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QoS-guaranteed Mobile IPTV service in heterogeneous access networks

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ABSTRACT

Internet Protocol Television is defined as a multimedia service delivered over IP-based networks supporting quality of service (QoS), quality of experience (QoE), security, interactivity, and reliability. This service is rapidly expanding to both wireless and mobile networks through mobile devices. This trend demands a seamless IPTV service architecture for those mobile devices in heterogeneous access networks. This is because the convergence of the heterogeneous access networks can resolve their own service-coverage limitations, eliminating dead spots. We first briefly research on the background and trend for the seamless IPTV service for heterogeneous networks. Next we propose a new system architecture taking the relevant technical issues into account. This architecture is mainly composed of three parts, (i) information of network conditions on client, (ii) signaling for communicating between client and server with information of network conditions, and (iii) adaptive streaming based on information of network conditions. The proposed architecture can be deployed on any Internet protocol layers such as application layer, transport layer and network layer. In this paper, we evaluate two cases such as (i) RTSP in application layer and (ii) SCTP in transport layer and compare them through the performance evaluation. The results in the evaluation show that the proposed architecture meets well the requirements of the minimum IPTV service performance recommended by ITU-T international standard for the QoE over heterogeneous access networks.

1. Introduction

Internet Protocol Television (IPTV) service has rapidly been expanded to wireless mobile areas. In other words, users are able to use IPTV services everywhere and even in motion. The traditional IPTV service targets for the quality-of-service (QoS) and the quality-of-experience (QoE) guaranteed wired networks which should provide at least 10 Mbps according to the ITU-T specification. Therefore, seamless IPTV service in wireless mobile environments (a.k.a. Mobile IPTV) [1] must overcome several technical obstacles for the commercial service. Mobile IPTV implies at least one wireless network between the source and the destination. Therefore, most of the technical challenges are related to the lack of bandwidth and the mobility of mobile devices in the wireless networks.

In particular, mobile devices equipped with multiple access technologies including wired and wireless network interfaces are becoming common. Consequently, more frequent handovers between different access technologies become required. These mobile devices (e.g., mobile phones, smartphones or even laptops) may be reachable through

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multiple interfaces even simultaneously. The possibility of using a single or multiple interfaces at a time for sending and receiving IP packets depends on the mobile device capabilities. In both cases, handover between heterogeneous networks (a.k.a. vertical handovers) can occur. A significant change in the access network as a result of a handover may also affect End-to-End (E2E) path properties such as bandwidth, latency, data throughput, bit-error rate, and so on. Eventually, this situation makes IPTV systems have more challenges to provide seamless IPTV services with IPTV mobile devices equipped with multiple network interfaces.

The rest of this paper is organized as follows. Section 2 shows the background and motivation of Mobile IPTV in brief. Section 3 describes related work and Section 4 describes our Mobile IPTV system architecture, service modeling, and vertical handover decision algorithm. Section 5 describes evaluation criteria based on the ITU-T requirements. Based on the system architecture and evaluation criteria, we describe two approaches such as RTSP-based approach in Section 6 and SCTP-based approach in Section 7, respectively. Finally, Section 8 concludes this paper along with future work.

2. Background and motivation

IPTV service expansion has several technical issues when in heterogeneous access networks with the support of handover, the IPTV may affect E2E path properties such as bandwidth, latency, data throughput, and bit-error rate [2]. Note that these properties are parts of Information of Network Characteristics (INC). The changes of the INC in the local access network and consequently those in the E2E path are usually not detected nor reacted quickly enough by higher layer transport protocols and applications. Typically the higher layers do not react to the changes in path properties until certain mechanisms, such as congestion control or error recovery, eventually get invoked at some point later. This may cause undesirable disruptions, performance degradation to the ongoing connections, unnecessary underutilization of the available network capacity, or sudden overloading of the next access network involved in handover. This can lead to the dissatisfaction for IPTV service in the expansion to more heterogeneous access networks.

For example, in the case of Mobile IP [3] where a mobile node performs a handover from IEEE 802.11b WLAN network (high bandwidth link) to CDMA Cellular network (low bandwidth link), the home agent and correspondent nodes may still continue transmitting at the rate adapted to 802.11b bandwidth. As the actual path capacity becomes now smaller, a packet loss burst will occur and often result in inefficient loss recovery at the transport protocol level. This situation could be resolved by explicitly informing the other connection peer of the significant changes of the INC in the local access network. Unfortunately, existing IP mobility, transport and application layer protocols do not provide any facility to indicate which type of network the mobile node is currently attached to or what kind of changes happened on the local access network.

As of now, a wired network is used for the communication between the fixed IPTV device at home (via set-top box as usual) and the IPTV streaming server at IPTV service provider. Recently, a wireless network is popularly used for the communication between the Mobile IPTV device and the IPTV streaming server in both indoor and outdoor via various wireless network technologies such as Wireless Local Area Network (WLAN, e.g., Wi-Fi) and Wireless Wide Area Network (WWAN, e.g., WiMAX and Cellular Networks such as 3G, 4G and even LTE-Advanced) as depicted in Fig. 1. The conditions of the local INC may also vary significantly as a result of a handover between the networks of the same type (called horizontal handovers).

For example, the current network may have significantly more traffic load than the previous network or the new route taken by the IP traffic may have different E2E path properties. Moreover, even if the mobile node stays on the same network, the conditions of the local INC may change significantly due to various reasons, for example, because of sudden variations of the traffic load on the current network. All of these situations may lead to similar as much negative effects as those with vertical handovers. Therefore, to support the seamless IPTV service in heterogeneous access networks, a Mobile IPTV system architecture becomes required at this point. In next section, for this seamless IPTV, we will propose a Mobile IPTV system architecture.

3. Related work

In this section, we introduce related work in terms of seamless streaming multimedia services over the Internet. Nowadays, streaming contents over the Internet are provided by multiple transport protocols for data delivery rather than the unified solution. Most of significant example is Real Time Streaming Protocol (RTSP) [4] that is making the transmission of data even more efficient than other previous protocols. Especially, RTSP is ideal for video broadcasting since it places a high priority on continuous streaming rather than on other factors. However, the biggest issue with RTSP is that the protocol or its ports may be blocked by routers or firewall settings, preventing a device from accessing the streaming contents.

In contrast to RTSP, Hypertext Transfer Protocol (HTTP) [5] is more widely supported in content distribution networks and does not depend on any special sever rather than a standard HTTP server. This is why HTTP is more popularly used than RTSP. Also HTTP is generally accessible and allowed to traverse firewalls using TCP port 80, which can facilitate the HTTP delivery of contents in many cases. As the standard protocol for the Web, HTTP is originally designed to reliably transfer data (e.g., text documents, email, executable programs, and HTML web pages) over the Internet, while enforcing maximum reliability and data integrity rather than timeliness. However, when HTTP is used to transmit the streaming contents relying on time-based operation, it is much more likely to cause major packet drop-outs due to TCP based retransmission for packet loss, and it cannot deliver nearly the same amount of streams as RTSP transmission. Along with RTSP, various protocols can be used for supporting seamless IPTV service in heterogeneous access networks. Regarding contents streaming in Mobile IPTV, an IPTV architecture should