

# A Research on Compliant Digital Cinema Playback System

Fang Lu

Academy of Fine Arts, Dalian University, Dalian, China, 116622

E-mail: shining\_112@live.cn

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**Abstract.** Digital Cinema outperforms traditional films and attracts the movie industry. This paper has developed a Digital Cinema Playback system compliant with the DCI Specification. It can extract and play the 2K resolution component from the 2K/4K DCP (Digital Cinema Package) files at 24 fps, and support an up to 350Mbps video streaming service. Connected to Barco projector and Dolby digital device, this system can display the standard fully or partially encrypted test materials fluently and correctly. The synchronization of audio and video meets the DCI specification.

## Introduction

Over the last few years, many significant technology developments have enabled the digital playback and display of feature films at a level of quality commensurate with that of 35mm film release prints. These technologies include high-resolution film scanners, digital image compression, high-speed data networking and storage, and advanced digital projection. It is much cheaper and simpler for postproduction and distribution, since the digital cinema contents are stored with the digital media. Besides, it allows for multicasting of the content with the central storage. [1, 2]

These technological advances were recognized by the movie industry [3]. In 2002, Digital Cinema Initiatives, LLC (DCI) was created to establish uniform specifications for Digital Cinema. DCI was formed by the seven motion picture studios: Disney, Fox, Metro-Goldwyn-Mayer, Paramount Pictures, Sony Pictures Entertainment, Universal Studios, and Warner Bros. Studios. The Digital Cinema System Specification V1.0 was released in July 2005. This specification defines the image and audio formats, compression standard, packaging, transport, theater systems, projection, and security [4].

In recent years, researchers have focused on compression technologies [5], security including watermarking [6] and right management [7], network distribution [8], etc. The distribution and playback systems have been researched and implemented by different companies and institutes, such as, [9], Dolby, Doremi, GDC, and so on.

[10] describes a super-high-definition movie distribution system which can transmit and display high quality movies. But it is not fully compliant with the DCI Specification. In the mean time, no detail techniques can be found about the products from the business vendors.

Our research group has developed a playback system compliant with the DCI Specification. This system supports unpacking, AES decryption, image decoding, color space transform, synchronization of audio and video and dual-link HD-SDI output. It can extract and display the 2K-resolution component from the 2K/4K files at 24 fps. When connected to a Barco projector (DP90P) and a Dolby digital device (CP650), our system can play the standard fully or selectively

encrypted test materials fluently and correctly, and the skew between audio and video of a 3-hour material is less than 20ms. That meets the DCI requirement of the frame-based lip sync from the beginning to the end of presentation.

This paper is organized as follows. The DCI Digital Cinema System is reviewed in section 2. Section 3 introduces our playback system. Performance evaluations are described in section 4. Conclusions are drawn finally.

## Digital Cinema Playback System

The proposed Digital Cinema Playback system is depicted in Fig. 3. It has 1TB of RAID5 storage, and the video and audio boards consist of several FPGA and ASIC chips. FPGA chips on the video board take charge of the unpacking, decryption, compressed image component separation, color transform, and dual link output. ADV202 chips are used to decompress the image.

The CIE XYZ tristimulus values must be calculated with a normalizing constant that sets the Y tristimulus value equal to the absolute luminance. With this specification of the color, the following equations define the encoding transfer function.

$$CV_{X'} = \text{INT}[4095 * (\frac{X}{92.37})^{1/2.6}] \quad (1)$$

$$CV_{Y'} = \text{INT}[4095 * (\frac{Y}{92.37})^{1/2.6}] \quad (2)$$

$$CV_{Z'} = \text{INT}[4095 * (\frac{Z}{92.37})^{1/2.6}] \quad (3)$$

The key parts of the playback system are introduced as follows.

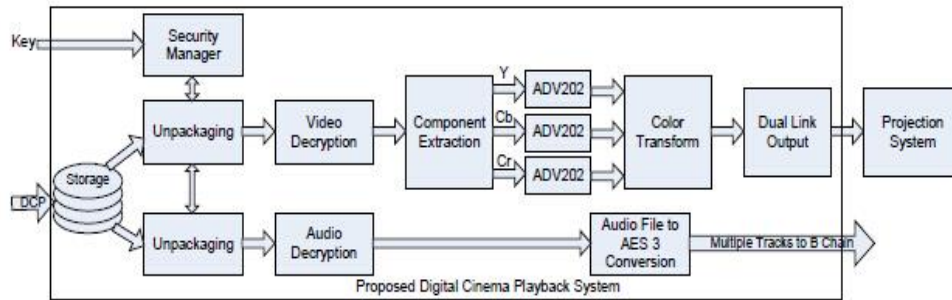


Figure.1 The proposed Digital Cinema Playback System

DCP and CPL files are the system inputs. Audio and video reels are sent to the audio board and video board separately. The cipher key is decrypted with the private RSA key. Unwrapped DCP files are decrypted with the cipher key in real-time. If 4K resolution images are inputted, 2K resolution data is extracted from the file. The Y, Cb and Cr components are separated before sending to ADV202 chips. The decoded image components are transformed to X'Y'Z' color space. The image data is organized according to SMPTE 372M for the Dual Link HD-SDI interface. The audio data is converted to an AES3 format.

## Performance Evaluation

We have tested the system with the standard test materials from DCI, Hollywood, Disney and Fox.

Table1Standard test materials

Material	Master	Frame size	Frame number
StEM	DCI	2048x857	16773
StEM	4K	DCI	4096x1714
Ice	Age	Fox	2048x1080
The	other	project	Disney
Sync	Hollywood	2048x1080	240
Pink	Hollywood	2048x1080	480

Our Display server is connected to Barco projector(DP90P) and Dolby digital device (CP650) to test the playperformance. Experimental results show that it can play thestandard fully or partially encrypted test materials fluentlyand correctly, and the skew between audio and video of a 3 hour material is less than 20ms. This system can play outvideo materials at up to 350Mbps, which is much higherthan the maximum bit-rate required by the DCISpecification.

The selected image displayed by this system is shownin figure 2.



Figure.2A scene of StEM.

## Conclusions

A Digital Cinema Playback System compliant with the DCISpecification has been designed. It can play the 2Kresolution component from the 2K/4K DCP files at 24 fps,and provides an up to 350Mbps video streaming service. Wewould work on 2K-3D and 4K Digital Cinema Playersystem in the future.

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