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A Survey of Routing Algorithms in MPLS Network

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Abstract— The Multi-protocol label switching (MPLS) network is an Internet Service Providers (ISPs) network where the packets are transmitted based on labels only. MPLS has the capability of enhancing the IP routing functionality and improving the network performance. Routing in MPLS network is established over label switch path (LSP).Thus routing algorithms are needed to discover an efficient LSP so as to meet quality of service, bandwidth guaranteed path, low complexity and reduced delay requirements. In this paper, we focus on some recent routing algorithms such as Minimum Delay Maximum Flow (MDMF) algorithm, Multiple Path Selection (MPS) algorithm, Light Minimum Interference routing algorithm (LMIRA), Minimum Interference routing algorithm for Delay (MIRAD). We analyze the algorithms on the basis of constraints such as bandwidth, delay and computation complexity.

Keywords— MPLS, LSP, computation complexity, constraints, MPS.

I. INTRODUCTION

The Multi-Protocol Label Switching (MPLS) technology was addressed efficiently to meet the drawbacks of today's communication network which uses the traditional IP routing technology. MPLS is a new label switching mechanism. In MPLS the forwarding of data packets are done based on labels only while in IP routing the forwarding is based on destination address. MPLS acts as a core technology between layer 2 switching and layer 3 routing. Thus MPLS integrates the layer 2 and layer 3 technologies. MPLS also provides differentiated class of services to the network users in order to meet the QoS requirements of the next generation network.

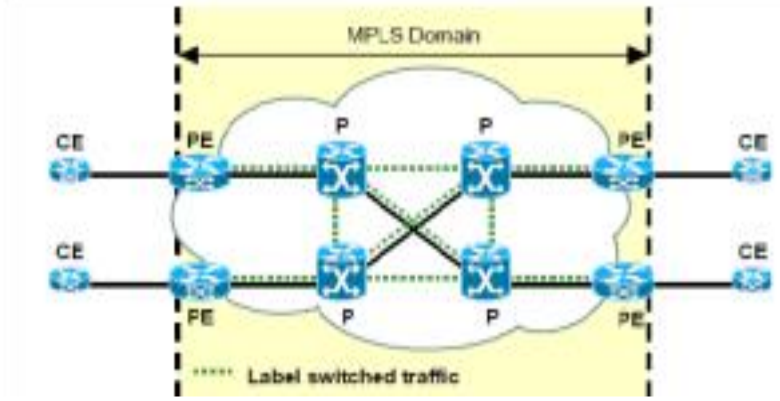

Fig.1. MPLS Network [1].

Considering the above figure of a reference MPLS network there are different types of nodes in an MPLS network. The types of nodes are as follows:

Provider Router (P) – The Provider (P) router is also called as core router since it is at the core of an MPLS domain. It is responsible for assigning and removal of an MPLS label in the data packet.

Provider Edge Router (PE) – The Provider Edge router operates at the edge of an MPLS domain. The Provider edge router which acts as an entry point to an MPLS domain is called as ingress router and the Provider edge router which is at the exit point of MPLS domain is called as egress router. The Provider edge is responsible for differentiating the packets based on their class of services as well as assignment and removal of label in the packet at the entry and exit point of an MPLS network.

Customer Edge Router (CE) – Customer Edge routers are responsible of forwarding the common ipv4 packet to the MPLS network.

MPLS Label

The MPLS labels are used for making forwarding decision. The MPLS label is of 4 byte (32bits) in size. Multiple labels can be used for MPLS packet encapsulation. The outer label in label stack is used for switching the MPLS packet in network while the inner label is used for other services mainly in virtual private networks.

Fig.2. MPLS Frame Format [2].

An MPLS label consists of four fields:

- Label: Label value of 20 bits. It is used as pointer for forwarding the packet.
- Exp: It is of three bits in length.
- S: Flag which indicates whether the label is at bottom of stack, on enabling it to one bit indicates that label is at bottom of stack. It is useful when multiple MPLS labels are used.
- TTL: Time to live (TTL) is of eight bits in length.

MPLS operation

There are mainly three key operations carried on MPLS network which are push, swap and pop. These operations can be illustrated as follows:

Push – The ingress router classifies the packet and assigns a label in the incoming ipv4 packet.

Swap – The (P) router performs swap operation by replacing the label with a new label and forwards the packet.

Pop – The egress router removes the label in the packet and forwards the packet to its destination.

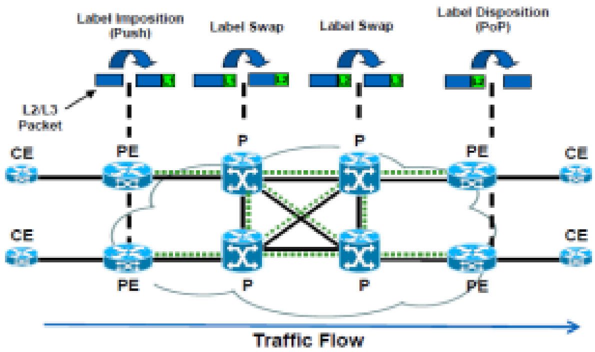

Fig.3. Forwarding operation [1].

In MPLS, signaling is done along the Label Switch Path (LSP) and labels are distributed among nodes in an MPLS network using a signaling protocol such as Label Distribution Protocol (LDP). Initially, the LDP protocol and other routing protocol such as OSPF and BGP work together to build the routing table on each P router by assigning the labels onto the routing table of each nodes and mapping the label with the remote nodes. Thus, the label information base (LIB) is created. On receiving a packet, the PE (ingress) node determines the class to which the packet belongs and labels the packet, and forwards it to next hop along the LSP. Thus each P router looks up its forwarding table for next hop and forwards it. When the PE (egress) node receives the packet, it disposes the label from the packet and performs IP forwarding.

II. LITERATURE SURVEY

In this survey we mark our observations and describe about the recent algorithms such as the Minimum Delay Maximum Flow (MDMF) algorithm, the Multiple Path Selection (MPS) algorithm, Light Minimum Interference routing algorithm (LMIRA) and the Minimum Interference routing algorithm for Delay (MIRAD) in detail.

A. Minimum Delay Maximum Flow (MDMF) Algorithm

In Minimum Delay Maximum Flow algorithm [3], initially it eliminates the link with least amount of bandwidth so as to meet future bandwidth requirements. The goal of reducing delay is established by incrementing the bandwidth in each and every iteration. At the iteration process, it calculates the delay of a path and it compares whether the delay is less than the requested delay or not, so if the delay is more, then it increments bandwidth by one unit of a link with large residual bandwidth. This process is dynamic and the algorithm can even compute for denser network.

B. Multiple Path Selection (MPS) Algorithm

The Multiple Path Selection (MPS) algorithm [4], finds out multiple label switch paths (LSPs) by considering the maximum available bandwidth in a path with minimum hop to reach destination. Although the algorithm selects LSP with maximum available bandwidth but fails to carry out a check of whether requested bandwidth by source is met or not. Traffic is allocated to each path in order to measure the round trip time. Then the source undergoes a dynamic adjustment of traffic by distributing the traffic evenly among the LSPs (label switch paths). The LSP with heavy traffic releases some amount of traffic to the other LSP which has least amount of traffic. The LSP with longer round trip time has the heavy amount of traffic. Thus it decreases delay and conforms to adjust the traffic dynamically. As a result, the complexity of algorithm to compute path and dynamic adjustment is low.

C. Light Minimum Interference Routing Algorithm (LMIRA)

Light Minimum Interference routing algorithm [7], has an advantage of reduced computation complexity than that of other existing minimum interference algorithms. This reduced computational complexity is achieved by avoiding numerous executions of maxflow algorithms for the identification of critical links. The lowest capacity algorithm was introduced to find out the path. In lowest capacities algorithm, the flow at a node should be the smaller value of either current flow value of the node or the flow value at the link. Thus the lowest capacity algorithm eliminates the critical links and the links with least amount of bandwidth. As a result, it offers bandwidth is guaranteed paths. But the algorithm does not focus onto minimizing delay. Thus, delay is not reduced which is the main drawback of the algorithm. The lowest capacity algorithm, moreover resembles the dijshktra's algorithm. Dijkshtra's algorithm also avoids critical links by selecting link with least weight which has more amount of bandwidth.

D. Minimum Interference Routing Algorithm for Delay (MIRAD)

The Minimum Interference Routing algorithm for delay [5], generally resembles the MDMF algorithm, but the difference is that initially MIRAD computes the path using MIRA (Minimum Interference Routing Algorithm) [9] to avoid critical links while in MDMF it applies only dijshktra's algorithm to avoid critical links. It offers bandwidth guaranteed path by eliminating the links with least residual bandwidth. Similarly as that of MDMF it reduces the delay by incrementing the bandwidth of a link in a path by one unit iteratively until the delay is decreased. The algorithm is more complex than MDMF. Since it uses MIRA algorithm which undergoes number of executions of maxflow algorithms to avoid critical links and minimize the interference of the path.

III. ANALYSIS

The analysis done to put forth our literature survey mainly focus on constraints such as bandwidth, delay and computational complexity of algorithms such as MDMF (Minimum delay and Maximum Flow), MPS (Multiple path selection), MIRAD (Minimum Interference routing algorithm for Delay) and LMIR (Light Minimum Interference routing) for MPLS network is discussed in detail here.

Table 1. Comparison of MDMF, MPS, LMIRA and MIRAD

Constraints	MDMF	MPS	LMIRA	MIRAD
Bandwidth	Importance to meet future bandwidth requirements	Feasible LSPs found by largest available bandwidth	Bandwidth achieved by eliminating less residual bandwidth links.	Meets bandwidth just like that of MDMF.
Delay	Conforms to minimize delay until request gets rejected.	Source adjusts the traffic and RTT gets decreased	Does not provide importance to reduce delay	Conforms to minimize delay until request gets rejected.
Computation Complexity	Computes even for dense network.	Computes LSPs easily and dynamic traffic adjustment.	Reduces the computation to find critical links.	More complex to find path using MIRA

Bandwidth:

MDMF,LMIR and MIRAD conforms the bandwidth requirements by eliminating the links with residual bandwidth less than the requested bandwidth but MPS prefers the largest available bandwidth for each LSPs and does not conforms to meet the requested bandwidth.

Delay:

On analysis MDMF, MPS and MIRAD strives to decrease the delay constraint while LMIR, does not consider delay constraint. MDMF minimizes the end to end delay by increasing the bandwidth by one unit at each and every iteration while computing delay and so the delay decreases by increasing the bandwidth. MIRAD does the same procedure like MDMF to minimize delay and offer bandwidth guaranteed paths but for path computation it uses MIRA unlike MDMF. MPS also conforms to reduce delay each time after dynamic adjustment of traffic the range of delay is computed.

Computation Complexity:

Compare to MDMF, MPS and LMIR the MIRAD algorithm shows more complexity to find path. Since MIRAD uses MIRA algorithm to compute the path initially where in MIRA it shows complexity to find maxflow values by following several algorithms to minimize the interference in path computation, so LMIR reduces this complexity by finding out least capacity path. MPS shows less complexity to find multiple LSPs and undergoes dynamic adjustment of traffic to minimize the delay. MDMF algorithm finds the feasible LSP using dijshktra algorithm and increases bandwidth to decrease delay so it can even operate for dense network. More the amount of bandwidth in a link addresses to less weight of a link. Since bandwidth is inversely proportional to weight.

IV. CONCLUSIONS

On analysis through algorithms like MDMF(Minimum delay and Maximum Flow), the Multiple Path selection (MPS), the Minimum Interference routing algorithm for delay (MIRAD) and Light Minimum Interference routing (LMIR) algorithm, we conclude on basis of factors such as bandwidth, end to end delay and less computational complexity that MDMF can be give much better performance than all other algorithms since it satisfies to meet bandwidth and minimum end to end delay to fulfill future requirements and reduces the complexity to operate even for denser network.

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