DIFFSERV-AWARE GMPLS in IP/WDM ADMISSION CONTROL WITH FUZZY LOGIC

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Abstract—Traffic control algorithms can optimize network resources in deploying GMPLS networks. Connection admission control enables the network to admit connections that they can cater the QoS to. Future direction suggests direct GMPLS IP to Optical Wavelength Division Multiplexing (WDM) connections could provide faster provisioning of services, eliminating the electronic bottleneck currently imposed by the ATM or SDH infrastructure. This will save costs in terms of less delay and less electronics used.

This paper describes a proposal on admission control based on fuzzy logic control for DiffServ-aware GMPLS Internet network. A simulation study was developed for admission control with preemption in the GMPLS environment.

Key words: GMPLS, DiffServ, Fuzzy Logic, Traffic Control

I. INTRODUCTION

The DiffServ-aware GMPLS architecture is envisioned to be the solution for providing QoS in the Internet while effectively optimizing resources. An important feature of the GMPLS is the ability to set up Label Switched Paths (LSPs) which potentially can provide end-to-end connectivity for different services hierarchically. There are two basic network models for IP over WDM, i.e. overlay and peer models. An overlay model has two control planes for the IP and optical network respectively where the IP edge router acts as a client to the optical network. Whereas in the peer model, only one control plane exists. Here the edge router has full knowledge of optical resources. This work focuses on a WDM network which comprised of a number of optical cross connects (OXC) interconnected via fiber optic links and controlled by IP routes in an integrated traffic The LSPs and λSPs are provisioned dynamically on demand based on class of traffic. The peer model is used where each OXC is controlled by an IP router. A network simulation model was developed for the study.

Fuzzy logic on the other hand is a problem-solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controllers to large, networked, multi-channel PC or workstation-based data acquisition and control systems [1]. It can be implemented in hardware, software, or a combination of both. Fuzzy logic is a promising technique that can be used for enforcing QoS guarantees in the DiffServ-aware GMPLS Internet. The research work is concentrated on using fuzzy logic controllers to help support QoS and improve network performance in the DiffServ-aware GMPLS network. Potentially, the development of fuzzy logic based algorithms for traffic control will improve network performance and thus increase efficiency and reduce network costs by optimal usage of resources in a DiffServ-aware GMPLS Internet network.

Section II describes the fuzzy logic-based traffic control model. Section III and IV describes preliminary work conducted based on the network model. Lastly, Section V discusses the conclusion. Description on DiffServ and G/MPLS technology can be referred to the following references [2-5].

II. CONNECTION ADMISSION CONTROL SCHEME

For handling heterogeneous source traffic at an IP switch a two-level CAC scheme can be employed [6]:

• Level 1: Make decision to accept/reject connection by comparing the current service class to the maximum number allowed for that service class.
• Level 2: Redistribute unused capacity to other service classes that need it.

The first level is a very simple and fast process whereas the second level requires computation to ensure allocations conform to the QoS requirements. At the DiffServ-aware GMPLS edge router the following flow is proposed to be implemented for new connection admission:

• Connection Set-up Request is made
• A check is made on the BW requirements of the new connection based on class type
• A check is made on BW availability in the network. Also check on signs of congestion of other lower priority classes and decide whether BW preemption/ borrowing is feasible.
• Decide to admit or reject the connection If admit decide on LSP and λSP assignments on wavelength routing.
III. FUZZY LOGIC REGULATOR FOR CONNECTION ADMISSION CONTROL

A Fuzzy LSP Regulator is used in facilitating preemption strategies in the network. The regulator is part of the ingress node, i.e. node 1.

The DiffServ-aware GMPLS network under study (Fig. 1) is assumed to cater for three types of traffic, i.e. premium, assured and best effort traffic. The premium service, using the EF PHB, is for low-delay, low-jitter service such as for real time traffic like video conferencing or mission critical traffic like stock exchange information. The assured service, based on AF PHB, is for reliable and predictable service like non-real time virtual private network data. The best effort service is for the rest of the other Internet data.

The Fuzzy LSP Regulator comprised of three input parameters and one output parameter. The input parameters are the EF utilization normalized value, the AF borrowed bandwidth normalized value and the BE borrowed bandwidth normalized value. The normalized EF utilization is derived from taking the ratio of the bandwidth being utilized by the EF traffic over the EF class bandwidth allocation. The AF normalized borrowed bandwidth is the ratio of the amount of bandwidth borrowed from the EF class by AF traffic over the total amount of bandwidth allocated by class EF for borrowing. Whereas, the BE normalized borrowed bandwidth is the ratio of the amount of bandwidth borrowed from the EF and AF classes by BE traffic over the total amount of bandwidth allocated by classes EF & AF for borrowing. The output value is the preemption decision, i.e. whether to downsize or reroute lower priority traffic or reject an admission request.

The fuzzy rules used in the fuzzy LSP regulator are shown in Table 1.0. There are 7 rules that relate the three inputs with the fuzzy LSP output. One other possible rule, i.e. when all the inputs are low, have been eliminated since in this condition the admission request will be fulfilled and the process flow would not enter the fuzzy LSP regulator. From the table we see that situations that have EFUtil as low, AF Borrow low and BE Borrow high as antecedents will see the longest existing BE traffic rerouted. The same set of rules would be triggered every time the fuzzy LSP regulator is invoked, whereby an appropriate consequent will be executed.

The requirements for Service Provider’s support of DiffServ-aware MPLS Traffic Engineering, as outlined in [7] include the fundamental requirement to support different bandwidth constraints for different classes of traffic. A bandwidth constraint model provides the ‘rules’ to support the allocation of bandwidth to individual class type. This work uses the Russian Dolls Model (RDM) [8] which has been recommended as the default bandwidth constraint model for DiffServ-enabled MPLS traffic engineering [7].

Both preemption within a Class-Type and across Class-Types are allowed. Where 8 Class-Types are active, the RDM Bandwidth Constraints can also be expressed in the following way:

- All LSPs from CT7 use no more than BC7
- All LSPs from CT6 and CT7 use no more than BC6
- All LSPs from CT5, CT6 and CT7 use no more than BC5 etc.
- All LSPs from CT0, CT1, CT7 use no more than
BCO = “Maximum Reservable Bandwidth”

Since this work is using only three classes so the best effort can borrow from the assured and premium classes while the assured class can only borrow bandwidth from the premium class bandwidth. The premium class traffic could not borrow from any of the other two classes. The bandwidth constraint ratio used is 90:5:5 for each class respectively, i.e. EF: AF: BE. The fuzzy LSP regulator complements the RDM model by formalizing a dynamic preemption facility in it.

IV. SIMULATION WORK

A simulation study was made for the proposed fuzzy LSP/$\lambda$SP based on the DiffServ-aware MPLS network of Figure 3.0. There are 11 nodes in the network, i.e. 3 sources, 3 sinks and 5 GMPLS nodes which are IP/WDM routers. The ns-2 [9] network simulator with the MNSV2 extension [10] was used in the simulation work whereas the fuzzy LSP regulator component was developed in MATLAB [11] and ported to ns-2. Sugeno, min-max and centroid defuzzification techniques were employed. To study the performance of the fuzzy logic component, the premium traffic is gradually admitted to the DiffServ-aware MPLS network from a smaller to a bigger load, i.e. 1 to 10 Erlangs, whereas the assured and best effort traffic load were fixed with 50 Erlangs respectively. These values were chosen to investigate the network behaviour under heavy load. Each of the admitted traffic would be assigned an LSP based on class. The LSP will be based on peak rate value for EF traffic, and adaptive rate-capable AF traffic. The best effort traffic is allocated its mean bandwidth as the LSP bandwidth. Using the effective bandwidth of the traffic is an alternative for the AF traffic. The bandwidth on the $\lambda$SP can be borrowed based on the Russian Dolls model.

The blocking probability of the premium traffic in the network with the Russian Dolls model and fuzzy preemption mechanism at the ingress node is compared with the network with Russian Dolls model but limited to borrowing only (Fig. 4). The blocking probability of the premium traffic is lower in the Russian Dolls model with fuzzy logic regulator scenario. The blocking probability is the ratio of the number of rejected requests over the total number of requests made. Fig. 5 shows the blocking probabilities for all three traffic types where the premium traffic shows a slight increase in the blocking probability for loads more than 5 erlangs. The number of LSPs admitted for each traffic type are shown in Fig. 6 and the number of resized AF and rerouted BE traffic are shown in Fig. 7. It is observed that the number of LSPs for the three traffic types were able to be sustained (Fig. 6) through the resizing and rerouting activities (Fig. 7).

V. CONCLUSION

This paper deliberates on an admission control mechanism in a DiffServ-aware GMPLS network. It introduces the fuzzy LSP/$\lambda$SP regulator as a novel approach to provide preemption and facilitate traffic engineering in a DiffServ-aware GMPLS network. The performance study shows that the fuzzy regulator is able to sustain the number of LSP creations in the network. We attribute this to the capability of the fuzzy logic engine to accommodate to the traffic condition and decide the necessary action accordingly.
VI. REFERENCES


