A QoS negotiable service framework for multimedia services connected through subscriber networks

Yeonjoon Chung, Min Ho Park, and Eui Hyun Paik

Abstract —*This paper presents a novel QoS negotiable service framework (QNSF) to provide QoS based multi-room application services. The QNSF provides service bandwidth guaranteed services as well as priority based QoS services on home server based Ethernet networks. The QNSF works on Ethernet networks and legacy network devices. Although the QNSF can support priority based QoS services, in order to provide high quality multimedia services from subscriber networks, our scheme supports the service bandwidth guaranteed services because different home applications from multi-rooms compete for limited bandwidth resources. When application session setup begins, our QNSF negotiates a QoS service level of applications through QoS client APIs. Application services can perform any number of dynamic QoS negotiations before the service starts. Thus, the QNSF can provide well adapted QoS providing service to home multimedia applications. The QNSF consists of some functional blocks. A QoS client module defines QoS negotiation APIs for home service applications that require QoS negotiations. QoS proxy, QoS manager, and traffic monitor modules support service based QoS provision functions like dynamic bandwidth negotiation, QoS admission control, service profile based rate control, and adaptive parameter mapping. Packet classifier, class marker, and best effort traffic controller modules enable dynamic input traffic classification and support policy based rate controls. Using dynamic resource reservation and QoS negotiations, our scheme provides efficient QoS guaranteed services for the multimedia traffics from subscribe networks, such as high quality multimedia service. Our prototype implementation shows the feasibility of the QNSF for the provisioning QoS based application services in multi-room home networks.*

Index Terms — Quality of Service, QoS negotiation, QoS manager, QoS proxy,

I. INTRODUCTION

The rapid growing of home networks makes the multimedia and broadband services more and more close to the home residents.

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The ability to provide Quality of Service (QoS) is one of important requirements of multimedia services for the home networks. In the near future, services requiring wide bandwidth and guaranteed quality, such as high quality AV streaming and Internet TV, will become mainstream in the home networks. Applications such as AV streaming and VoIP have real time requirements which are delay sensitive. But, file transfer applications, for example, email or background home applications, don't have real-time requirements for the services. Unfortunately, current QoS frameworks, such as UPnP QoS architecture [7], doesn't support efficiently guaranteed QoS mechanism for the multimedia contents transmitted from the outside of home like high quality VoD services, IPTV, etc. In this paper, we present a new QoS provisioning architecture for multimedia services connected through subscriber networks.

The outline of this paper is as follows. In section II, we introduce the overview of the QoS based home networks and the UPnP QoS architecture. Section III presents the overview architecture of the QNSF and functional modules of the QNSF to provide QoS based home networks. Section IV describes functional interoperations of the QNSF and its QoS negotiation flows. In section V, we show our implementation of the proposed scheme. Finally, section VI gives our conclusions.

II. THE QOS BASED HOME NETWORKS

Usually, Internet is not yet ready for QoS since the best effort network such as Ethernet is still widely used. The Quality of Service(QoS) requirements for the AV streaming over the home networks are quite different from the requirements for the transmission of non-realtime data. QoS requirements can be determined by four parameters: Bandwidth, Latency, Jitter, and Packet Error Rate.

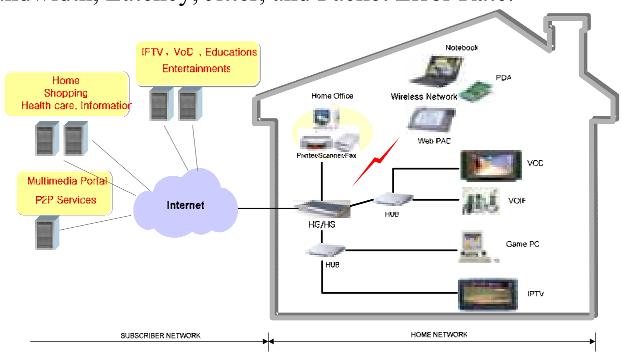

Figure 1. The Configuration of Home Networks

In order to provide noiseless services for the AV streaming, the required bandwidth of applications is fully supported on end to end connections because the lack of service bandwidth usually increases AV packet delays as well as packet loss rates. The bandwidth can be the most important a QoS parameter among QoS parameters. Figure 1 presents the configuration of IP based home networks. As one can see in Figure 1, multimedia content services provides to home resident through a subscribe network. The HG/HS distributes incoming packets from a subscribe network to home residents and transmits resident's packets to the outside of home. IP routing and NAT functions are installed in a HG/HS. Inside the home, all network devices share the same subnetwork and use Layer 2 interconnection for communications. We assume the home network architecture is a Tree based network structure, in which consumer network devices are interconnected through L2 network devices, such as hubs or wireless access pointers. By increasing the demand of QoS for the home networks, nowadays, UPnP Forum released the standardized service descriptions for Quality of Service v1.0. UPnP QoS Architecture assumes that all the network devices in the home network support the UPnP protocol. UPnP QoS consists of three elements: QoS policy holder, QoS device, and QoS manager. The control pointer requests QoS services and keeps the knowledge of source, sink and content to be streamed, along with its Tspec. The QoS device exists within one or more layer-2 devices to receive and apply the access priority for a traffic stream.

III. ARCHITECTURE OF THE QOS NEGOTIABLE SERVICE FRAMEWORK

Since the home networks primarily uses Ethernet as a backbone network to interconnect legacy home network devices, delivering QoS for the multimedia home services is one of the key issues in home IP networks. We propose a QoS negotiable service framework(QNSF) to provide end-to-end QoS guaranteed services as well as priority based QoS services for the AV streams connected through subscriber networks.

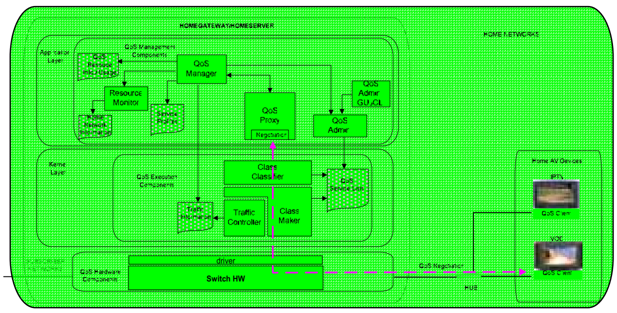

Figure 2. An Overview of the QNSF

We present an overview of the QoS negotiable service framework for the multimedia service networks in Figure 2. The QNSF consists of some functional blocks as described in Figure 2. In order to negotiate service QoS degree with a HG/HS system, A QoS client module defines a QoS negotiation protocol and QoS client's APIs for resource reservation negotiations for QoS guaranteed multimedia home services. The QoS proxy arbitrates resource reservation requests between QoS manager and QoS client modules. If QoS client's bandwidth reservation request is accepted, the QoS manager adds the reservation request into active resource reservation service lists to provide a QoS guaranteed service. The QoS manager gets the required service bandwidth information from either a QoS negotiation message or built-in service profile lists about well known multimedia services. Using QoS client API modules, the application service can perform any number of dynamic QoS negotiations before the service starts. Our QoS manager refers to the usage information of the network resources and home service profile information from the service profile table to determine whether service can be provided as a QoS guaranteed service. Resource monitor and traffic controller modules monitor and control the amount of best-effort traffics. If the transmission rates of best-effort traffics is over a threshold value set by the QoS manager, Traffic controller drops the overflow packets with RED(random early detection) mechanisms to maintain the transmission limits of best-effort traffics. Our QNSF provides the priority based QoS mechanism, applied by the UPnP QoS or a diffserv model, by using adaptive priority mapping. Packet classifier and Class marker enable dynamic input traffic classification and support dynamic rate controls. Class marker classifies incoming traffics to a QoS guaranteed service class and best-effort service classes with referencing QoS service lists. Basically, the QNSF assumes best-effort service packets inherit the TOS field of IP packets by adjusting its service priority. Class marker assigns packet's service classes to each packet by marking the IP packet's TOS field. Finally, the traffic cache module monitors the QoS guaranteed service traffics and regularly gathers its service status information. If abnormal service status occurs, the QoS manager deletes the abnormal service from QoS guaranteed service lists.

IV. QOS PROVISIONING SERVICE IN HOME NETWORKS

We present functional interoperations among the QNSF component blocks and QoS negotiation flows in Figure 3. To provide QoS guaranteed services in the multi-room home networks, QoS client devices such as DTV devices and wireless PDAs require the capabilities of QoS negotiations using QoS client API modules.

A. QoS Negotiation Messages

When QoS clients requests resource reservation to the QoS Manager, they exchange QoS negotiation messages until the negotiation completes. When a QoS client requests resource reservation, a negotiation message basically includes traffic identification information and required resources. The QNSF classifies the traffics with destination

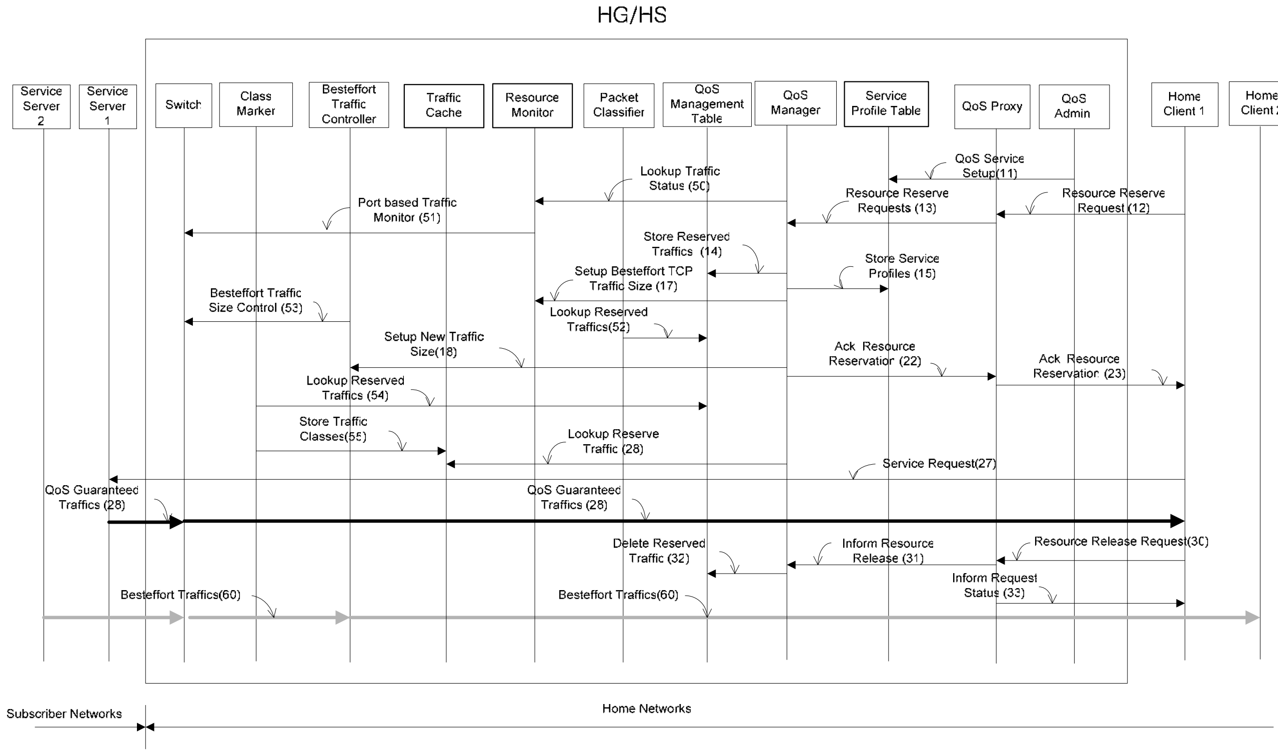

Figure 3. Interoperations among function blocks and QoS negotiation flows

IP address, destination service port number, and protocols. Selectively, QoS negotiation messages contain the service profile information, such as service name, codec, and etc.

B. QoS Negotiation Flows

When application session setup begins, our QNSF negotiates a QoS service level for multimedia applications through QoS client APIs. When a QoS client requests service's resource reservation to the QoS Proxy, the QoS manager checks whether the requested resource is available. If the resource is available, the QoS manager inserts application information on the QoS management tables and updates the resource usage of reserved paths, as well as replies to a QoS client that the request is approved. If the resource is not available for the request, the QoS manager informs a QoS client that the request is denied. If application services want to renegotiate QoS parameters, a QoS client module can perform any number of QoS negotiations before the service starts. If the QoS guaranteed service finished, a QoS client informs the QoS manager that the current OoS guaranteed service is ended. Then the QoS manager deletes the service information from a QoS management table and releases reserved resources.

C. QoS Guaranteed Services and Best Effort Services

The QNSF provides two QoS service categories: QoS guaranteed services and priority based best effort services. Initially, the QNSF decides the maximum guaranteed service bandwidths and the remaining portion of total link capacity assigns as the best effort service bandwidths. Normally, a QoS guaranteed service reserves required resources by QoS negotiations until the service finishes. In case of priority based best effort services, the QNSF provides its service priority based on the DSCP values of best effort service packets. The QNSF supports three kinds of best effort services which are high, medium, and low priority service. Class marker maps its service class with referencing the DSCP value of packets. We use a commercial Ethernet switch to provide the rate controls for QoS based traffics.

V. IMPLEMENTATION

Based on the proposed scheme, we implemented the QNSF on the Linux based a HG/HS system. The objectives of our implementation work were to demonstrate the suitability of the propose solution. Before we describe the QNSF, we briefly describe a HG/HS system. The HG module serves a role as a home gateway. A HG module consists of one Intel's xscale 533Mhz network processor and various home network interfaces. The QoS proxy and the QoS manager modules are installed on the HG module. A HS system is built on an Intel 1.7Ghz CPU hardware platform. The HS system provides various user applications that require in the ubiquitous home environments. Our QoS client module is installed on the HS system. Figure 4 shows a demonstration configuration to validate the feasibility of our QNSF solution. In this configuration, a VoD server is located in the outside of home. When a home resident plays a vod movie from vod contents lists, the video streams is transmitted to a HG/HS system and a HS system displays a video on a HS monitor.

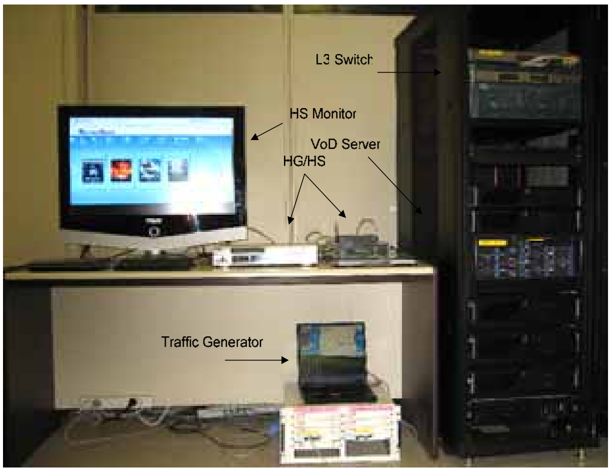

Figure 4. A demonstration of the proposed QNSF

To test the validity of our proposed scheme, under condition that the traffic generator generates massive best effort traffics inside the home, we compared image qualities of the QoS guaranteed service and simple best effort services. As described before, our development work was performed on a HG/HS system and we demonstrated the suitability of the proposed scheme using a high quality VoD service.

Figure 5. QoS guaranteed vs. best effort service

Figure 5 represents the image quality of a movie "Tomb Raider" encoded with MPEG2. In Figure 5, traffic generator generates massive best effort traffics on both test cases. The left image of Figure 5 presents a QoS guaranteed vod service provided by the resource reservation and the right image shows a best effort service of the same video title. As one can see, although a best effort service case shows some image distortion caused by massive best effort traffics, the QoS guaranteed service provides noiseless images without any image distortions.

VI. Conclusion

We have presented the design and implementation of QoS Negotiable Service Framework for the QoS provisioning multimedia service networks. In our work, we have shown that the proposed framework efficiently provides resource reservation based approaches as well as priority based QoS service for the multimedia home networks. We have described the feasibility of our proposed scheme for the efficient QoS based multimedia home services. As the future works, we are now planning to expand the scope of the current framework. We will propose the wireless QoS services framework for the wireless home multimedia networks in the future.

References

[1] P. Wang, Y. Yemini, D. Florissi, P. Florissi, and J. Zinky, "Experimental QoS Performances of Multimedia Applications," INFOCOM 2000, March, 2000
[2] J. Walker, O. J. Morris, and B. Marusic, "Share it! – The architecture of a rights-manages network of peer-to-peer set-top boxes," Proc of EUROCON 2003, Sept., 2003.
[3] D. Kang, K Kang, S. Choi, and J. Lee, "UPnP AV Architectural Multimedia System with a Home Gateway Powered by the OSGi Platform," IEEE Tran. on CE., vol. 51, Feb. 2005
[4] E. Topalis, L. Mandalos, S. Koubias, and G. Papadopoulos, "QoS support for real-time home automation networks management via high-speed internet connection," ICOIN 2002, Aug., 2002
[5] F. Giovanelli, G. Bignini, M. Solighetto, and P. Maggi, "A UPnP-based bandwidth reservation scheme for In-Home Digital Networks," ICT 2003, March, 2003
[6] E. Topalis, L. Mandolos, S. Koubias, G. Papadopoulos, and I. Nikiforakis, "A novel architecture for remote home automation e-services on an OSGi platform via high-speed Internet connection ensuring QoS support by using RSVP technology," IEEE Tran. on CE., vol 48 Nov. 2002
[7] UPnP Forum, UPnP QoS Architecture:1.0, March 2005
[8] S. Ando, M. Ohmoto, and Y. Shimizu, "QoS technology for home networks," IEEE CCNC 2004, Jan. 2004
[9] OSGi Alliance, OSGi Service Platform rel. 3, IOS press, 2003
[10] M. Jeronimo, and J. Weast, "UPnP design by example," Intel Press, 2003
[11] J. Crowcroft, M. Handley, and I. Wakeman, "Internetworking Multimedia," Morgan Kaufmann Publishers, 1999

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