22nd International Conference on Advanced Information Networking and Applications - Workshops

Overlay Multicast Architecture Supporting QoS over NGN*

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Abstract

NGN is a communication network which can make use of multiple broadband and QoS-enabled transport technologies. One of the main service issues over NGN is a multimedia service, like IPTV and VOD, which is using multicast technology. And overlay multicast technology is one of the promising solutions instead of general multicast technology which has a few problems, and supports flexibility and scalability for multicast services. Also, the main controversial topic in NGN and overlay multicast at present is QoS.

In the present paper, we designed an agent in each receiver's network and a manager which is in a source network and which manages the whole multicast network. Both of them are communicating with each other and applying resource policies to their multicast network. This mechanism enables overlay multicast to support QoS, focusing on RACF in NGN architecture.

1. Introduction

Current networks are evolving to NGN(Next Generation Network) which supports guaranteed quality of broadband multimedia services that are integrated with communication, broadcast and the internet. NGN environment should enable various services requiring high-level QoS like real-time services to be provided seamlessly even though users use any kinds of communication networks and terminals. For this, one principal factor of NGN is resource management technology that makes a decision about whether a service request can be accepted or not.

One type of services that maximizes the service efficiency over NGN is a multicast service, and IPTV over the internet is a good example to illustrate multicast services. However, since the media server in point-to-point communication cannot guarantee service quality when numerous clients request one service at the same time, unicast is not useful. The solution to streaming services is the introduction of multicast technology. However, there are unsolved problems like security and stability in multicast technology. Furthermore, to implement multicast, networks should be incorporated with new routing and forwarding mechanisms. Overlay multicast, one of the technologies to solve these problems, holds promise for the realization of large scale internet multicast services. The concept of overlay networks allows multicast to be deployed as a service network rather than a primitive network mechanism.

For these reasons, in the present paper, we proposed new overlay multicast architecture by deploying overlay multicast over NGN. We designed a manager in a source network and an agent in each receiver's network, and they communicate with each other based on a resource management mechanism that is provided by NGN QoS Architecture [1].

2. Background

2.1. NGN QoS Architecture

NGN QoS architecture is composed of Service Stratum in charge of application signaling and Transport Stratum in charge of packet transmission as shown in Figure 1 [1].

* This research was supported by the 'Seoul R&D Program'.
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978-0-7695-3096-3/08 $25.00 © 2008 IEEE
DOI 10.1109/WAINA.2008.189

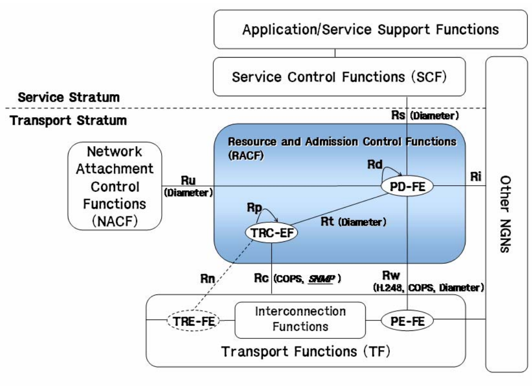

Figure 1. NGN QoS Architecture

SCF (Service Control Functions), which implements signaling with terminals, transmits QoS requirements to real networks via RACF in order to provide network services.

TCF (Transport Control Functions), which is made up of NACF and RACF, acts as an arbitrator for connecting two strata, Service Stratum and Transport Stratum. NACF (Network Attachment Control Functions) provides a registration function at the access level and an initialization function of end-user functions to access NGN services. These functions provide network-level identification/authentication, and also authenticate an access session. RACF (Resource and Admission Control Functions) provides QoS control functions including a resource reservation, admission control and gate control in order to get desired QoS for communication and permission to access certain resources. RACF is composed of PD-FE (Policy Decision - Function Entity) which exchanges signaling and resources information with SCF, and TRC-FE (Transport Resources Control - Function Entity) which analyzes network resources and status.

TF (Transport Functions) is the set of functions that support the transmission of media information and control/management information. To collect resource status and inform RACF of that, SNMP protocol is used to implement our mechanism.

2.2. Overlay Multicast

Over the past few decades, a number of studies have been conducted on overlay technologies owing to its flexibility and scalability. Overlay multicast scheme is developed to provide multicast services over the public internet environment that doesn't support IP multicast, called application multicast. In general, overlay multicast service is provided by combination of unicast tunneling and IP multicast. Data in overlay multicast service are delivered by unicast tunneling mechanisms, hop-by-hop basis. Overlay Multicast is readily deployable, as well as has acceptable performance [3][4].

An overlay multicast protocol consists of group member control topology and data delivery topology. The former is made as a mesh structure to support various connections among members, and the latter is made as a tree structure to transmit data. The control mesh is used to transmit control messages and overlay routing tables at the application layer. The data delivery tree is used to deliver the multicast traffic on the overlay network [5].

2.3. SNMP

SNMP(Simple Network Management Protocol) is a simple protocol which monitors and manages networks with little network overhead. Since this protocol is operated at the application layer using a transport-layer protocol, SNMP can be operated on every kind of hardware [6].

In general, SNMP consists of one or more agents and a manager. An agent is operated as a server and a manager can be a client. An agent is software that works in a node which is located in managed networks, stores each field in a data structure, called MIB(Management Information Base), and shows the data through one unified interface. Network status and network interfaces, as well as system information such as CPU, memory, disk, etc, can be collected in MIB. Preparing to reply for the request from a client is also the role of servers which are keeping the information about the requests. A manager, software in a terminal that is located in a monitoring network, gets data about networks communicating with agents in the monitored networks periodically [6].

3. Overlay Multicast Architecture over NGN

3.1. QoS Requirement and Composition in Overlay Multicast Environment

In general, the delivery quality should be synchronized with the member located in the lowest quality environment in overlay multicast networks because a data delivery tree is made on a virtual network. Although a member is in high quality network environment, it is not guaranteed that the member can get a high-level service. Therefore, in the present paper, we propose OMA(Overlay Multicast Agent) that collects and manages information about each network to provide proper QoS for each network. This means that OMA can support a diversity of receivers' environments. OMAs, which are implemented as a SNMP agent, collect and manage the information about each network to provide suitable QoS for each environment in which receivers are. Also, there is OMAS(Overlay Multicast Agent in Source network), implemented as a SNMP manager, in a source network so as to take charge of the quality management of the whole overlay multicast topology.

In addition, there are a media server and management server that work in existing multicast, and a relay which works in overlay multicast. In our approach, a few functions, such as communicating with OMA/OMAS and applying the policy that is established by OMA/OMAS, are added to them.

3.2. Architectural Model

NGN architecture is divided into core networks and several types of access networks, and they are operated separately. The network which tries to improve QoS should get accurate resource information from each network communicating with oneself, and an overlay multicast network also should do.

Figure 2 depicts the architecture, which we propose, for overlay multicast over NGN. To transmit data from a source network to destination networks, the data are passed through a core network, which is an IPv6/MPLS network and uses a unicast method.

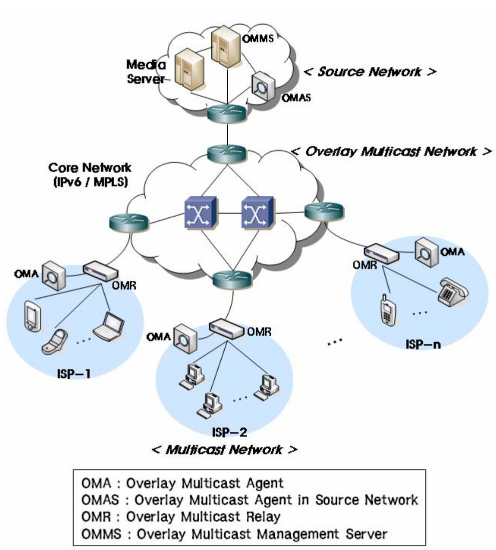

Figure 2. Overlay Multicast Architecture over NGN

1) OMA (Overlay Multicast Agent)

OMA collects the resource information of its own network, decides whether there are sufficient resources to support the service, and arranges the level of this service that will be informed to OMR(Overlay Multicast Relay) so that OMR applies this level to a data relay policy. - OMA and OMR may be implemented in one machine, or not. This working is performed in each ISP network. The result of this data delivery policy made by OMA is transmitted to OMAS. OMA uses SNMP MIB in collecting resource information, and informing OMAS of its policy.

There is information used in OMA as follows.

Table 1. OMA Configuration Information

Information	Description
OMA ID	OMA Identification
OMA Mode	General OMA / OMAS (OMA in Source network)
OMA Location Information	IP Address Network Identification including a kind of networks such as PSTN, Wireless, etc
SNMP Version	SNMP Version
OMA Start Time	OMA Starting Time to Work
OMA Status	OMA Collection Status (Grade Labeling : High / Medium / Low / Poor)

Table 1 shows the information which is configured when OMA starts working in each network. Table 2 includes policy information to manage network resources that are collected.

Table 2. Resource Measurement Policy Information

Information	Description
Packet Type	Used Packet Type
OMA Working Period	Period of Collection / Adaptation / Transmission
Retry Policy	The Number of Retry in Failing

Table 3. Collection Data

Information	Description
Collection Time	OMA Time to Collect Resource Information
One Way Delay	Time that it takes for a packet to reach its destination
Packet Number	The Number of Sent / Delivered Packets
Jitter	Variation of signal characteristics between OMA and CPE (Customer Premise Equipment) (Grade Labeling: Maximum / Average / Minimum value)
Packet Loss Ratio	Maximum / Minimum Packet Loss Ratio

OMA collects the network information in Table 3 and analyzes the present status of its network using this information. After that, OMA applies the result to its relay in the same network as OMA, and transmits the information which appears in Table 4 to OMAS.

Table 4. Information from OMA to OMAS

Information	Description
OMA ID	OMA Identification
OMA Location Information	IP Address Network Identification including a kind of networks like PSTN, Wireless, etc
OMA Starting Time	OMA Starting Time to Work
Service Level	Grade according to the status of each network (Grad Labeling : Premium / Gold / Silver / Bronze / General)

2) OMAS (Overlay Multicast Agent in Source network)

OMAS manages the whole overlay multicast topology. OMAS' work consists of Join Handling and Service Controlling.

Join Handling Once OMMS receives join request signal from a subscriber, it sends a resource requirement message based on subscriber's information to OMAS. OMAS makes a decision about whether this service can be accepted or not. If this service can be accepted, OMAS specifies its transmission quality based on the information from OMA which is in the same network as the subscriber. If this cannot be accepted, this service is rejected so as to maintain the current service processes. These steps are similar to OMA's. And then, OMAS applies a new policy to a media server via OMMS.

Table 5. Information from OMAS to OMA

Information	Description
OMA ID	OMAS Identification
OMAS Location Information	IP Address Network Identification including a kind of networks like PSTN, Wireless, etc (This field is needed only at first.)
OMAS Starting Time	OMAS Starting Time to Work (This field is needed only at first.)
Service Level	Service Progress Status (Service Progress Grade and the last time if there were service points in trouble)
Service Acceptance and Level	Acceptance or Rejection of a Service and Grade of the Destination OMA

Service Controlling OMAS periodically gets each network's information in Table 4 from each OMA. OMAS puts resource information from each OMA together, makes a delivery policy, and allows a media server to transmit data according to this policy so that the service goes on smoothly considering resource status of each network.

Table 5 shows the information, a service control message, from OMAS to OMA. OMAS transmits this message when service requests are processed at first, and then transmits this one periodically while service is in progress.

3) OMR (Overlay Multicast Relay)

As it is depicted above, overlay multicast topology is made up of group member control topology and data delivery topology. When group member control topology is constructed, OMR in each network gets information from OMA located in the same network, and uses it in relaying packets on data delivery topology.

OMR not only takes a role as a normal relay but also relays data according to OMA's policy. For instance, in a wireless environment, the quality of service may be far lower than that of wired network service because the transmission rate is influenced by several factors like the number of obstacles or the distance between a receiver and OMR. In addition, the circumstances can be changed so easily. Therefore, the number of retries may be different from that in wired network service. This policy is made by OMA, and OMA notifies OMR of this policy in order to apply this to real service relaying.

4) OMMS (Overlay Multicast Management Server)

Generally, a management server in the existing multicast environment is just a server that manages joining and leaving processes. That is to say, in the case of general multicast, a management server adds a receiver to a multicast service tree immediately regardless of the network status, when it gets a service request signal form a receiver. However, OMMS communicates with OMAS to transmit receiver's information and get the policy made by OMAS.

3.3. Overlay Multicast Procedures over NGN

Figure 3 shows the overall procedures of an overlay multicast network over NGN in the present paper.

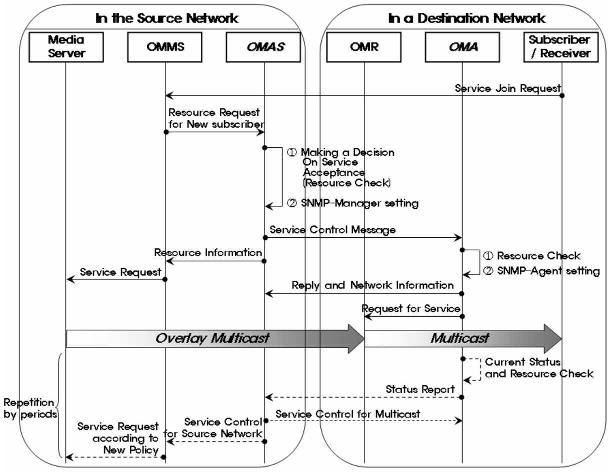

Figure 3. Procedures of Overlay Multicast over NGN

Once a subscriber sends join request signal to OMMS, OMMS sends a resource request message with subscriber's information to OMAS. Then, OMAS makes a decision about whether it can be accepted or not, based on subscriber's information so as to permit the subscriber to join. If it is accepted, OMAS sends a service control message to OMA in the network so that OMA is set up as a SNMP agent after OMAS is set as a SNMP manager to get the quality information of the network within which the subscriber is.

After OMA sets itself as a SNMP agent, OMA sends not only a reply message to OMAS but also a request message, that is for overlay multicast data transmission, to OMR which is located in the same network. And then, OMA analyzes packets which are similar to real service's some generated by itself by periods, or real data packets in order to collect the network information such as a packet loss rate, one way delay, delay transition, and so on. OMAS makes a decision about a delivery policy based on the information from each OMA. These steps are executed periodically.

In the above process, OMA is using SNMP MIB not only in order to provide the management functions such as configuration, inquiry and modification, but also in order to transmit the result of resource measurements to OMAS that acts as a SNMP manager.

4. Performance Evaluation

We implemented a simulation using one of the network simulators, called OMNeT++ to evaluate our mechanism [7]. For an overlay multicast service, we configured our network with 1 source and 4 relays which are in a different type of networks separately. Figure 4 illustrates a testbed environment built by OMNeT++.

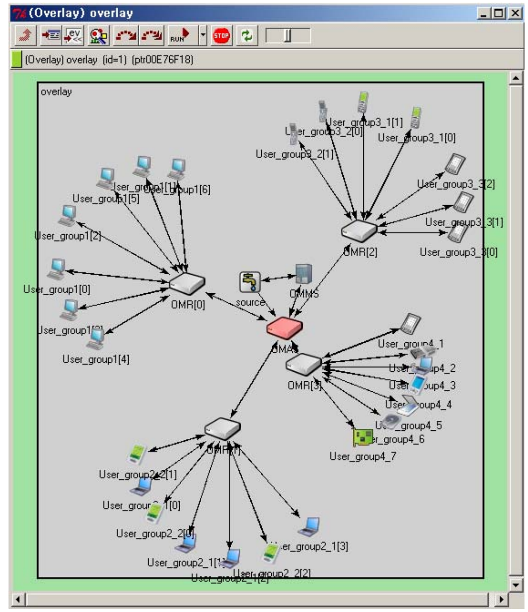

Figure 4. Overlay Multicast Network to be simulated

We adopted delays between OMR and terminals in the OMR's network, differently from 5 ms to 20 ms considering specific features of the network. Our simulation environment is made up of LAN, wireless LAN, cellular network and mobile network. Also, we measured the data rate in each terminal.

It is necessary to assign a level index to QoS mechanisms. Therefore, we made a level index based on the real service network, and assign the index to our simulation. It can be adjusted, as needed. Table 6 shows the level index in our simulation.

Table 6. Level Index

	Premium	Gold	Silver	Bronze	General
LAN	98 and more	95~97	91~94	86~90	85 and less
xDSL	96 and more	91~95	86~90	81~85	80 and less
WLAN	94 and more	88~93	81~87	71~80	70 and less
Mobile Network	91 and more	81~90	71~80	61~70	60 and less

unit: % (data rate)

OMA collects its own network's information in every 10 seconds, makes the service level, and notifies OMAS of the result. Figure 5 depicts a result of the data rate of terminals in our simulation, especially in a mobile network.

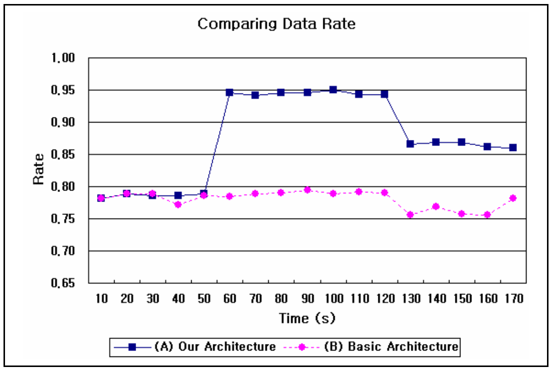

Figure 5. Simulation result (1)

Figure 5 illustrates the average data rate of terminals in a mobile network. We can see that the data rate is high between 60-second point and 120-second point; and after that, the rate goes low a little. This means that if the data rate improves because of the decreasing of receiver' number or not moving, OMA becomes aware of that situation by collecting the network information periodically, and informs OMAS of the higher service level. After this process, OMAS transmits high quality data to the terminals in this network, and there is the data rate improvement. In our simulation, this happens at 60-second point. On the contrary, as you can see the change at 130-second point in Figure 5, if the factor of the low data rate comes up in a mobile network, it does not need to send high quality data to the terminals. OMA becomes aware of this situation, and does something, as stated above.

Figure 6 shows a result of the terminals' average data rate in each network, and this was simulated for 10 days in simulation time. This bar graph tells us that there are numerical differences between our architecture and basic architecture. We can tell that the more extreme fluctuation of the data rate is due to a variety of environmental factors such as a mobile environment, the better the data rate is comparing the basic architecture.

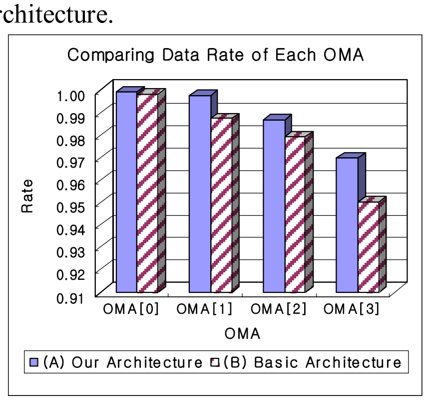

Figure 6. Simulation result (2)

5. Conclusion

To guarantee QoS, RACF in NGN QoS architecture has been proposed and studied. We extended the role of RACF in order to provide high quality services in an overlay multicast network. We designed OMA that takes charge of RACF so that it works based on the network resource information when a subscriber joins the multicast group and receives data. This mechanism could be used as multicast technologies, guaranteeing QoS and scalability. We can guarantee QoS which is suitable for each network, and manage each network independent of other networks in the whole overlay multicast network by utilizing this mechanism.

Also, one main aspect of multimedia services is to grasp the receiver's situation such as a network type, terminal type, receiver level, and so forth, in order to analyze QoE(Quality of Experience) to provide the service suited to each receiver in a real service. Our mechanism will help this work. In addition, Quality Management Center, which acts on behalf of specific service or content providers and NGN Managers, can obtain the service and network status from OMA/OMAS, and this information will be used to regulate a NGN policy, fix the price of the service, create new services, and so on.

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