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Advanced Network Architectures (M132)

Assignment 4

MPLS characteristics and advantages.

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1 MPLS emergence from IP and ATM

The key idea for MPLS was introduced as an alternative to IP with all it is characteristics whereas the flows are introduced in order to handle IP traffic with a more efficient way. It introduces reliability to the networking part and make switching faster by adding a notion of layer 3 intelligence in the way that the routes in the network are identified. In the layer 3, routing speed is slower comparing with layer 2 switching speed. Thus MPLS is often informally described as operating at Layer 2.5 as a mechanism that combines layer 2 and layer 3 functionality in such way that the routers by the use of routing protocol predefine the routes-paths in the network and forwarding the packets with high speed. This is achieved by aggregating the traffic into flows and setting up virtual connections through the network and achieving cut through operations and particularly high speed by immediately switching the traffic across the nodes in the network.

The notion of the layer 3 intelligence is encapsulated in the following rational. Instead of having a huge IP Router processing the traffic, a fast switch is used instead, capable to switch the traffic at very high speeds using a label. It is combined with a smaller IP Switch Controller (ex. Smaller Router or Entity or Node) able to handle only the local traffic from a particular interface. The controller takes decision locally in the Node in cases that the flows at some point need to be splitted or terminated. With this mechanism a type of tunnel is created through the network.

ATM was a strikethrough when it was first introduced as it would be very easy to be implemented and because it provides an aggregation mechanism able to differentiate the different kinds of traffic, different services. As the network has started to be expanded due to emerging needs the ATM started to be very costly and not much flexible to scalability. It was difficult to scale it as a backbone technology due to many interfaces and processing resources needed. Thus, switches started to have a bigger size and thus be more expensive. So, it is very efficient but is difficult to implement it in the core part of the Network. Also, ATM is connection oriented so between any pair of switches and routers there is a permanent connection PVC leads to an increasing setup time delay proportional with the scaling. If optimal routing is required then a full mesh of those PVCs should be established and the complexity is proportional to all combinations of all the mesh nodes interconnected in a full mesh connectivity this is N^2 (N = # of Nodes) complexity because ATM does not support the powerful routing protocols of IP.

There is an increasing need in IP networks for new technology emergence and its implementation to increase throughput i.e. transmission rate, decrease delay and jitter for better QoS delivery. The routes deduce through IP routing protocol follow the shortest path routes or least cast routes leading to network congestion, underutilized network resources/links and no proper load balancing procedures at the network level. In an ISP IP network, the forwarded traffic performs the destination IP address lookup in the router to send the data to desire destination. If destination is external to ISP network, which means an external IP prefix exists in the routing table of every ISP network router. Border Gateway Protocol (BGP) is responsible for both external internet and customer prefixes so every router of an ISP network must depend upon BGP protocol. In the ATM switching there is a standardized software for controlling the traffic with a lot of complexity and delays added due to the implementation issues to the efficient approach of fast label switching. So, the motivation for the emergence of the MPLS from ATM and IP Networks is to reduce the processing time in the Nodes and mainly to provide QOS. MPLS combines the Routing Capabilities of IP with the fast label swapping mechanism from ATM in a new architecture where for routing the IP Routing Protocols are used and QOS is offered in layer 2 (Link Layer) very efficiently and with very high speeds.. Note that Every switch has a limited number of interfaces connected directly to its neighbours (other switches). So, the complexity of the routers from the processing has been reduced dramatically as the size of the routing table inside every router where is performed the longest prefix matching has been reduced to almost eliminated.

2 Main principle of operation

2.1 Label Switch Router (LSR)

MPLS architecture consists of MPLS routers connected through mesh topology. MPLS infrastructure network consists of following routers:

- **Ingress/Egress Label Switch Router (LSR)** LSRs deployed at perimeter of MPLS network which provides an interface to inside MPLS domain and to outside the IP network. The role of ingress/egress LSR is to insert and remove labels when deployed as an ingress and egress. An ingress **LER (Label Edge Router)** inserts label on the data packet called as imposing LSR and forward it towards egress LSR after passing through number of hops where egress LSR removes the label called as disposing LSR and forward it towards data link. These two routers are also known as Provider Edge Routers.
- **Intermediate label switching Router** LSR are devices present in MPLS domain to perform swapping, push and pop operations of incoming and outgoing packets towards ingress/egress LSRs. They receive an incoming label packets swap, push and pop labels perform packet switching and forward it towards correct data link. The packet forwarding mechanism based on information present at each label.

2.2 Label Switching Path (LSP)

It is a sequence LSR path from ingress LSR followed by number of selectable intermediate paths towards egress LSR. If the packet has already been labelled by ingress LSR then this case is called as nested LSP.

2.3 Forward Equivalent Class as means of flow aggregation

This term is used in MPLS to allow same group of packets to follow along same path and should be treated identically during packets forwarding. Layer 3 packets following towards destination IP address contain prefix, it might be certain group of multicast packets or packets based on precedence or forwarding treatment, and also layer 3 IP address maintaining same BGP prefix and same next BGP hop are some examples of Forwarding equivalency class. As described in [1] one way of partitioning traffic into FECs is to create a separate FEC for each address prefix which appears in the routing table. However, within a particular MPLS domain, this may result in a set of FECs such that all traffic in all those FECs follows the same route. The procedure of binding a single label to a union of FECs which is itself a FEC (within some domain), and of applying that label to all traffic in the union, is known as "aggregation". The MPLS architecture allows aggregation. Aggregation may reduce the number of labels which are needed to handle a particular set of packets and may also reduce the amount of label distribution control traffic needed. Given a set of FECs which are "aggregatable" into a single FEC, it is possible to (a) aggregate them into a single FEC, (b) aggregate them into a set of FECs, or (c) not aggregate them at all. Thus, we can speak of the "granularity" of aggregation, with (a) being the "coarsest granularity", and (c) being the "finest granularity". When order control is used, each LSR should adopt, for a given set of FECs, the granularity used by its next hop for those FECs. When independent control is used, it is possible that there will be two adjacent LSRs, Ru and Rd, which aggregate some set of FECs differently.

2.4 Labeled Switched Path as means of providing traffic engineering

Traffic engineering (TE) LSP develops a TE topological database to perform CBR (Constant Bit rate) along with shortest path first algorithm. Both work in integration to implement CSPF (Constrained Shortest Path First) algorithm to determine shortest path and optimal path approximation but are unable to guarantee optimal traffic mapping stream for network resources. MPLS TE signals LSP through RSVP by introducing following objects.

a) Label Request It is used to bind label at every hop.
b) Label It is used for Resv message distribution.
c) Explicit Route It define explicit hop list for signalling.
d) Record Route This object gather label and hop information during signalling path.

e) Session Attribute It defines LSP attribute requirement such as protection, priority etc.

2.5 Presentation of the key MPLS chain of operations in an example

1) Referring to the routing protocols in MPLS, (BGP,ISIS,OSPF) are the same like IP Networks performing equally in the terms of exchange reachability and information they have about the particular

network. Along with the IP part there is the label switching part. So along with the running IP routing protocol there is the label routing protocol running in parallel.In the example the label routing protocol is the Label Distribution Protocol (LDP).The LDP is responsible for the so called “Label mapping” by taking into account information from the routing protocol. Regarding the packet destination, information is provided from the IP and a label is assigned accordingly based on the different destinations.Once the label is assigned the packet is forwarded (based on the information in order to label switched) through the network. As a preliminary part is considered the path creation-establishment.

2)The Ingress label edge router receives a certain packet and put a label to it according to its destination. Then is switched through the LSRs so it is forwarder through label swapping to a certain destination.

3) At first a label of 10 is been assigned and then is forwarded through the specific (for this label) output interface to another LSR where the label is swapped to 20 and switched to an output interface accordingly. Then similarly it swaps the label to 40 and is switched to output interface and forwarder to the egress edge router.

4) Egress Edge Router removes the label from the packet so it becomes a regular IP packet that has to be addressed to the subnetwork that is part of the router or routed over the other part of the network(through several IP Routers)

3. MPLS traffic engineering

3.1 Main reason for implementing Traffic Engineering

The purpose of traffic engineering in MPLS [2] is to give the ISP precise control over the flow of traffic within its network. Traffic engineering is necessary because standard IGPs compute the shortest path across the ISP's network based solely on the metric that has been administratively assigned to each link. This computation does not take into account the loading of each link. If the ISP's network is not a full mesh of physical links, the result is that there may not be an obvious way to assign metrics to the existing links such that no congestion will occur given known traffic patterns. Traffic engineering can be viewed as assistance to the routing infrastructure that provides additional information in routing traffic along specific paths, with the end goal of more efficient utilization of networking resources. Traffic engineering is performed by directing trunks along explicit paths within the ISP's topology. This diverts the traffic away from the shortest path computed by the IGP and presumably onto uncongested links, eventually arriving at the same destination. Specification of the explicit route is done by enumerating an explicit list of the routers in the path. Given this list, traffic engineering trunks can be constructed in a variety of ways. For example, a trunk could be manually configured along the explicit path. This would involve configuring each router along the path with state information for forwarding the particular label. Such techniques are currently used for traffic engineering in some ISPs today. Alternately, a protocol such as RSVP can be used with an Explicit Route Object (ERO) so that the first router in the path can establish the trunk. The computation of the explicit route may include considerations of policy, static and dynamic bandwidth allocation, congestion in the topology and manually configured alternatives.

3.2 Resource Reservation Protocol–Traffic Engineering (RSVP-TE)

Resource Reservation Protocol (RSVP) [3] is a protocol that is used to reserve resources along the end-to-end path of a traffic flow in an IP network. RSVP messages are sent by the headend router in a network to identify resource availability. An RSVP request consists of a FlowSpec that specifies the Quality of Service (QoS) requirement for the traffic flow and a FilterSpec that defines which flow must receive the QoS priority. Once the necessary bandwidth is reserved along the path with RSVP, the application that made the request begins to transmit the traffic. RSVP is primarily used by real-time and multimedia applications to set up bandwidth reservations. RSVP thus communicates the requirements of specific traffic flows to the network. The RSVP signalling protocol was extended with MPLS features to support MPLS TE. In details the headend router can then direct traffic through new tunnels based on the resource requirements of the traffic being transmitted.

References

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