VLAN-based QoS Control in Mobile Networks

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Abstract – Recently, it has become important to provide a convenient environment for real time applications such as VoIP and streaming. It is therefore an urgent matter to construct a network environment that supports Quality of Service (QoS) in a mobile network. This paper proposes a QoS support method using a VLAN which is applied between Mobile IP functional nodes. The effectiveness of the proposed method is verified by flooding streams in the experimental network. It is shown that the proposed method guarantees latency and bandwidth. The result proves the effectiveness of end-to-end priority control.

1. INTRODUCTION

In recent years, real time applications such as VoIP and streaming are often used in a mobile environment. It is therefore an urgent matter to construct a Mobile IP [1] network environment which supports Quality of Service (QoS). In this paper, we propose a QoS supporting method which works in a mobile network constructed by Ethernet. The proposed method constructs a VLAN [2] dynamically according to movement of mobile nodes and by using the priority control function defined in IEEE802.1p. Furthermore, by combining the proposed method and the Traffic Control function of a corresponding node, consistent QoS control inside the mobile network can be realized. Details of the proposed method, an outline of the experiments and evaluation results are reported.

There are related studies which consider the QoS approaches. For example, Ref [3] proposes a SLA (Service Level Agreement) which defines a user service condition trend. This consists of three factors: terminal, service type and access network. By taking a balance between these three, a user service condition trend is defined.

2. PROPOSAL OF QoS SUPPORT USING VLAN IN MOBILE IP NETWORKS

To set a control policy (such as QoS, access control etc) of each respective user, a method to use different VLAN ID (VID) is defined to distinguish and control priority. Ethernet switches that support priority control in frame forwarding using VLAN, defined in IEEE802.1p, is widely adopted. According to this, switches are used for frame forwarding control. The mobile nodes are considered to move among various networks. There are several methods to provide end-to-end QoS using RSVP [4], MPLS [5] and so on. In this paper, most of the core network is assumed to be constructed using the Ethernet. We will therefore propose a method for connecting Mobile IP and VLAN, and then realize QoS support in Layer 2 in a mobile access network [6].

3. LOCATION REGISTRATION PROCESS WITH QoS CONTROL

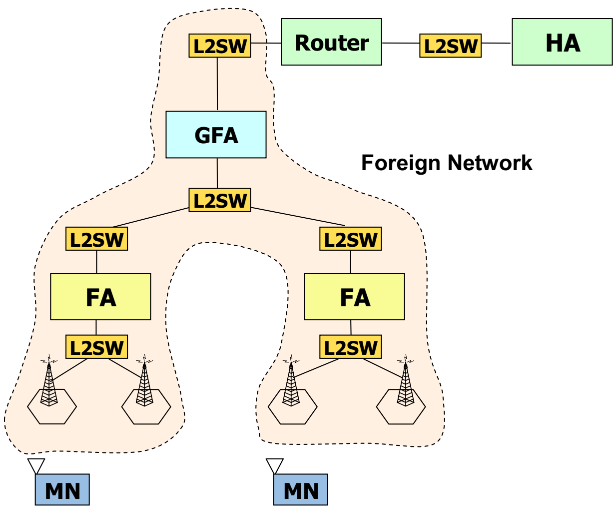

Fig. 1 Proposed Mobile IP Network configuration supporting QoS

The registration process to integrate location management of a mobile node with QoS support is explained below. For generalization, a simple network is illustrated in Fig. 1. The area surrounded by the dotted line is a Foreign network. The GFA (Gateway FA) is placed above FA (Foreign Agent). The following will explain the location registration method proposed in this paper (Fig. 2).

(1) When the mobile node (MN) sends a RRQ (Registration Request) to FA, which is located in the foreign network, a newly defined VLAN information Extension (VIE) is added to the priority and VID.

(2)-(4) RRQ is delivered to home agent (HA) by transferring FA and GFA. FA and GFA rewrites VIE.

(5)-(6) After authentication of RRQ, HA obtains the priority and VID from VIE when attached. HA compares the priority set in MN which was set previously. The chosen priority and VID is then stored in the VIE of RRP (Registration Reply), and forwarded to the next hop router which is designated to GFA. It is possible to set up the system to send a GVRP (Generic VLAN Registration Protocol) [7] Join message to the interface of the sending (Router side) segment.

(7)-(8) GFA receives the RRP from the router concerned, holds the priority and VID, and then sends a GVRP Join message to the FA side segment. This can also be sent to the segment of the receiving interface side (Router side).

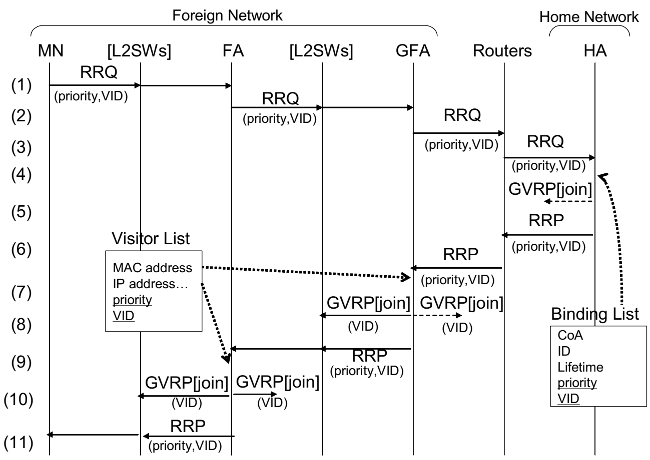

Fig. 2 Process for registration in Mobile IP network

(9)-(11) FA acquires and holds the priority and VID in the RRP which is forwarded from GFA. This sends the GVRP message to the segment of the MN side and interface of the receiving side (GFA). Afterwards, FA sends the RRP to the MN.

4. QoS SUPPORT INSIDE MOBILITY AGENT

To combine the proposed method and QoS support held in the mobility agent (HA, GFA, FA), we used the Linux TC (Traffic control) function. TC is a mechanism for scheduling, band limiting and filtering incoming and outgoing traffic. When a new session for MN is organized, HA and FA set up the Linux fib (Forwarding Information Base). This is a forwarding table which is created according to IP routing information.

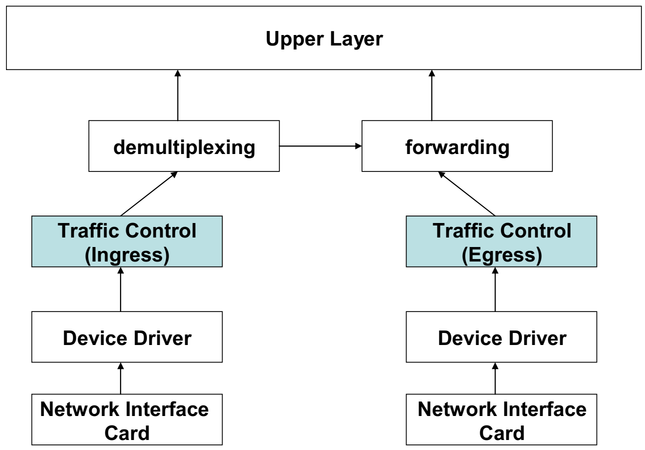

Fig.3 TC's disposition inside Linux kernel

Traffic control in the receiving direction is carried out before the received packets are sent to the upper protocol layer. Traffic control in the outgoing direction takes place at the same moment when the packets are given to the network driver from the upper layer (Fig.3). Several queuing controls were set to each mobility agent to control the traffic.

5. EXPERIMENTAL NETWORK

The network used for experiments consists of a hierarchical network which has several FA under GFA (Fig.4, Fig.5). Ethernet is used to connect each node and the maximum forwarding speed is 100Mbit/sec. From mobility node MN1, 2, 3 to destination node CN1, the data size of the traffic is 200-1500 bytes (100 byte steps). This is sent in intervals of 60 seconds. Details

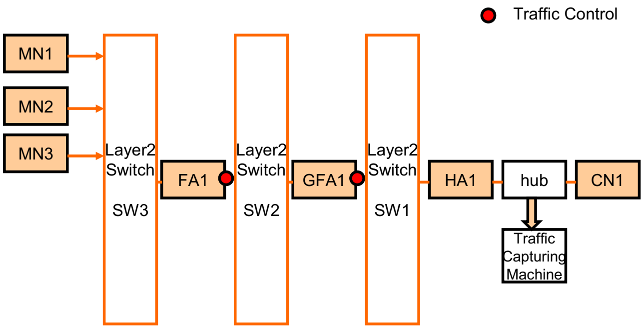

Fig.4 Flow of stream and traffic control in experiment (Uplink)

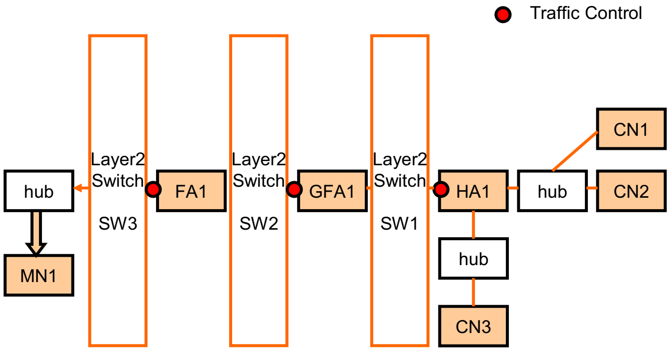

Fig.5 Flow of stream and traffic control in experiment (Downlink)

for uplink streaming, such as traffic control points, are shown in Fig.4. In this experiment, MN1 transmits Bulk traffic, MN2 transmits Interactive traffic and MN3 transmits Best-effort traffic. When the stream flows in the downlink direction, data packets flow from CN1, 2, 3 to MN1 (Fig.5). In this case, CN1 transmits Bulk traffic, CN2 transmits Interactive traffic and CN3 transmits Best-effort traffic. In both cases, when transmitting each traffic, traffic generator was used.

For the experiments, end- to- end forwarding rate and latency were measured. Several kinds of traffic controls are set in GFA and FA. One of these traffic controls is prio (Priority Scheduler) + tbf (Token Bucket Filter). Prio is default QoS support in the Linux system and this limits the bandwidth of the traffic. Tbf enables control of the packet by tuning the speed and restraining the burst. The other traffic control is called htb (Hierarchical Token Bucket) [8]. This uses a Token Bucket Filter to divide the available bandwidth by using several classes. The network can lend vacant bandwidth to reduce the traffic.

The traffic control method “Elastic Weighted Round Robin” (EWRR) was also tested [9]. EWRR is a method which can control service differentiation according to each service class. EWRR has several queues, assigns a service level respectively and transfers packets in a fixed order. Each queue holds a credit, and according to the order of a queue’s credit, packets are transmitted. Packets sent from each queue, and the total data amount transmitted from one cycle of a round robin, is defined as a scheduling window (SW). The incoming packet is variable in length. When the first packet of the queue is over the credit, it is transferred but the next SW decreases the credit of the overfull part. On the other hand, when the next cycle does not hold a packet or the sum of packets is not full, the next SW can add extra credit.

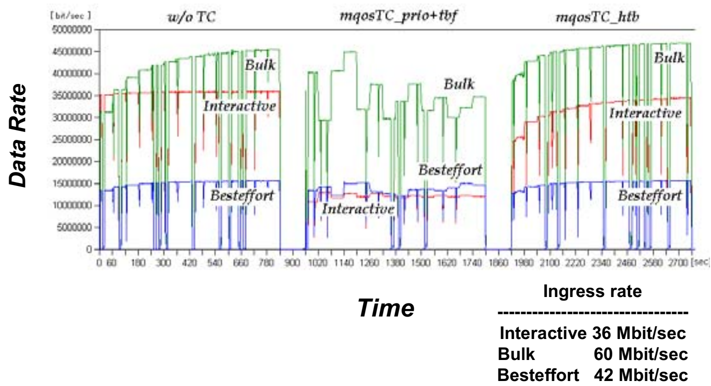

Fig.6 Data rate of traffic control (Uplink) (without TC, prio+tbf and htb)

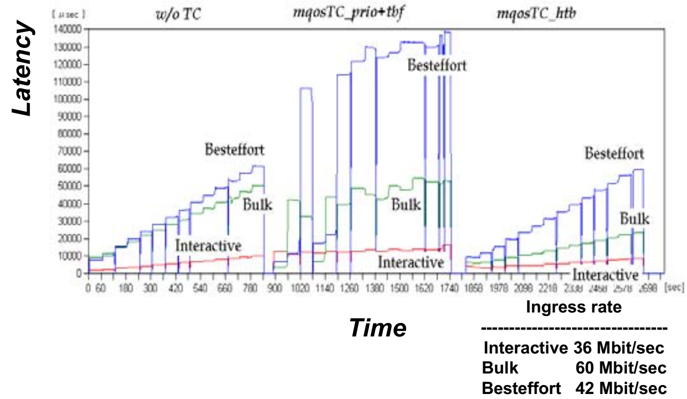

Fig.7 Latency of traffic control (Uplink) (without TC, prio+tbf and htb)

In this experiment, 3 types of traffic, Interactive, Bulk and Best-effort are set. Interactive has the highest priority, next is Bulk and Best-effort has the lowest. The traffic credits are 36, 60, 42 Mbit/sec, respectively in the uplink case. When maintaining bandwidth, according to the priority of the stream, a limit on the bandwidth was set at each node. The limiting rates are 13, 31, 15 Mbit/sec in tbf. In the downlink case, the

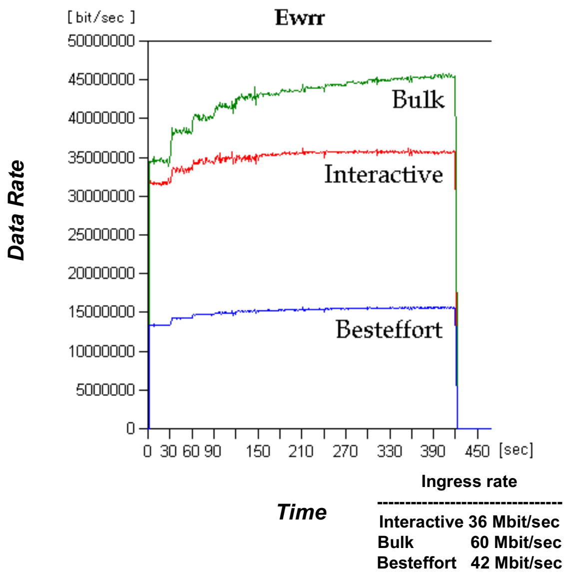

Fig.8 Data rate of traffic control (Uplink) (EWRR)

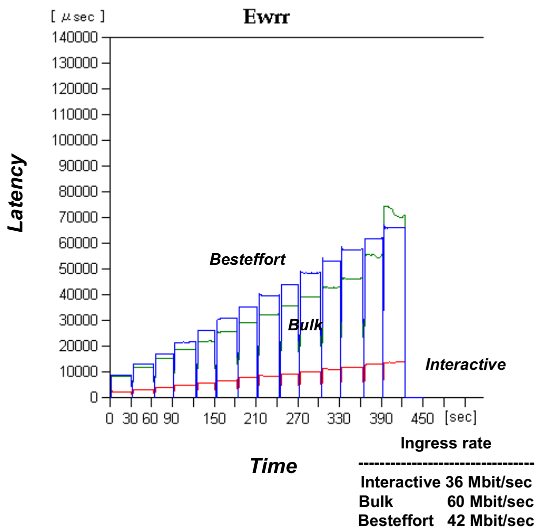

Fig.9 Latency of traffic control (Uplink) (EWRR)

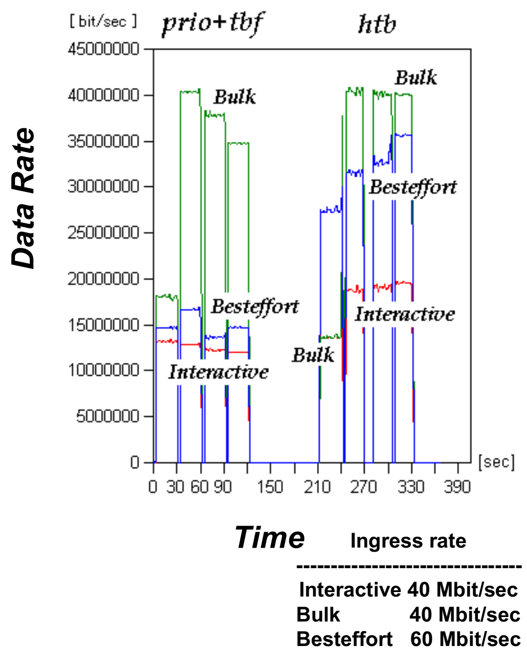

Fig.10 Data rate of traffic control (Downlink) (prio+tbf and htb)

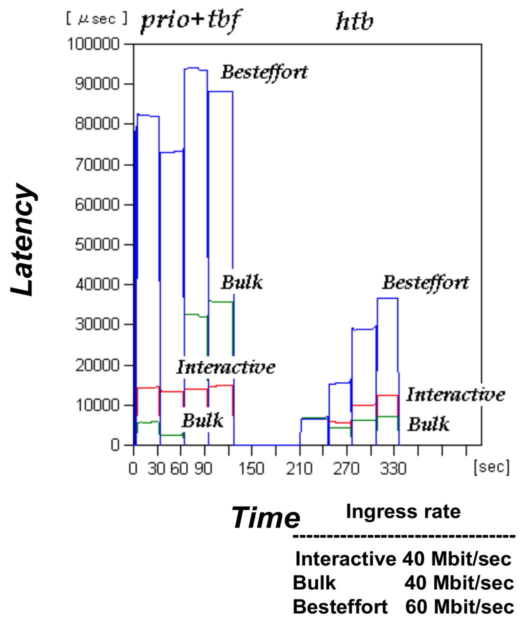

Fig.11 Latency of traffic control (Downlink) (prio+tbf and htb)

traffic credits are 40, 40, 80 Mbit/sec and the TC shaping rates are 12, 30 and 14 Mbit/sec.

6. EXPERIMENT RESULTS

The transition of throughput is shown in Fig.6 and the latency of the traffic is shown in Fig.7. For uplink cases when testing without Traffic Control (TC), prio+tc and tbf are used. For traffic control using prio+tbf, the data rate and latency shift differently. Interactive is able to obtain a steady throughput and at the same time, it is able to avoid latency. Best-effort is able to save the bandwidth but on the other hand, latency may occur. For traffic control using htb, priority is working, and the high priority packets have low latency. From the experiments, by combining Linux traffic control with the

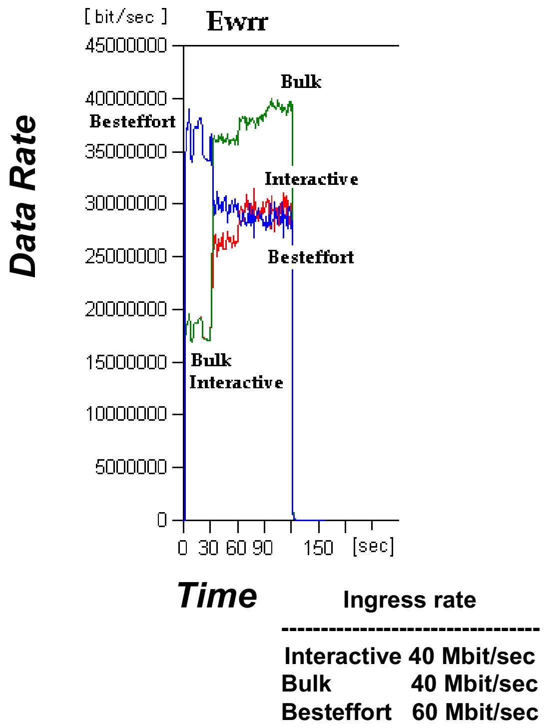

Fig.12 Data rate of traffic control (Downlink) (EWRR)

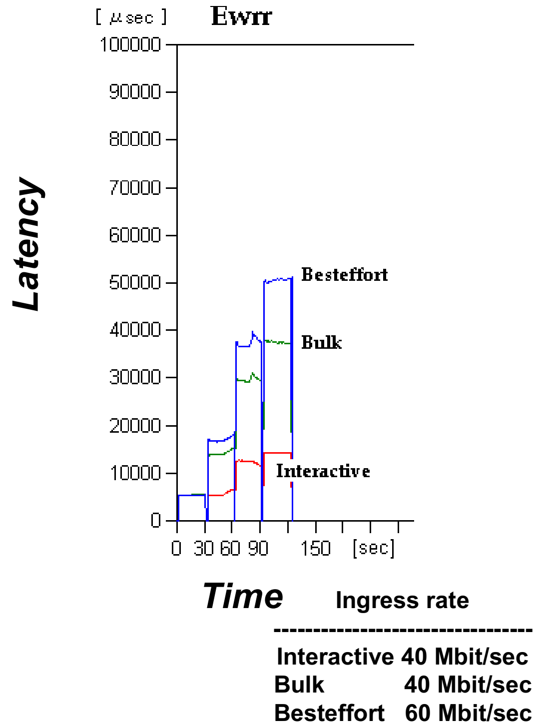

Fig.13 Latency of traffic control (Downlink) (EWRR)

previous proposal, QoS support was provided to the Ethernet link and mobility agent.

Fig. 8 and Fig. 9 show throughput and latency respectively, when the EWRR control method is applied to uplink cases.

Evaluation results for downlink cases are shown in Fig.10 – Fig.13.

Comparing the data rate of EWRR (Fig.8) with TC using tbf and htb (Fig.6), Interactive shows constant transfer from the beginning. Because the bandwidth is sufficiently large, packets flow constantly in a 60 sec cycle. But on the other hand latency occurs more in bulk (Fig.9) compared to TC using htb (Fig.7).

In the experiment on the downlink case, comparing the data rate of TC using htb with tbf, best-effort has a higher rate (Fig.10). Comparing the latency in Fig.11, TC using htb has low latency in interactive, bulk and best-effort respectively. Fig.12 shows the data rate of EWRR. The first 30 seconds flow for interactive does not occur.

The TC shaping rates of interactive, bulk, best-effort are 12, 30 and 14 Mbit/sec. Beside this data rate, interactive transfers double the data rate of the shaping rate. Interactive shows a high data rate compared to TC using tbf and htb, which is considered important. Fig.13 shows the latency of the EWRR. Compared to Fig.11, this is not as low as TC using htb, but low compared to TC using tbf. These results show that the end-to-end priority control is working.

7. CONCLUSION

In this paper, we proposed a method to provide QoS support in mobile environments using VLAN. The performance of the proposed method was evaluated through experiments using mobileIP networks. The results obtained by experiment showed the effectiveness of the adaptive control method. By adopting the priority control using VLAN defined in IEEE802.1p, end-to-end priority control was realized.

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