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A Pragmatic Media-Sharing Device for ATSC Mobile DTV Broadcasting

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Abstract

The recent proliferation of smart and portable devices has made multimedia streaming services available in mobile communication networks, which sometimes causes heavy traffic and network congestion problems. In contrast, there are no network congestion issues in mobile broadcasting networks. Due to the unidirectional property of mobile broadcasting networks, it is possible to provide multimedia streaming services efficiently. This paper, therefore, proposes a pragmatic media-sharing device capable of receiving ATSC Mobile DTV broadcast and relaying it to several smart and portable devices through Wi-Fi. The proposed device provides both multimedia streaming and data services of ATSC Mobile DTV broadcast and works well with smart devices based on different mobile operating systems such as Android and iOS.

Keywords: *ATSC Mobile DTV, Smart Device, N-screen, RTSP, HLS.*

1 Introduction

The successful deployment of smart and portable devices such as smart phones and tablet computers makes ubiquitous access to digital multimedia contents easy. Due to the powerful connectivity of smart and portable devices, N-screen services attract much attention from communication operators, broadcasters, and content providers in [1]-[3]. As well known, it is a technology or service enabling uninterrupted access to contents with different interconnected terminal devices and allows new service creation by combining the services provided by each of the different devices. Its popular service is real-time and live multimedia content streaming such as sports and concerts. However, it will incur a significant amount of traffic when it is delivered to individual viewers over a mobile communication network. Furthermore, the mobile communication network might break down because of an abrupt increase of traffic. In contrast, a mobile broadcasting network is suitable for such a service since it can deliver the service to a massive population over a wide coverage area.

Advanced Television System Committee (ATSC) standard for terrestrial digital television (DTV) has been used for fixed reception in North America and Korea. In 2009, ATSC Mobile DTV standard was established to enable mobile reception retaining compatibility with legacy ATSC systems in [4]-[6]. Since it is an in-band system using a portion of the 6 MHz frequency bandwidth allocated for legacy ATSC systems, mobile DTV services can be provided without affecting existing services. Recently, its field tests have been carried out in major cities of the United States. ATSC Mobile DTV is built on a robust transmission system using vestigial sideband (VSB) modulation, coupled with an Internet Protocol (IP) based transport system to consider its integration and compatibility with mobile phones and portable devices. However, smart and portable devices deployed in the market cannot receive ATSC Mobile DTV because they don't have an embedded chipset solution supporting it.

In this paper, therefore, a pragmatic media-sharing device enabling smart and portable devices to receive ATSC Mobile DTV broadcast is presented. It can receive ATSC Mobile DTV broadcast and relay it to several smart and portable devices, that might work on different mobile operating systems (OSs), through Wi-Fi in order to provide multimedia streaming and data services. In addition, it is implemented by using an ATSC Mobile DTV module, a ARM core processor, and a Wi-Fi module, and its software stack supports real-time streaming protocol (RTSP) [7]-[9] and HTTP live streaming (HTS) [10]-[12] protocols.

2 ATSC Mobile DTV Broadcast

The ATSC Mobile DTV broadcast system is illustrated in Fig. 1. It exploits the Reed-Solomon (RS) frame structure providing two-dimensional virtual interleaving. It can improves the mobility when compared to the legacy ATSC DTV broadcast system. The logical data channel, called as Ensemble, is composed of continuous set of the RS frames. Each ATSC Mobile DTV frequency can carry a maximum of 32 Ensembles which are logical pipes for IP packets and provide mobile broadcast services. In ATSC Mobile DTV receivers, RS frame decoding of Ensembles causes some problems in terms of computational complexity and power consumption, that restricts the number of Ensembles to

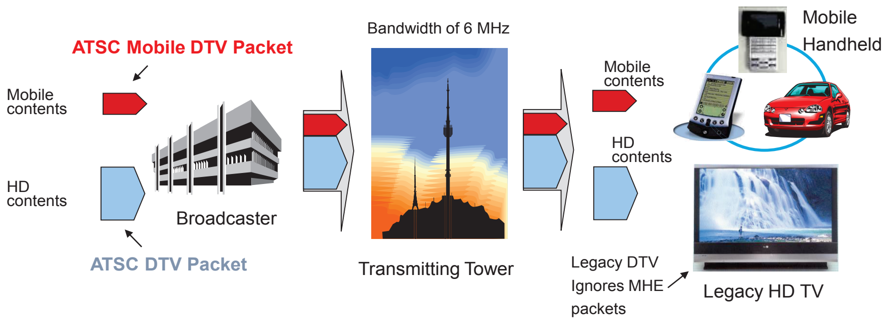

Figure 1: ATSC Mobile DTV broadcast system.

be received and processed [13].

The ATSC Mobile DTV layer model is shown in Fig. 2 where, as mentioned above, mobile broadcast services from contents provider are carried on IP packets consisting of different elements such as Service Signaling Channel (SSC), Real-time Transport Protocol (RTP), and File Delivery over Unidirectional Transport (FLUTE), etc. The SSC provides the basic information, the logical structure of mobile broadcast services and the audio and video (A/V) decoding parameters. The RTP carriers A/V streams and the FLUTE carriers Electronic Service Guide (ESG) of Open Mobile Alliance (OMA) Mobile Broadcast Services Enabler Suite (BCAST). To receive mobile broadcast services, an ATSC Mobile DTV receiver searches and processes the Fast Information Channel (FIC) including cross-layer information to enable a fast service acquisition. The FIC and SSC provide the list of services available with their respective IP addresses and port numbers, as well as other program information. Then, a user can select a particular service by using information from the FIC and SSC and enjoy it by processing the RTP.

3 Pragmatic Media-Sharing Device

In this section, the proposed pragmatic media-sharing device is described to receive ATSC Mobile DTV broadcast and deliver its services to smart and portable devices working on different mobile OSs such as Android and iOS. To share mobile broadcast services with smart and portable devices, we have to convert them to streaming formats used in smart and portable devices. For multimedia streaming, Android supports both Real-Time Streaming Protocol (RTSP) and HTTP Live Streaming (HLS), and iOS supports HTTP Live Streaming (HLS).

RTSP is a network control protocol published by the Internet Engineering Task Force (IETF) [7], which is designed for use in entertainment and commu-

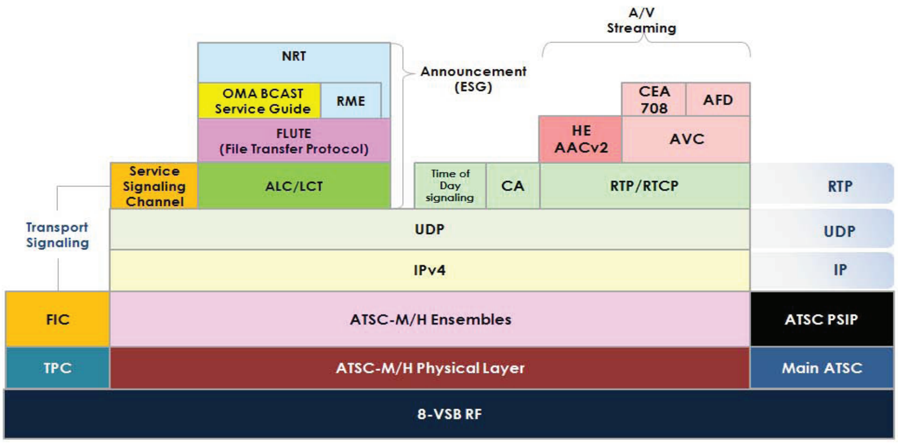

Figure 2: ATSC Mobile DTV layer model.

nications systems such as Voice over IP (VoIP), teleconferencing, etc . Most RTSP uses Real-time Transport Protocol (RTP) in conjunction with Real-time Control Protocol (RTCP) for media stream delivery where RTP/RTCP are used for actual media streaming and quality of service (QoS), respectively. In addition, RTSP provides media replay information and media server control requests such as play, pause, etc. Thus, RTP/RTSP protocols, shown in Fig. 3, can provide low-latency data transmission and efficient media delivery between an Android device and a Pragmatic Media-Sharing Device. Since ATSC Mobile DTV uses the RTP format, it requires a minimum effort to implement RTP/RTSP protocols.

HLS is an HTTP-based media streaming protocol defined by Apple [10], so it is used for multimedia streaming with iOS devices. Especially, it can provide video resolution selection according to hardware performance and network conditions [14], whereas it requires additional works such as MPEG-2 transport stream (TS) encoding, stream segmentation, and media indexing as shown in Fig. 4. It is worth knowing that H.264/MPEG-4 Advanced Video Coding (AVC) and Advanced Audio Coding (AAC) are used in ATSC Mobile DTV broadcast systems and these are supported by most smart devices.

The proposed pragmatic media-sharing device is illustrated in Fig. 5. It consists of an ATSC Mobile DTV receiver module, a main processor, and an Wi-Fi module. The main processor works on an ARM9 core operating at 345 MHz, and the Wi-Fi module supports average data rates of approximately 10 Mbps. The data rates of ATSC Mobile DTV multimedia audio/video contents are about 600 to 700 kbps. Therefore, more than 10 simultaneous client connections can be provided, but less than 10 connections are practically provided due to low power operation requirements [15]. The software stack provides functions of ATSC Mobile DTV Rx chipset controller, Rx data buffer management,

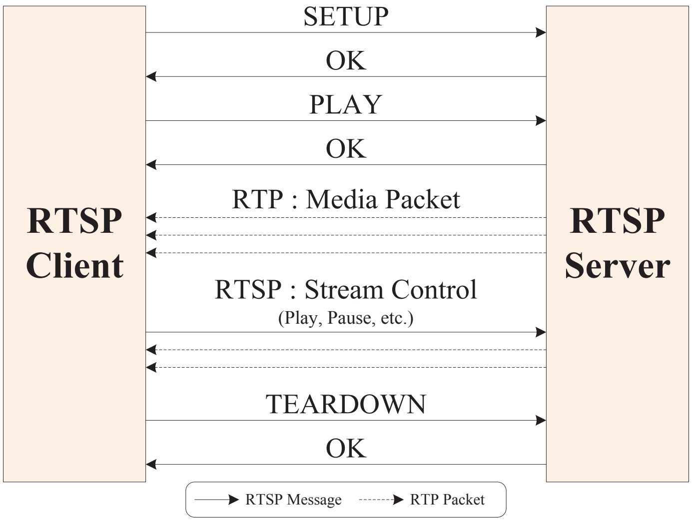

Figure 3: RTP/RTSP protocols between an Android device (client) and a pragmatic media-sharing device (server).

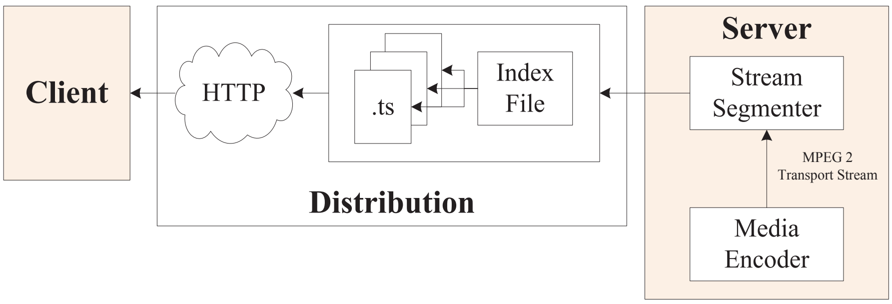

Figure 4: HLS Protocol between an iOS device (client) and a pragmatic media-sharing device (server).

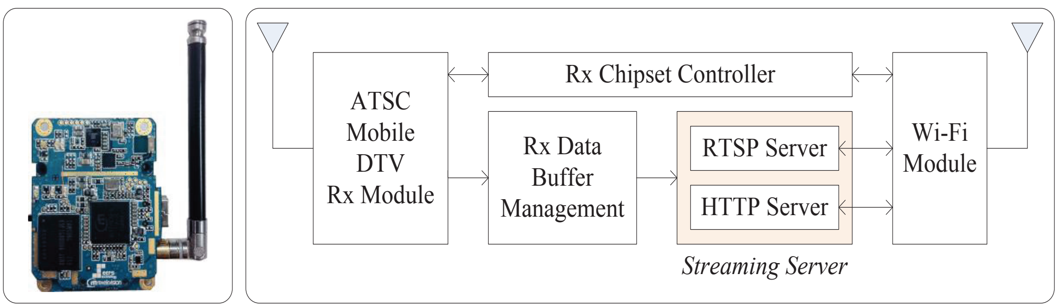

Figure 5: Pragmatic media-sharing device.

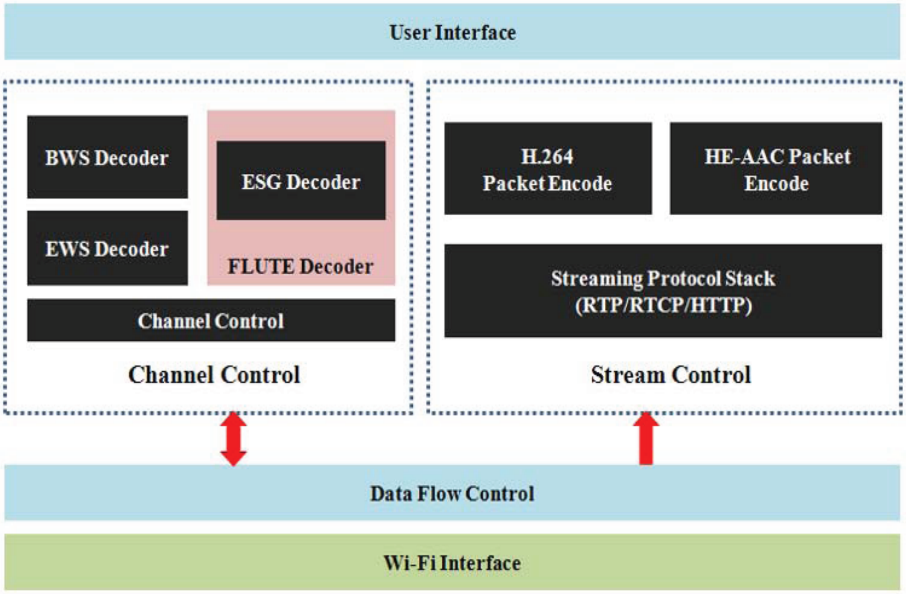

Figure 6: Software stack on smart devices.

HTTP web server for HLS, and RTSP server. For streaming to smart devices, it performs FIC/SSC decoding and audio/video timing synchronization.

Fig. 6 shows the software stack on smart devices to provide ATSC Mobile DTV broadcast services. It is roughly composed of two parts: a channel control block and a stream control block. The channel control block exchanges channel and control information between a pragmatic media-sharing device and a smart device and has Electronic Service Guide (ESG) and Emergency Alert System (EAS) decoders to provide additional data services related to the ATSC Mobile DTV. The stream control block decodes the media streaming (namely, RTSP or HLS) from a pragmatic media-sharing device according to its mobile OS.

Fig. 7 shows a communication protocol between a pragmatic media-sharing device and a smart device. The proposed device and the smart device act as a server and a client, respectively. By using the User Datagram Protocol (UDP) protocol, they communicate with each other where the server delivers the received broadcast data to each of the connected clients and the client processes the ATSC Mobile DTV configuration and setup data. After connection establishment, the client sends information about its mobile OS to the server. Then, the server prepares itself for the corresponding client and goes into standby mode. The client sends a frequency tuning command to the server to receive the ATSC Mobile DTV broadcast services. As a response, the server sends the Ensemble information to the client. The client decodes and extracts the FIC and SSC from the Ensemble and obtains information about the available services. Based on the service information, the client request multimedia

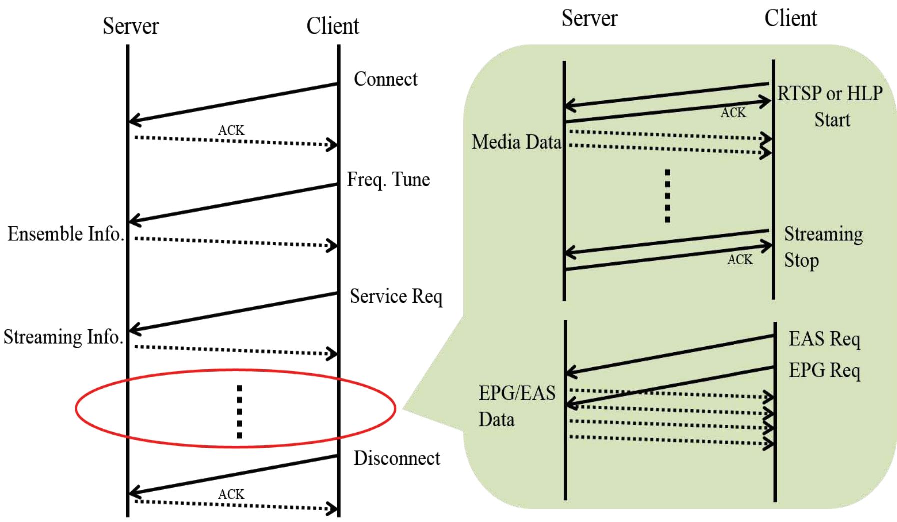

Figure 7: Communication protocol.

streaming to the server by using RTP/RTSP or HLS. In addition, the client can request ATSC Mobile DTV data services. For example, the client knows the existence of Electronic Program Guide (EPG) from Guide Access Table (GAT) in the SSC and request the EPG data to the server.

The proposed device can support multiple connections to different smart devices by using their own IP addresses but process only one Ensemble at a time since it has only a single ATSC Mobile DTV receiver chipset.

4 Experimental Results

This section represents the implementation and lab-test results of the proposed pragmatic media-sharing device. Fig. 8 illustrates the experimental environment consisting of an ATSC Mobile DTV signal generator, the proposed device, and smart devices (iOS and Android). The proposed device receives ATSC Mobile DTV broadcast (multimedia streaming or data services) and relays it to smart devices by using RTP/RTSP or HLS in accordance with mobile OSs. The smart devices (iOS and Android) show the multimedia streaming service and EPG service, respectively. In Fig. 9, the iOS device plays the multimedia streaming service about six seconds later due to its overhead related to HLS such as MPEG2-TS streaming, segmentation, and indexing when compared to the Android device.

The power consumption and time delay of the proposed pragmatic media-sharing device are shown in Table 1. In standby mode, the power consumption of the proposed device is about 91 mW. In A/V play mode, the maximum instantaneous power consumption is about 291 mW. The time delays for A/V

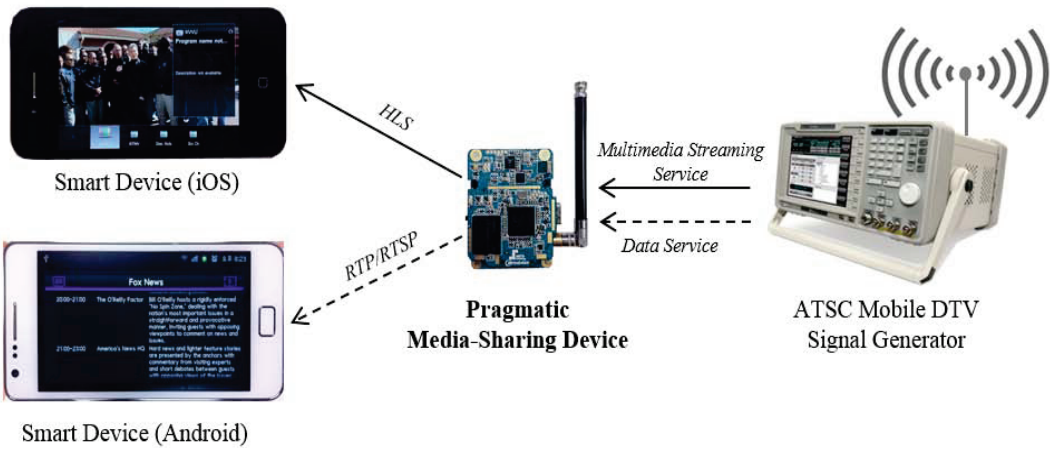

Figure 8: Experimental environment: ATSC Mobile DTV signal generator, pragmatic media-sharing device, and smart devices (iOS and Android).

Table 1: Power consumption and time delay

Power Consumption (mW)	Time Delay (s)
Standby (91)	RTSP (1∼2)
Channel Scan (227)	HLS (6∼9)
Play (291)	

presentation on smart devices are about 1∼2 for RTSP and 6∼9 for HLS, respectively.

5 Conclusion

In this paper, a pragmatic media-sharing device was presented to enable smart and portable devices to receive ATSC Mobile DTV broadcast. It was designed and implemented by using an ATSC Mobile DTV receiver module, a main processor, and an Wi-Fi module. In addition, its software stack could provide functions of ATSC Mobile DTV Rx chipset controller, Rx data buffer management, HTTP web server for HLS, and RTSP server. The software stack on smart devices and the communication protocol was developed to realize ATSC Mobile DTV broadcast services.

Experimental results showed that the proposed device could receive ATSC Mobile DTV broadcast such as multimedia streaming and data services and relay it to smart devices on different mobile OSs (iOS and Android) by RTS/RTSP and HLS protocols through Wi-Fi. It is expected that the proposed device can provide effective N-screen services without serious traffic problems and new

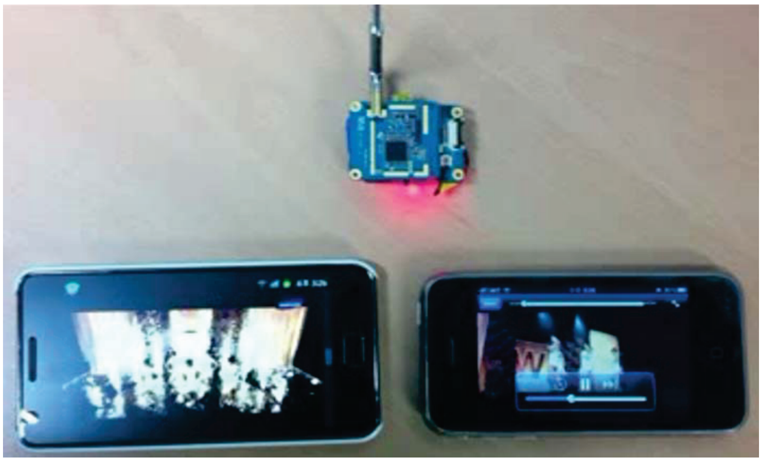

Figure 9: Implementation and lab-test results.

business opportunities to communication operators, broadcasters, and content providers.

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