具 QoS 能力的居家閘道器

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摘要

居家閘道器是一個將各項家用設備連接在一起以提供彼此間訊息交換及連接網際網路的通訊設備，是家用網路效能優劣的關鍵角色。然而在網路應用日增及頻寬需求遽升下，如何對它的有限網路頻寬提供一個有效地最佳管理機制已成為極具意義的課題。本篇論文即提出一個具有 QoS 的居家閘道器，以整合性服務及差異性服務提供具透通性的 QoS(TQM) 機制以達到有效率地使用網路頻寬資源。另本系統乃建構於 Linux 平台上，故而具備有容易整合、維護、成本低及容易升級等的特性。

關鍵詞：居家閘道器、QoS、服務品質。

QoS-based Residential Gateway

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Abstract

Residential Gateway (RG) is a device that coordinates various home devices to communicate each other and links up the Internet. It plays an important role in home network, especially the applications in home network are evolving and growing quickly to demand the additional feature QoS (Quality of Service) to meet network resource requirement. This paper presents a RG with a Transparent QoS Mechanism (TQM) in IntServ and DiffServ to utilize the limited network bandwidth more efficiently. The RG is implemented on the Linux platform, features inexpensive, easily interoperability, maintainable from both software and hardware perspectives, and also easily upgradeable to meet market demands for new multimedia services.

Keyword: Residential gateway, QoS, and Quality of Service.

I. Introduction

Today, the major obstacle to the 'digital networked house' is the access network; it is the well-known 'last mile problem'. This topic has been improved by the innovation in broadband access technology and the investment in access infrastructure such as copper enhancements (ADSL, SDSL, and VDSL), Fiber-To-The-Home (FTTH), and Wireless Local Loop (WLL) [5], but now the new barrier to the end-to-end broadband service provisioning is home network. For example, the bandwidth inside home can be over 400 Mbps (e.g. Home Audio/Video interoperability (HAVi) [6] is based on IEEE 1394), but that of the access network is generally below 512 kbps.

Currently the Internet offers the straightforward delivery service called "best effort". In this manner, data will be delivered as possible as the node it can, and the available bandwidth is contended by all nodes, therefore there is no commitment to bandwidth or latency for senders. However, the applications of network tend to diversification as the rising and flourishing development on the Internet, and more and more distributed multimedia applications like video-conference and Video-On-Demand (VOD) have been developed; these applications are delay-sensitive that the best-effort delivery model is inadequate even under modest network loads. Therefore, it is necessary for the Internet to provide Quality of Service (QoS) according to different users and applications. For addressing the requirement, IETF (Internet Engorging Task Force) develops two types of QoS: Integrated Service (IntServ) [2] and Differentiated Service (DiffServ) [1]. IntServ reserves network resources for per-flow in accordance with requests from the end application, but its scalability is a controversial issue. DiffServ provides a scalable scheme by defining different QoS-classes for packets and allocating resources on a per-class basis.

The current generation of RGs less provides

with the QoS mechanism [4], hence would not be able to meet the requirements of multimedia applications. This paper presents a RG with QoS mechanism that provides a transparent QoS mechanism on RG to support IntServ and DiffServ to utilize network bandwidth resource more efficiently. The rest of this paper is organized as follows. Section II covers the proposed RG network architecture. Section III describes the proposed transparent QoS mechanism on RG. Finally the conclusion and future works are presented in section IV.

II. System Architecture

The home network may transport data, audio/video, residential handling, and entertainment services; hence it has to integrate the heterogeneous environments in the network. One potential solution is through a residential gateway, an electronic sub-system that provides interface and routing services and some management functionality to distribute and regulate the use of information services in the home. The residential gateway would interconnect the home network and the public access network, and provide the capability of remote control in order to reach the goal of intelligence home network; it resides between public network and home network, and is the "ingress" node for the home network, and provides the server capability in order to realize the ingress functions in Fig. 1.

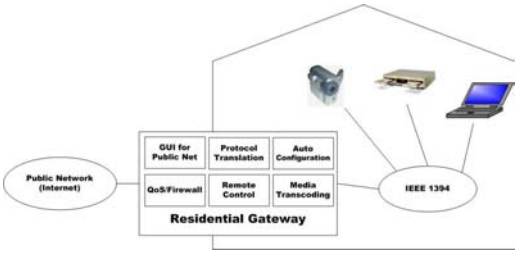

Figure 1. The proposed residential gateway architecture.

For the requirements and characteristics, RG has to take some topics into the considerations such as the dynamic access outside home, protocol translation/address translation between the IP and the (proprietary or non-IP) home devices network protocol, appropriate media translation function between the home network and the public network, the QoS supporting for IntServ and DiffServ to utilize the limited network resource, that is, the access point can be any kind of nodes e.g. PC, PDA, or mobile phone at anywhere to communicate with RG. IP firewall is also a component of RG; it follows the firewall rules to scan each incoming and outgoing IP packet, and performs the relevant action as a match is found. The rule-matched packets are then passed forward for further processing, or redirect to divert port.

The implementation of RG is shown as in Fig. 2, which interconnects the Internet and the home network, the IEEE 1394 AV network. The IEEE 1394 system uses the isochronous mode to transfer A/V data. These implementations of RG are based on the Linux platform. Linux is developed under the GNU General Public license and its source code is freely available to everyone. This, along with its good stability and real time capabilities makes this OS a good candidate in developing low cost RG. Dynamically loading code, as it is needed is attractive as it keeps the load of the RG at a minimum and makes it easy to update different modules from a remote server, without rebuilding the kernel and rebooting the RG.

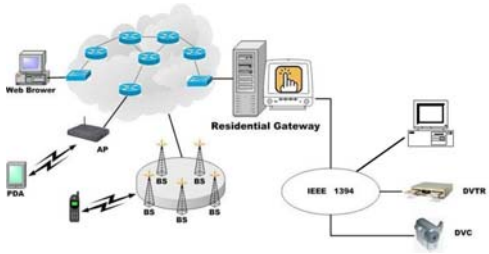

Figure 2. Implementation of the residential gateway.

III. The Transparent QoS Mechanism on RG

IntServ and DiffServ have been proposed to offer diverse services rather than the "best-effort" service offered by the original Internet. These service architectures intend to service the growing diversity of applications for QoS delivery and to supply the controlled network resource guarantees. One of the central tasks for making use of these architectures is able to use the QoS delivery capabilities in a simple manner and efficiently allocate the underlying resources among competing requests.

Each of QoS provisioning services provides QoS using different paradigms. IntServ is a flow-based reservation service deployed in both ends and intermediate devices (e.g., routers). DiffServ is a packet-based priority service developed in intermediate systems, and provides differentiated service priorities. Each QoS

provisioning service serves applications by providing their own custom user interfaces, which include QoS specifications and Application Programming Interfaces (API). IntServ uses the Resource ReSerVation Protocol (RSVP) [3] and it's API (RAPI). DiffServ uses the Bandwidth Broker, and edge routers to mark packets. Therefore, applications need to cope with heterogeneity of user interfaces to acquire their QoS.

In this paper, a Transparent QoS Mechanism (TQM) is presented to let Internet applications easily interact with the QoS provisioning services. As Fig. 3 shown, TQM shelters the diversity of end applications and underlying provisioning services by placing a middle mechanism between them. TQM provides a general sender-host framework to establish RSVP session of applications in IntServ, or mark packet with service class (PHB) in DiffServ. Through this mechanism, RG (Sender) can easily set QoS parameters for Internet applications in IntServ or DiffServ.

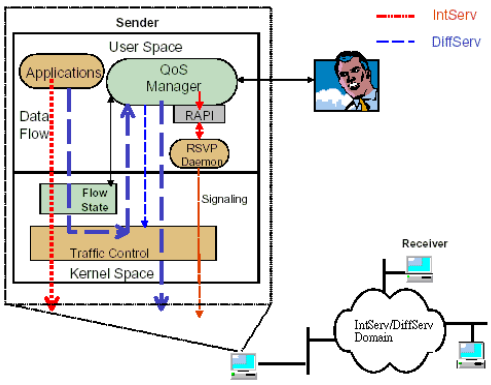

Figure 3. TQM scenarios between applications and IntServ/DiffServ.

In TQM architecture, Internet applications do not need to be rewritten themselves in order to know how to use underlying provisioning services. In TQM, an agent called "QoS Manager" is used to respond user input and setup QoS for Internet applications. QoS Manager collects flow information of Internet applications and displays to user. According to these information, user can choice any flows these applications generate to provide QoS. In this way, user has autonomous QoS control in flow-based approach to make Internet application QoS-aware rather than in a "per-application" basis. When user decides to provide QoS for specific flow that some application generates in IntServ, QoS Manager uses RAPI to create RSVP session for this flow. Further, user also can mark service class for some flow in DiffServ; this IP flow is first redirected to QoS Manager, then QoS Manager updates TOS value of IP header; finally the modified IP Packets are sent back to IP stack and continue traveling forward.

Besides, TQM can be appended other module to decide how much resource to reserve in IntServ, or what strategy to mark packet according to the content of IP packets. Because TQM is located in RG (Sender host), and it can best understand the service that they desire for specific flows or packets of specific applications. Video-communication application is one of QoS-required applications due to its sensitive to network congestions. For example, RG (Sender) usually don't know how much bandwidth to reserve appropriately for VBR video-streaming applications. However, video encoding techniques result in high autocorrelation for streaming traffic. With traffic prediction, TQM estimates bandwidth requirements for VBR video-streaming applications, and dynamically reserves bandwidth in IntServ. Besides, RG (Senders) can mark packet according to SLA (Service Level Agreement) or the content of IP packets. But the packet marking strategy is another open issue for VBR video stream in DiffServ. TQM just provides a framework to develop marking strategy in DiffServ.

TQM is a user-oriented and flow-oriented mechanism to make Internet applications QoS-aware. As Fig. 4 shown, TQM uses QoS Manager to collect flow information of applications and user decisions, and then invokes QoS setting for this flow. In QoS Manager, there are three components to collect management information: User Interface, Application Database, and Application Filter.

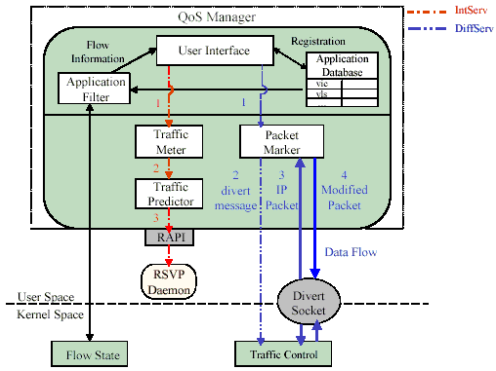

Figure 4. TQM Architectures.

User can register application name to Application Database through User Interface. Application Filter collects flow information of the running applications in RG. By querying Database, Application Filter drops some flow information that user may would not wish to provide QoS. Then User Interface shows these flows information from Application Filter to user. User can choice any flow to provide settings for underlying QoS.

TQM supports RSVP signaling and packet marking for underlying QoS. In order to raise utility rate of network resource, TQM uses dynamic QoS to reserve appropriate bandwidth in IntServ, and provides user to on-line adjust service class in DiffServ. To provide dynamic QoS in IntServ, traffic prediction is adopted to solve how much bandwidth to reserve in terms of video autocorrelation. When user decides to provide IntServ settings for some flow that VBR video-streaming application generates, Traffic Meter begins to gather traffic statistics for this flow. Then Traffic Predictor gets historical traffic statistics from Traffic Meter, and predicts required bandwidth of this flow in next time. Afterward, QoS Manager signals RSVP messages that records QoS specifications. In receiver, RSVP agent is used to receive RSVP message, and requests RG (sender) with same QoS specifications to reserve required bandwidth. Further, Packet Marker is used to set service class of packets in DiffServ. From information of User Interface, Packet Maker knows which flow is needed to mark and what service class to mark. Packet Marker redirects this flow from IP stack to itself; then updates the TOS field of IP header with service class for each packet; finally the modified packets are sent back to IP stack and continue traveling forward. Divert socket is a socket interface for IP packets interception and injection. Divert sockets with IP firewall can intercept the incoming and outgoing packets as well as a router. Divert socket provides a quickly alternative solution to modify the IP packets traveling the RG without rewriting original applications which generate those packets, or inserting a new kernel module.

IV. Conclusion and Future Works

This paper presents a QoS-based residential gateway using Transparent QoS Mechanism (TQM), which interconnects home network and public network. TQM provides a general sender-host framework to establish RSVP session of applications in IntServ, or mark packet with service class (PHB) in DiffServ. Through QoS Manager to react user input and setup QoS for Internet applications. So RG can easily set QoS parameters for Internet applications in IntServ or DiffServ. Therefore, the proposed RG can utilize network bandwidth resource more efficiently. The RG offers a solution that meets the key goals of a cost-effective, low-maintenance, upgradeable multimedia gateway.

Today the in-home networking exists more than 50 candidate technologies, working groups and standard specifications, divides into new wires (such as IEEE 1394, Ethernet, USB), no new wires (such as ApBus, X-10, CEBus, Lonworks, PLC), and wireless (such as IEEE 802.11, Bluetooth, IrDA, and HomeRF) [5]. Next step the proposed RG will add X-10 system, Bluetooth, and so on. At that time the packets containing A/V data could deteriorate the quality of sound or image if there is time delay during the transmission of the packets, but the home device control traffic sometimes is very important, e.g. fire alarm or gas alarm may cause serious damages if the control packets are not processed in time. How to make the minimize delay, quickly transfer different traffic packet and delay analysis in RG is the key issue.

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