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Disjoint Path Algorithm for Load Balancing in MPLS network

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ABSTRACT: In this paper a new path computing algorithm named as Disjoint Path Algorithm (DPA) to ensure the efficient load balancing in MPLS networks to minimize the congestion and prominent use of network resources to support the traffic engineering feature of MPLS (MPLS-TE). This algorithm finds the alternate path called as Disjoint Path (DP), for selected flow sharing no common path to other flow paths. Then routing of flow via Disjoint Path is done by using the explicit path routing technology of MPLS network. Network Simulator (NS2) is used as simulator tool for analysis of the performance of algorithm. Simulation results shows that DPA effectively balances the load between the links in the network to improve the real time traffic service quality by lowering end to end delay, packet arrival time and packet drop rate and increasing throughput while reducing the congestion and improving the network utilization.

KEYWORDS: Disjoint Path Algorithm (DPA), Multiple Protocol Label Switching (MPLS), Traffic Engineering (TE), load balancing, Shortest Path First (SPF).

INTRODUCTION

Tremendous increase in rate of internet usage has led to the increasing importance of internet traffic control function and network management. Existing network infrastructure and its capacity does not satisfy all the needs of internet traffic. Thus adding bandwidth is not the solution to solve the problem of congestion as it will deliver poor returns on the investment because of unpredictable behaviour of today's telecommunication market. Congestion occurs when the resources are insufficient to carry all the traffic and when resource are routed inefficiently via available resource so that the part of network is over-utilized while another part is under-utilize. Thus this unbalanced distribution of network traffic is the primary cause for network congestion. Thus for improvement in performance, both at traffic level and resource level, minimization of congestion is crucial [1].

TRAFFIC ENGINEERING

To support resource oriented performance objective such as efficient resource utilization and resource management, Traffic Engineering (TE) came into existence. TE aims to optimize the network performance and its utilization by efficiently routing the traffic over the network. Typical feature of TE is load balancing which is to distribute the load more evenly over the network so as to ensure some links are not heavily loaded while others are lightly loaded. Thus the traffic stream from congested network is routed over alternate path available in the network to avoid the congestion.

Routing by conventional IP routing algorithm such as Open Shortest Path First (OSPF), Routing Information Protocol (RIP) and Intermediate System- Intermediate System (IS-IS) does not provide sufficient capabilities to serve different traffic properly and congestion avoidance in the network. Routing decision made by these protocols via shortest path is based on destination address only, without taking the traffic characteristics and bandwidth constraint into consideration. Thus the best path calculated by these protocols can become congested at peak times leaving other segments over alternate paths under-utilized. So TE came into existence to address this problem [2].

MPLS TRAFFIC ENGINEERING

Many current strategies incorporating TE such as constraint based routing [4], IP-over-ATM [3] and many more are in practise but Multi-Protocol Label Switching –Traffic Engineering (MPLS-TE) is a flexible technology enables effective routing and overrides other technologies. Thus due to its strong technical support for implementation of QoS, MPLS is prominently used for TE. Explicit routing technology of MPLS is extensively used as it enables much greater control over the traffic to be routed in the network which in turn used to balance the load much effectively.

Concept of load balancing is important asset of MPLS-TE as it focuses on minimises the maximum link utilization by mapping the traffic on multiple parallel or alternate path rather than shortest path to reduce the localisation of load on it potentially causing congestion. Many load balancing algorithms have been proposed to support MPLS-TE [6]. In his paper we proposed Disjoint Path Algorithm (DPA) for load balancing in MPLS-TE and compared its performance efficiency over Shortest Path Algorithm (SPF).

DISJOINT PATH ALGORITHM

Adaptive adjustment is necessary to address the highly unpredictable nature of internet traffic. DPA provides network traffic adjustment according to traffic flow requests. Thus enabling congestion control mechanism over the resources.

CONCEPT OF DPA

Assume that there are many flows for Label Switch Path (LSP) in a network, two flows are selected from the congested LSP. Find shortest path for respective flow. Find the common path between these shortest paths. It may include single or consecutive links. Single node among the path id not consider as an common path. If such path exists find alternate path called as Disjoint Path (DP) to route the traffic through this disjoint path using explicit routing technology of MPLS or else route by Shortest Path Algorithm (SPF). If no common path exists between he two traffic flow no algorithm is applied in such case. Congestion is monitored for LSP, if paths are still congested then above procedure is followed again, else stopped. Figure 1 shows the Flow char t of DPA.

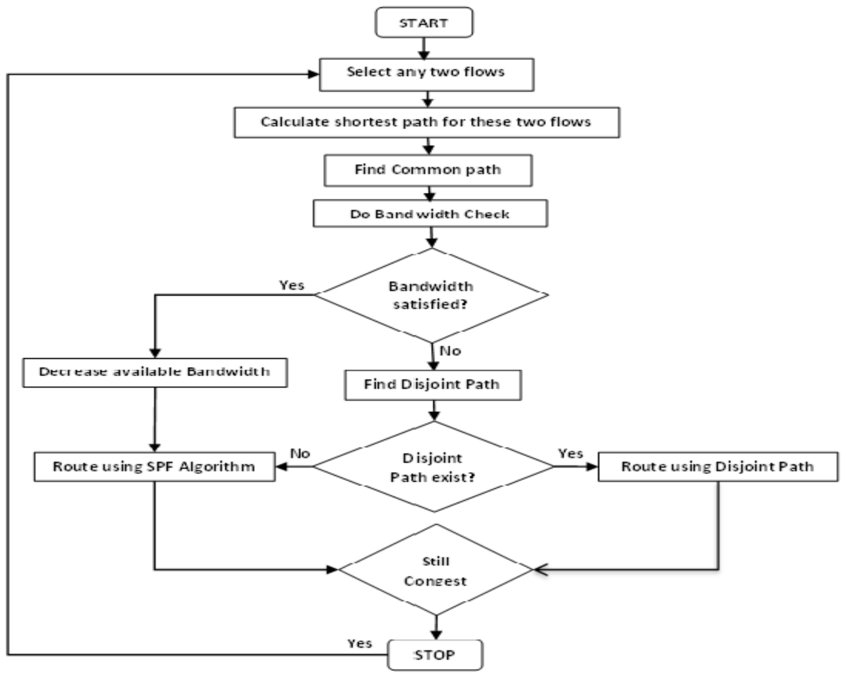

Figure 1: Flow chart for DPA

EXPLANATION WITH EXAMPLE

Consider the IP topology as shown in figure 2, where the circular shape represents IP nodes and all links is having bandwidth of 2Mbps and delay of 10ms. There are two request- request 1 and request 2 from IP(1) to IP(3) and IP(2) to IP(4) each having bandwidth of 1.5Mbps respectively.

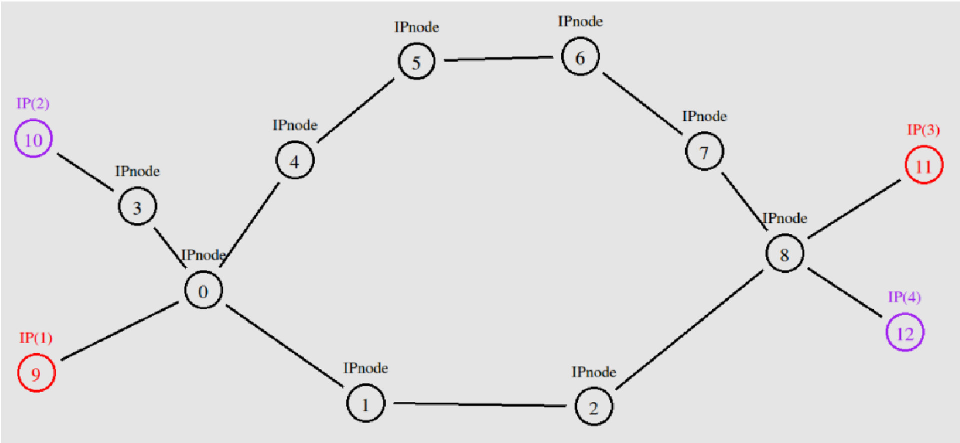

Figure 1: IP Network Topology

In conventional IP routing, flow 1 corresponding to request 1- will follow the route 9-0-1-2-8-11 and flow 2 corresponding to request 2- will follow the route 10-3-0-1-2-8-12, by Shortest Path Algorithm leading to congestion in common path 0-1-2-8 as the capacity requirement of two flows is 3Mbps while the links are of bandwidth 2Mbps each(0-1, 1-2, 2-8). As a result buffer at node 0 will overflow dropping the packets from tail at node 0 as shown in figure 4.

Now consider MPLS network where backbone domain is MPLS to which IP network is connected, as shown in figure 3. Here to distinguish from traditional IP network MPLS nodes ate represented in Square shape. Each MPLS node is deployed Label Switched Router (LSR) having all other consideration same as IP network.

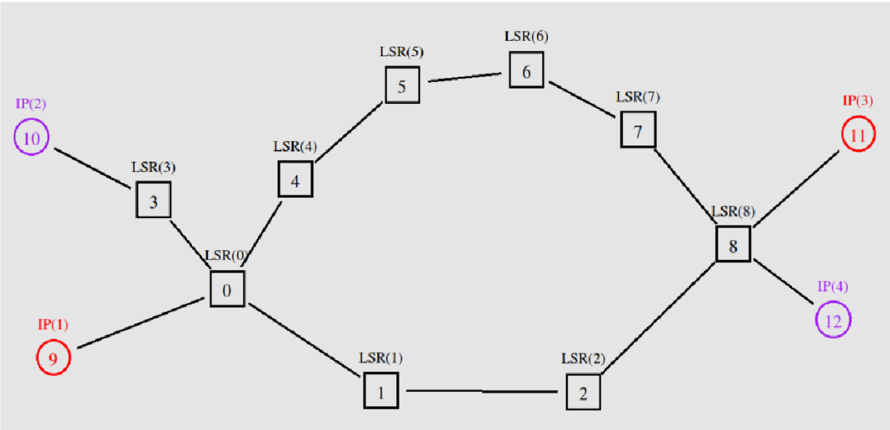

Figure 3: MPLS Network Topology

Now we apply DPA, which makes use of explicit routing technology of MPLS network to avoid congestion. DPA is applies only in MPLS domain. In DPA first we will calculate the shortest path for two requests i.e. for request 1 it is 9-0-1-2-8-11 and for request 2 it is 10-3-0-1-2-3-8-12. Considering node as distance metric, it is clear from the path that shortest path for flow 1 is shorter than that of shortest path for flow 2.Thus calculating Disjoint Path for request 2 will be more advantageous than for request 1.hecne DPA will find disjoint pat for request 2 which is - 10-3-0-4-5-6-7-8-12. Though this path is somewhat longer than the shortest path for request 2, it is more reliable than shortest path avoiding congestion as shown in figure 5.

thus by using explicit routing of MPLS network flow 2 is routed along the path 10-3-0-4-5-6-7-8-12 avoiding congestion and increasing overall performance of network.

SIMULATION RESULT

An open source network simulator (NS-2.34) is used for simulation. Figure 2 and figure 3 shows the network topologies for simulation. Graphs are drawn showing the effectiveness of DPA over SPF from the trace file generated using simulator. Characteristics of flow 1 by shortest path are compared with characteristics of flow 1 by DPA. Results for flow 2 can also be compared but results of flow 1 are sufficient to provide the efficiency and feasibility of DPA over SPF.

Figure 4 shows the Packet dropping in SPF routing when traditional IP network is used. At node 0, demand of capacity for forwarding link sharing common path will be 3Mbps (Flow1 -1.5Mps + Flow2-1.5Mbps). But as bandwidth of each link is 2Mbps only, the buffer at node 0 will overflow dropping the packets.

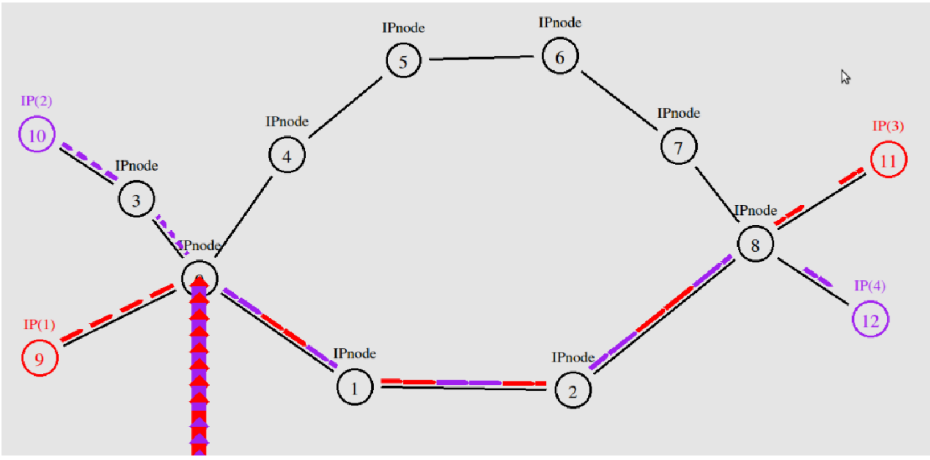

Figure 4: Dropping of Packet in SPF Routing

Figure 5 shows the avoidance of congestion by using DPA in MPLS based network, leading to no packet drop in the network. Figure 6 shows the graph for packet drop rate for DPA and SPF, it is clear from graph that there is no packet drop since we apply DPA.

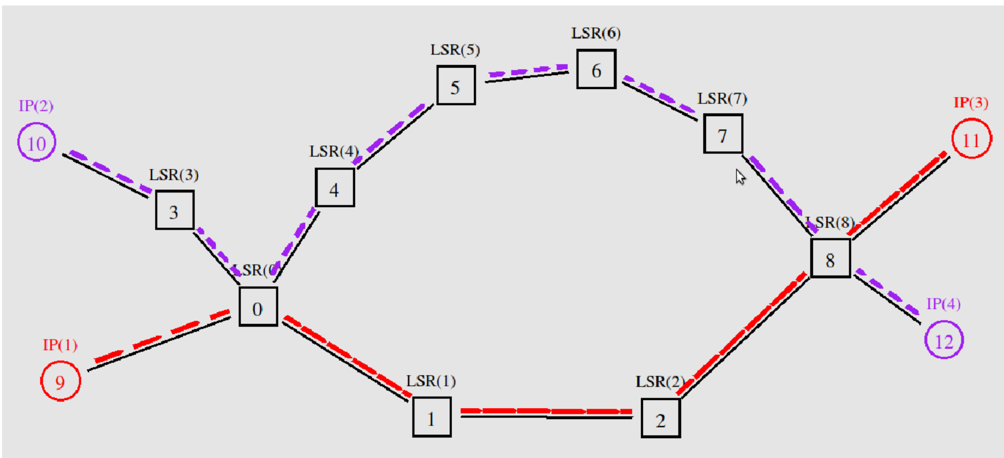

Figure 5: Zero packet drop after application of DPA

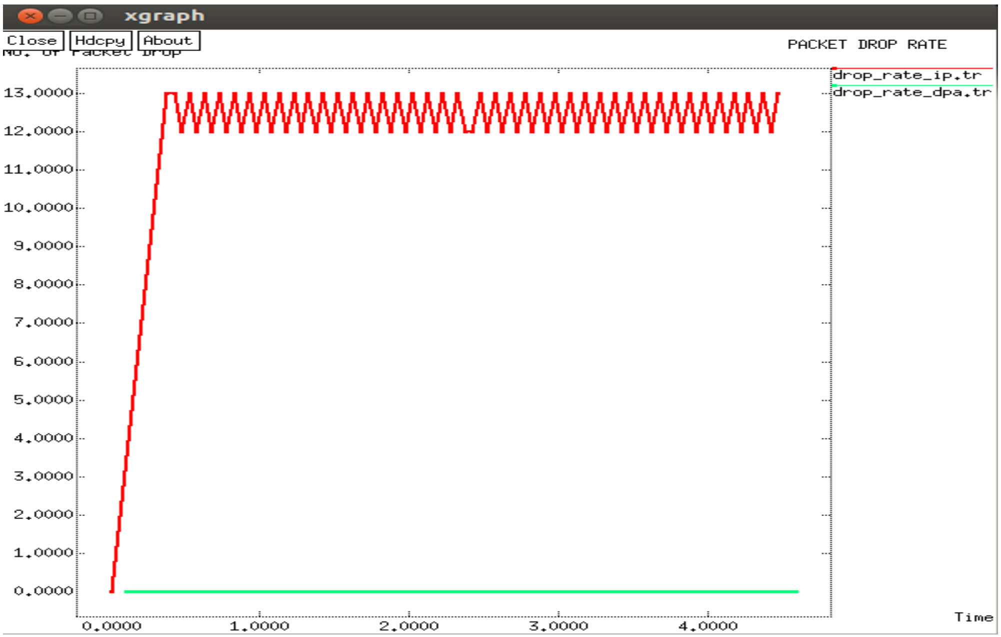

Figure 6: Graph for Packet drop rate

Figure 7 shows the throughput comparison of traditional IP routing using SPF and explicit routing in MPLS using DPA. Throughput is calculated at node 11 i.e. IP (3). Graph shows that there is considerable increase in throughput after applying DPA. SPF throughput is less than DPA as packets are dropped due to congestion.

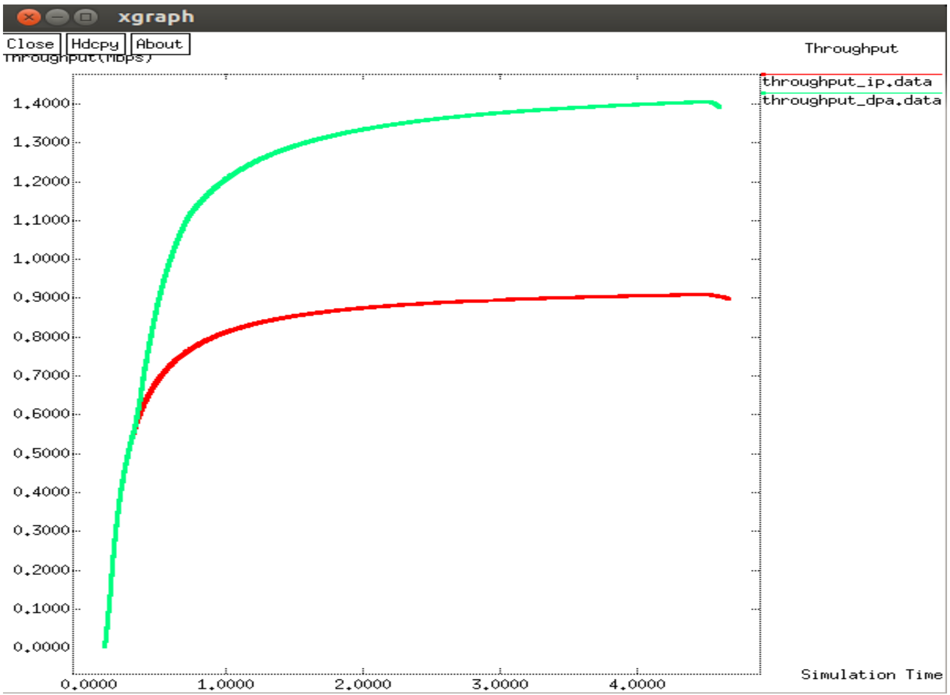

Figure 7: Graph for Throughput

Figure 8 shows end to end packet delay for flow 1.It is clear from the graph that packet delay increases first and after applying DPA it stabilises around 60ms. There is a steady flow as packet arrival time variation is zero leading to constant end to end delay. Thus DPA leads to reduction in end to end delay and data transmission avoiding congestion.

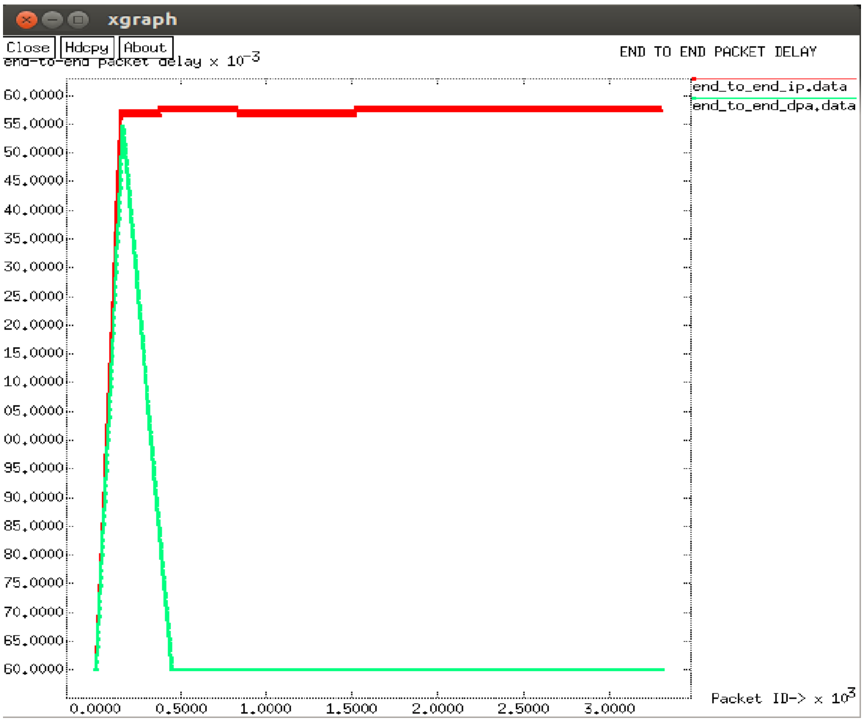

Figure 8: Graph for End-to-End Packet Delay

Table 1 shows the statistical comparison of both the algorithm, which in turn state the delay reduction efficiency and throughput efficiency of DPA is 62% and 33% respectively over SPF. Thus DPA considerably improves network performance and quality of service by reducing end to end delay, packet drop rate and improves throughput

Table 1: Statistical comparison of both Algorithm

Routing Algorithm → Parameter ↓	Disjoint Path Algorithm	Shortest Path First	Efficiency of DPA (%)
Number of Packet Dropped	0	1048	-
Average End-to-End packet Delay (in ms)	60	157	62
Average Throughput (in Kbps)	1400	910	33

CONCLUSION

In this paper we discuss bottleneck in conventional IP routing algorithms and discuss the importance of traffic engineering. How MPLS effectively support TE. Then we presented the concept of DPA and implemented it in NS2 for simulation of path computational algorithm in MPLS network. From Simulation and results it is clear that he proposed algorithm addresses the shortcoming of currently used SPF algorithm and seeks to balance the load on the network avoiding congestion and better resource utilization improving network performance.

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