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IEEE 802.21-based seamless multicast streaming with dynamic playback control

Hsiang-Fu Lo [a], S. Guizani [b], Tin-Yu Wu [a,*], Wei-Tsong Lee [a], Hung-Wei Lin [a]

[a] Department of Electrical Engineering, Tamkang University, Taiwan, ROC
[b] Electrical Engineering Department, Alfaisal University, Saudi Arabia

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ABSTRACT

With the explosion of video streaming available on the Internet, online multimedia applications become more popular in our days and the video quality of the Internet multimedia applications is directly affected by the network transmission state, which will be worse while switching the ongoing network connection from one wireless interface to another heterogeneous wireless technology, such as IEEE 802 families, UMTS (universal mobile telecommunications system) network and 3GPP LTE (3rd generation partnership project-long term evolution). In order to perform seamless handover between heterogeneous wireless networks, IEEE group proposed the "IEEE 802.21 standard" and defined a middleware function called "media independent handover function (MIHF)" to smooth the handover. In this paper, a dynamic playback control for multicasting streaming based on IEEE 802.21 is proposed to reduce the influence of handover between heterogeneous networks. In addition, we evaluate three different rate modes for seamless multicasting streams. The simulation results show that different playback frame rate modes, including the usual, incremental and linear modes, can achieve different video quality and can extend the playing time for handover video playback.

1. Introduction

With the advancement and development of wireless network technologies and hand-held/mobile devices, getting popular multimedia streaming applications not only would be another kind of "killer" application for future ubiquitous networks, but also one of the most economical techniques for sending a packet stream from one location to other locations on the Internet, simultaneously. Differing from broadcasting that the data is sent to every possible receiver, multicasting means that the data is only sent to the receivers who requested. Therefore, regardless of the number of client connections, multicasting can minimize network congestion by using a fixed amount of bandwidth.

However, when a mobile node changes the access media, these heterogeneous networks may delay and lead to frame dropping or loss in real-time communication services. In order to perform seamless handover between heterogeneous networks, IEEE group proposed the IEEE 802.21 standard and defined a middleware function named "media independent handover function (MIHF)" to smooth the handover.

In the original MIH architecture, the MIHF is located between the data link layer (layer 2) and network layer (layer 3). Therefore, the information elements (IEs) belong to MIH information service (MIIS) and can be subscribed by layer 3 and above layers for supporting a handover. Furthermore, MIHF provides the event, command and information service messages to facilitate the vertical handover, but no additional and non-normative messages are accepted and sent by the MIHF. At present, due to the rapid advancement of heterogeneous network handover technologies, many auxiliary handoff mechanisms, like network selection or buffer management, have been proposed to integrate with the MIHF framework. However, the next important issue is how to integrate these new mechanisms with the MIHF.

In order to solve the above-mentioned problems, the concept of service specific layer (SSL) was proposed in [13]. The MIHF with an additional buffer communicates with the SSL function to satisfy the processing requirement of the application layer. In this work, we will further modify the SSL architecture by adding a set of dynamic playback control and handover duration forecast to facilitate seamless handover for multicast streaming.

The rest of this paper is organized as follows. Section 2 introduces the background and related works for seamless handover and buffer management. The dynamic playback controller for multicast streaming is described in Section 3. Section 4 provides our simulation model and experimental results. Finally, Section 5 concludes the paper and discusses our future work.

* Corresponding author. Address: No. 151, Yingzhuan Rd., Danshui Dist., New Taipei City, 25137 Taiwan, ROC. Tel.: +886 2 2621 5656x3292; fax: +886 2 2620 9814.

E-mail addresses: superalf@gmail.com (H.-F. Lo), sguizani@gmail.com (S. Guizani), tyw@mail.tku.edu.tw (T.-Y. Wu), wtlee@mail.tku.edu.tw (W.-T. Lee).

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2. Related work and background

This section will introduce the background of IEEE 802.21 MIH and related works and analyses about buffer space limitation for streaming.

2.1. IEEE 802.21 MIH framework

The main purpose of the IEEE 802.21 is to eliminate service interruption of handovers between heterogeneous technologies (including IEEE 802 and cellular technologies) and to enhance mobile terminals users' experience. The IEEE 802.21 establishes a middleware, media independent handover function (MIHF), between lower layers (layer 2 and below) and MIH user (layer 3 and above). MIHF defines MIH event service (MIES), MIH information service (MIIS) and MIH command service (MICS) [1,2,15]. The architecture of MIHF is shown in Fig. 1.

The streaming service will be delayed or disrupted due to the handover procedure. In [10], the MIHF was used to perform fast binding update for a low latency handover procedure. In [18], in order to offer a vertical handoff decision with a minimum of processing delay, the MIHF was adopted as transport service. In [4], a playback buffer is further added to the MIH framework to make the handover seamless. The service specific layer (SSL) that contains a buffer control to manage the buffer space according to the actual non-connection time during the handover is proposed in [13]. Moreover, the total handover latency time in different scenarios is calculated in [3,4,16].

Fig. 2, presented in [20], explains different steps of the handover progress in two phases and reveals the IEEE 802.21 message exchanges in mobile- and network-initiated handover procedures in the case that the mobile node hands over from a Wi-Fi to the 3G cellular network and then to a WiMAX network.

In phase I, the mobile node has two network access options: a Wi-Fi network or the cellular operator's 3G/UMTS network. In order to discover the candidate PoAs (point of attachment), the mobile node MIHF employs MIIS to gather static information about the surrounding networks. The request issued over the currently used WiFi access is obtained from the Information Server that may reside in a different network instead of the one currently in use.

After receiving the response as the Information Request, the mobile node queries about the availability of the desired network resources and initiates the handover process. The requests are delivered through the serving PoS (point of service) of WiFi, which disseminates the requests to the MIH PoSs of the candidate networks, 3G-PoS and WiMAX-PoS. Next, the response indicating the capabilities of the two candidate networks is returned to the mobile node MIHF from the serving PoS. Based on this information and the policies and the output of the mobile node's network selection algorithms, an MIHU on the mobile node determines which network to handover to. Next, a handover commit request message is sent. After the candidate network makes its final commitment for the handover, the mobile node establishes a layer 2 connection with the PoA in the area of the candidate PoS, i.e. the 3G-PoS in our example. Thanks to the successful intertechnology handover, the resources used in the previous link can be released optionally. When no resources are explicitly reserved, this step can be skipped.

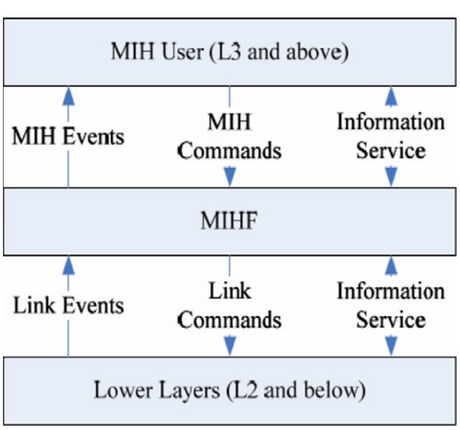

Fig. 1. Architecture of the MIHF.

In Phase II, the device goes through a cellular technology handover from 3G/UMTS to enhanced data rates for GSM evolution (EDGE). At the same place, the WiFi network is still available and a new WiMAX network has just been detected. Therefore, the Wi-Fi or the WiMAX network should be considered on vertical handover. The network-side MIHU initiates a handover to the WiMAX network. For example, the result of observing congestion in the cellular network that indicates that a new PoS should be found for the mobile node. The serving 3G-PoS collects the information about the networks in the mobile node's range from the information server. Upon determining a suitable WiMAX candidate network that can serve the mobile node, the 3G-PoS triggers a network-initiated handover. First, the serving PoS requests the permission from the mobile node to proceed along with the handover. If the mobile node does not object, the serving PoS proceeds with the rest of the handover procedure, which is similar to the mobile-initiated handover described previously except that it is handled by a network entity.

2.2. Buffer space limitation for streaming

To provide a high-quality end-user experience, buffer plays an essential part in creating, delivering, rendering streaming media content, and enabling media players. To maintain the quality of streaming service, we must pay special attention to the streaming buffer space. However, the larger the buffer size is, the longer the broadcast may be delayed. The advantages and disadvantages of several proactive and reactive buffer management approaches are discussed in [19]. In an ideal situation, the streaming buffer should be kept between the buffer's lower-bound and upper-bound. In order to prevent the streaming from underflow, the lower-bound is researched in [5]. Usually, the lower-bound is restricted by the streaming or the network condition while the upper-bound is affected by many factors, like the cell phone storage limitation. As for real-time services, time sensitivity certainly influences the upper-bound. Therefore, how to maintain the streaming between the lower-bound and upper-bound is an important issue in multimedia applications.

Buffer management model during the handoff was discussed in [6,7,9,11]. In [6], an additional buffer was reserved before the handoff in client queue for multicast service. Further discussion on how to limit the lower-bound and upper-bound was presented in [7]. Generally, these boundaries are decided by the interactions between servers and clients. Seamless stream handoff theoretical results that can be guaranteed in terms of the minimum buffer and backlog requirements were derived from [9]. A novel model-based adaptive media playout (AMP) buffer control was proposed to mitigate the risks of buffer outage in [11]. In this paper, we only focus on the improvements in the balance of handover duration and playback control by using the SSL for the MIHF.

3. Dynamic playback control for seamless multicast streaming

To guarantee the seamless streaming service during the handover, this section proposes a novel playback frame rate adjustment mechanism with the SSL for MIHF framework previously