홈 네트워크에서 PCF 와 규율을 가진 QoS 보증 분석

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Analysis of QoS Assurance with PCF and Queuing Disciplines in Home Network

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요 약

일상생활을 편하고 재미있고 안전하게 만들기 위해 홈 네트워크가 수집과 전기적인 많은 장치를 연결한다. 이더넷과 거주 게이트웨이의 단하나의 함께 나눠 진 광대역 커넥션에 대한 무선 기술의 수렴은 집 네트워크의 주요 특징이다. 이런 종류의 다종다양한 네트워크는 다른 QoS 장치를 실행할 필요성을 인식했다. 이 논문에서는 기본적으로 IP QoS을 통합하고 홈 네트워크에서 QoS 단언을 위한 QoS 장치의 타전을 한다. 이 논문에는 PCF와의 결합 지연시간과 사용자 요청의 알고리즘을 결합 비교하고 사용자 조합과 PCF의 결합 실행이 가장 좋다는 것을 결론을 짓는다.

ABSTRACT

A home network is a collection and connection of many electronic and electrical devices in home in order to make daily life comfortable, entertaining and safe. The convergence of Ethernet and wireless technology to a single shared broadband connection in residential gateway is the key feature of the home network. This kind of heterogeneous network has realized the need to implement different QoS mechanisms. Basically, in this paper we propose to integrate IP QoS and Wireless QoS mechanisms for QoS assurance in home network. This paper compares the combination of PCF with two queuing algorithms Low Latency Queuing (LLQ) and Custom Queuing (CQ) and concludes that the combination of CQ and PCF performs best for home network.

키워드
QoS, PCF, LLQ, CQ, Home Network, Wireless

Ⅰ. Introduction

Home Networks carry diverse multimedia applications such as data, video, voice, and time-sensitive control information. Most of these applications are internet based which provides only best-effort service. No guarantees are provided that the packets will be lost, that packet propagation times will be constrained, that packets will travel along particular path, or that packets will arrive in sequence [1]. Non-real time home applications such as email, web surfing, and file transfer are not delay sensitive where as real-time home applications like video conferencing, video streaming, teleconferencing, games, distance learning etc are delay and delay variation sensitive. If real-time voice and video packets are also delivered in a best-effort manner, they may experience unpredictable

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amounts of delay, jitter, and packet loss. Successful launching of real-time applications necessitates end-to-end QoS guarantees in terms of delay, bandwidth, bounded delays and delay jitter [2].

This paper focuses on analysis of queuing disciplines and Point Coordination function for providing QoS in home network. Section 2 describes the IP based QoS assurance in home network with different Queuing disciplines, LLQ, CQ along with classification of home network applications. Section 3 describes QoS assurance in wireless networks for real-time applications with Point Coordination Function (PCF). Section 4 describes the experimental set up for the simulation of PCF with four queuing disciplines. Section 5 shows the achieved results and finally concludes with section 6.

II. IP QoS

Based on the network requirements for internet based home network applications, different QoS may be required for different types of traffic. The service differentiation requirement is the fundamental requirement for IP QoS. The IP QoS solution is predicted on three fundamental requirements [2].

- To provide mechanisms to offer different levels of services to different users.
- The service should not be completely denied to lower-priority traffic.
- There should not be wastage of valuable network resources.

There are several optional mechanisms to provide QoS guarantee throughout the IP based network. The technology, which becomes very popular, namely Differentiated Services (DiffServ) differentiates between traffic classes and handles them according to their priorities using different queuing mechanisms with the aim of providing minimized loss rates, higher bandwidth and faster handling for certain traffic.

The DiffServ approach basically divides packets into several priority classes based on their QoS requirements. A field in the packet header, the type of service (TOS) byte, is used to identify the priority class [3].

2.1 Classification of home network applications

To use the Differentiated Services, home network applications can be classified into four classes based on the internet traffic characteristics and QoS requirements, which are briefly described below.

- Class 1 (Interactive Multimedia)

This class has the characteristic which is sensitive for the delay and jitter, such as interactive voice and video conferencing. We used low latency queuing scheduling to give priority for this class of traffic like VoIP. This class of multimedia applications has bounded delay and loss rate and hence given highest priority.

- Class 2 (Home Automation and control)

This group has the characteristics that are generated uncertainly such as control packet for home automation and sensitive to delay. This kind of time-sensitive traffic has small size packet. Hence it is transmitted using prioritized QoS mechanism.

- Class 3(Multimedia Streaming)

This group of traffic can tolerate small delay but sensitive to packet loss rate such as audio/ video streaming. So it has bounded packet loss rate.

- Class 4 (Best Effort Services)

This group of traffic such as HTTP, Email, FTP, is based on the best effort as they are non-real-time applications. So this group of services has lowest priority.

2.2 Queuing disciplines

There are many different queuing mechanisms used in IP routers in Differentiated Services. In this paper, we discuss two queuing mechanisms suitable for home network.

2.2.1 Low latency queuing

LLQ is the combination of Priority Queuing (PQ) and Weighted Fair Queuing (WFQ) in which the overall traffic is divided into two categories; normal and low latency. The normal traffic is handled using WFQ. The priority queue is serviced before any of the weighted fair queues allowing the real-time traffic to be processed as fast as the network elements allow. Byte Count Attribute is not used and its value is ignored by the scheduler for preferred services. If the preferred queue is empty, other queues are serviced fairly based on the Byte Count attribute settings [4].

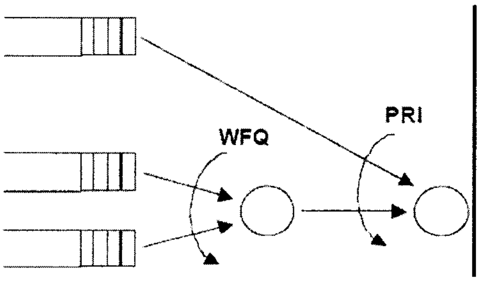

그림 1. 지연시간
Fig. 1. Low latency queuing

LLQ can be used to provide strong guarantees for a given data flow in a heterogeneous network like home network [4]. The home network can basically benefit by providing better service to preferred traffic during congestion as shown in Fig.1. Basically LLQ may be good solution for interactive voice traffic in home network as preferred traffic. The bandwidth shared from residential gateway is still dependent on other traffic available on the network. But for other kinds of traffic it may introduce delay while preferring priority to one case.

2.2.2. CQ

Custom Queuing (CQ) is designed to address the limitations present in PQ and WFQ. In CQ, as described in [5], each packet is classified as belonging to a particular service class and is placed in the queue for that class. Each service class is assigned a weight that corresponds to the percentage of the output bandwidth allocated to it. Packets from each queue are transmitted based on the weight assigned to their queues. It provides differentiated service, as well as guaranteed output bandwidth for each service class (even for low-priority traffic). To provide these services, routers determine the number of bytes to be transmitted for each queue based on the interface speed and configured percentage. When the calculated byte count for a given queue is has been transmitted, the router completes transmission of current packet and moves on to the next queue, servicing each queue in a round robin fashion [6]. This method is shown in Fig.2.

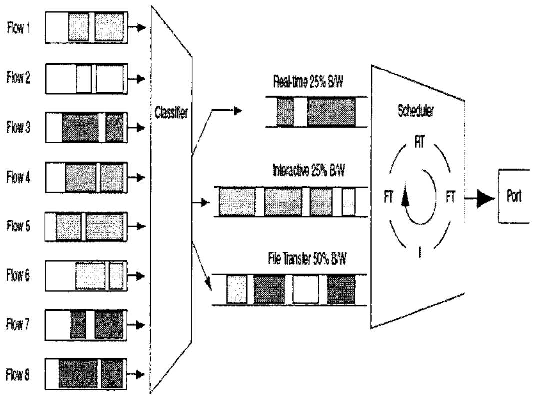

그림 2. 사용자 요청
Fig. 2. Custom queuing

With custom queuing, the unused bandwidth of one class can be dynamically allocated to any application that requires it [6]. Another advantage is that it can be implemented in hardware. With these all features this type of queuing sounds prefect for home network where home users can allocate required bandwidth for each class of home network traffic and unused traffic can even be utilized dynamically by demanding applications. It also overcomes the limitations of PQ by ensuring that lower-priority queues are not bandwidth- starved. The only limitation of this queuing discipline is that the mean packet should be known in advance to provide correct percentage of bandwidth to each service class [6].

Ⅲ. QoS in wireless networks

The wireless access point is connected to the wired LAN in home network enabling the access to resources that are located on the wired LAN such as residential gateway [1]. Since the characteristics of wireless links include lower bandwidth, higher latency and higher errors when compared to wired links, it is more important to assure QoS in wireless traffic in home network.

3.1 MAC protocol

The 802.11 MAC protocol consists of a Distributed Coordination Function (DCF) and a point coordination function (PCF). The DCF is the fundamental access method providing asynchronous service where as PCF is optional method providing synchronous service. In this protocol the time is divided into Contention Periods (CP) where DCF access is used and Contention Free Periods (CFP) in which PCF access is used [7].

DCF uses Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) for channel access, Request-To-Send and Clear-To-Send(RTS/CTS) messages for reservations and Acknowledgements (ACK) for reliability. The DCF method provides a best effort type of service whereas the PCF guarantees a time-bounded service because the frames in DCF do not have priorities, and there is no mechanism to guarantee an access delay bound to the stations. Hence, the real-time applications voice or live video transmission suffers with this protocol.

PCF would be especially well suited for real-time traffic as it permits to allocate the radio channel according to applications requirements [8]. Hence we analyze the effect of enabling PCF functionality in wireless devices for QoS assurance in home network.

3.2 Point coordination function

The 802.11 standard defines the PCF, which enables the transmission of time-sensitive information. With PCF, a point coordinator within the access point controls which stations can transmit during any give period of time. Within a time period called the contention free period, the point coordinator will step through all stations operating in PCF mode and poll them one at a time. [9].

The PC first senses the channel for PIFS (PCF Inter Frame spacing) seconds and then starts a CF (Contention Free) period by broadcasting a beacon signal. All other stations add the CF period duration to their NAV. During this CF period, stations are allowed to transmit in only two cases either in response to a pool from PC or for transmission of an ACK a SIFS interval after a packet receipt [8]. The PC continues to poll each station until it reaches the maximum duration of the CFP and the PC can terminate the CFP by sending a CF-End frame [8].

Thus, PCF is a contention-free protocol and enables stations to transmit data frames synchronously, with regular time delays between data frame transmissions. This makes it possible to more effectively support information flows, such as video and control mechanisms, having stiffer synchronization requirements.

Ⅳ. Experimental setup

The simulation experiment was set up as shown in Fig. 3 with VoIP, Video Conferencing and FTP applications to analyze the voice video and data traffic in OPNET simulator.

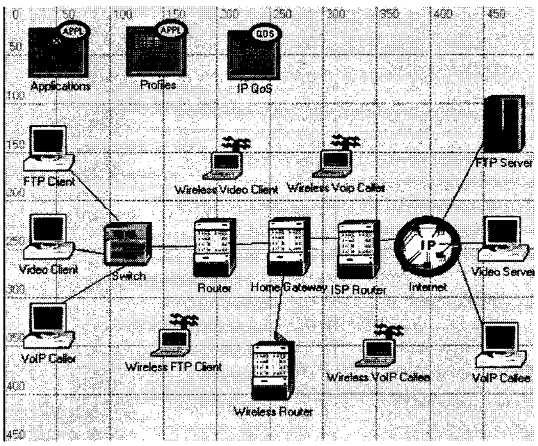

그림 3. 시뮬레이션을 위한 실험적인 설정
Fig. 3. Experimental setup for simulation

The FTP application was set with heavy load and best effort delivery ToS. The video conferencing traffic was set with low resolution video and streaming video traffic. Hence video has higher priority than data. PCM Quality Speech with interactive voice was chosen for voice traffic to provide class 1 priority for voice. The simulation did not include class 2 traffic since it does not consume much traffic. So analysis was performed with class 1, class 3 and class 4 types of applications.

So the simulation was performed in three scenarios LLQ_PCF and CQ_PCF to explore the best combination of PCF with two Queuing Disciplines LLQ and CQ. The PCF parameters were enabled in wireless devices to combine PCF in each queuing discipline.

V. Results analysis

The analysis was performed for all three kinds of traffic, voice, video and data. We also analyzed the wireless LAN performance in terms of packets dropped, delay and media delay.

5.1 Voice traffic analysis

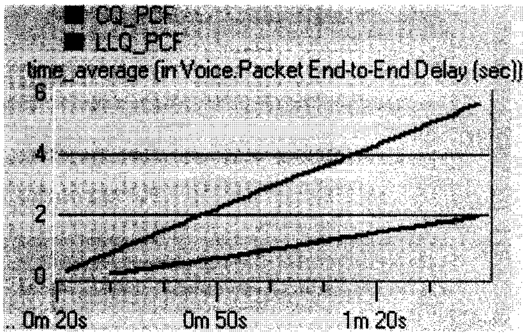

그림 4. 보이스 패킷 end-to-end 지연시간
Fig. 4. Voice packet end-to-end delay

From the Fig. 4. it is seen that the voice traffic was improved in custom queuing with less packet end-to-end delay and low jitter. Though LLQ is expected to improve for high priority voice packets for interactive VoIP, the delay decreased by LLQ was compensated by PCF parameters. Due to polling system, no collisions were there and less packets were dropped and more and more packets were waiting in a queue resulting in delay. The jitter in custom queuing with PCF was found to be almost zero as shown in Fig. 5. Hence CQ with PCF performs best for interactive voice traffic in home network.

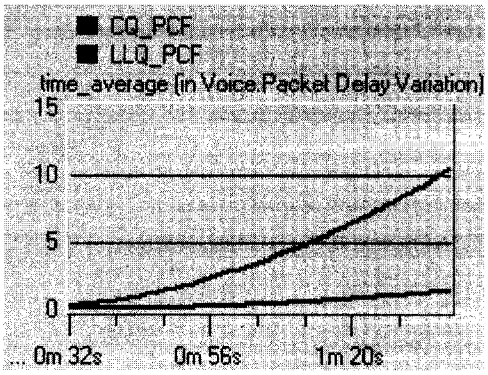

그림 5. 보이스 패킷의 지연시간 변화
Fig. 5. Voice packet delay variation

5.2 Video conferencing traffic analysis

For streaming video traffic with Video conferencing applications, CQ with PCF performed better with almost constant delay and zero jitter when compared to LLQ with PCF as shown in Fig. 6 and 7. It showed that with zero jitter and constant delay the streaming multimedia is assured in quality with custom queuing and PCF in home network.

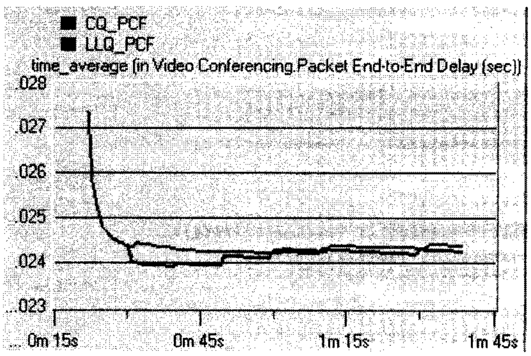

그림 6. 비디오 패킷의 end-to-end 지연시간
Fig. 6. Video conferencing packet end-to-end delay

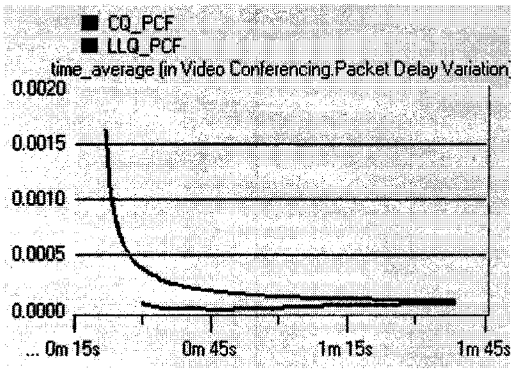

그림 7. 비디오 패킷의 지연시간 변화
Fig. 7. Video conferencing packet delay variation

5.3 FTP traffic analysis

For data traffic with FTP application also, LLQ with PCF performed better with decreased delay as shown in Fig. 8. As ftp traffic is serviced with best effort, a small delay introduced in custom Queuing with PCF does not affect much in overall QoS of home network.

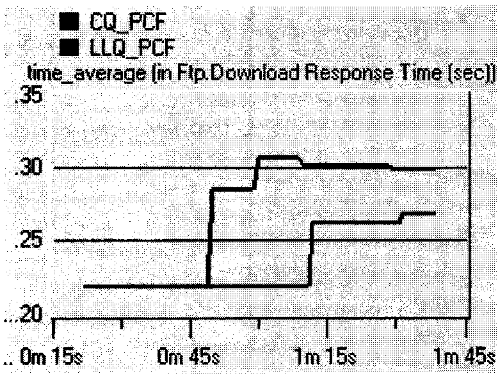

그림 8. FTP 다운로드 응답 시간
Fig. 8. FTP download response time

5.4 Wireless LAN traffic analysis

Since PCF was specially enabled for wireless devices in home network, an analysis was also performed for wireless devices. The overall wireless delay was also found to be decreased by almost 60 % with custom queuing and PCF when compared to LLQ and PCF as shown in Fig. 9.

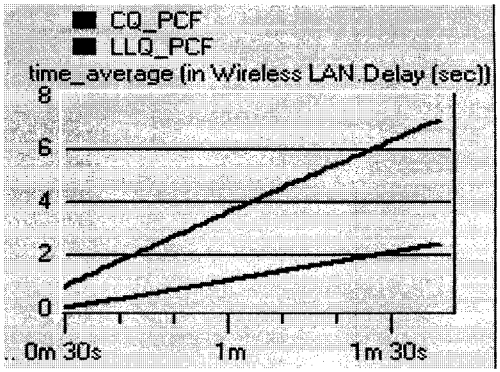

그림 9. 무선 네트워크의 지연시간
Fig. 9. Wireless LAN delay

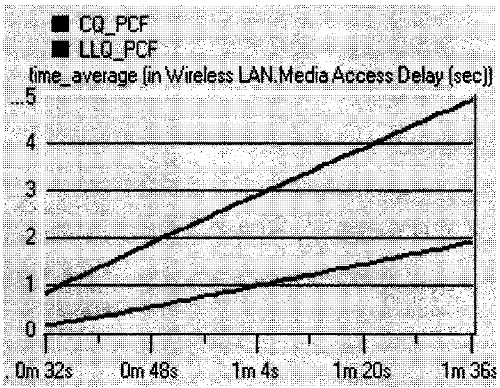

그림 10. 무선네트워크의 매체 접근 지연시간
Fig. 10. Wireless LAN media access delay

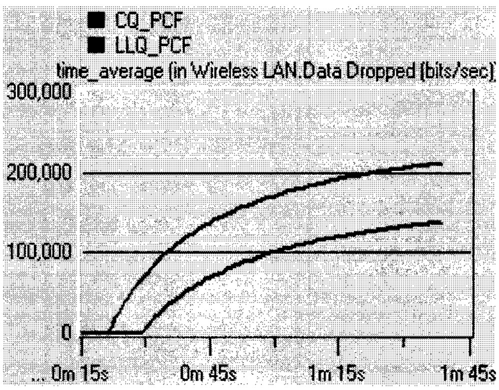

그림 11. 무선네트워크의 데이터 손실
Fig. 11. Wireless LAN data dropped.

A further analysis in Media Access Delay with PCF was studied with CQ and LLQ. It was observed that media access was also decreased by integration of CQ with PCF when compared with LLQ with PCF as shown in Fig. 10 due to bandwidth allocation and enabling PCF functionality.

The wireless LAN data dropped was also decreased more in CQ with PCF by 25% when compared to LLQ with PCf as shown in Fig. 11.

Ⅵ. Conclusion and Future works

With this analysis, we can say that class based custom queuing with PCF parameters enabled in wireless devices in home network performed the best to assure the QoS in home network in terms of bandwidth management, delay, jitter and packet loss when compared to LLQ with PCF. Specially, the real-time applications carrying voice and video traffic showed much better performance with custom queuing when compared to LLQ. In this analysis we have considered to improve the IP QoS and wireless QoS in home network. In future we would like to focus on QoS of wireless mobility in home network.

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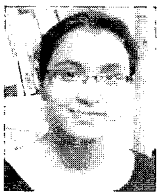

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