An Efficient QoS Control Mechanism for IMS based Convergence Network

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Abstract. In this paper, we propose a novel QoS control mechanism called IPFIX (class fixing in IP option header) which is intended to identify IMS user residing in conventional Internet for resources reservation in DiffServ core network. The work was motivated by the need of interoperability between QoS-enabled UMTS network and conventional Internet unable to support QoS for NGN (Next Generation Network). IPFIX does not force user in Internet to be equipped with any resource reservation protocol such as PDP or RSVP. Instead it utilizes the option field of IP header that contains the minimum information of QoS. Our numerical analysis and implementation results show that IPFIX outperforms PDP and RSVP in terms of control overhead.

1 Introduction

In this paper, we discuss how to support QoS in IMS based convergence network. There are still limitations to support multimedia services, which is one of the major demands of the current Internet user. These include difficulties to control (or reserve) resources from a source to a destination, to design acceptable QoS provisioning, to identify reserved session (or class) and others. The IP Multimedia Subsystem (IMS [1]) specified by 3GPP is regarded as a promising solution to the problem. IMS is a key technology to combine cellular networks and Internet. IMS was originally intended to support realtime multimedia services in UMTS wireless network [2] [3]. However, the current version of the standard (i.e. Release 7) extends the capability to support multimedia service for both wired network and wireless network. In particular, the next generation network (NGN) has adopted IMS as the core function for session control. Two key elements of IMS that especially we consider in this paper are SIP (Session Initiation Protocol) [4] and PDP(Packet Data Protocol) [5].

In IMS, SIP establishes a session and PDP is used for resource reservation to support QoS. Hence, a user of multimedia service necessarily resides in UMTS network and the two protocols are required. However, to meet with future demands of NGN, it is highly recommended that IMS is capable of interoperability

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between heterogeneous access networks. That is, functionalities to support QoS should consider not only UMTS wireless network but also various wired and wireless networks. We suppose a simple scenario, where a UE in UMTS tends to establish a session required QoS support to a corresponding entity locating in conventional Internet. In this case, the UE in UMTS is able to reserve network resources between SGSN (Serving GPRS Support Node) and GGSN (Gateway GPRS Support Node) that is enough to guarantee his QoS requirements. Yet the corresponding entity has no way to reserve any resource. As a result, the multimedia session can satisfy with its QoS requirements partially (i.e. within the UMTS network). We note here that the current Internet is mostly regarded as a best effort network even though there already exist several QoS model such as Intserv and DiffServ.

In this paper, we propose a QoS control scheme called IPFIX (class fixing in IP option header) which supports functionalities to identify QoS user and to reserve network resources. Especially, IPFIX aims to satisfy with the need of interoperability between QoS-enabled UMTS network and a conventional Internet for NGN. The scheme is much efficient than commonly used schemes such as RSVP or PDP which is necessary to support QoS in UMTS. This is mainly due to the fact that IPFIX just utilizes the option field of IP header in the absence of resource reservation protocol. Consequently, IPFIX can reduce the number of processing steps in establishing a session resulting in short call setup time (see section 4).

The organization of this paper is as follows. Section 2 presents a network model and various scenarios that we consider in this paper, thereafter we propose straightforward solutions to each of the cases. Section 3 propose the IPFIX scheme. In section 4, we describe numerical analysis of the IPFIX in comparison with PDP. Finally, we conclude the paper in Section 5.

2 Problem Statements

Fig. 1. illustrates a network model where we consider three different scenarios based on the capability to support QoS of the networks to which communication entities (i.e. A, B, C and D) belong. We present a straightforward mechanism for each of the scenarios.

Scenario 1: UMTS user A to UMTS user B

This scenario shows the case of utilizing functionalities of IMS to guarantee QoS for a session established between A and B. Both A and B are able to use PDP specified by 3GPP because both UEs reside at UMTS network, where we only assume that the two communication peer are compatible to the functionalities specified by 3GPP. As a result, resources are properly reserved in an end to end manner, thereby a multimedia session can be served well.

Scenario 2: UMTS user A to IntServ user C

UE A is able to reserve network resources as discussed in the scenario 1. Also, user C in IntServ enabled network can reserve resources by using RSVP [6]. Like

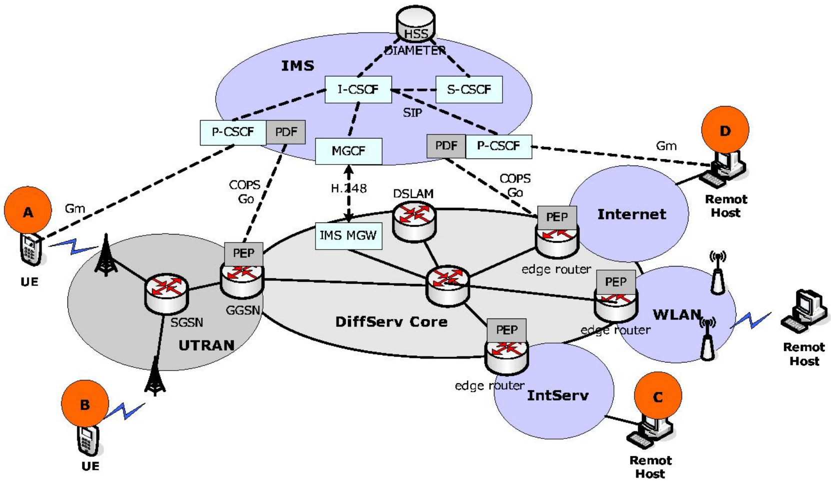

Fig. 1. Network model

the scenario 1, a QoS session can be established under the requirement that there should be an edge router for interconnecting between IntServ network and DiffServ core network [7].

Scenario 3: UMTS user A to conventional Internet user D
In case of the UMTS user A, the way to reserve resources is same to the scenario 1 and 2. The problem is on the user D since he resides at the conventional Internet, where any resource reservation mechanism such as PDP or RSVP is not available. Thus a session required for a specified QoS requirement can not be established.

In the following, we consider such an asymmetric QoS architecture (i.e. the third scenario). It is highly difficult challenge in Internet to support QoS as does UMTS even though user device is equipped with either RSVP or PDP. Therefore, we much focus on IMS user identification for resource reservation in DiffServ core network rather than finding network-wide solution. That is due to the fact that packets are marked and handled as a BE (Best Effort) class if there is no mechanism for pre-performed user authorization or no way to identify the packet once the packet arrives at the DiffServ core network that is handled by IMS. QoS requirements of packets can not be guaranteed even in UMTS network. Now, we presents the conceptual solution to the problem.

- **Method 1. Resource reservation using PDP**
  PDP is a straightforward solution for supporting user identification and interworking with DiffServ Core network. To do this, it is required to implement PDP on the device of user D residing in conventional Internet.
- **Method 2. Resource reservation using RSVP**
  This method is similar to the method 1. The major limitation of the method

is the requirement of implementation RSVP on the device of user D. In addition to RSVP, D is also required to be equipped with SIP for session control.

– **Method 3. QoS support by using extension of SIP**
  We may use the extension of SIP described in [8] for support end-to-end QoS. The advantageous of this method over both previous methods is that an additional reservation protocol such as PDP or RSVP is not necessary. Instead, L-PDF, which is used for resource control in access network, and L-Proxy, which is used for identification of QoS requester and resource reservation, are required. This method also requires implementation of the SIP extension on the user D.

As we described above, all methods are required for complex implementation to reserve network resources. In particular, both PDP and RSVP are not originally designed for a user in conventional Internet but specified for UMTS and IntServ network respectively. It seems to be better solution than both method 1 and 2 to use the third method (i.e. using extension of SIP). However, there still exist a limitation of installing additional network components such as L-PDF and L-Proxy.

3 Proposed scheme

In this section, we propose IPFIX as an efficient resource reservation mechanism which allows a conventional Internet user to establish a QoS enabled session over DiffServ core network. Moreover, as mentioned in the previous section, IPFIX does not demand complex implementation for resource reservation of the Internet user. It uses the option field of IP header to exchange QoS information necessary for resource reservation.

3.1 IPFIX

Fig. 2 shows the field format of the IP option header to identify IMS user using IPFIX. The option header for IPFIX consists of fourfields: Type, CAC, DiffServ Class and Authorization Token fields.

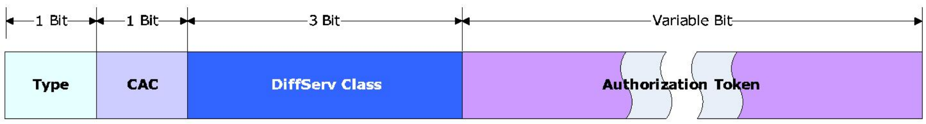

Fig. 2. IP option header format for IPFIX

The syntax and semantic of each of the fields are as follows.

Type (1 bit): This field allows UE to distinguish whether the message received is QoS request or response. If this field set to one, it is used for a request of resource reservation. Otherwise the message is used as a response to the QoS request.

CAC (1 bit): This field indicates whether or not QoS request is accepted. If the field set to one, the QoS requirements of UE are accepted.

DiffServ Class (3 bits): UE records differentiated class information in this field according to the investigating results of parameters contained in SDP extensions. Four different classes are specified by 3GPP as follows.

- Conversation class : This is a sort of EF(Expedited Forwarding) class for delay sensitive applications such as VoIP, where QoS requirements are 100msec in end to end delay and 50msec in jitter.
- Highly interactive class : This is a AF (Assured Forwarding) class for audio streaming applications of which requirements are equal to those of conversation class.
- Low interactive class(video) : This is a AF class for video streaming applications of which requirements are 400msec in end to end delay and 50msec in jitter.
- Data class : This is a best effort class.

Authorization Token (variable bits in size): This field contains the media authorization token. Contents of the field are directly mapped to the P-Media-Authorization header information in SIP. Hence, only a request message for resource reservation uses this field (i.e. not for response message).

3.2 IPFIX Operation

Fig. 3 shows a session setup procedure in case of using IPFIX. UE1 sends INVITE request message containing initial SDP to the P-CSCF. Upon receiving the INVITE request, UE2 sends the 183 (Session Progress) response back to UE1 via the P-CSCF with the accepted SDP. The UE1 received the 183 Session Progress sends PRACK request. At the same time, the UE1 sends an Activate PDP Context message to the GGSN via SGSN. The UE1 associates the PDP context to the session by including the media authorization token information and the flow identifier(s) information. Upon receiving the PRACK [9] request, the UE2 selects class identifier according to parameters in SDP extensions, and UE2 sends the 200 OK response back to UE1 with recoding the media authorization token and selected class information in the option field of IP header. This procedure is such as PDP context. Upon receiving the 200 OK response message containing the option field of IP header, the edge router generates COPS request message according to information including media authorization token, type of QoS class and source IP address, then sends it to PDF. Thereafter the edge router operates Policy Enforcement procedures. If the Diffserv edge route receives IP packet (UPDATE [10]) destined for UE2, the edge route forwards the packet to UE2 after setting CAC field of option field of the packet to one. UE2 decodes the option field of IP header to investigate whether or not his request was accepted. Then, UE2 sends 200 OK back to UE1 as a response to the UPDATE message. The last steps are followed by the IMS standard. Resource release procedures are triggered by BYE message generated by UE2. Call setup is finally released by receiving 200OK as a response to the BYE message. To release resources in Diffserv Core network, P-CSCF sends COPS DEC message to DiffServ Edge router. IPFIX is intended to support QoS for a user residing

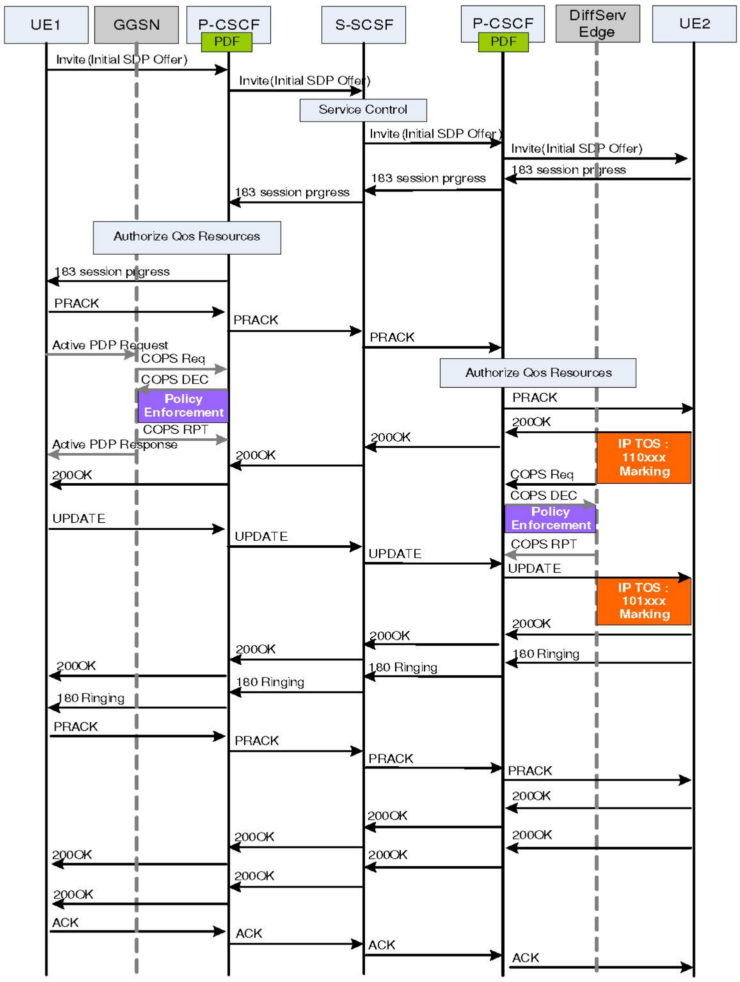

Fig. 3. Procedure of end-to-end call setup

in conventional Internet. It can be done by sending the media authorization information to DiffServ edge router during session setup phase. As we described above, IPFIX does not force a user in Internet to be equipped with any resource reservation protocol such as PDP or RSVP, instead it use the option field of IP header. Consequently, IPFIX much efficient than PDP or RSVP in terms of control overhead and time it takes to perform call setup.

4 Numerical Analysis

In this section, we analyze the signaling cost for resource reservation of IPFIX in comparison with the case of using PDP and RSVP. In particular, we focus on differences in signaling procedures among the three schemes, that is the time period from sending PRACK to receiving 200OK. Table 1 denotes notations used for the comparison.

Table 1. Define signaling message for resource reservation

Detail		PDP(3GPP)	RSVP(IntServ)	IPFIX
SIP	PRACK	S_P	S_P	$S_P\|\|auth\|\|FIX_{oriHdr}$
	200OK	S_O	S_O	$S_P\|\|FIX_{oriHdr}$
QoS	Request	R_{pdpQ}	R_{rsvpQ}	*None*
	Response	R_{pdpR}	R_{rsvpR}	*None*
	Ori-header	PDP_{oriHdr}	$RSVP_{oriHdr}$	FIX_{oriHdr}
COPS	Request	C_Q	C_Q	C_Q
	Decision	C_D	C_D	C_D
	Report	C_R	C_R	C_R
Authorization Token		auth	auth	auth

The signaling cost of each of three schemes are as follows.

- *Resource reservation by using PDP*

$$PDP_{overhead} = S_P + R_{pdpQ} + R_{pdpR} + C_Q + C_D + C_R + S_O. \tag{1}$$

- *Resource reservation by using RSVP*

$$RSVP_{overhead} = S_P + R_{rsvpQ} + R_{rsvpR} + C_Q + C_D + C_R + S_O. \tag{2}$$

- *Resource reservation by using IPFIX*

$$IPFIX_{overhead} = S_P||auth||Fix_{oriHdr} + C_Q + C_D + C_R + S_O||Fix_{oriHdr}. \tag{3}$$

The cost difference between PDP and IPFIX can be computed by

$$\frac{IPFIX_{overhead}}{PDP_{overhead}} = \frac{auth||FIX_{oriHdr} + FIX_{oriHdr}}{R_{pdpQ} + R_{pdpR}}, \tag{4}$$

where R_{pdpQ} is referred to as the authorization token information, that is

$$R_{pdpQ} = auth + PDP_{oriHdr}. \tag{5}$$

Thus, we can derive the result from the equation 4 and 5, such that

$$\frac{IPFIX_{overhead}}{PDP_{overhead}} = \frac{2(FIX_{origHdr})}{PDP_{origHdr} + R_{pdpR}}, \tag{6}$$

where the response message for resource reservation contains IPFIX header information except Authorization Token.

In case of applying 5 bits Fix_{oriHdr} and 275 bytes PDP_{oriHdr} in size, which is presented in [5], and 20 bytes R_{pdpR}, which is the minimum size of the field, to the equation 6, we can derive the cost gain of IPFIX over PDP, such that

$$\frac{IPFIX_{overhead}}{PDP_{overhead}} = \frac{10bit}{(275 + 20) \times 8bit} = \frac{10}{2360}. \tag{7}$$

Similarly, we can derive the cost gain of IPFIX over RSVP, such that

$$\frac{IPFIX_{overhead}}{RSVP_{overhead}} = \frac{10bit}{(120 + 124) \times 8bit} = \frac{10}{1952}, \tag{8}$$

where we use the minimum size of PATH and RESV message (i.e. 120byte PATH and 124 bytes RESV presented in [11]). According to above two equations, IPFIX is the most efficient way to support QoS for a conventional Internet user.

Because, IPFIX is able to resource reservation without PDP or RSVP. Then, PDP or RSVP for resource reservation procedure include in SIP packet. Thereforce, If resource reservation of procedure is used to IPFIX, the most efficient way to decrease signaling delay such as PDP or RSVP.

5 Implementation and Demonstration Result

5.1 Implementation of IPFIX

We have developed IPFIX on Linux computers. Further, to demonstrate IPFIX, we have implemented P-CSCF, S-CSCF, Diffserv edge router (support IPFIX and PDP context), UE (support IPFIX), PDF, and PEP(for policy enforcement). P-CSCF and S-CSCF have been implemented by modifying the source code of SIP Express router, which was developed by IPTEL [12].

- P-CSCF has been developed on laptop computers using Linux kernel version 2.6.3 provided by the Red Hat Linux Fedora Core 1. P-CSCF provides SIGCOMP (signaling compression), policy based PDF (Policy Decision Function), and functionalities to support P-Media-Authorization header and P-Extension header.

– S-CSCF has also been developed on laptop computers. S-CSCF performs as a service broker and includes functions for IMS procedure, HSS database and AKA-MD5v1.

– DiffServ edge router has been implemented by modifying the kernel version 2.4.20-8, the kernel version provided by the Red Hat Linux version 9.0. DiffServ edge router supports traffic control, DSCP field marking, WF2Q scheduling, multi field classifying, policy based PEP(Policy Enforcement Point) function.

– DiffServ core router performs as a traffic controller, PHB(Per hop Behavior) handler, WF2Q scheduler and single field classifier in DiffServ core network.

– We use softphone application implemented on WindowsXP computer as a IPFIX UE. UE is able to support P-Extension header, PRACK method and UPDATE method. Also, it supports IPFIX and PDP context for resource reservation. Fig. 4 shows a framework of our softwares.

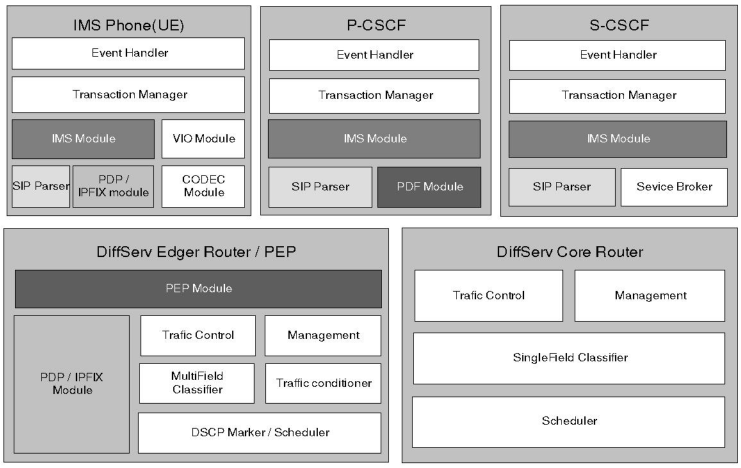

Fig. 4. Framework of software

5.2 Demonstration and experimental results

Fig. 5 shows a simplified architecture of our testbed to demonstrate IPFIX and Fig. 6 shows a demonstration result.

In the demonstration, we use the following scenario.

– First, UE in conventional internet tends to use multimedia streaming service.

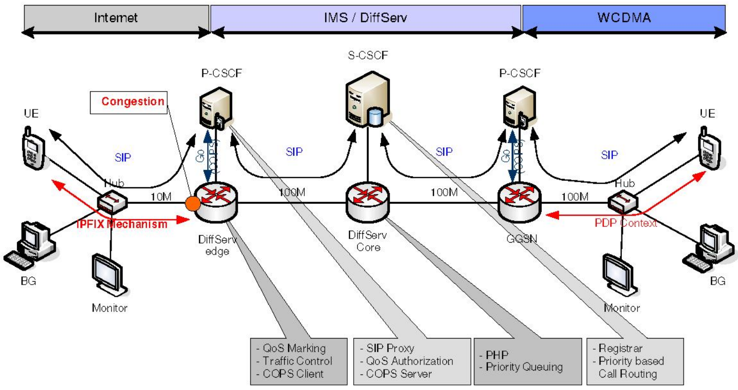

Fig. 5. Testbed architecture

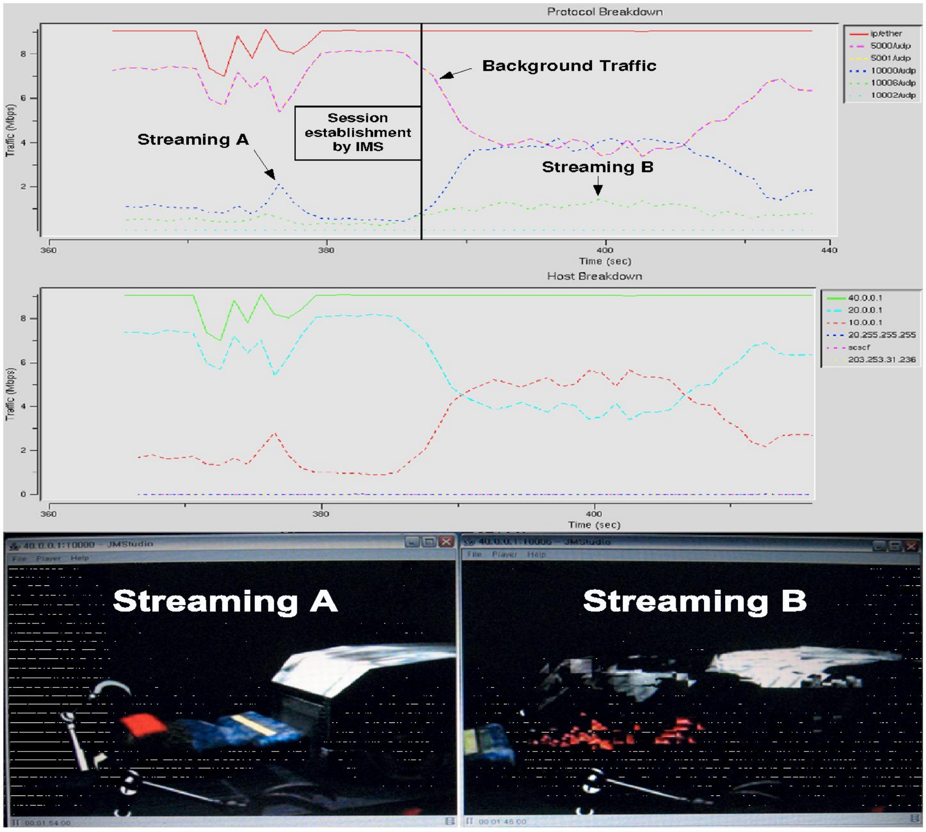

Fig. 6. Demonstration result by using IPFIX

- Congestion is occurred at Diffserv edge router(we have used background traffic for generating the congestion).
- Diffserv edge router of processing priority is as follows. 1. SIP packet, 2. EF class packet, 3. AF class packet, 4. BE class packet(As a result, Generating the congestion at Diffserv edge router is able to success resource reservation by high priority of SIP packet).
- UE in Internet starts the procedure of SIP session setup by using IMS.
- During the procedure of SIP session setup, UE utilizes IPFIX for resource reservation.
- After the session setup procedures followed by the IMS standard, Diffserv edge router is able to provide differentiated QoS class with UE (see the results denoted by 'Streaming A' and 'Streaming B' in Fig. 6).

6 Conclusion

In this paper, we have proposed IPFIX which provides an efficient way to reserve network resources. The main advantage of the scheme is that it does not require user in Internet to be equipped with any resource reservation protocol such as PDP or RSVP. Consequently, we can avoid complex implementation to support QoS and reduce control overhead and time it takes to perform call setup. In IPFIX, such procedures can be performed by recording the minimum information of QoS in the option field of IP header. Our implementation result shows that IPFIX can support differentiated services well in converged network scenario.

Acknowledgement

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