A Study on Bandwidth Guarantee Method of Subscriber Based DiffServ in Access Network

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Abstract. In this paper, we describe the structure of the access network and we propose bandwidth guarantee scheme for subscriber and service. The scheme uses two kinds of the classification table, which are called "service classification table" and "subscriber classification table." Using the classification table, we can identify the flow of the subscriber and service. Also, we compute the number of hash table entry to minimize the loss ratio of flows using the M/G/k/k queueing model. Finally, we apply to deficit round robin (DRR) scheduling through virtual queueing per subscriber instead of aggregated class.

1 Introduction

The traditional IP network offers best-effort service only. To support quality of service(QoS) in the Internet, the IETF has defined two architectures: the Integrated Services or Intserv[2], and the Differentiated Services or Diffserv[3]. They have important differences in both service definitions and implementation architectures. At the service definition level, Intserv provides end-to-end guaranteed or controlled load service on a per flow (individual or aggregate) basis, while Diffserv provides a coarser level of service differentiation. By enabling QoS, which essentially allows one user gets a better service than another. The internet is a media transmitted data. Gradually, it needs the transmission of a triple play service such as voice and video. Ethernet passive optical network (EPON) is generally used as an optical subscriber network. The main configuration of this paper is an analysis of the QoS structure in the EPON access network. In this paper, QoS of the optical line termination (OLT) system has been implemented with the conjunction network processor and provisioning management software[1]. The remaining part of the paper is as follows. The system architecture of access network using the network processor is proposed in Sect. 2. In the Sect. 3, we propose the bandwidth guarantee scheme for subscriber and service in optical sub-scriber network. Finally, the result of simulation with analysis has been described in Sect. 4 and we give our conclusion in Sect. 5.

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2 System Architecture

Figure 1 show the interconnection architecture of the OLT. The OLT system is located between Internet backbone network and fiber to the home (FTTH) subscriber through EPON. The main functions of the OLT are it offers basic routing protocol, it provides the function of IP broadcasting and subscriber authentication, and it offers the function of QoS and security. EPON master is physically interconnected with line card of OLT, and a PON bridge is consisted to ONU and ONT through optical splitter, and then, subscribers are connected. Authentication server+ performs two kinds of functions. One is authentication function for subscriber and service. Another is the function setting of the QoS profile for subscriber and service.

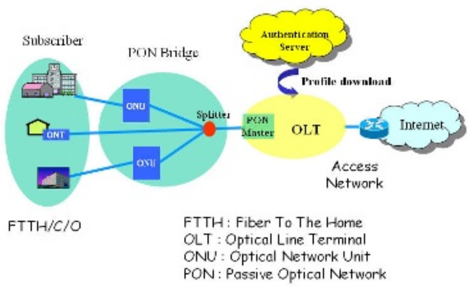

Fig. 1. The Structure Of PON Access Network

3 Bandwidth Guarantee Scheme

Packets of broadcasting channel using multicasting address are copied in egress network processor of the OLT and transmitted to the PON bridge area. Therefore, we could not distinguish the address of subscriber in OLT. So, we don't know the information of the bandwidth of a subscriber. For bandwidth guarantee of the subscriber and service in OLT system, we should be resolved the number of two problems. First, QoS control server should allocate dynamically the bandwidth and QoS profile of subscribers and services. Second, Network processor in line card of the OLT must provide the packet transmission function through classification table to distinguish subscribers and services.

3.1 Hierarchical Classification

Figure 2 shows data structure of the hierarchical classification table and the flow of dynamic bandwidth allocation. The 6-tuple classifier takes selected fields of an IPv4 header and the input port as a lookup key. The lookup result contains flow_id (identifier of a packet flow) and class_id (a relative identifier of a target QoS queue). To accommodate color-aware srTCM, the classifier may also set color_id. If a hash table lookup fails, the classifier sets default values the above metadata variables.

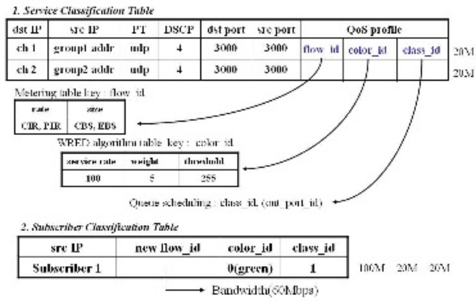

Fig. 2. Hierarchical Classification Table

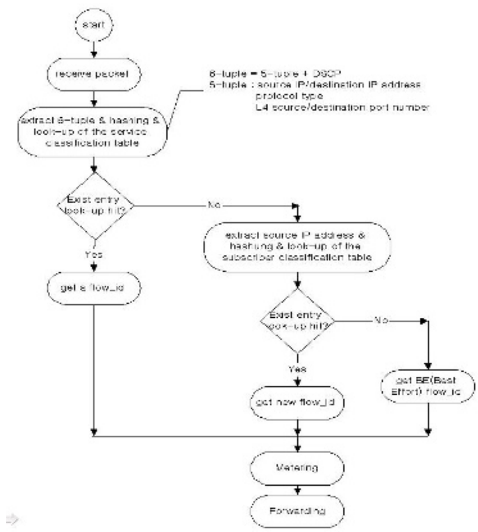

Fig. 3. Flow Chart of Packet Classification

Figure 3 shows the processing flow of packet received in ingress micro engine. When packet is received, it extracts 6-tuple of the packet, hashing and then look-up service classification table with the result value of the hashing. If look-up is success then we get a flow_id, color_id and class_id of the entry. If look-up is not success, the packet is not a packet of a registered service. So, we need one more look-up the subscriber classification table with the source IP address of the packet. If, the look-up is success, it is a packet of registered premium subscriber. We get a new flow_id, color_id, and class_id. If second look-up is failed, the packet is using best-effort service for normal subscriber. So, we get a default flow_id, color_id and class_id.

3.2 Number of Hash Table Entry

Arrival process of flows are according to a poisson process with rate λ. There are k rooms in the hash table, each of which stores a single flow information. If there is no room in the hash table at a new flow arrival, the new flow is rejected and lost. The sojourn times of flows are assumed to have distribution B(x) and density function b(x). Then the system can be modeled by the M/G/k/k queueing system. In this queueing model, the number of flows in the hash table is according to the following distribution[5]: **Expression 1**:

$$\mathrm{P}\{n\ customers\ in\ the\ system\} = \frac{\dfrac{(\lambda E[\mathbf{B}])^n}{n!}}{\displaystyle\sum_{i=0}^{k} \frac{(\lambda E[\mathbf{B}])^i}{i!}}, 0 \le n \le k \tag{1}$$

Then the loss probability due to the limitation of the hash table size is given by **Expression 2** :

$$P_{loss} = \frac{\dfrac{(\lambda E[\mathbf{B}])^k}{k!}}{\displaystyle\sum_{i=0}^{k} \frac{(\lambda E[\mathbf{B}])^i}{i!}} \tag{2}$$

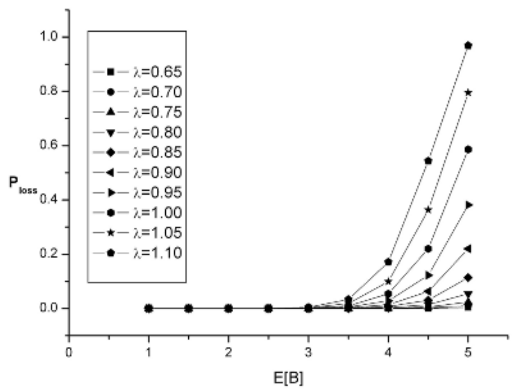

Fig. 4. Loss Probability According to E[B]

Figure 4 shows the loss probability according to E[B]. We have to regard that loss probability is increased hastily when E[B] is more than 3.

3.3 Queueing and Scheduling per Subscriber

Consider a DRR (Deficit Round Robin) scheduler with n queues having weights $\phi_i, (1 \le i \le n)$. Then it is known that the latency θ_i of queue i is given by[4] **Expression 3**:

$$\theta_i = \frac{1}{r}\left[(F - \phi_i)\left(1 + \frac{\overline{P}_i}{\phi_i}\right)\sum_{j=1}^{n} \overline{P}_i\right] \tag{3}$$

Where, $\overline{P}_i$ is the maximum packet size of flow i and $F = \sum_{i=1}^{n} \phi_i$. Now assume

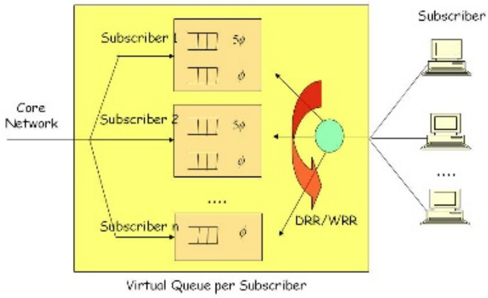

Fig. 5. The Example of DRR Scheduling

that all weights are fixed. Then, when we want to accommodate CBR type real time traffic with delay bound δ in queue i, it is necessary to satisfy $\theta_i < \delta$ from which we can get the maximum allowable number of queues. Figure 5 shows the DRR algorithm allocating virtual queue per subscriber. Subscriber n has BE (best effort) service and subscriber 1 and 2 have a internet service of best effort and premium service. Packets received from core network queued to virtual queues according to subscriber and transmitted to subscriber through DRR algorithm. In this paper, we allocates the weight ϕ to the BE service and weight 5ϕ to the premium service to simplify the computation. We assume the following conditions to induce value n satisfy the delay bound. $\phi_i = \phi, (1 \leq i \leq n)$, premium subscribers occupies 20% of the total subscriber, $P_i = MTU$(Maximum Transfer Unit) where, 64Kbytes with worst case, and $\gamma = 10Gbps$ (The performance of network processor).

4 Simulation and Analysis

Figure 6 shows the relation of latency θ_i and the number of subscriber n. We know there is difference between premium service and best effort service. For

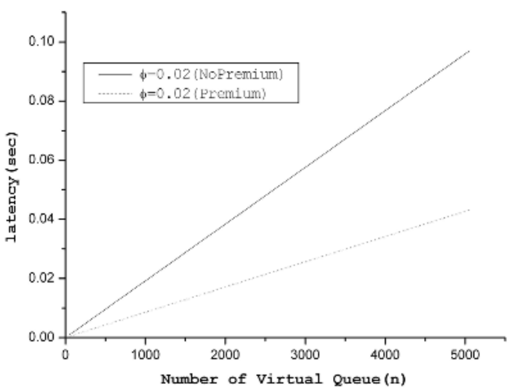

Fig. 6. Maximum Subscriber According to Latency

example, if the delay bound δ of the target system is 20ms$\sim$50ms then, the number of subscriber meets the delay bound is 1000$\sim$2700. This result derived according to worst case. Therefore, there is difference between the design of a real system network and the result of in this paper.

5 Conclusion

Based on the basic idea of DiffServ, we decouple the control plane and data plane functions in optical subscriber network. The low overhead and implementation simplicity makes a hierarchical look-up of classification table an attractive candidate for adoption in optical subscriber network based IP DiffServ.

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