A Study on Implementation of a MPLS Router Supporting Diffserv for QoS and High-speed Switching

Tae-won Lee and Young-chul Kim
[1] Department of Electronics and Computer Engineering & RRC HECS
Chonnam National University,
Yongbong-dong 300, Buk-ku, Gwang-ju, Korea
Tel. +82-62-530-0369, Fax.: +82-62-530-1759

e-mail : twlee@neuron.chonnam.ac.kr, yckim@chonnam.chonnam.ac.kr

Abstract: In this paper, MPLS Router module supporting Differentiated Service(Diffserv) for Quality of Service (QoS) and High-speed switching is proposed and implemented. And we compare and analyze the proposed architecture with the conventional one in terms of CLR (Cell Loss Rate) and average delay. Switch is an extended system of Queue of each VOQ and PHB in the manner of Input Queuing for QoS. Algorithm, Priority-iSLIP is used for its scheduling algorithm. The proposed architecture is modeled in C++ and verified.

1. Introduction

A rapid growth of the Internet and proliferation of new multimedia applications lead to demands tof high speed and QoS. To enable such services, MPLS have been introduced to provide with solutions delivering the enhancement of their networks' performance. The MPLS is able to offer a simpler mechanism for traffic engineering and multi-service functionality with the added benefit of greater scalability. The MPLS is a part of the evolution of the Internet to decrease complexity for fast packet forwarding. The MPLS is based on a label-swapping forwarding algorithm and label distributions are fundamental in the label-swapping forwarding algorithm. A label is a short, fixed-length value such as a VPI/VCI in ATM. It is carried in the packet's header to identify a FEC (Forwarding Equivalence Class). A FEC is a set of packets forwarded over the same path for the scalable connectivity even if their ultimate destinations are different [1].

To provide end-to-end guaranteed services, Integrated Services(Intserv) has been introuduced by IETF. A singaling and reservation protocol, RSVP, for sertting up end-to-end QoS reservation along a flow's path was also proposed and standardized. However, due to its need for performing per-flow management at core routers, the scalibality of the Intserv architecture has been questioned. Thus, to address the issue of scalability, the IETF has introduced the Diffserv model, which achieves scalability by offering services for an aggreate traffic rather than on a per-flow basis[10].

The concept of aggregated flow is similar to that of FEC (Forwarding Equivalence Class) of MPLS. Thus, the support of DiffServ in MPLS networks is very important.

In high-speed router, VOQ (Virtual Output Queuing) is used to switch fabric. Such VOQ manner should introduce an adjustable scheduling to solve blocking and unfairness, and high-speed scheduling should be carried out to fit into dealing with the speed of packet. Also, fast switching structure should be applied.

In this paper, we suggests H/W structure of Diffserv Router which is possible high-speed switching through H/W scheduler.

The rest of this paper is organized as follows. In section 2, the structure and the function of MPLS Router supporting Diffserv is explained. In section 3, we presents the structure and the algorithm of the proposed MPLS Router supporting Diffserv. In section 4, we shows the results of experiment. Finally conclusion is address in section 5.

2. Diffserv over MPLS Router

2.1 MPLS

MPLS enables packets to be forwarded without undergoing layer-3 routing to speed up the communication of packets by using short and fixed labels. In the router, forwarding has been achieved by checking each IP packet header and then decides the next hop. Because this way has to be carried in every packet and every router in the router routes, it is inefficient in dealing with multimedia traffic. Therefore, MPLS has an advantage of increasing the speed of communication in networks with its simple forwarding process compared to the existing IP forwarding. The simple forwarding process of MPLS is completed by combining router in layer-3 routing and switching functions like ATM or Frame Relay in layer-2 switching. After observing which FEC (Forwarding Equivalence Class) packet belongs to on the base of layer-3 routing route information at the ingress of MPLS network, each FEC are assigned label and packets are encapsulated and transmit it to next hop. The next node received labeled packet examines the label value without analyzing layer-3 routing information and carries out packet sending.

2.2 Diffserv

The demand of various services on the internet requires a new technology to change the existing service circumstances. IntServ has a high-speed transmission because it assigns a resource to a specific packet or flow, and a number of connected flows arises expansion problems. DiffServ offers QoS easily than IntServ model by assembling PHB (Per Hop Behavior) which is defined as forwarding and treating discriminately.

Traffic streams in DiffServ networks are classified from routers which progress to receive the sending formula and marked. Mainly traffic controls like complex classifiing, policing and shaping are carried from a boundary node in the network. Its advantage is that it doesn't need to maintain its state to flow or keep the information go in the core part of network because from inside it fits its inputted packet to its agreed service beforehand.

2.3 MPLS Router supporting Diffserv

Figure 1 shows the function of Diffserv router. Boundary node and core node have a different structure in DiffServ. Core node has simple structure rather than boundary node. Boundary node is the structure of classifing packets and controlling traffic according to policy or user specification and marking PHB and then guaranteeing traffic QoS. Core node structure is simply to classify traffic and mark PHB.

To support Diffserv in MPLS network, Packet Classification, Traffic Condition, PHB Policing, PHB Mapping, QoS Label Mapping have to be supported at the same time. This is defined as IETF Draft and the study is on the progress.

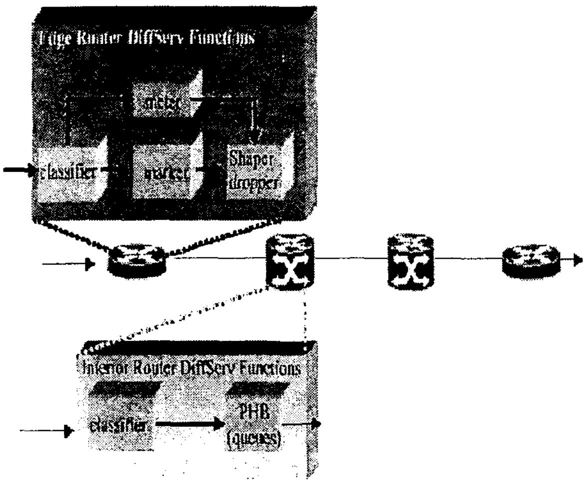


Figure 1. The function of DiffServ Router

DiffServ	MPLS
EF(Expedited Forwarding) PHB	Gold service
AF1(Assured Forwarding)PHB	Silver service
AF2 PHB	Bronze service
DE(Default) PHB	Best effort

Table1. Mapping between PHB and MPLS Service Class of DiffServ

In MPLS router supporting Diffserv, this function has to be dealt high-speed, and metering and classifying are carried in traffic controller by using bucket structure. PHB mapping uses the information from SLA (Service Level Agreement) or Bandwidth Broker and make label correspond to PHB according to the network policy.

Queue management like RIO and RED are applied to guarantee QoS, and each PHB Queue is composed to satisfy QoS of each PHB. For the output from queue to link, scheduling algorithm is applied, and now it is used from priority scheduling to complicated manners like CBQ or WRR.

Like the high-speed switching manner, input queue, crossbar switch fabric and output queue are composed in Gigabit/Terabit Router. The major method among input queuing is VOQ (Virtual Output Queuing). However, it raises HOL (Head of Line) blocking problem and unfairness service. To solve the problem, an adequate scheduler needs to compose and to operate high-speed. Typical scheduling algorithm is PIM, iSLIP and LRU and these algorithm can solve HOL blocking and fairness.

3. Proposed MPLS Router's Structure Supporting Diffserv

MPLS Router supporting Diffserv consists largely of traffic controller, signal protocol, routing protocol, switch fabric and so forth. Switch fabric differs from the manner of queuing and scheduler. In the early study, researchers used VOQ in the manner of input queuing and set up a hypothetical queue according to each output and it was communicated to link according to scheduling algorithm after stored in output queue. Output queue should be organized in each PHB to support Diffserv and also needs another scheduler. Accordingly, this research removed the scheduling element by simplifying output queue and instead accomplished input queue selected hypothetical queue in advance, therefore, adopted a structure to maximize the queue's efficiency and improved throughput. Figure 2 shows the structure of scheduling and queue.

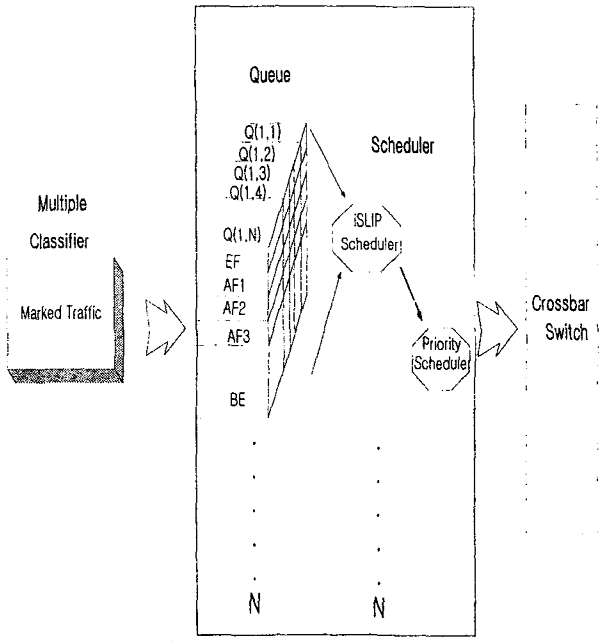


Figure 2. . The structure of Scheduler and Queue of Switch fabric

Input queue is composed of hypothetical queue in each output, and VOQ is classified by each PHB hypothetically. Priority-iSLIP was used as scheduling algorithm. Unlike the choice of PIM at random, iSLIP algorithm finds the best match by increasing pointer with the manner of round-robin This helps to use the substitution equally and fairly and to realize high-speed. Also, priority algorithm simply guarantees Diffserv QoS. [2][3]

Marked traffic is stored in its appropriate hypothetical queue according to output port and PHB from a traffic controller. It requests scheduler to be passed crossbar switch in the order of arrival. ISLIP scheduler decides whether to accept it or not by depending on the request and sends the accepted packet. This process relies on the PHB priority so when a packet is finished to be sent, the next packet of next PHB priority will be sent. PHB is divided into EF, AF1, AF2, AF3, BE, etc., and these are marked in traffic controller and inputted. EF has priority over everything and BE is the lowest.

PHB merging is available in the output structure. Considering an expansion in case of applying to a large scale, merging also needs to be considered and supported. Figure 3 shows proposed MPLS router's H/W structure Diffserv proposed in this paper.

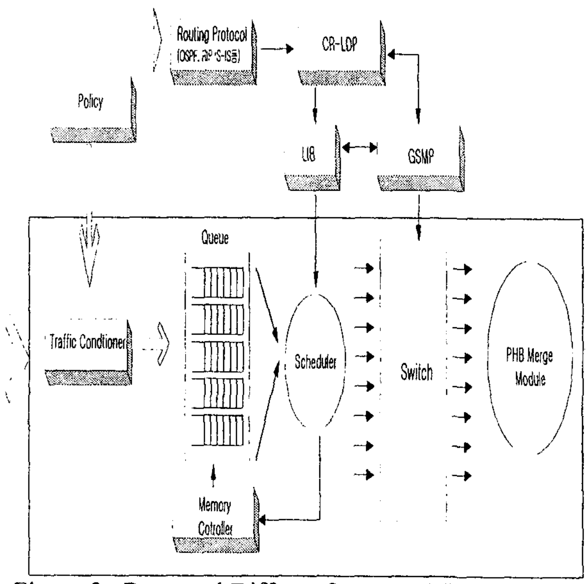


Figure 3 . Proposed Diffserv Support, MPLS Router's Structure

Traffic controller functions as a classifier and a marker. When in/out interface and port are decided by signal protocol, marked traffic is stored in hypothetical queue according to PHB and out port and then scheduling to be sent. For an efficient use of queue, memory controller is constituted and so are arbiter of iSLIP algorithm in scheduling module and priority algorithm. As for switch, crossbar is used and PHB merge forms a possible structure in output.

Figure 4 shows the process of data-handling. The inputted traffic by link policy accomplishes its duty like classify/meter/shape in traffic conditioner and then is assigned DSCP (DiffServ Code Point). On the base of LDP

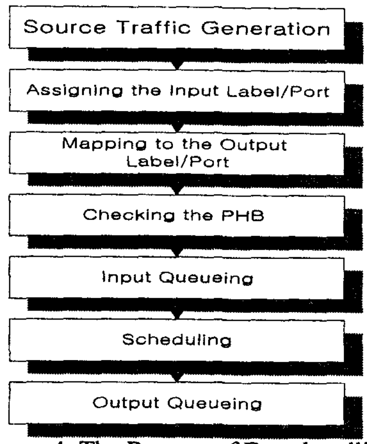


Figure 4. The Process of Data-handling

or CR-LDP which is a signal protocol and DSCP, it forms LIB (Label Information Base). LIB decides output port of VOQ and PHB queue which are to assign in traffic. Traffic stored in input queue passes crossbar switch by priority-islip scheduling algorithm and then is printed out link after a merging in demand of PHB merging.

PHB merging module is composed of OMs (Output Module) and Merge Scheduler. OM consists of a common memory pull and OM is composed of RBs (Reassembly Buffer) and five PHB FIFO OB (Output Buffer). The number of each OM is the same as the number of output port.

The inputted packets pass by switch and then are stored RBs by PHB. Stored packets by PHB merging scheduler are merged by its same destination and separated by its class and get some service and then output.

4. Simulation result

For verification of suggested structure it was modeled in C++ and experimented by network loads. The experiment has existing Input Queuing structures. The manner of scheduling after queuing by PHB in output queue and the suggested manner was compared. For this experiment, on-off traffic and IPP traffic generators were used and produced traffic by each PHB.

In the case of EF PHB and AF1 PHB traffic that have a priority, we used on-off traffic model and IPP model to AF2 and AF3 for its busty characteristic and generated input traffic. The transfer rate for output link is 155 Mbps, and traffic was generated by the rate of EF 20%, AF1 20 %, AF2 15 %, AF3 15 %, BE 30% each PHB.

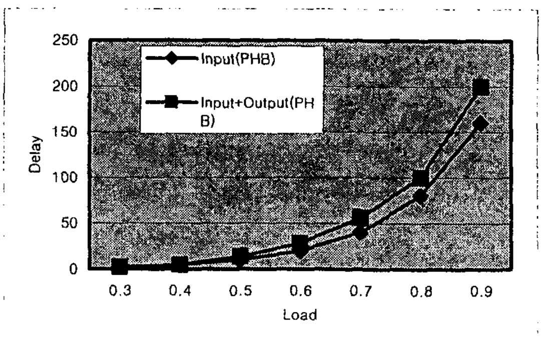


Figure 5. The delaying time by load

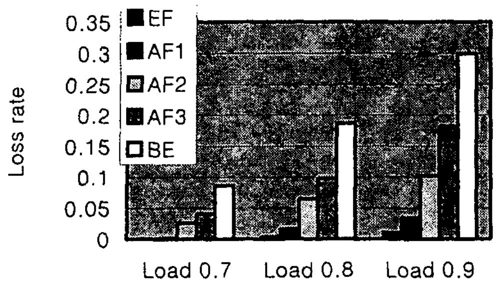
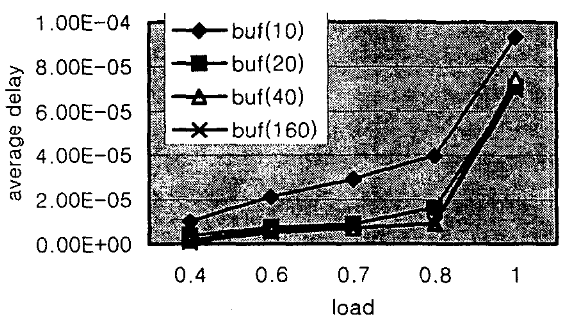


Figure 6. The loss rate by load

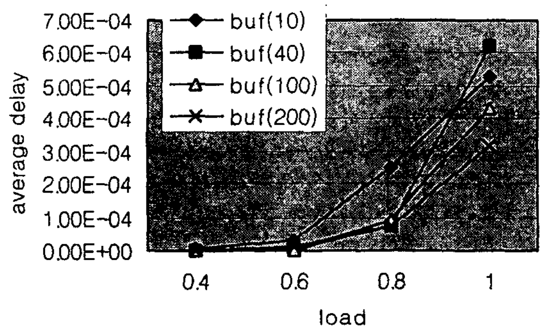
Figure 5 shows that VOQ is used in the manner of suggested delay and input queuing and shows a delay of which manner constructed output queue by PHB. As we see in the picture, the method suggested in this paper is much more efficient than that forming output queue by PHB. This is the result of that the manner of VOQ by PHB utilized queue more efficiently.

Figure 6 shows the loss rate by PHB. As loads increase, the loss rate also increases but little difference. This represents the two manners both guarantee QoS properly and no particular difference in throughput. In Output port PHB merging is performed to guarantee expansion, and reassembly buffers and merge schedulers are formed additionally.

Figure 7 shows the Buffer-efficiency of two ways. As we can see, in the specific size of Buffer or more than that size, same results were found and Buffer is used efficiently in the proposed architecture



(a) Buffer capacity in proposed architecture



(b) Buffer capacity in typical architecture

Figure 7. Buffer Capacity by Load

5. Conclusion

According to a rapid increase in the traffic on networks and the demand of various services, MPLS was applied as a method that provides Diffserv which demands high-speed switching and QoS security. In order to provide Diffserv, however, the scheduling and queue structures should be revised beforehand to serve each PHB properly.

This study presents a structure which enables QoS and high-speed switching by using queues efficiently. The experiment shows that suggested method in this paper gets more excellent results than input queuing method utilized in high-speed routers. PHB Merge is used efficiently to guarantee the expandability which makes it possible to be used in a massive networks.

The suggested structure is going to be designed after H/W modeled

Reference

[1] R. Callon, P. Doolan, N. Feldman, A. Fredette, G. Swallow Viswanathan, "A Framework for Multiprotocol Label Switching", Internet Draft, Sep. 1999.

[2] Pankaj Gupta and Nick McKeown, "Design and Implementation of a Fast Crossbar Scheduler," Hot Interconnects VI, Standford University, August 1998

[3] Sambit Sahu, Don Towsley, Jim Kurose, "A Quantitative Study of Differentiated Services for Internet", Umass CMPSICI Technical Report 99-09

[4] Francois Le Faucheur, Liwen Wu, "MPLS Support of Differentiated Services", IETF Internet Draft

[5] M. Carlson, W. Weiss, S.Blake, Z. Wang, D. Black, E. Davies, "An Architecture for Differentiated services", IETF RFC 2475, Dec. 1998

[6] D. Awduche , J. Malcolm , " Requirements for Traffic Engineering Over MPLS" , IETF RFC 2702, Sep. 1999

[7] Arun Viswanathan, Nancy Feldman, Zheng Wang, Ross Callon :" Evolution of Multiprotocol Label Switching" , IEEE Communication Magazine, May 1998

[8] R. Braden, L. Zhang, S. Berson, S. Helzong, S. Jamin, "Resource ReSerVation Protocol (RSVP)- Version 1 Functional Specification", RFC 2205, Sep. 1997

[9] Andreas L.Schmid, "Analysis of VC Merging in ATM", Computer Engineering and Neworks Laboratory in Switzerland, March.1998

[10] Shingo Ata, Masayuki Murata and Hideo Miyahara, "Analysis of Network Traffic and Its Application to Design of High-Speed Routers", IEICE TRANS. INF.&SYST., Vol.E83-D, No. 5, May 2000.