A DiffServ Management Scheme Considering the Buffer Traffic Rate in Ubiquitous Convergence Network*

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Abstract. Ubiquitous convergence network consists of access networks to provide heterogeneous network services for mobile users. In this paper, we propose a hierarchical policy-based architecture model and the policy procedures based on access networks connected with Ubiquitous convergence networks. We also present a dynamic traffic management scheme which uses DiffServ mechanism and SLA for the management of end-to-end QoS in access networks. At the end of this paper, we will analyze the performance of the proposed schemes through computer simulation.

1 Introduction

Ubiquitous convergence network means a linked network system that is able to use not only each mobile access network's services but also other heterogeneous network services by structuring a unified convergence network [1], [2]. Through these convergence networks, mobile users can use a variety of heterogeneous network services as well as existing network services.

The research for ubiquitous convergence network is currently being progressed actively, but it is still at the beginning stage in which network connection models in some parts are just suggested. The noticeable point of the QoS guarantee for the transmission services is that IP transmission techniques are used for network services [13]. To provide stable and reliable support for ubiquitous networks, therefore, end-to-end QoS mechanisms should be supported [3]. By applying policy-based structure, the research for the convergence network construction of heterogeneous network is made progress and three kinds of convergence network models are suggested. However, the suggested models don't place priority to the QoS management structure through policy agreement procedures among heterogeneous access networks. They also don't consider any scheme for traffic control in network [8].

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Two approaches, IntServ and DiffServ, have been proposed at IETF (Internet Engineering Task Force) to provide end-to-end QoS support for existing IP traffic services [5]. On the other hand, as a service support method for end-to-end QoS guarantee, IETF suggested SLA (Service Level Agreement) method, which receives IP services through the agreement between service providers and service users. If SLA is entered into an agreement between service providers and service users, then SLS (Service Level Specification) is decided to provide SLA based services [9]. SLA is a descriptive parameter related to end-to-end QoS support for network services, therefore, a user can get a corresponding service based on the parameter. CADENUS and TEQUILA projects in Europe have actually applied the method that a user can use a service through SLA in a large IP network [4], [6]. Consequently, SLA method should be considered for IP-based service support in ubiquitous network, which is a heterogeneous network set.

In this paper, we propose a policy-based DiffServ QoS management structure referring PBMN (Policy-based Management Network), which is hierarchically structured to construct heterogeneous access network convergence networks, and SLA, which is to control end-to-end QoS. Hierarchical PBMN means that PDP (Policy Decision Point) in core network controls lower PDPs by performing a role of controller through the communication with PDP in each access networks to connect with other heterogeneous access networks [10]. For this, we suggest total ubiquitous network construction and control procedures. Policy-based DiffServ QoS management structure referring SLA is an approach that manages traffic classes by the policy definition information received from PDP of each access network. It also distinguishes dynamically traffic classes by using the policy decision information of PDP, and refers a method that controls traffic classes by setting two critical values of output buffers. If the critical value of each stage is exceeded, the entrance into the output buffer for particular traffic class is limited, so the overload is reduced. Therefore, the services of higher traffic classes are guaranteed.

This paper consists of 5 sections. Section 2 describes the proposed policy-based DiffServ QoS management structure considering SLA and the communication model. Section 3 shows the policy-based DiffServ QoS control mechanism. Section 4 explains the simulation environment and the performance evaluation of the proposed method, and Section 5 describes our conclusion.

2 Policy-Based DiffServ QoS Management Structure Considering SLA

For end-to-end QoS support to heterogeneous access network and for effective traffic control between heterogeneous networks, we suggest DiffServ QoS management scheme considering hierarchical policy-based QoS management scheme, resource status of each access network, and SLA of subscribers [5]. Fig. 1 shows the layout and components of proposed policy-based DiffServ QoS management structure considering SLA.

As you can see in Fig. 1, core network is the center of the structure, and access networks are linked together through GER (Global Edge Router). LER (Local Edge Router) links a domain of access network to another. Core network and each access network consist of PDP (Policy Decision Point), PEP (Policy Enforcement Point), and PR (Policy Repository) to provide policy-based QoS management [10], [7]. PDP decides the operation policy of each network by approaching PR of each network, and transfers it to PEP so that traffics can be controlled by the decided policy. PDP collects network resource status and information, which is necessary for policy decision, analyzes the collected information and policy information of PR, decides the execution, and performs the policy control. Information transmission for the policy control between PDP and PEP uses COPS (Common Open Policy Service) proposed at IETF [11]. COPS, a TCP/IP-based request/reply protocol, is designed to support a variety of clients without protocol change, and provides message-dimensioned secure for authentication and message integrity.

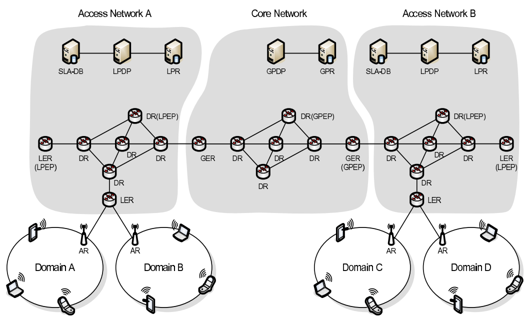


Fig. 1. Policy-based DiffServ QoS management structure considering SLA

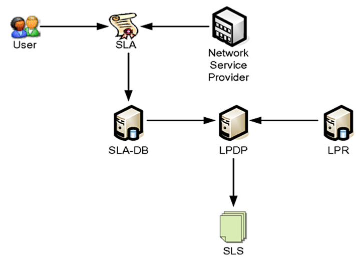


Fig. 2. The relation between SLA and SLS in the proposed structure

SLA-DB is a database system that stores SLA between access network providers and subscribers and performs information storage functions such as detail information for service usage between network providers and subscribers, authentication of subscribers, or service charges. If a access network user asks connection service or particular service, PDP deduces user-level SLS considering network resource status and the subscriber's SLA by approaching SLA-DB and PR, and transmits it to the subscriber to create traffic based on SLS limited by PDP. Fig. 2 describes the relation between SLS, which is assigned between access network providers and users, and SLS [9].

SLS is a detail parameter used for end-to-end support of subscribers, and its priority can be different with the parameters used in each heterogeneous access network. Therefore, to communicate between heterogeneous access networks, a function which can changes SLS parameter to be suitable for each access network is necessary. This function is performed by SLST (SLS Translator) included in GPDP of core network. GER of core network is a gateway for traffic entering to core network, and performs its functions as an interface between core network and each access network. GER is an edge router of DiffServ, and includes packet tunneling and header change function for communication between heterogeneous networks. Edge routers of core network and each access network classifies traffics into traffic class based on policy decision information which is received from their PDPs, and then the routers perform DSCP field marking of IP header. On the other hand, DR (DiffServ Router) is designed to refer policy decision information and DSCP field and to perform PHB (Per Hop Behavior) for the traffic control by DiffServ mechanism.

In this paper, we propose the method that decides SLS based on SLA of LPDP and transmits service traffics for access network users. For this, mobile terminals should perform subscriber authentication by communication with LPDP if connection is requested, and receive SLS that is available based on SLA. If LPDP receives connection request from a mobile terminal, LPDP requests SLA information of the subscriber. LPDP also deduce SLS for the mobile user by using the resource status of Resource Manager and the policy information which is currently being applied. SLS is transferred to the mobile terminal. If SLS of a mobile user should be changed depending on the resource status or policy change, new SLS is created by the SLS deduction procedure and is sent to the mobile terminal. (a) of Fig. 3 represents message transmission procedure depending on the connection request of a mobile terminal, and (b) shows the message transmission procedure depending on the resource or policy change.

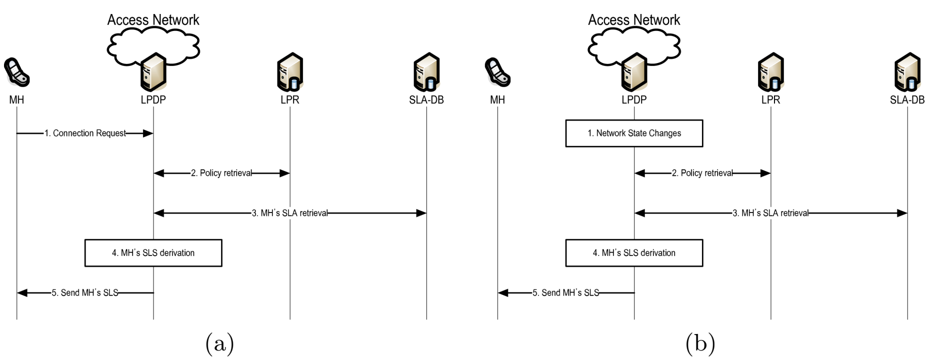


Fig. 3. SLS control procedure of mobile terminals

In the structure proposed by this paper, PEPs of Core network and access networks don't store the status information of mobile terminals. It's an advantage because PEP's overhead for traffic control of mobile terminals can be reduced and mobile user traffic can be controlled by its policy. The core network and each access networks include PDP, PEP, and PR. That is, each network has policy and all rules for policy decision making which are necessary for operation and management of network services, and it means that independent operation at each network can be guaranteed without consideration of other network's situation. Additionally, end-to-end QoS is guaranteed and the procedures necessary for policy information exchange or negotiation are able to be simplified when core network's GPDP performs its role as a medium in a heterogeneous access network communication, so traffic is created by considering the characteristics and status of corresponding access network. Therefore, our proposed structure in this paper can guarantee the extendibility and the independence of each access network in heterogeneous convergence networks.

3 Policy-Based DiffServ QoS Control Scheme

In this section, we describe the function of ER and DR, which are applied policy-based DiffServ QoS control scheme proposed in this paper to manage dynamic QoS, and the structure for traffic control. We suggest a dynamic traffic control scheme through the traffic reset method or scheduling weight adjustment by network resource management policy.

If a traffic transmitted from a mobile terminal has arrived to ER, then ER classifies the traffic depending on the policy decision information received from PDP, and transmits the information to DR. DR constructs output buffer using received traffic by CBWFQ (Class Based Weighted Fair Queue) and PQ (Priority Queue) depending on the network resource management scheme, and performs PHB [12].

Fig. 4 shows the detail structure of ER in policy-based DiffServ QoS management structure proposed in this paper. ER consists of four components; Classifier, Meter, Marker, and Policy Controller.

Policy controller stores policy decision information received from PDP, and creates Filtering Rule, Traffic Profile, and Marking Rule for function accomplishment of Classifier, Meter, and Marker, and also creates threshold value for output buffer management. Table 1 describes parameters created by Policy Controller in ER for each component in detail.

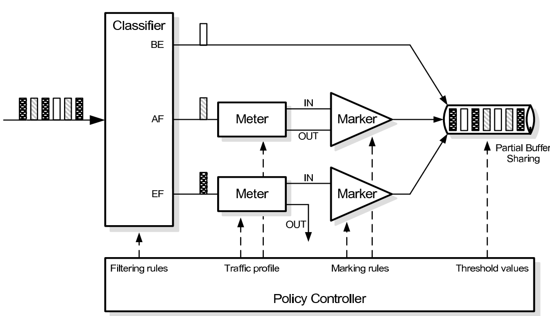


Fig. 4. The structure of policy-based ER

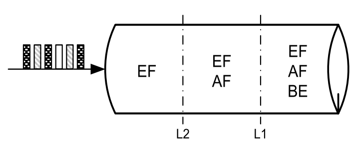


Fig. 5. Partial buffer sharing

Table 1. Detail functions of Policy Controller in ER

Parameter	Detail content
Filtering Rule	Criteria that classifies traffics arrived to ER into traffic classes
Traffic Profile	Characteristics of traffic allowed in each traffic class
Marking Rule	Marking criteria using the metering result
Threshold Value	L1, L2 Weights for construction of output buffer

3.1 The Function and Structure of ER

Classifier applies Filtering Rule of Policy Controller to classify traffics into three traffic classes, EF, AF, and BE, and delivers the information to Meter. Traffics classified into each traffic class are measured by traffic profile measurement. After that, Marker performs DSCP marking by applying Marking Rule depending on the metering result.

If traffics classified into EF class by Classifier satisfy the traffic profile, then Marker performs marking. Otherwise Marker abandons corresponding traffic. If traffics classified into AF class can't satisfy the traffic profile, Marker doesn't perform marking, and change the traffic to BE traffic class. If the traffic profile is satisfied, Marker divides the metering result into AF1, AF2, AF3, and AF4 by Marking Rule. In case of BE class, the control of metering or marking is not performed.

Output buffer uses PSE (Partial Buffer Sharing) method to provide services dynamically by referring traffic priority and overload classified by DiffServ mechanism. Output buffer applies L1, L2 weights provided by Policy Controller. If it is over the weights, particular traffic class is only queued in output buffer, and other traffic classes are abandoned. As you can see in Fig. 5, all traffic classes are allowed to be queued in buffer before the L1 weight, but EF and AF classes are only queued and other traffic classes are all abandoned if it is over of L1 weight. If it is over beyond the L2 weight, only EF class is queued, and other traffic classes are all abandoned.

As we apply PSB method, the overload of ER and DR by the continuous increase of traffics transmitted from mobile terminals can be reduced, and the service rate of higher-level traffic class can be guaranteed by providing traffic services depending on the priority of traffic classes. If lower-level traffic class is continuously abandoned because of the continuous overcrowding from mobile terminals, ER requests policy control to PDP to manage QoS dynamically. Then PDP classifies lower-level traffic class as higher-level by changing Filtering Rule and Traffic Profile.

3.2 The Function and Structure of DiffServ Router

Fig. 6 describes the structure of DiffServ Router. DiffServ Router consists of four components; Classifier, CBWFQ, PQ, and Policy Controller. Policy Controller accomplishes the function that saves policy decision information received from

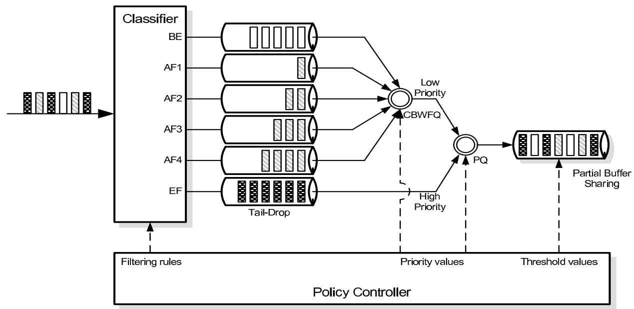


Fig. 6. The structure of polish-based DR

PDP, and creates Filtering Rule for function accomplish of Classifier, CBWFQ, and PQ components, Priority Values, and Threshold Values for output buffer management. The parameters created for each component by Policy Controller are shown in Table 2.

Table 2. Detail functions performed by Policy Controller of DR

Parameter	Detail function
Filtering Rule	Criteria queuing up traffics arrived at DR in traffic class buffer
Priority Value	Priority information applied at CBWFQ and PQ
Threshold Value	L1, L2 weights for output buffer construction

Classifier refers DSCP field of traffics and then delivers it to each class buffer. At that time, Filtering Rule of Policy Controller makes it possible to deliver the information to higher- or lower-level traffic class buffer without DSCP field change for particular traffic class. It's for dynamic traffic control in case that some traffics passing through particular area have a bottle-neck syndrome, or service rate of higher-level class should be increased.

Traffics delivered to each traffic class buffer are queued up in output buffer by CBWFQ and PQ based on the priority information provided from Policy Controller. By applying CBWFQ and PQ in the proposed structure in this paper, traffic services can be increased by the traffic class priority of mobile terminal traffics and QoS of mobile users can be guaranteed.

EF class is designed to be scheduled by PQ without passing CBWFQ, AF and BE classes are designed to be scheduled by CBWFQ and PQ considering priority information. EF class has the lowest disposal rate, and AF has the priority levels and much lower disposal rates in this order: AF1, AF2, AF3, and AF4. BF has the lowest priority level and the highest disposal rate. If the threshold value applied PSB method used at ER is over the L1 or L2 weight, the lower-level traffic classes are abandoned. In case of continuous disposal of particular traffic class, dynamic QoS can be managed by requesting policy control to PDP.

4 Simulation and Performance Analysis

ER distinguishes traffic classes provided to mobile users into three classes; EF, AF, and BE. AF is divided into AF1, AF2, and AF3, so ER transmits these six traffic classes to DR. We produced 100 traffics per every second to evaluate the performance of proposed ER. The traffics consist of EF class 20%, AF class 60%, and BE class 20%. The packet sizes of each traffic class are supposed as EF 350KB, AF 200KB, and BE 100KB. ER can process traffics in speed of 20MB/sec, and we measured the disposal rates (%) of each traffic class for 10 minutes by 5% overcrowding the transmitted traffics per every second.

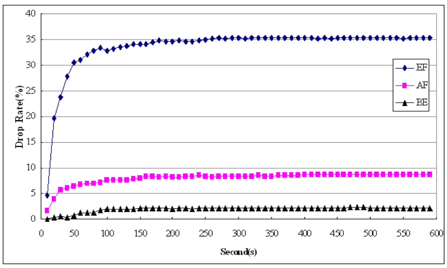


Fig. 7. Disposal rates depending on the traffic classes

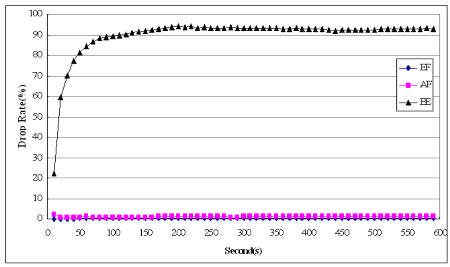
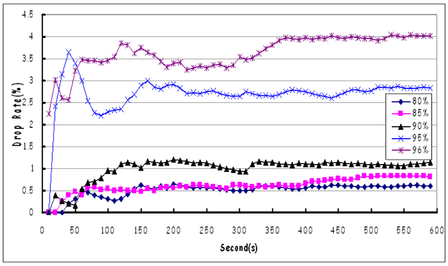


Fig. 8. Disposal rates per traffic classes in the case that L1 weight is set as 80%

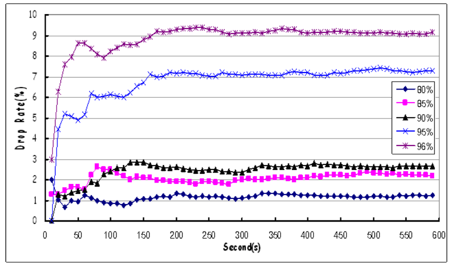
Fig. 7 describes the disposal rates of each traffic class in case of traffic overcrowding if the proposed structure is not applied. We can see that about 3% traffics of BC class is abandoned, but about 35% traffics of EF class and 9% traffics of AF class are abandoned. We analyzed and concluded that EF and AF class traffics, which have much bigger packet size than BE class's, couldn't enter to buffer because of traffic overcrowding, and increased the service lowering by being abandoned.

Fig. 8 shows the result of simulation in which the proposed structure is applied but the situation is same with Fig. 7. When we set L1 weight as 80%, the figure shows disposal rates of each traffic class. As you can see in the figure, the result shows that the disposal rate of BE class which doesn't guarantee its service rate is increased from 3% to 90%. We also can see that the disposal rates of EF and AF classes which guarantee their service rates are seriously increased from 3.5% and 9% to 0.6% and 1.2%. Through the Fig. 7 and 8, we could sure the fact that our ubiquitous convergence model and traffic control structure have effective performance for the service lowering caused by traffic overcrowding. Additionally, if policy control is requested because of continuous BE class disposal shown in Fig. 8, ER or DR can manages traffics dynamically through the weight resetting by requesting policy control to PDP.

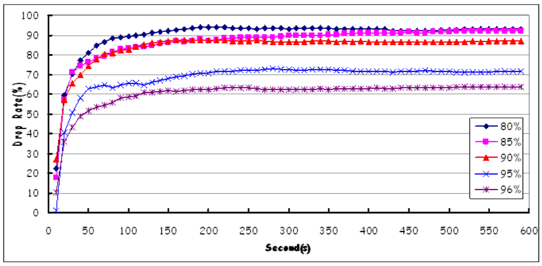
Fig. 9 shows the change of disposal rates of each traffic class when we simulated depending on L1 weight change in the proposed method in this paper. When L1



(a) EF traffic class



(b) AF traffic class



(c) BE traffic class

Fig. 9. Disposal rates of each traffic class depending on L1 weight setting

weight is set as 96%, we can see that the disposal rate of BE traffic class is kept at 60% as you can see in Fig. 9 (c), while the disposal rates of EF and AF classes are kept at 4% and 9% as you can see in Fig. 9 (a) and (b). Weight management of output buffer is an important element for traffic control, and it should be managed dynamically through continuous monitoring. Consistence rate in each class of produced traffics and average size of packet are also important elements to have influence directly on the disposal rate and service rate. These elements are provided resource status information from ER and DR, which performs the role of PEP, to PDP. PDP manages traffics dynamically by the policy decision information referring corresponding information, and provides end-to-end QoS.

5 Conclusion

Ubiquitous network is a convergence network that provides heterogeneous access network services as a form of service to mobile users of each access network. To construct this ubiquitous convergence network, a number of researches are proceeding in the world. However, it is still in the beginning stage and is for the partial work for heterogeneous access networks. This paper doesn't suggest a model for the linkage of particular access network. This paper suggests a model using hierarchical policy-based structure by generalizing access network structure which will be linked with ubiquitous convergence network, message transmission procedures for policy control, and dynamic buffer management method for traffic control in network components.

If hierarchical policy-based structure and dynamic buffer management method proposed in this paper are applied for access networks, then we expect that network extendibility, end-to-end QoS management between heterogeneous access networks, and management independence of each access network can be guaranteed. In addition, we regard it as a proper model for ubiquitous convergence network construction by providing dynamic traffic services through policy-based DiffServ QoS control method which considers SLA, and by reducing service delay and network overload caused by traffic overcrowding.

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