

# Channel Change Time Analysis System for Measuring the Performance of Television Broadcasting Systems Using the CZT Channel Offloading Method for MMT Technology

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## 1. Abstract:

The remote-control process is crucial for TV channels, especially for changing channels when an advertisement starts, as this concerns advertisers. Studying this effect has been a focus for researchers in the media technology field in the past decade. This article presents an empirical analysis of channel change time, an important metric for measuring the quality of the broadcast service experience, in relation to MMT and MPEG technologies. The important factors determining channel change time for each technology are studied analytically.

Additionally, an efficient method is developed to enable faster channel switching for MMT technology. Furthermore, the efficiency of channel offloading time is measured, and a comparison is made between MMT and MPEG technologies in terms of segmentation for the television broadcast channel.

Keywords: remote control, television broadcasting, TV advertisers, media technology, MPEG, MMT.

## 1. Introduction

The last decade of the 20th century witnessed significant advancements in modern technological systems related to digital television broadcasting. The period following it experienced a special kind of development in media technology systems in general, and especially in television broadcasting systems concerning content delivery [1-3]

Among the most important changes in media content are the emergence, spread, and evolution of Ultra High Definition (UHD) video, as well as the rise of multimedia devices such as smart TVs, smartphones, and tablets. Additionally, Internet Protocol (IP) networks began to grow and evolve effectively, becoming widely used across different services. This evolution made it essential to implement a hybrid delivery coordination process that involves delivering media content over heterogeneous networks to enable new services and distribution models for broadcast systems. As a result, these changes have provided new opportunities for broadcasters, but also present a set of technical challenges [4-6].

It is worth noting that in digital broadcast systems, the media transport and delivery technologies in use are limited in their ability to accommodate the aforementioned changes. For example, the transport stream size for Motion Picture Experts Group (MPEG) data is small and fixed, making it an effective standard for coordinating broadcast programs.

However, this becomes ineffective for delivering UHD video, which requires a high bit rate. For UHD video, the maximum bit rate that must be supported is around 100 Mbps. As for bitrates, the MPEG-2 transport stream, which is fixed at 188 bytes, is inadequate. Given that MPEG-TS networks are not IP-based, using MPEG-2 TS to deliver content over IP networks becomes one of the primary challenges in digital television broadcasting technology [7-9].

Based on the challenges and developments mentioned, new MPEG standards were developed for content

delivery in broadcast systems. Among the most important of these is the Multimedia Middleware Transport (MMT) technology, which is the latest MPEG technology for transporting and delivering multimedia content across heterogeneous networks, including both bidirectional IP networks and unidirectional broadcast networks. The goal is to provide next-generation multimedia services with new features such as UHD video content, multiple audio tracks, and multi-device display capabilities. Additionally, MPEG-DASH is an adaptive bit rate streaming technology that enables high-quality media

streaming using the developed HTTP protocol [10, 11]. Due to its flexibility and scalability, MMT and MPEG have been adopted as protocols for service delivery in broadcast systems and online live streaming services. Channel offloading time refers to the delay between the moment a user selects multimedia content (such as TV service) and the moment the content is displayed on the terminal device. It is generally the sum of several delays that occur during the channel offloading process, including tuning, forward error correction (FEC) at the physical layer, de-jittering, service information acquisition, stream access point (SAP) delay, audio/video decoding and rendering, and conditional access (CA)/digital rights management (DRM) decryption. This paper presents an empirical analysis of channel offloading performance for MMT and MPEG technologies, highlighting the factors that determine offloading time for each technology. A simple and efficient method is proposed to enable faster channel offloading for the MMT standard. This paper focuses on minimizing delays directly related to protocol operations [12-14].

## 2. 2. Previous Studies

**Junior et al. (2024):** This paper suggests a method to evaluate latency tolerance considering both OTA (Over-The-Air) and OTT (Over-The-Top) delivery scenarios using the multi-stream delivery capabilities of MPEG-H Audio. The evaluation is conducted using a network delay

simulator with a Gaussian-based delay profile [15].

**Nionom et al. (2020):** In this paper, the researchers evaluate subjective experience quality and objective service quality at the application level for video transmission over IP with H.264/AVC and AL-FEC (Application-Level Forward Error Correction) mechanisms for MMT (MPEG Media Transport), an application-level protocol for video transmission [16].

**Zhao et al. (2022):** This paper presents the transport layer (TL) requirements, a brief overview of the candidate technologies, test report analysis with further details,

standardized evaluation [17]. **Asakura et al. (2023):** They conducted full verification trials in four urban cities in Japan. These trials confirmed that basic services such as UHD content for fixed reception and HD content for mobile reception could be delivered simultaneously. Furthermore, they verified MMT/IP-based integrated broadband broadcasting services using broadcast and broadband

data [18].

**Kohn et al. (2023):** This paper discusses the implementation of a new main terrestrial television system capable of receiving both ATSC 3.0 UHD terrestrial broadcast signals and ATSC 1.0 HD broadcast signals simultaneously [19].

**Xi et al. (2024):** This review focuses on classifying and distinguishing existing concepts, connecting them with recent literary reports, to provide readers with an overview of the thermodynamic and kinetic aspects of green manufacturing using TPS. Furthermore, the review summarizes the potential of green solvents and green polymers for preparing materials based on TPS to combat post-consumption waste and expand their application [20].

## 3. Proposed Model

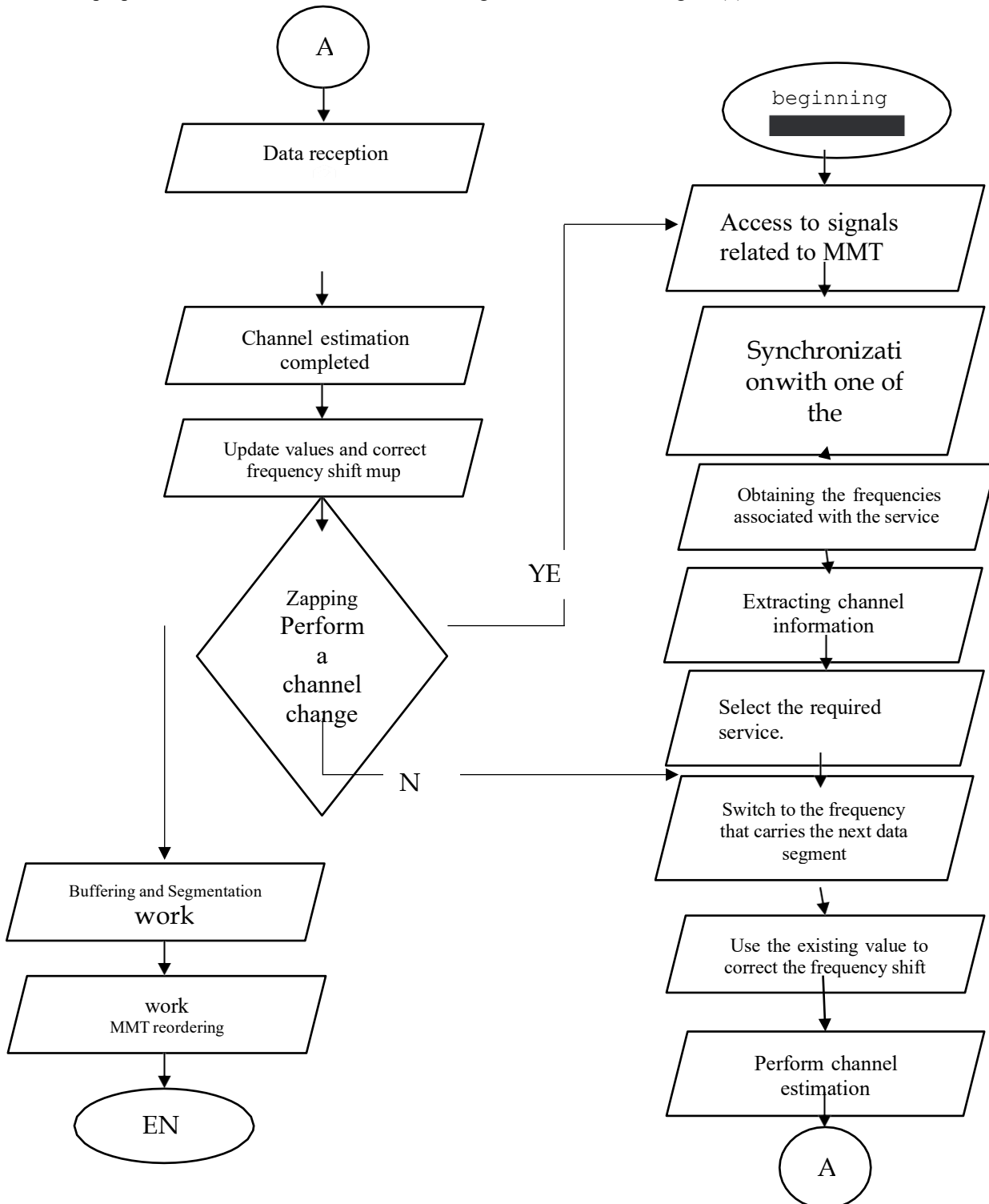
Hybrid broadcast services enable the operation of digital broadcast services through multimedia broadcast networks that are primarily based on the Internet Protocol (IP). The channel change time, which is the delay occurring when the user switches between TV channels, should not fluctuate significantly due to delays in heterogeneous delivery networks. Thus, it is a crucial metric for the quality of experience in next-generation broadcasting systems. In the following section, channel change operations for the MMT and MPEG standards are compared in a broadband network environment.

To operate media content, an MMT client must first obtain the necessary signaling messages. Using the information in the signaling message, the MMT client acquires location information for the MMTP packet streams that deliver the assets composing the specific bundle (e.g., a TV program) and begins receiving the

corresponding media processing units. The media processing unit not only carries audiovisual data but also includes metadata for configuring MMT receiver entities, such as the media processing unit's sequence number, decoding configuration information, and display timestamps. Therefore, acquiring service information and configuration from the signaling messages and received media processing units is the first mandatory step for the MMT client to play the specified media content.

To this end, a specific modeling approach has been proposed to measure the performance of television broadcast systems using the Channel Zapping Time method, leveraging the

properties of both MMT and MPEG technologies, as illustrated in Figure (1).



### Channel Offloading Time Analysis (MMT)

The media processing unit (MPU) metadata is transmitted in the first packet when switching to a service so that the MMT client can receive service information and the MPU unit without additional delays. As a result, the channel offloading time  $t_{MMT(zapping)}$  is affected only by the unit reception time  $t_{MPU}$  and the time elapsed from decoding to displaying the MPU unit. It should be noted that buffering time  $t_{buffering}$  can be influenced by the state of the delivery networks. When network performance is weak, the MPU unit may be long, and the MMT client must process the MPU unit immediately after it is collected and decoded to meet the display time for the MPU unit. If the MMT client fails to receive the signaling message before the first packet of the MPU unit ( $m + 1$ ) arrives, even though the client can receive the signaling message midway through the media processing unit and the remaining packets from the multimedia processing unit ( $m + 1$ ), the MMT client cannot display the content of the received MPU unit. This is because the client failed to receive the metadata. This failure adds the delay  $t_{MPU(periode)}$  to the total channel offloading time, and the MMT client can only display the contents of the MPU unit ( $m + 2$ ).

For MMT services, the channel offloading time  $t_{MMT(zapping)}$  can be simplified within the following

$$t_{min} < t_{mmt(zapping)} < t_{max} \tag{1}$$

$$t_{min} = t_{mpu} + t_{bufferin} \tag{2}$$

$$t_{max} = t_{mpu} + t_{bufferin} + t_{mpu(periode)} \tag{3}$$

In the case of regular television broadcasting, the channel discharge time can be reduced by  $(t_{mpu(periode)} / 2)$  compared to the non-reordering method. When reordering is applied, the channel discharge time for MMT services can be explained as follows:

4o mini

$$t_{max}$$

$$\begin{aligned}
 &= t_{mpu} \\
 &+ t_{bufferin} \\
 &+ \frac{t_{mpu}(pe\&iod)}{3(4)}
 \end{aligned}$$

#### 4- Results and Discussions

Two dedicated media servers were used to provide high-definition (HD) video content with a frame rate of 30 frames per second and a resolution of  $1920 \times 1024$ , along with media clients connected to the media servers via a Gigabit Ethernet interface. In the experimental setup, when a channel switch is requested, it is assumed that the media client will switch to another media server running on a different device to begin processing the media display.

This is done within the context of video sequence encoding.

When applying the proposed channel discharge process, the efficiency of that channel was calculated in three different scenarios: the first scenario involves the normal reception state, the second scenario involves the buffering state, and the third scenario is the application of the proposed channel discharge, which achieved the best results during the MPU unit time period, as shown in Figure (2).

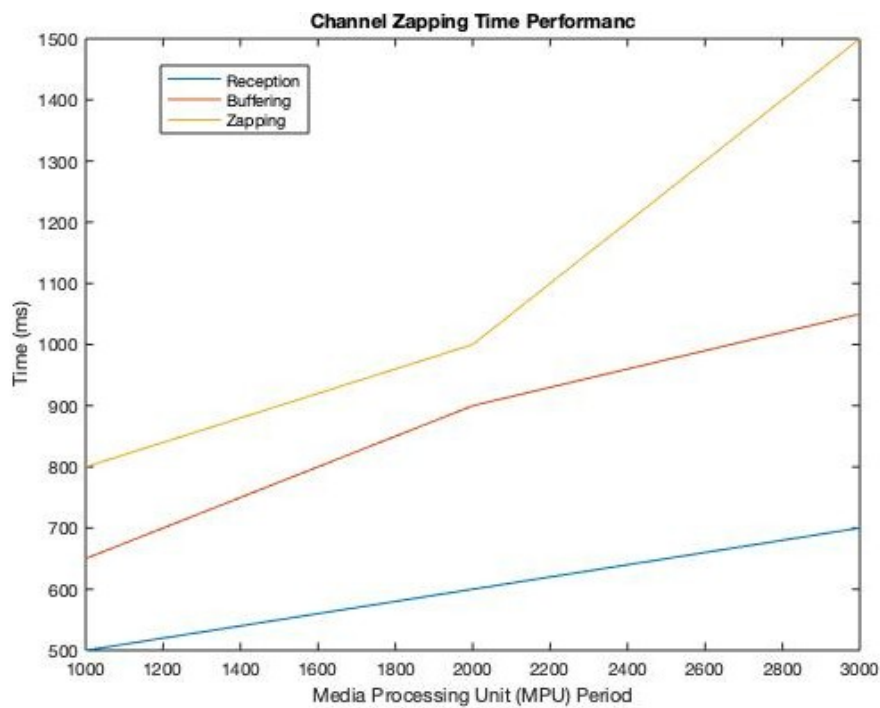


Figure (2).The MPU unit time period

For the purpose of making a comparison between MMT and MPEG technologies in terms of segmentation, it became clear that better results were obtained with the MMT technology used, as shown in Figure (3).

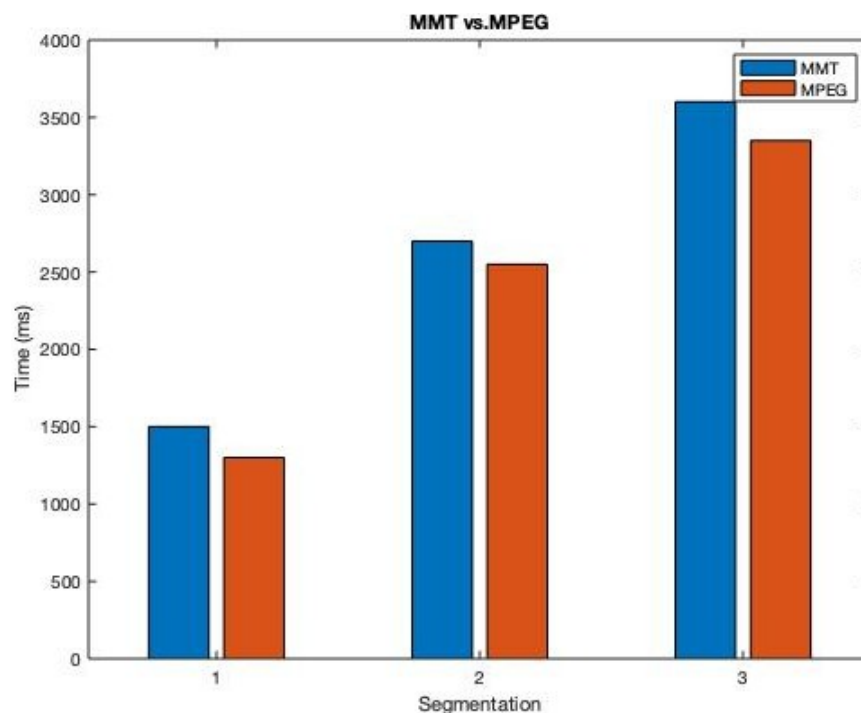


Figure (3): Comparison of MMT and MPEG technology in terms of segmentation time.

## 5- Conclusions

The Channel Zapping Time, an important metric for measuring the quality of broadcast services, has been studied, discussed, and analyzed. Additionally, a simple yet effective method was proposed to quickly discharge the channel for MMT services through the reordering of the MPU transmission packet. Channel zapping times for both MMT and MPEG technologies were compared by altering import parameters and configurations. It was concluded that both technologies can achieve acceptable channel zapping times, but the MMT technology provided better results, even in a broadband network environment.

However, bandwidth costs vary due to differences in the signaling information required to acquire the service.

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