Improvement in Traffic Engineering using MPLS-TE

B.Nageswara Rao, J.HemaLatha, G.N.vijay Kumar, L.Jayanthi, G.Krishna Sai

***Abstract*— In traditional IGP, all traffic follows the shortest path computed by shortest path algorithm which soon gets congested. In this some paths are unutilized and some paths are over utilized. The over utilization of path results in congestion which causes packet drops and degrades quality of service (QoS). Congestion in the traffic can be minimized by allocating fixed path for the incoming traffic, which is possible through the MPLS network through explicit path setup. Traffic Engineering is the process of controlling the traffic flows in a network, so as to optimize resource utilization and network performance. MPLS Traffic Engineering attempts to correct the inefficiencies of typical datagram routing protocols by more evenly spreading the flow of traffic across all available resource. Our aim is to do the analysis of MPLS and non-MPLS network. Also we are going to implement the optimized path computation algorithm which will find out the most optimized path as an explicit path for all traffic in MPLS network. The algorithm guarantees conflict free network due to most optimized explicit path. Since the network will be conflict free, there will be no congestion, no packet drops which ultimately improves QoS.**

***Index Terms*— IP (Internet protocol), Traffic Engineering, VPN (Virtual Private Network), MPLS (Multi Protocol Label Switching).**

I. INTRODUCTION

IP Routing- IP Routing is the process of transporting data from source to destination on a determined path across two or more networks. IP routing enables two or more devices on different TCP/IP networks to connect with each other. IP routing provides the path for reaching the destination device. IP has become the most popular protocol after the expansion of the internet for network layer (routing), mostly due to its simplicity and robustness. But as the internet grew bigger in quantity and in data volume, the basic methods become cumbersome for every router. The number of entries in the routing tables grew exponentially. With the improvement in electronics and thus with increase in data transfer rate the routers were able to cope up with increasing demand.

Traffic Engineering-Traffic Engineering can be thought of as the process of selecting the paths used by the data traffic in order to optimize resource utilization and traffic performance in the network. ***The main objectives of TE can be broadly classified as being***:

Traffic Oriented: where the objective is to minimize delay, minimize packet loss, maximize throughput and enforce the Service Level Agreement (SLA).

Resource Oriented: where the focus is to optimize the bandwidth utilization (by resource we mainly refer to bandwidth). One should be ensure that a subset of the network is not congested while another is being under used.

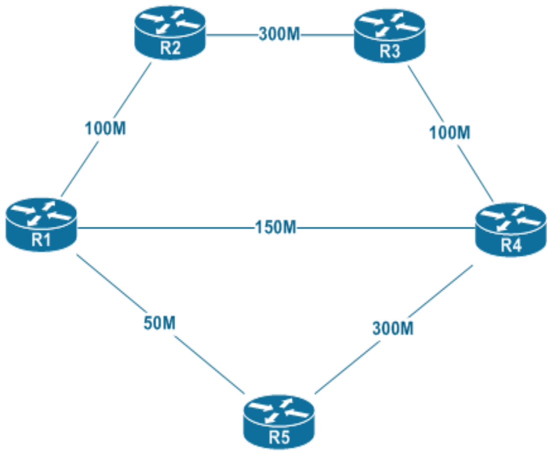

Figure:1 Architecture Of IP Routing

Virtual Private Network- A ***virtual private network (VPN)*** extends a private network across a public network, such as the internet. It enables a computer or network-enabled device to send and receive data across shared or public networks as if it were directly connected to the private network, while benefiting from the functionality, security and management policies of the private network. A VPN is created by establishing a virtual point-to-point connection through the use of dedicated connections, virtual tunneling protocols, or traffic encryptions. Major implementations of VPNs include OpenVPN and IPsec. Still big internet service providers used ATM networks in their core infrastructure for reserving paths with use of Virtual Private Networks (VPN).

Multi Protocol Label Switching- Cisco went ahead with the concept and created a full scale label switching protocol for packet routing. "Multiple Protocol Label Switching" (MPLS) Multiprotocol Label Switching (MPLS) is an Internet Engineering Task Force (IETF)– specified framework that provides for the efficient designation, routing, forwarding, and switching of traffic flows through the network. MPLS is used to meet the bandwidth management and service requirements for Internet protocol (IP) based networks. MPLS addresses issues related to scalability and routing and can exist over existing ATM and frame-relay networks. In MPLS, a short fixed-length label is generated and it is used as an alternative representation of an IP packet's header. All the routing decisions are made based on the MPLS label and not the original IP address. As the name says it is mainly a

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switching method. It uses Labels instead of IP addresses for forwarding a packet to next router. MPLS is designed such that it can be implemented inside the already established networks. Another main advantage of MPLS is that it can provide preset paths for packets. Depending upon their type, their prefixes etc.

II. EXISTING SYSTEM

IP routing is based on the basic fundamental of table lookup. In every table entries of adjacent routers, their path cost (the path cost can be something like bandwidth, hops, ECHO time etc.), and the destination IP address. A table contains entries for all routers in the network. If a router goes down or comes up, a complete network map has to be calculated again by using Link State Protocol. Consider a following network of routers. The boxes represent routers and the numbers near the lines represent the line cost. Here it is assumed that line cost is measured in terms of ECHO request return time. The higher the time the more costly the path is. It is assumed that every router knows its neighbors and has map of whole network. It knows all the costs and lines. Instead of IP addresses we will use letters (A to E) for simplicity. The line costs are assumed to be the ECHO request time. The lower is the cost here the better path it will be.

Let's see what C knows.

Now C will choose only the lowest cost paths from this table. Actually there might be more entries but these entries cover most of the important paths.

For example, if a packet comes a C, and has to go to D, without line costs mentioned it will take C-D path. But a 3 hop A-B-D is shorter.

The point here is that C has to keep entries of all the routers in its table. Now we have assumed letters for routers. But if IP addresses are considered, every IP destination address will have a separate entry in table. Prefixes can be used for shortening the tables, but still table runs into hundreds or sometimes thousands of lines. A midsized service provider might have some 100-200 routers in its infrastructure. Now how big a table might be for such routers?

IP as stated has a cumbersome process of comparing destination address with every entry in routing table. This means a router has to open IP packet from frames.

Analyze its destination address, compare it, put into frames and send on the line. For small traffic it might seem nothing, but on heavy paths it is significant delay. Another drawback is, as the network size increases the complexity/size of routing increases by double amount, called as O (n2). Hence expanding will create some delays.

IP uses the shortest path for routing. It might be short/less in terms of ECHO time, hops etc. But what happens is it will always use that path for routing. And will leave other paths unused for a particular destination address. What if a particular destination address suddenly gets a lot data coming in, a line considered shortest will get congested, whereas a little longer route will be completely unused for that destination address.

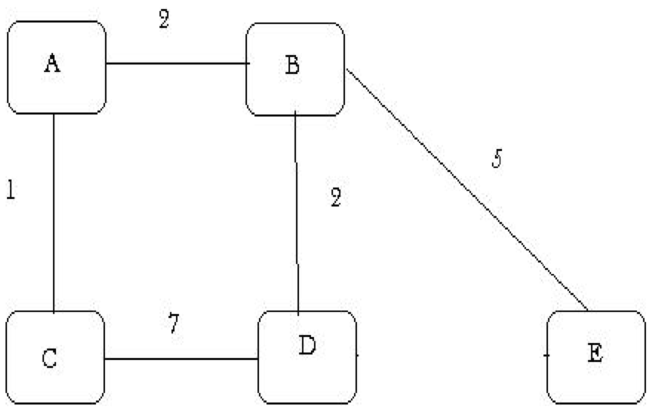

Figure:2 Example Of IP Routing Network

Destination	Line	Hops	Total Cost	Next Hop
A	C-A	1	1	A
B	C-A	2	3	A
D	C-D	1	7	D
D	C-A	3	5	A
E	C-A	3	8	A
E	C-D	3	14	D

Figure:3 A Look-Up Table For Given Example

Here if D gets a lot of traffic coming from C, C will route it in C-A-B-D route. But it will get congested. And another route which costs higher by 2 will not be used. Hence a lot of bandwidth and resources will be wasted along with unnecessary delay. Now we will consider maximum bandwidth for line B-E to be 50mbps. But what if bandwidth of D-B is 30mbps and that of C-A and A-B is 40mbps. Hence C will send data on path C-A-B-E and D will send on path D-B-E. But if both C and D operate at

maximum bandwidth, B will get 70mbps, which is 20mbps more than line B-E's bandwidth. Hence for some time B will store the excess data in its buffer but when the buffer is full, it has no option other than to drop the packets and signal congestions. On IP networks, all packets get same treatment. Any protocol can be used for data and sent on IP network. But the drawback is failure to provide good Quality of Service (QoS). Voice may need low bandwidth but delay is not tolerable. Files may need high bandwidth but delay can be handled, as the file is not used till downloaded completely. This goes on for all types of data on internet. Some protocols can be improved for forcing

QoS by buffering etc, but eventually it will fail for high synchronization needs etc. After knowing drawbacks of IP a logical question will arise, why use IP? The reason lies in early days on internet. IP was designed to be connection-less protocol. IT just sends packet and forgets about it. All active connection illusion is given by TCP layer above network layer. IP is robust, but it is not so good in providing differentiated services and high reliability in normal conditions. It was designed to be flexible but not stagnant. It became popular because it was able to satisfy all internet needs earlier, but now as the traffic on internet grows more in quantity and complexity; the IP is becoming more and more inefficient in engineering the traffic.

III. PROPOSED SYSTEM

Multi Protocol Label Switching (MPLS):
MPLS terminology-

Forwarding Equivalence Class (FEC): A group of IP packets which are forwarded in the same manner (e.g., over the same path, with the same forwarding treatment).
Path: The collection of router from ingress to egress that packet will cross as they are forwarded through the network.
Label Switched Path (LSP): A complete path that has the ability to map incoming MPLS labeled packets to some outgoing action.
Ingress Label Switched Router -Ingress LSR: The entry point into the MPLS network. It calculates the path through the MPLS network.
Transit Label Switched Router – LSR: An MPLS router somewhere along the LSP that forwards traffic based on MPLS labels that are neither the source nor the destination.
Egress Label Switched Router – Egress LSR: The exit point connecting an MPLS network to a traditional network, the mapping of inbound label to the router itself.

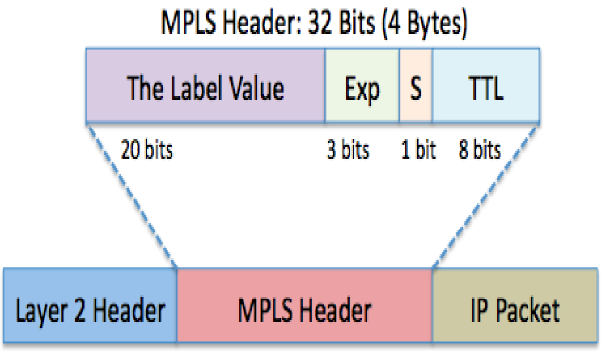

Figure:4 MPLS Header

The Label Value – this 20-bit value serves as the basis for packet forwarding in the MPLS cloud. You should think of this value as an index that MPLS will use for a quick lookup in the MPLS forwarding table.

The EXP Field – these 3-bits are the Experimental Bits. They are most commonly used for Diffserv support on the MPLS network and typically carry the IP Precedence value from the IP Packet. The original Cisco proposal for Tag Switching called this field the class of service (CoS) field. However, there was no consensus within the IETF for defining this field as the CoS field. This field received its EXP bit name as a result of RFC 3032.

The Bottom of Stack Bit (S-bit) – there are many instances when MPLS headers are stacked within a packet. This bit is set on the bottom header to indicate the bottom of the stack has been reached.

Time-To-Live Field – as you would guess, this field is used for loop prevention and possibly path-tracing in the MPLS cloud. This value decrements with each hop and packet discards occur at a zero value

MPLS ARCHITECTURE:

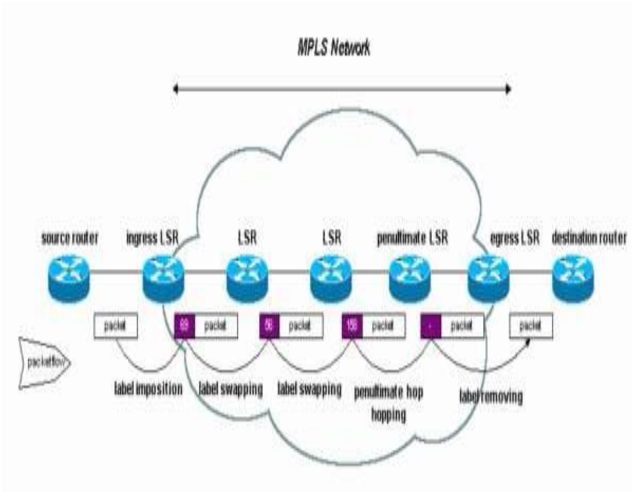

Figure:5 Architecture Of MPLS Network

A.) MPLS-Traffic Engineering (MPLS-TE):

MPLS Traffic Engineering attempts to correct the inefficiencies of typical datagram routing protocols by more evenly spreading the flow of traffic across all available resources.

B.) Components of MPLS-TE:
It consists of the following components,

1. Packet Forwarding Component:
Using the label swapping techniques MPLS would direct the traffic along a predetermined path called the Label Switching path or LSP. When an IP packet arrives at the ingress, an MPLS Label is appended to the packet and it now reaches the egress via MPLS label swapping mechanisms and not IP hopping. At each hop till the egress, the label is swapped helping the packet reach the next transit LSR. Finally at the Egress, the label is popped off and traditional IP forwarding continues.

2. Information Distribution Component:
Traffic engineering require a great knowledge about the network topology as well as the dynamic information about network loading and hence a good information distribution component is required to distribute it. This component can easily be implemented by defining relatively simple extensions to the IGPs so that link attributes are included as part of each router's link-state advertisement. The standard flooding algorithm used by the link-state IGP ensures that link attributes are distributed to all routers in the ISP's routing domain. Each LSR maintains network link attributes and topology information in a specialized Traffic Engineering Database (TED). The TED is used exclusively for calculating explicit paths for the placement of LSPs across the physical topology.

3. ***Path Selection/Computation Component:***
This component decides the path taken by the packets while travelling within the network. There are two ways by which path can be selected
Explicit Routing:

Here the path is pre-decided at the ingress router itself. Each hop or subset of hops that the packet will take is decided at ingress itself.
Constraint based Routing (CBR):
In this the path is computed by considering the information present in TED. The ingress LSR determines the physical path for each LSP by applying a Constrained Shortest Path First (CSPF) algorithm to the information in the TED. CSPF is a shortest-path-first algorithm that has been modified to take into account specific restrictions when calculating the shortest path across the network.

4. Signaling Component:
Using the explicitly configured route or CSPF computed explicit route, the Signaling component now sets up the LSP. The signaling components generally used are [RSVP-TE] which are extensions to the [RSVP], a resource reservation protocol and [CR-LDP] which are extensions to the [LDP], label distribution protocol.

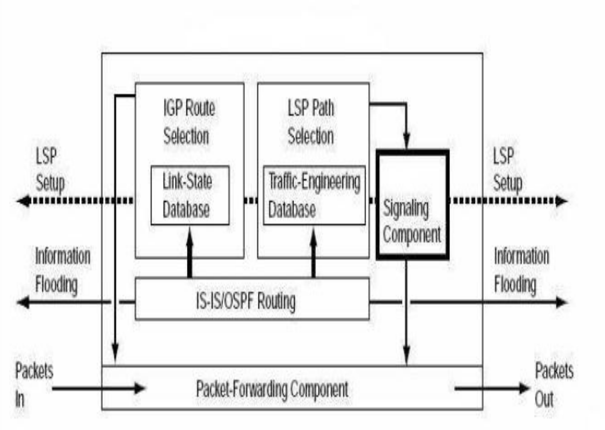

Figure shows a block diagram of these components and how they interact.

Figure:6 Diagram Of Components and Their Interaction

C.) Signaling Protocols

While setting up of an LSP basically there are two ways to specify the path. They are
(***i)Strict explicit routing LSPs***: In this, we specify list of all nodes with their actual addresses of each node on the path from source to destination.
(***ii)Loose explicit routing LSPs***: In this mechanism, we group the related nodes into single abstract node. And while specifying the path we specify these abstract nodes instead of all nodes on the path.

There are two types of protocols in signaling. Such as,

1. Traffic Engineering-Resource Reservation Protocol (TE-RSVP):

TE-RSVP is a soft-state protocol (i.e. it maintains a timer value for keeping the track of resources for LSPs. Once the timer value becomes zero it de-allocates the resources for LSPs without need of any explicit messages.) and uses user datagram protocol as signaling mechanism for LSP setup. So for sending PATH and RESV messages it uses UDP protocol.

2. Constrained Routing-LDP (CR-LDP):

CR-LDP was built on LDP and the current development in CR-LDP is less than RSVP-TE.CR-LDP implementation does not require additional protocol. It uses existing structures and extends some required data structures to implement traffic engineering. CRLDP also supports strict and loose explicitly routed LSPs. In CR-LDP, UDP is used for discovering MPLS peers and TCP is used for control, management, for sending label requests, and mapping.

IV. NEW PATH COMPUTATION ALGORITHM

Routing protocols usually characterize a network through a single metric (the cost of the link). In the case of QoS routing protocols and constrained-based path computationalgorithms, instead, the network is described by means of multiple metrics. The most common ones are the following:

Cost: it is an additive metric, because the cost of a path is the sum of the costs of the links.
Bandwidth (or residual bandwidth): it is a concave metric. Indeed, we define the bandwidth of a path as the minimum of the residual bandwidth of all links on the path (bottleneck bandwidth).
Delay: it is an additive metric, since the delay of a path is the sum of the delays of its links. It consists of three components: propagation delay, transmission delay and queuing delay.

Computation of first two metrics is quite easy but computing end to end delay is not easy because of one of its component queuing delay since it is not a deterministic quantity. Hence we compute an upper bound of delay. The upper bound of the delay Di, experienced by a packet, which belongs to the generic flow I and goes through K nodes, may be computed as:

$$D_i = \frac{M}{r_i} + \sum_{j=1}^{K} S_i^j \qquad (1)$$

where
-M is the maximum burst size
- r_i is the guaranteed rate for flow i
- S_i^j is the delay due to node j, which may be calculated as:

$$S_i^j = \frac{L_{MAX}}{R_j} + \frac{L_i}{r_i} \qquad (2)$$

where:
- L_{MAX} is the maximum packet size
- L_i is the maximum size of a packet belonging to flow i
- R_j is the output link bandwidth.

ALGORITHMS:

4.1 Wang- Crowcroft Algorithm (WC):

Wang-Crowcroft Algorithm aims at finding a path which satisfies multiple QoS constraints, given in terms of bandwidth (BMIN) and delay (DMAX). Every link (i,j) of the network is characterized by two parameters: bij (residual bandwidth) and dij (propagation delay).

The Algorithm consists of the following steps:

1. Set $dij = \infty$ if $bij < BMIN$
2. Compute the path P with the minimum delay (applying the Dijkstra algorithm)
3. Calculate the delay D^* of P
4. Compare the delay with DMAX. If $D^* < DMAX$, select the path, otherwise the request cannot be satisfied.

4.2 Wang-Crowcroft with Sorting (WCS):

Wang-Crowcroft with Sorting (WCS) tries to improve the performances of the WC algorithm, when all the path computation requests cannot be satisfied. The basic idea behind the WCS algorithm is to analyze the path computation requests after reordering them based on their bandwidth and delay requirements.

The Algorithm consists of following steps:

1. N requests given
2. WC algorithm is applied
3. Z requests are accepted
4. Is Z=N?

If Z==N then
Exit
Else
Go to 5

5. (A) Consider Bandwidth based re-ordering
(B) Delay Based Re-ordering
6. (A) WC algorithm
(B) WC algorithm
7. (A) X requests Accepted
(B)Y requests Accepted
8. Choose the best path out of X, Y, Z
9. Exit.

In particular, given a random sequence of N path computation requests, our algorithm checks whether they can be satisfied as a whole by applying the WC algorithm. If some of them is rejected ($Z < N$), we compute the number of requests that can be accepted
When,
1) They are sorted top-down according to the bandwidth BMIN requirements;
2) They are sorted bottom-up according to the delay DMAX requirements.

Finally, the best solution according to a pre-defined cost function (e.g. the maximum number of reservation requests that can be accepted) is chosen. Therefore, the WCS algorithm always performs not worse than the original WC algorithm

V. CONCLUSION

IP based routing had many drawbacks like congestion, packet drop etc. By setting explicit path MPLS can solve it. MPLS reduces the loss of packets traveling over the LSP and improves the QoS. Analysis between MPLS network and Non MPLS network showed that in MPLS network the packet drop is drastically reduced. New path algorithm selects the most optimized path as it takes into considerations constraints like bandwidth and delay…

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ABBREVIATIONS

ATM -Asynchronous Transmission Mode
CR-LDP- Constraint Label Distribution Protocol
CoS -Class of Service
FEC -Forward Equivalence Class
IGP -Interior Gateway Protocol
IS-IS- Intermediate System to Intermediate System
LDP -Label Distribution Protocol
LER -Label Edge Router
LSP -Label Switched Path
LSR -Label Switched Router
MPLS- Multi Protocol Label Switching
NS2 -Network Simulator 2
OSPF-Open Shortest Path First
QoS -Quality of Service
RSVP-Resource Reservation Protocol
TE-Traffic Engineering

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