Seamless Handover for Multimedia Applications between Heterogeneous Wireless Networks

Hung-Wei Lin
Department of Electrical Engineering,
Tamkang University,
Tamsui, Taipei County,
Taiwan 25137, R.O.C.
696450047@s96.tku.edu.tw

Kuo-Chih Chu
Department of Electronic Engineering,
Lunghwa University of Science and Technology,
Guishan, Taoyuan County,
Taiwan 33306, R.O.C.
kcchu@mail.lhu.edu.tw

Wei-Tsong Lee
Department of Electrical Engineering,
Tamkang University,
Tamsui, Taipei County,
Taiwan 25137, R.O.C.
wtlee@mail.tku.edu.tw

Jim-Min Lin
Department of Information Engineering and Computer Science,
Fengchia University,
Seatwen, Taichung,
Taiwan 40724, R.O.C.
jimmy@fcu.edu.tw

***Abstract*—In recent years, the mobile equipments with powerful functions and convenient service feature are getting more and more popular. Those mobile equipments not only provide us many types of wireless network connections services but also with one of popular service which is video streaming. However, the most concerned problem is handover between networks during the video streaming transmission. So we propose a new algorithm based on IEEE 802.21 standard, which can dynamically adjust frame rate according to handover process in order to decrease the impact of handover. Finally, video stream can playback smoothly until end of handover procedure.**

Keywords—IEEE 802.21; Handover; Buffer management; Frame rate control

I. INTRODUCTION

The Internet multimedia applications are more and more popular at the present age. A lot of applications become parts of our life such as online game, network TV, video phone and etc. In these services, the network transmission arrive rate will affect the video streaming quality directly. Multimedia service will be delayed or interrupted by end-to-end time delay, jitter, frame error, and packet loss. However, these facts would also happen during handover.

In order to perform seamless handover between heterogeneous wireless network, IEEE group propose the IEEE 802.21 standard. IEEE 802.21 defines a middleware function to make handover smoothly, which is called Media Independent Handover (MIH) function.

When a mobile host (MH) tries to handover into another network, the media streaming must be interrupted until the new connection is established to new point-of-attachment (POA) or base station (BS). Unlike handoff in same network, there usually have no any proxy server between different networks during handover. So we try to find client side solution. Our research focus on how to make streaming continued during handover in MH. We propose a novel buffer management and frame rate control to provide enough frame packets for streaming. By this method, the multimedia service can make handover seamlessly between heterogeneous wireless networks.

The rest of this paper is organized as follows. Section 2 introduces how to calculate the total handover time in the MIH system, and introduces the buffer management of video streaming. Section 3 presents the novel buffer management of video streaming during handover. Section 4 provides our simulation model and experimental results. Finally, section 5 concludes the paper and discusses the future work.

II. BACKGROUND AND RELATED WORKS

A. IEEE 802.21-MIH

IEEE 802.21 establishes a middleware between low layers (layer 2 and below) and MIH user (layer 3 and above), which is called Media Independent Handover (MIH) function. MIH function also defines three kinds of functions: MIH Event Service (MIES), MIH Information Service (MIIS) and MIH Command Service (MICS) [1] [2]. The MIH function architecture is shown in Fig. 1.

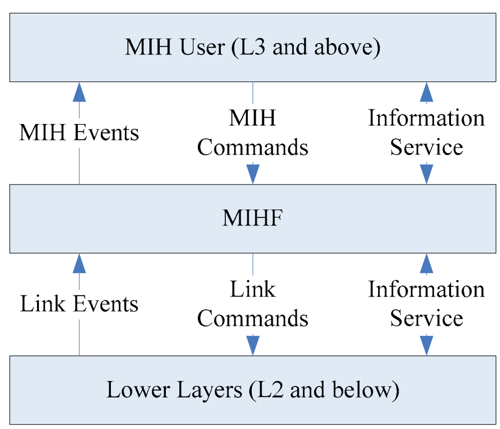

Figure 1. Architecture of MIH function.

Handover procedure can be described simply as follow. First, when MH's MAC and PHY detect link is going down with legacy BS, will scan for all candidate networks, and check resource availability of new BS. Second, MH request resource reservation to new BS through legacy BS. And then, new L2 connection is established. MH should establish the new connection before old connection is broken. Finally,

978-0-7695-3762-7/09 $26.00 © 2009 IEEE
DOI 10.1109/IIH-MSP.2009.286

MH executes higher level handover, and release resource of legacy BS through new BS [3]. The streaming service will be disrupted or delayed due to handover procedure.

In [4], a playback buffer is added into MIH framework to make handover seamlessly. Service Specific Layer (SSL) contains a buffer controller to take control of the buffer. The buffer size depends on actual no-connection time during handover. Paper [3] [4] calculate the total handover latency time in different scenario. For video streaming, we should not only concern about handover latency time, but also focus on the influence when handover happen. We will explain buffer management of video streaming later.

B. Buffer Management for Streaming

To maintain the quality of streaming service, we should concern about the buffer size of streaming. In ideal situation, the streaming buffer should be kept over low-bound and under up-bound. In order to prevent streaming underflow, low-bound is researched in [5]. Low-bound is restricted by streaming or network condition. Up-bound will be affected by a lot of facts. For example, when using cell phone to watch streaming video, storage size may limit buffer size. And in real-time service, time sensitivity influence up-bound certainly. How to keep streaming between low-bound and up-bound is an important issue in multimedia applications.

Paper [6] [7] show buffer management models during handoff. In [6], they reserve additional buffer before handoff in client queue for multicast service. In [7], they discuss how to limit low-bound and up-bound. These boundaries are decided by the interaction between server and client.

III. Frame Rate Control for MIH Buffer Management

A. Handover Duration Forecast and Buffer Control

We propose a novel frame rate control with MIH for streaming based on IEEE 802.21 during heterogeneous handover. SSL controls the buffer according to application service and MIH function. The buffer management becomes application awareness.

Fig. 2 is the proposed architecture for buffer management of multimedia applications in client queue during handover. Before handover start (H_{start}) (phase 1), stream buffer should be kept near up-bound. When handover begin (phase 2), streaming service will be disrupted temporarily. P_{loss} means streaming break point. Client would not receive frame packets during this packet until the new connection is established. The total handover time will be explained clearly in next paragraph. When new connection is established (Phase 3), the streaming service should be resumed. And stream buffer should be kept near up-bound as before.

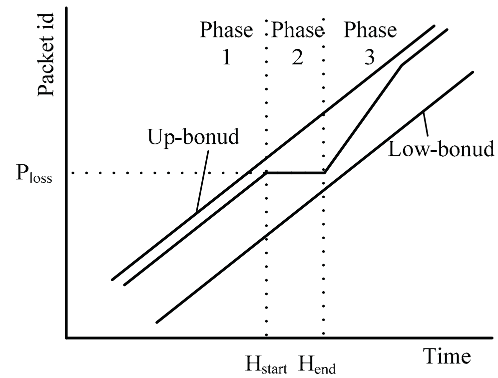

Figure 2. Architecture of MIH function.

So the total handover time Htotal can be calculate as follow:

$$H_{total} = H_{end} - H_{total} = L_2(t) + V(t) + R(t) \qquad (1)$$

Where $L_2(t)$ is the total time of Layer 2 connection. V(t) represent video session reconnection time. And R(t) is the time spend on transfer resuming.

Unlike handoff between BSs in same network, handover usually has not any proxy or mechanism to help handover procedure. And the client will use different IP to access server before and after handover. It lead server to recognize same MH as different clients after handover. So, the MH should reconnect to streaming session again and request frames from break point. That is the reason why we consider V(t) and R(t) into total handover time.

B. Playback Frame Rate Control

In this section, we discuss the buffer management in simulcast streaming service during handover. Most of simulcast streaming services is sensitive to time. Therefore, the up-bound should be decreased to transmit video immediately. That means the frame buffers in client queue are not too many. Streaming will be disrupted more easily during handover.

We propose a framework in client side to improve streaming service during handover. In our model, shown in Fig. 3, we implement a buffer control and handover duration forecast mechanism in SSL. When MIH receive a Link Going Down message from MAC, MIH will forward handover message to SSL. Then the buffer control mechanism starts to measure the rest of frames in buffer. And handover duration forecast mechanism calculates the total handover time. If the rest of frames are not enough to play in predicted total handover time, the SSL will notify applications that the streaming will disrupt due to frame run out and suggest application to adjust frame rate. Once MH decides to handover, application should begin adjusting frame rate according to the estimated total handover time.

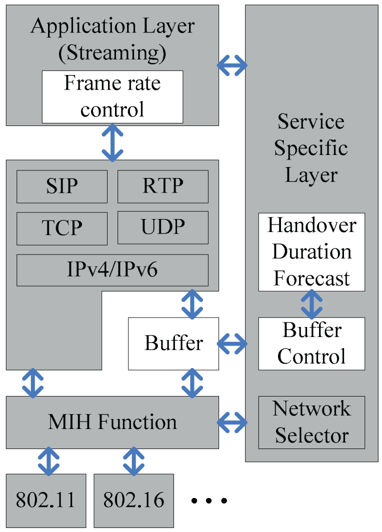

Figure 3. Buffer in MIH framework.

Fig. 4 is an example of frame rate control mechanism. In the case of playback without dynamically adjust frame rate, shown in Fig. 4a, the video frames will be played stage by stage. The queue should provide frames how many streaming want. And streaming use static frame rate to play.

Because the up-bound is decreased strictly, we have to find a method to prevent streaming underflow. Our solution is making low-bound more flexible. Fig. 4b demonstrates a simple frame rate control mechanism. At T_n, we assume the connection is broken for handover. The streaming is aware that the frames in buffer will be run out, so the streaming will slow down the frame rate. Streaming play 3 frames rather than 5 frames between T_n and T_{n+5}. At T_{n+6}, the connection is reestablished to new BS, so the frame rate should be kept up to original frame rate gradually. So streaming play 7 frames rather than 5 frames between T_{n+6} and T_{n+10}. And then the frame rate should be resumed as before. The frame rate is decreased and increased at T_n and T_{n+6}. But in real situation, the streaming plays about 30 frames per second. Although we reduce one or two frame in a second, viewers might not feel the video quality become lower.

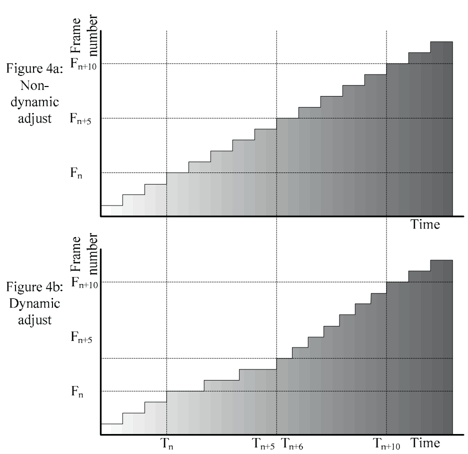

Figure 4. Example of dynamically adjust frame rate.

C. *Adaptive Algorithm for MIH*

We proposed an algorithm will be adaptive with network situation as fellows in Table 1.

TABLE I. DIAGRAM OF OUR ALGORITHM

	During Handover *(decrease)*	*After Handover* *(increase)*
$Q_{buf} > H_{total}$	$T_F = T$	$T_F = T$
$\frac{T}{T_L} H_{total} < Q_{buf} < H_{total}$	$T_F = \frac{H_{total}}{Q_{buf}} T$	$T_F = \frac{Q_{buf}}{H_{total}} T$
$Q_{buf} < \frac{T}{T_L} H_{total}$	$T_F = T_L$	$T_F = T$

When SSL decide to hop to another network, we will get a forecast value of handover duration time H_{total}. Q_{buf} is the time of rest of frames in queue can be played. SSL and application will check Q_{buf} when handover start. T is basic period of frame, which will be 33ms. T_L is the limited period, which will be determined by streaming quality. If frame rate is lower than T_L, the viewer would not accept streaming quality. TF present the period after frame rate control.

If $Q_{buf} > H_{total}$, that is, the frames in buffer are enough to play during handover. So we don't need to adjust frame rate. If Q_{buf} between H_{total} and $(T/T_L)*H_{total}$, we suggest to adjust frame rate during handover, and the frame rate should be return to T after handover. When $Q_{buf} < (T/T_L)*H_{total}$, although frame rate has been adjusted, the rest of buffers are not enough for total handover time. So the streaming is still disrupted.

IV. PERFORMANCE EVALUATION

We assume that the worst H_{total} is 10 second, and the T_L is 56ms. The streaming is constant bit rate. We also give Q_{buf}= 6 second. Fig. 5 performs that in normal situation playback streaming will be interrupted during handover because playback buffer is run out in the same time. Our proposed algorithm result will be present in Fig. 6. Playback size will be decreased when handover procedure started. After handover, we use increase mechanism to increase frame rate until T_F= T.

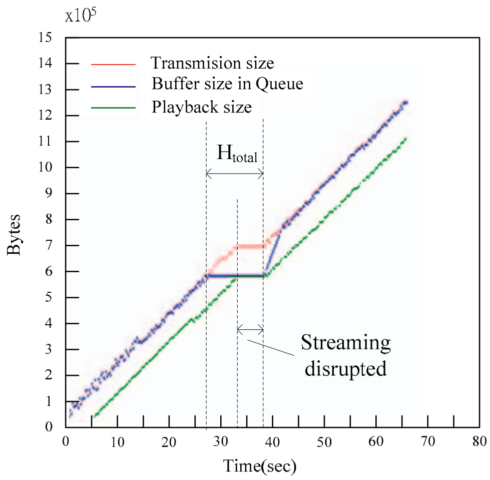

Figure 5. Playback without frame rate control.

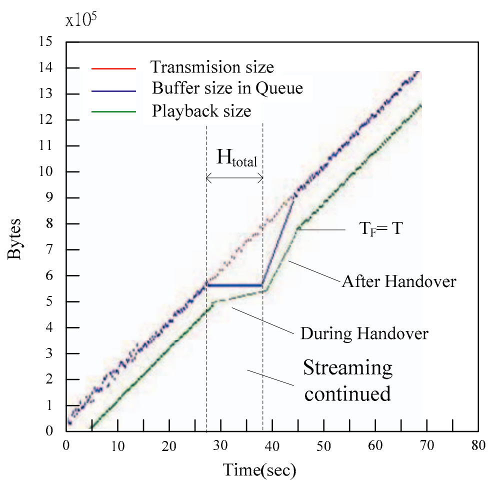

Figure 6. Playback with frame rate control.

V. Conclusion and Future Work

This paper proposed and explained a novel frame rate algorithm for multimedia applications. Video streaming will be play smoothly during heterogeneous handover based on IEEE 802.21 standard by our mechanisms. We introduce a framework of Buffer Management in MIH functions. Then we suggest to dynamically adjusting frame rate during handover for simulcast streaming.

The video encode and decode technologies are more and more mature nowadays. Some technologies even can help streaming transmit, such as error recovery, scalable video coding and so on. For the future work, these technologies can be included in our algorithm to make streaming smoothly during heterogeneous wireless handover.

Acknowledgment

This study was supported by the National Science Council, Taiwan, under grant no. NSC-96-2628-E-032-002-MY3.

References

[1] IEEE 802.21, http://www.ieee802.org/21/

[2] Antonio De La Oliva, Albert Banchs, Ignacio Soto, Telemaco Melia, Albert Vidal, “An overview of IEEE 802.21: media-independent handover services”, IEEE Wireless Communications, Aug. 2008, pp. 96-103.

[3] Ok Sik Yang, Seong Gon Choi, Jun Kyun Choi, Jung Soo Park, Hyoung Jun Kim, “A handover framework for seamless service support between wired and wireless networks”, IEEE ICACT 2006, 20-22 Feb. 2006, pp. 1791-1796.

[4] Yu-Chin Wang, Hsiang-Fu Lo, Ya-Chun Li, Wei-Tsong Lee, “Seamless Handover with Buffer Prediction for Wireless Networks Based on IEEE 802.21”, ICOIN 2008, 23-25 Jan. 2008.

[5] Hsiao-Chiang Chuang, Ching Yao Huang, Tihao Chiang, “On the buffer dynamics of scalable video streaming over wireless network”, IEEE VTC2004-Fall, 26-29 Sept. 2004, pp. 2582-2586.

[6] Sheau-Ru Tong, Sheng-Hsiung Yang, “Proactive hot-zone flow control for seamless stream handoff under mobile multicast networks”, IEEE ICME 2005, 6-8 July 2005.

[7] Sheau-Ru Tong, Sheng-Hsiung Yang, “Buffer Control to Support a Seamless Stream Handoff in a WLAN that Employs Simulcast Streaming”, IEEE Transactions on Wireless Communications, Jan. 2008.

[8] Moon Kim, Tae-wook Moon, Sung-joon Cho, “A study on IEEE 802.21 MIH frameworks in heterogeneous wireless networks”, International Conference on Advanced Communication Technology, 15-18 Feb. 2009, pp. 242-246

[9] Bogdan Ciubotaru, Gabriel-Miro Muntean, “Smooth Adaptive Soft Handover Algorithm for Multimedia Streaming over Wireless Networks”, IEEE Wireless Communications and Networking Conference, 5-8 April 2009, pp. 1-6