

Design of Mastering System for Digital Cinema

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Abstract— Digital Cinema Initiatives released a set of technical specifications and requirements for Digital Cinema. The mastering system of digital cinema produces the Digital Cinema Package (DCP) which has been designed to deliver digital cinema contents such as image, audio and subtitle between Digital Cinema content processing centers. We propose a mastering system that covers the packaging process of DCP for Digital Cinema content and protection of it.

Keywords— D-Cinema, mastering

I. INTRODUCTION

Digital Cinema Initiatives, LLC (DCI) has established uniform specification for Digital Cinema. It covers technical specifications and requirements for the mastering of, distribution of, and theatrical playback of Digital Cinema content [1,3,6].

The mastering of Digital Cinema is the process to produce DCP(Digital Cinema Package) from DCDM(Digital Cinema Distribution Master). DCDM is the output of the Digital Cinema post-production process and is the image structure, audio structure, subtitle structure. It is compressed, encrypted and packaged to generate DCP. DCP is transported to the theater and is stored on a file server in the theatre. When playback, DCP is unpackaged, decrypted, and 01decompressed in Digital Cinema playback server at the theater. [2,3,7,9]

We propose a mastering system that covers the composing of DCDM, the packaging of DCP, and the generating and issuing of KDM for Digital Cinema. Proposed mastering system provides a scheme how the DCP is generated from mastering server and how KDM is generated and issued from mastering server.

II. DIGITAL CINEMA USE CASE SCENARIO

Digital Cinema content for distribution, DCP, is generated at the mastering time. The mastering process produces DCP from DCDM which is the output of the Digital Cinema post-production process and is a collection of image, audio and subtitle files. If DCP is encrypted to protect Digital Cinema content, the mastering process also produces security information like AES-128 keys used to encrypt image, audio

and subtitle of DCP[3,4,5,6]. The security information to issue KDM is stored in the form of KDM, called Master KDM. After the mastering process, DCP and Master KDM is stored into storage server.

If a theater requests DCP and KDM, DCP will be delivered to the theater through network, satellite, or hard-disk. And, KDM which is specific to Digital Cinema playback server in a theater will be issued by using the Master KDM. It will be delivered through e-mail, USB, or network [6]. After DCP is transported to the theater, it is stored on a file server in the theater until playback. Digital Cinema playback server will play DCP with KDM. During the playback and projection, digital cinema content will be played out in real time [5].

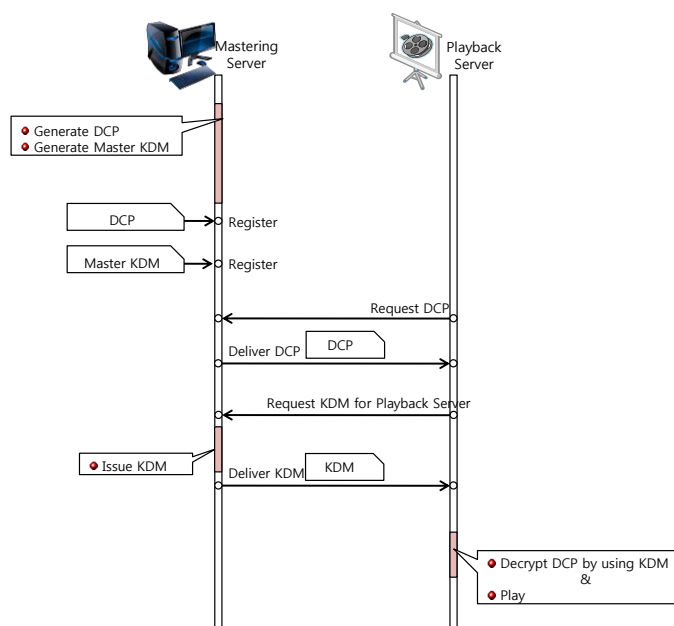


Figure 1. Use case scenario of Digital Cinema

III. PROPOSED MASTERING SYSTEM

Proposed mastering system defines the entities which involve in generating DCP and KDM. It consists of DCP

composing module, DCP and Master KDM generating module, and KDM issuing module.

The DCP composing module provides the composition of Digital Cinema content. A set of image, audio and subtitle DCDMs is composed into a reel. Several reels are composed into CPL. It provides DCDM input for each reel and reel input for each CPL.

The DCP and Master KDM generating module provides the encoding of image DCDM, the wrapping of the encoded image, audio DCDM and subtitle DCDM, and the generating of DCP such as ASSETMAP, CPL, PKL, and VOLINDEX. If MXF file is encrypted, it also generates the Master KDM of DCP.

The KDM issuing module issues KDM to a specific Digital Cinema playback server by using the Master KDM.

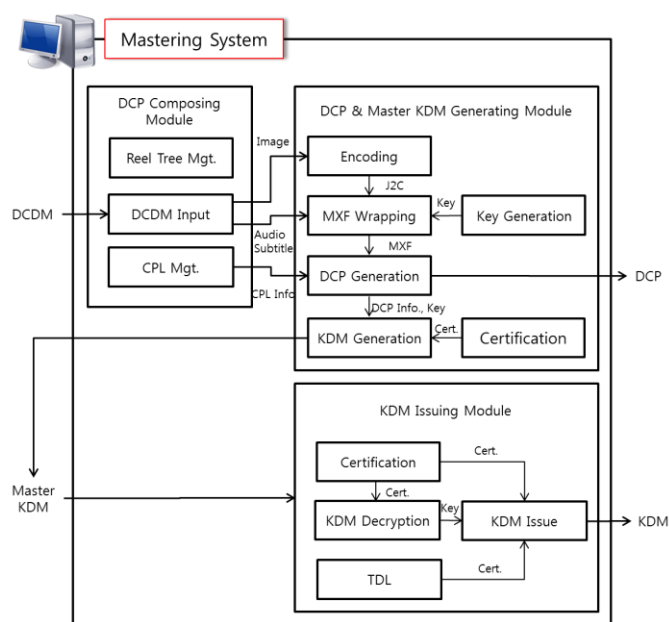


Figure 2. Overall architecture of mastering system

A. DCP Composing module

A reel consists of a set of image, audio, subtitle track files. It is conceptual period of time and has a specific duration between 20 ~ 30 minutes. The image, audio, and subtitle track files are in parallel and are synchronized in playback. Usually DCDM is delivered in the form of folders each of which contains image, audio, or subtitle DCDM from post-production. So, we can make some groups of image, audio, and subtitle DCDMs which are in the same period of time. The groups are the reels each of which contains image, audio, and subtitle track files which are in parallel and are synchronized in playback [1,12,14].

The structure of CPL contains a set of reels each of which contains image, audio and subtitle track. CPL specifies the sequence of reels and is a playlist for specifying how a composition is played and what track files are required.

Figure 3 shows the example of CPL which contains two reels. And, each reel contains image, audio, and subtitle tracks.

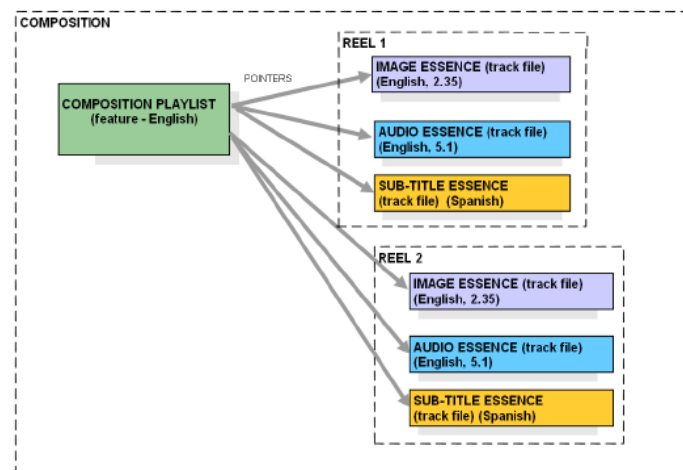


Figure 3. Example Composition Playlist[1]

The DCP Composing module provides a reel tree to build a set of reels which are used in CPL. It has a method to build the structure of reels. Figure 4 shows how to make the reel tree. “Add Reel” makes a new node of reel tree and attach it to reel tree. “Delete Reel” gets rid of selected a node in reel tree.

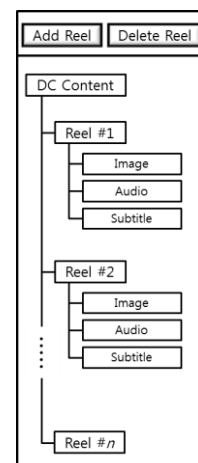


Figure 4. Tree structure to establish reels of CPL

If a tree of reels is established, The DCP Composing module provides a method to DCDM input for each reel. It is divided into three parts, image DCDM input, audio DCDM input, and subtitle DCDM input respectively. Image DCDM input will contain a path to the folder of image DCDM. Audio DCDM input will contain a path to the audio DCDM files. If audio has 5.1 channels, audio DCDM files consist of 6 files, e.g. Left, Right, Center, LFE, Left Surround, and Right Surround files. Subtitle DCDM input will contain a path to subtitle DCDM file, e.g. XML file. Figure 5 shows the three types of DCDM input methods corresponding to each reel. The DCP Composing module provides how to conceptually compose Digital Cinema contents, DCDMs, to reels by using reel tree and how to input

DCDMs for each reel in the reel tree by using DCDM input method.

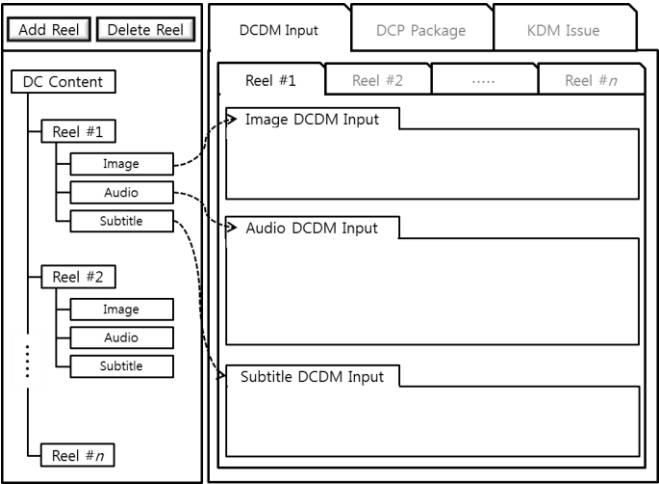


Figure 5. DCDM input for each reel

After the tree of reels has established and the inputs of reel has finished, the sequence of reels will be built into CPL. By clicking the “Add CPL button” a new CPL will be created. Then, by putting a reel into the created CPL with Drag and Drop, the sequence of reels will be created in the CPL. Figure 6 show the operation of CPL generation. If more CPLs are needed the creation of CPL will be repeated.

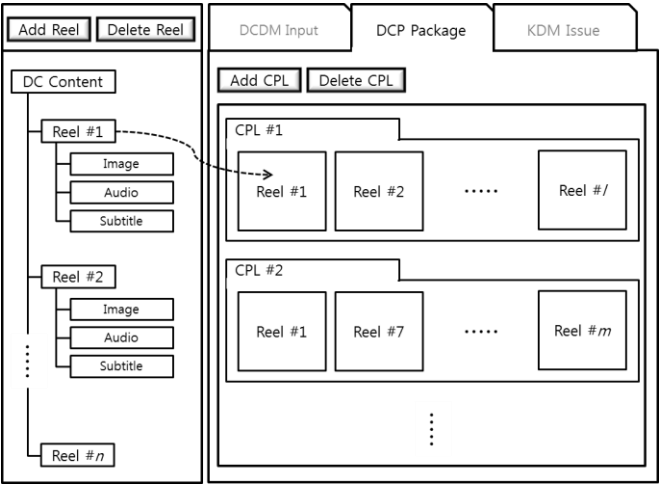


Figure 6. CPL input by using reel tree

We propose how to build a tree of reels to manage the DCDM, how to input DCDM data for each reel in reel tree, and how to make CPL which contains a sequence of reels from the reel tree. We establish a reel to the unit of handling DCDMs and make how to relate the reel and CPL. We propose a method that makes DCDM into CPL structure.

The structure of DCP is based on the created CPL information and image, audio, and subtitle track files. Next

chapter, DCP and Master KDM Generating module will explain how to generate DCP by using the created CPL Information and DCDM inputs. Master KDM Generating module will explain how to generate security information, called Master KDM which will be used to issue KDM.

B. DCP and Master KDM Generating module

DCP Generating module produces the package of Digital Cinema content, DCP, which contains all of the digital material needed for projection. And, Master KDM generating module provides the Master KDM of the generated DCP. Figure 7 shows the whole process of DCP and Master KDM generation.

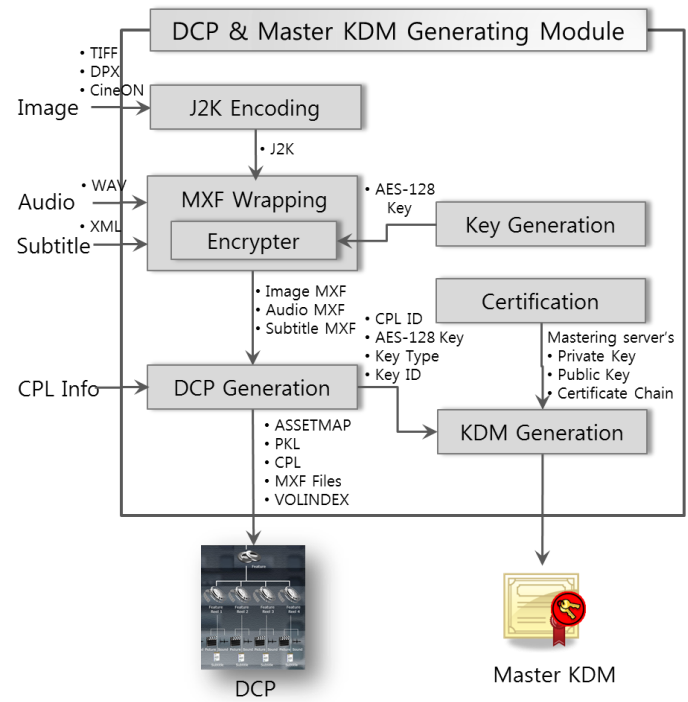


Figure 7. DCP and Master KDM generating module

For the DCP generation, Firstly, image MXF file generation occurs. Image files which are the image DCDM input are compressed into JPEG2000 images. The JPEG2000 images are encrypted by using a key from the Key Generation block. Then, the encrypted JPEG2000 images are wrapped into an image MXF file.

Secondly, audio MXF file generation occurs. From the audio files, we can get the frame data. For example, 5.1 channels consist of 6 WAV files. From the 6 WAV file, we can get the audio frame data which contain Left, Right, Center, LFE, Left Surround, Right Surround that match the frame. Audio frame data are encrypted by using a key from the Key Generation block. Then, the encrypted audio frame data are wrapped into an audio MXF file. Figure 8 show the process of making audio DCDMs into an audio MXF file.

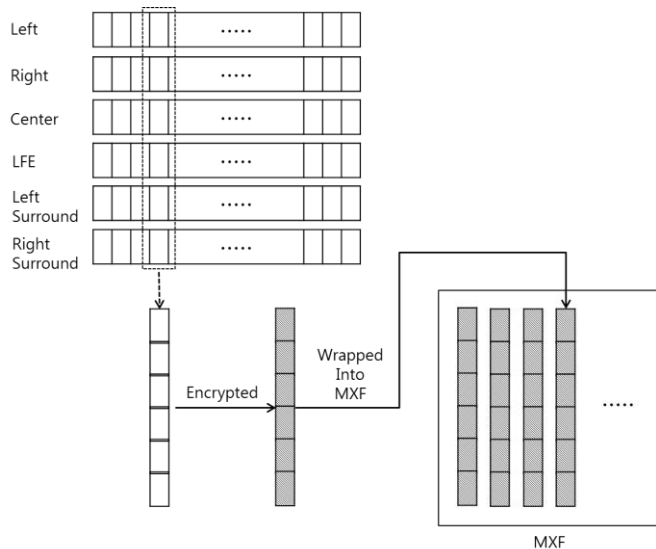


Figure 8. Audio MXF wrapping process

Thirdly, subtitle MXF file generation occurs. The subtitle file is encrypted by using a key from the Key Generation block. Then it is wrapped into a subtitle MXF file.

Now, we have image MXF files, audio MXF files and subtitle MXF files. The DCP Generation block makes the rest components of DCP, such as CPL file, PKL file, ASSETMAP file, and VOLINDEX file with the generated MXF files and other information such as the sequence of reels, duration, and etc.

After DCP generation, if any of MXF files is encrypted, Master KDM generation is needed. We design that mastering system includes KDM issue to Digital Cinema playback server. To produce KDM to a specific Digital Cinema playback server, the security information which is used to encrypt DCP is needed. We store the information in the form of KDM, called Master KDM. Figure 7 shows the process of Master KDM generation.

MXF Wrapping block requests an AES-128 key to Key Generation block. The generated key is used to encrypt a track file only but other track files. MXF Wrapping block sends the key, J2K frame, and plaintext offset to Encrypter. Then, it encrypts the J2K frame from the offset by using the encryption key. MXF Wrapping block will call Encrypter with the same key until the whole j2k frames of the track file are encrypted.

After the MXF wrapping, DCP and security information to generate Master KDM have been produced. KDM Generation module gets the AES-128 keys, key ids, and CPL Id from MXF Wrapping module. It encrypts the AES-128 keys with mastering system's public key and signed with mastering system's private key. The generated Master KDM is stored to a storage server.

C. KDM issuing module

We design that mastering system can issue KDM to a specific Digital Cinema playback server by using Master KDM which is generated from packaging process. Since Master KDM is encrypted by using mastering system's public key, it can be only decrypted with master system's private key. After decrypting Master KDM, it is possible to issue KDM for a specific Digital Cinema playback server. KDM will be encrypted with a specific Digital Cinema playback server's public key.

If a request to issue a specific KDM for a Digital Cinema playback server occurs, KDM Issuing module will select Digital Cinema playback server's public key which is already registered in TDL(Trust Device List) and rights usage. KDM Issuing module decrypts cipher data in Master KDM with its private key. It replaces the usage rights with the requested usage rights for the Digital Cinema playback server, encrypts the cipher data with the Digital Cinema playback server's public key, and digitally signs KDM with its private key.

The Digital Cinema playback server will convert the encrypted DCP into raw image, sound and subtitles with KDM and its private key.

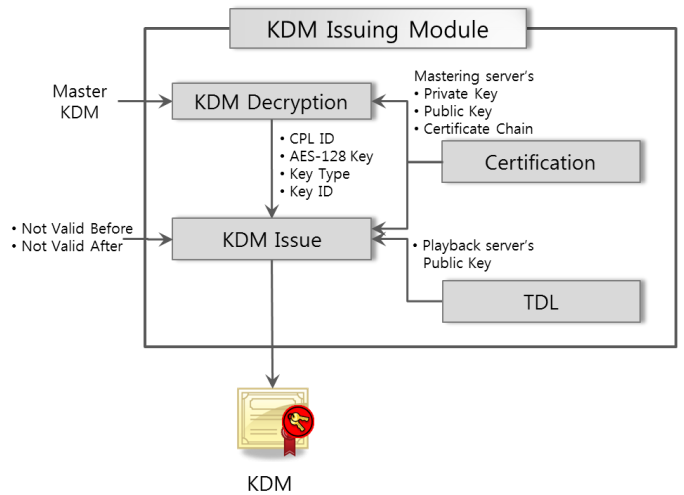


Figure 9. KDM Issuing module structure

IV. CONCLUSION

Digital Cinema Initiatives released a set of technical specifications and requirements for the mastering of, distribution of, and theatrical playback of Digital Cinema content. DCP has been designed to deliver Digital Cinema content. It contains image, audio, and subtitle essences. And, KDM has been designed to deliver security parameters and usage rights between Digital Cinema content processing centers. It contains security keys for decrypting DCP.

We propose a mastering system that covers the packaging process of DCP and the generating and issuing process of KDM for Digital Cinema. The proposed system provides a

scheme how DCDM is conceptually organized into reel and CPL structure, how DCP is generated in mastering system, and how KDM is generated and issued from mastering system to Digital Cinema playback server.

After the mastering process with the proposed system, DCP can be delivered to a theater and KDM can be issued to Digital Cinema playback server. It can provide DCP and KDM service of Digital Cinema.

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REFERENCES

- [1] Digital Cinema Initiatives, L., "Digital Cinema System Specification V1.2", March 07, 2008.
- [2] H. Zhaoing, G. Qiang, L. Yiguang, " A digital right management system based on smart card for digital cinema", Communications and Networking in China, 2008. ChinaCom 2008. Third International Conference on 25-27 Aug. 2008 Page(s):829 - 833
- [3] J. A. Bloom, "Security and rights management in digital cinema", Acoustics, Speech, and Signal Processing, 2003. Proceedings. (ICASSP '03). 2003 IEEE International Conference on Volume 4, 6-10 April 2003 Page(s):IV - 712-15 vol.4
- [4] J. A. Bloom, "Digital Cinema Content Security and the DCI", Information Sciences and Systems, 2006 40th Annual Conference on 22-24 March 2006 Page(s):1176 - 1181
- [5] Zhen-Song Wang, Ling Li, Xi-Shuang Wang, Ke Zhang, Kai Wang, Ping Yao, Wen-Dong Cao, Huang-Hui Shen, " A Digital Cinema Playback system compliant with the DCI specification", Picture Coding Symposium, 2009. PCS 2009, 6-8 May 2009 Page(s):1 - 4
- [6] P. Micanti, F. Frescura, G. Baruffa, "Digital Cinema package transmission over wireless IP networks", Wireless Communication Systems. 2008. ISWCS '08. IEEE International Symposium on 21-24 Oct. 2008 Page(s):154 – 158
- [7] Yeonjeong Jeong, Jungsoo Lee, Kisong Yoon, "Implementation of KDM system based on DCI", Advanced Communication Technology (ICACT), 2011 13th International Conference on, 2011. Page(s): 690 - 694
- [8] SMPTE 430-1-2006, D-Cinema Operations — Key Delivery Message, October 3, 2006
- [9] SMPTE 430-2-2006, D-Cinema Operations — Digital Certificate, October 3, 2006
- [10] SMPTE 430-3-2006, D-Cinema Operations — Generic Extra Theater Message Format, March 3, 2008
- [11] Digital Cinema System Specification Compliance Test Plan Version 1.1, May 8, 2009
- [12] SMPTE 429-3-2007, D-Cinema Packaging — Sound and Picture Track File, August 14, 2007
- [13] SMPTE 429-6-2007, D-Cinema Packaging — MXF Track File Essence Encryption, October 3, 2006
- [14] SMPTE 429-7-2006, D-Cinema Packaging — Composition Playlist, October 3, 2006
- [15] SMPTE 429-8-2007, D-Cinema Packaging — Packing List, June 25, 2007