CONGESTION CONTROL IN MPLS NETWORKS

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ABSTRACT

IP networks are widely used as a common platform between different operators, technologies and applications. However, in IP networks, it is difficult to deploy effectively traffic engineering due to the limitation capabilities of the IP technology. Also, they have some other drawbacks such as lack of QoS guarantees, lack of security, etc. A new architecture has been proposed to offer traffic engineering capabilities to the IP networks: Multi Protocol Label Switching (MPLS) [1,3]. Indeed, MPLS Traffic Engineering has been widely deployed during the last few years and was motivated by the need for congestion control, bandwidth optimization, fast recovery (MPLS TE Fast Reroute) and strict QoS guarantees to carry sensitive traffic over multi-service packet networks. In this paper, FATE (Fast Acting Traffic Engineering) and FATE+ mechanisms [2] have been considered as congestion control methods, which are studied and effectively extended to solve the congestion problem and to re-balance data streams through the core network.

Index terms – Congestion Control, FATE (Fast Acting Traffic Engineering), MPLS, Quality of Service (QoS), Traffic Engineering (TE).

1. INTRODUCTION

Internet is omnipresent and growing very fast during the last few years. The exponential increase of Internet users requires the additional and guaranteed conditions network resources. Indeed, new services (voice, multi-media, video, etc.) strictly require resource constraints and quality of service (QoS). However, the IP networks cannot respond well new requirements.

In traditional IP networks, routing decision is based on destination address, which is contained in layer 3 header (network layer). Each router, to determine the next hop, consults its routing table and determines the out-going interface towards which the package to be sent. The mechanism determination in routing table strongly consumes CPU time with the growth of the network size. It was thus necessary to find a more effective routing method. As result, a new architecture has been proposed by IETF (Internet Engineering Task Force) to offer traffic engineering capabilities to the IP networks: Multi Protocol Label Switching (MPLS) [1,3]. The goal of MPLS was in the beginning to give to IP routers a greater switching power based on decision of routing on information of label inserted between Data Link layer and Network Layer. The packets are switched based on label, without consulting the layer 3 header and routing table. The interest of MPLS is not currently any more the speed but the offer of services which it allows, with in particular Virtual Private Networks-VPN and Traffic Engineering, which are not realizable in traditional IP infrastructures.

2. FATE and FATE+ Mechanisms

FATE mechanism [2] has solved the congestion problem through the network by rebalancing flows during congestion periods. It proposed mechanisms and procedures which will make LSRs to use the mechanisms in MPLS networks to indicate which flows could be experienced packet loss. Based on customer SLAs (Service

Level Agreements) with the instantaneous flow information, LERs (Label Edge Routers) can then encourage changes with the road of LSP (Label Switch Path) to avoid congestion which would violate customer contracts.

When studying FATE and FATE+ mechanisms, some problems can be extended as described and investigated by simulation in the following Sections.

2.1. Shared reservation

When a CR-LSP (Constraint-based Routed Label Switch Path) is established, its resources can not be used. That causes the resource wasting. Indeed, FATE and FATE+ mechanisms have the case where the data are traced with the higher buffer, i.e. the higher buffer is not profited when congestion happens. Why doesn't router profit the redundant resources by mapping data on the higher buffer before the congestion? Therefore, router must re-examine when there are redundant resources in CR-LSPs. If reserved resources in CR-LSPs are shared, this will have following advantages:

- The redundant resources in CR-LSPs are profited if necessary.
- Requirements of CR-LSP still are guaranteed.

The use of the reserved resources, which are shared shows that the congestion happens only when the reserved resources cannot respond incoming traffics. Then, in FATE and FATE+ mechanisms, when the congestion takes place they do not map traffics in the higher buffer because they don't have more of the redundant resources.

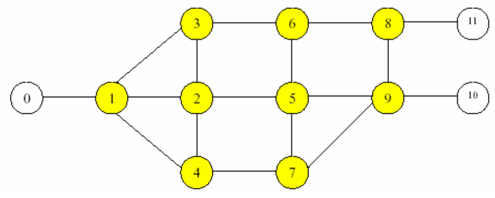

Figure 1: Network topology

For a bandwidth of 1Mbps, it's divided for three services: STS (signaling traffic service) is equal to 5%, RTS (real-time traffic service) is equal to 50% and BTS (best-effort traffic service) is equal to 45%; it means that STS service has 0.05Mbps bandwidth, RTS service has 0.5Mbps bandwidth and BTS service has 0.45Mbps bandwidth.

Considering all best-effort flows are classified in low priority buffers and real-time flows are classified in high priority buffers. If the traffics enter the buffers (higher than the maximum buffer value) that will not respond them all and some packets may be lost.

With a shared reservation scheme, if resources are shared between buffers:

- LSRs check high priority buffers, if they have redundant resources they will classify the best-effort packets in this buffer. Otherwise, best-effort packets are dropped.
- If high priority buffers are free but that is not sufficient, they will share their redundant resources.

Figure 2 describes the bandwidth of flows (low priority and high priority). A blue flow (RTS real-time flow) is reserved by 500Kbps bandwidth but it transfers with the rate 300Kbps; a pink flow (BTS - best-effort flow) transfers with the rate 700Kbps. Since link bandwidth is 1Mbps it can respond two flows (300Kbps + 700Kbps). Therefore, BTS flow can take the redundant part of RTS flow (500Kbps - 300Kbps = 200Kbps).

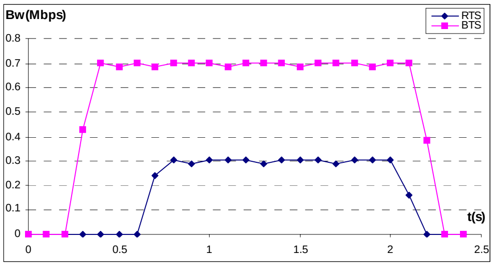

Figure 2: Sufficient sharing

2.2 Extension of FATE+ upstream mechanism

In FATE+ mechanism, the congested LSR makes decision to solve congestion. Therefore, this LSR will calculate a new path to reroute congested LSP. If the LSR does not find any path available, it will send a notification message CIN (Congestion Indication Notification) to its upstream LSR so that this LSR upstream looks for another available path with the required bandwidth. In FATE+ upstream mechanism, upstream LSR of a congested LSR reroutes congested LSP. If this upstream LSR can't find an alternative path, what will happen?

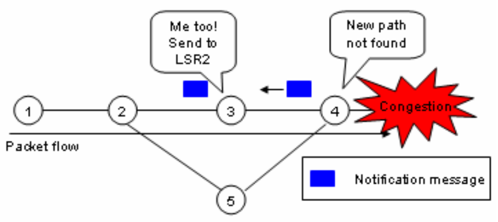

Figure 3: Upstream LSR's decision

In this case, it decides to send another CIN message to its upstream LSR. Upon CIN reception, upstream LSR knows that it must look for another path in order to reroute the congested LSP. That repeats until the LSR which finds an alternative path.

2.3 Repetition phenomenon

Suppose that the congested LSR finds an available path. If a new route goes through one of upstream LSRs of congested LSR, the rerouting at the congested LSR will waste resources and will increase the delay.

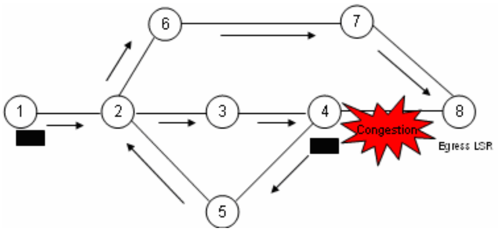

Figure 4: Repetition situation

In figure 4, the LSR4 found an alternative path 1-2-3-4-5-2-6-7-8, this causes bandwidth wasting. Indeed, if LSR4 sends the notification message to LSR2, LSR2 will switch the traffic by new explicit route ER=1-2-6-7-8.

To solve this problem, the congested LSR will send CIN message to LSR, which is joint between old and new LSPs. The following diagram shows the selection algorithm:

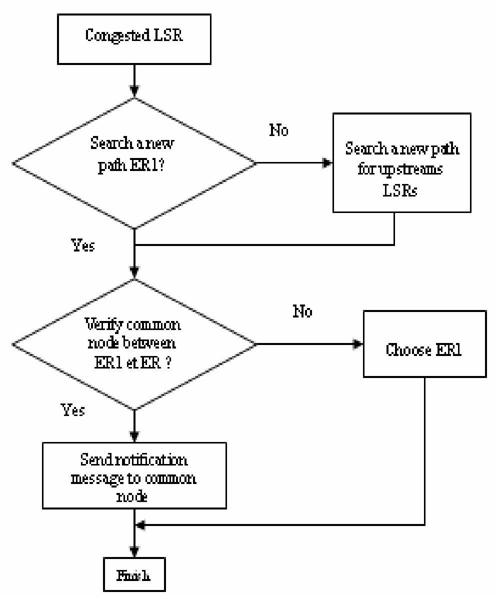

Figure 5: Selection algorithm of switching node

In figure 5, ER1 is the explicit route (ER) found after congestion and ER is one before the congestion.

2.4 Option between FATE and FATE+ mechanisms

To reduce delay, the decision-making option between two mechanisms is important. The following diagram shows this option:

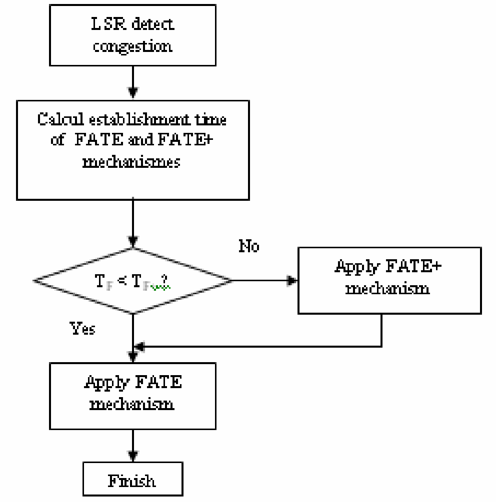

Figure 6: Option algorithm between FATE and FATE+ mechanisms

In figure 6, t_F is time when FATE mechanism establishes a new path and t_{F+} is that where FATE+ mechanism establishes a new path.

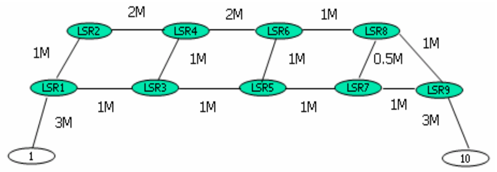

Figure 7: Network topology

In figure 7, nodes (1, 10) are considered as IP routers and LSRs are routers supporting MPLS. All links are duplex with the 10ms delay. The links between nodes and LSRs use DropTail queue and those between LSRs use CBQ queue (Class Based Queuing).

Scenario: FATE+ extension mechanism

The link delay between LSR2 and LSR1 is 50ms.

- At 0.1s, explicit route is established for the first flow which has 700Kbps rate, ER 1-2-4-6-5-7-9 and LSPID 1100.
- At 0.2s, backup path is established for first flow with ER 1-2-4-6-8-9 and LSPID 1200.
- At 1.0s, constraint route is established for the second flow with 700Kbps, ER 1-3-5-7-9 and LSPID 1000.
- At 3.5s, both flows are stopped.

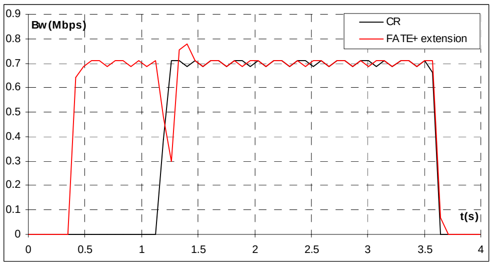

Figure 8: Result of FATE+ extension

Note that when LSR7 detects congestion at 1.19s, it finds a new path from itself to egress LSR. If it finds a path (7-5-6-8-9 in this case), it will check the new path and old explicit route (1-2-4-6-5-7-9). In parallel, it calculates the duration of resolution of the FATE and that of its. Then, it will make decision for the shortest mechanism. In this case, the duration of resolution of the FATE is 90.9ms and that of the FATE+ extension is 62.36ms. Therefore, it will solve the congestion by applying FATE+ extension mechanism. Then, it sends a notification message to common LSR (LSR6) so that the common LSR will switch traffics. The value 62.36ms is reached by relative calculation ([10+10] + [10+10] + [10+10] = 60ms). The first part is the duration of sending of a notification message to the LSR6 and the last parts are that of establishment of a new label.

There is a comparison between mechanisms as in figure 9 and table 1 as follows.

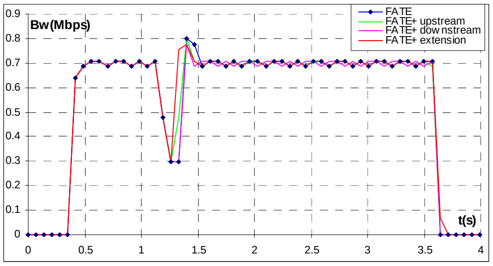

Figure 9: Comparison between mechanisms

Table 1

	FATE	FATE+ upstream	FATE+ downstream	FATE+ of extension
Time of congestion detection (s)	1.19	1.19	1.19	1.19
Switching time (s)	1.2811	1.2647	1.2760	1.2524
Solving duration (ms)	90.9	74.68	86.03	62.36
A number of packets lost at switching time	28	24	27	21

The congestion solving must be based by various parameters. However, the principal parameters are the duration of resolution, the delayed-action of the package and packet loss.

3. CONCLUSIONS

This paper focuses on extensions of FATE and FATE+ mechanisms to solve more effectively congestion problem. Indeed, congestion is solved with a shorter delay. In addition, propositions avoided repetition phenomenon which cause bandwidth wasting. Simulation results have shown these extensions.

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