure 9: PDR Comparisons after Link Failure

Link Failure occurs may be due to Power Failure or if lowest congestion path is utilized for long duration The Figure 9 shows that by using the proposed algorithm higher Packet Delivery Ratio (PDR) is obtained as compared to the Assured Quality of Service (ASQ) approach due to the selection of the second lowest congestion path in case of proposed algorithm, so by the definition PDR proposed algorithm performs better than ASQ approach.

Conclusion

Earlier route recovery models like Makam's model, Haskin model, One to One Backup model and Assured Quality of Service (ASQ) model do not consider the problem of congestion due to which link failure may occurs and communication gets interrupted. By the use of the proposed algorithm discussed in this paper we reduce the chances of link failure which may be due to the congestion on the link. Moreover first calculating the congestion on the paths that directs the traffic to the destination and then selecting the lowest congestion path offers improved Packet Delivery Ratio (PDR) and less Delay as compare to the earlier existing Makam's model, Haskin model, One To One Backup model and Assured Quality Of Service (ASQ) model.

Future Work

The proposed algorithm checks the congestion on the paths only for the one Forward Equivalence Class (FEC). A Forward Equivalence Class is a group of packets that are forwarded along the same path and same forwarding treatment is given to all the packets of a particular FEC. If for a long duration of time all the FECs traffic are passed along the same lowest congestion path then the battery of nodes on that path gets vanished and this may leads to a link failure in future, so to overcome this problem the proposed algorithm needs to check the congestion for each forward

Equivalence Class before switching the traffic so that none of the path gets congested and prone to link failure. By following this criterion, Packet Delivery Ratio (PDR) and Delay can be further improved for overall network.

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