

Implementation of Digital Cinema Mastering System

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Abstract— Digital Cinema Initiatives released a set of technical specifications and requirements for Digital Cinema. We implement the mastering system of digital cinema that produces the Digital Cinema Package (DCP) which has been designed to deliver digital cinema contents such as image, audio and subtitle and Key Delivery Message (KDM) which contains the security information to be used to decrypt the DCP and will be issued to a specific Digital Cinema playback server. We propose a mastering system that covers the packaging process of DCP for Digital Cinema content and the generating and issuing process of KDM to protect the DCP.

Keywords— D-Cinema, mastering

I. INTRODUCTION

The mastering of Digital Cinema is the process to produce DCP(Digital Cinema Package) from DCDM(Digital Cinema Distribution Master). DCP and DCDM have been defined by Digital Cinema Initiatives, LLC in their recommendations for packaging of Digital Cinema contents. DCDM is the output of the Digital Cinema post-production process and is the image structure, audio structure, subtitle structure. DCP is a collection of digital files used to store and convey Digital Cinema image, audio and subtitle. DCDM is compressed, encrypted, wrapped and packaged to DCP. It is transported to the theater and is stored on a file server in the theatre. When playback, DCP is unpackaged, decrypted and decompressed in Digital Cinema playback server at the theater. [2,3,7,9]

We implement a Digital Cinema mastering system that covers from the input of DCDM to the issue of KDM. We propose a mastering system that provides the composing and packaging of DCP, and the generating and issuing of KDM for Digital Cinema. It also provides a scheme how the DCP is generated with DCDM and how KDM is generated and issued with the generated DCP. It consists of reel management module, DCDM input module, DCP packaging module, DCP export module, and KDM issue module.

II. PROPOSED MASTERING WORKFLOW

Digital Cinema content for distribution, DCP, is generated at the mastering time. DCDM is delivered from Digital Cinema post-production. It is compressed, wrapped and packaged into DCP. Figure 1 shows the workflow of Digital

Cinema mastering process of the proposed mastering system. Each step of the workflow is as following.

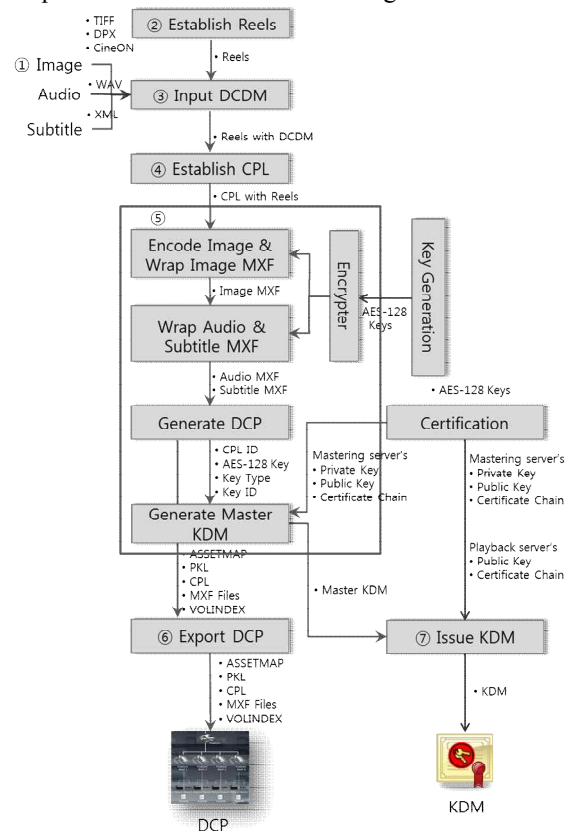


Figure 1. Use case scenario of Digital Cinema mastering

- ① DCDM is delivered in the form of TIFF, DPX, CINEON files for image DCDM, WAV files for audio DCDM and XML files for subtitle DCDM.
- ② Establish reels of DCP. Each reel has an image, audio and subtitle track.
- ③ Input the sources of each reel which are the file path to an image, audio and subtitle DCDM.
- ④ Establish CPL by adding reels.
- ⑤ Generate DCP.
 - Encode image DCDM into JPEG2000 format and wrap it into MXF file

- Wrap audio DCDM into MXF file.
 - Wrap subtitle DCDM into MXF file.
 - Generate ASSETMAP, CPL, PKL and VOLINDEX file.
 - Generate Master KDM file.
- ⑥ Export DCP to external storage.
 - ⑦ Issue KDMs for Digital Cinema playback servers

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 are stored into storage server.

If a theater requests DCP and KDM, DCP will be exported 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].

III. PROPOSED MASTERING SYSTEM

Proposed mastering system defines the entities which involve in generating DCP and KDM. It consists of reel management module, DCDM input module, DCP packaging module, DCP export module, KDM generate module.

The reel management module provides reel management such as add reel and delete reel. A set of image, audio and subtitle is composed into a reel. The DCDM input module provides DCDM input of image, audio, subtitle source. The DCP packaging module provides the composition of Digital Cinema contents. Several reels are composed into CPL. After CPL is composed with several reels, it 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 export module provides the copy of the generated DCP to target storage. It also provides the copy of DCP subset to target storage with linked package of the DCP subset. The KDM generate module issues KDM to a specific Digital Cinema playback server.

A. Reel management module

DCP consists of several reels to contain digital cinema contents. And each of the reels consists of a set of image, audio, and subtitle track file, which have a specific duration between 20 ~ 30 minutes with the same period of time. So, we use a tree which has a root node to represent DCP, child nodes of the root node to present a set of reels and the leaf nodes of the each child node to present image, audio, and subtitle.

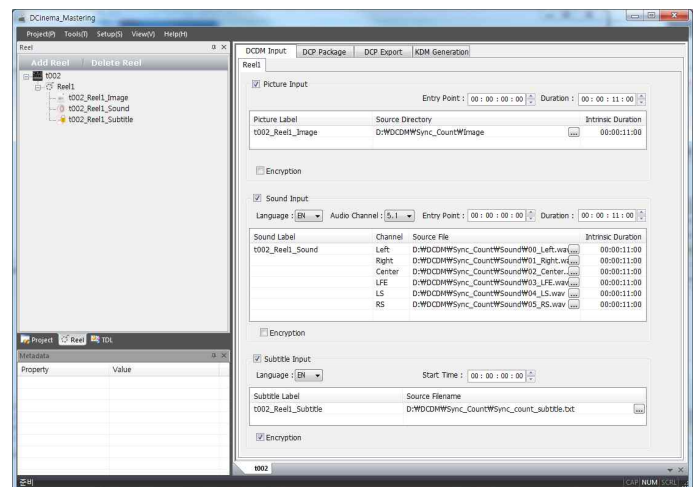


Figure 2. Proposed Digital Cinema mastering system

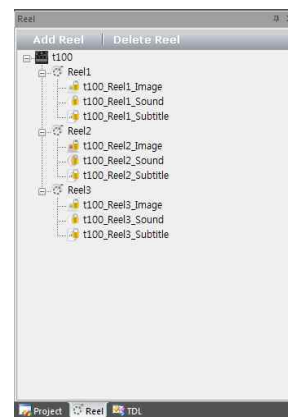


Figure 3. Tree structure to establish reels to input DCDM and to establish CPL

The reel management module provides a reel tree management to handle a set of reels which are used in DCP and has methods to establish the structure of reels. Figure 3 shows how to establish the reel tree. It has a method to make the structure of reels. “Add Reel” function makes a new node of reel tree and attach it to reel tree. “Delete Reel” function gets rid of selected a node in reel tree. It also provides an enable and disable function of image, audio and subtitle track for each reel.

B. DCDM input module

If a tree of reels is established, The DCDM input module provides a method to DCDM input for image, audio and subtitle of each reel. Image input is the folder path to raw image files such as TIFF, DPX, CineON, J2C and image MXF file. Audio input is the file path to wave files such as front left, front right, center, low frequency, surround left and surround right file, and audio MXF file. Subtitle input is the file path to subtitle XML, and subtitle MXF file.

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 4 shows the three types of DCDM input methods corresponding to each reel.

Figure 4. DCDM input module for image, audio and subtitle

C. DCP Packaging module

The DCP packaging module provides how to conceptually compose CPL by using the reels in the reel tree, to package Digital Cinema contents to DCP and to generate Master KDM.

After the tree of reels has established and the DCDM inputs of reel has been finished, the sequence of reels will be built into CPL which specifies the sequence of reels and is a playlist for specifying how a composition is played and what track files are required. The structure of CPL contains a set of reels each of which contains image, audio and subtitle track. 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. If more CPLs are needed the creation of CPL will be repeated. The package of Digital Cinema content, DCP, contains all of the digital material needed for projection. And, Master KDM generating module provides the Master KDM of the generated DCP.

For the DCP generation, Firstly, image MXF file generation occurs. Image files which are the image DCDM input are compressed into JPEG2000 images. Then, the JPEG2000 images are wrapped into an image MXF file. If encryption to the JPEG2000 images is needed, which means KDM is required to DCP, the JPEG2000 images are encrypted by using a key from the Key Generation block before being wrapped into the 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 also encrypted by using a key from the Key Generation block it is required. Then, the audio frame data are wrapped into an audio MXF file.

Thirdly, subtitle MXF file generation occurs. The subtitle file is encrypted by using a key from the Key Generation block if encryption is needed. The subtitle XML 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

Fourthly, Master KDM generation occurs if any of MXF files is encrypted. We implement 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. To generate Master KDM, DCP Packaging module gets the AES-128 keys, key ids, and CPL Id when DCP generating. It encrypts the AES-128 keys which are used to encrypt MXF files with mastering system's public key and make a KDM for the mastering system itself.

Figure 5. DCP Packaging module

D. DCP export module

If a request to export the generated DCP to a Digital Cinema playback server occurs after DCP generation, DCP export module will export to external storage. We implement that DCP export module can handle a linked package of DCP. It means it can export a sub set of DCP. So, user can choose some specific MXF files to export but not the whole of MXF files of DCP. DCP export module generates new ASSETMAP, PKL and VOLINDEX for the sub set of DCP. Figure 6 show the export module to support DCP or a sub set of it.

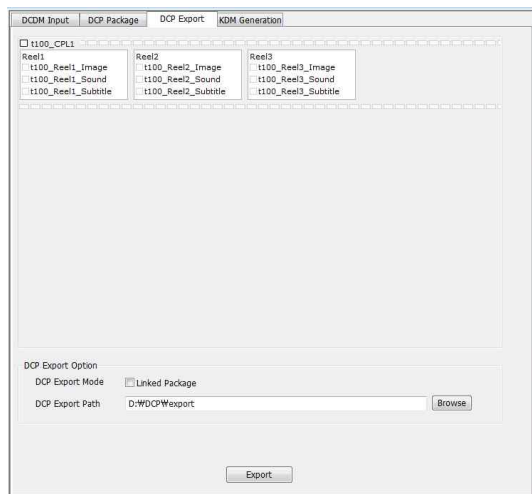


Figure 6. DCP Export module

E. KDM Issuer module

We design that mastering system can issue KDM to a specific Digital Cinema playback server by using Master KDM which is generated from DCP 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.

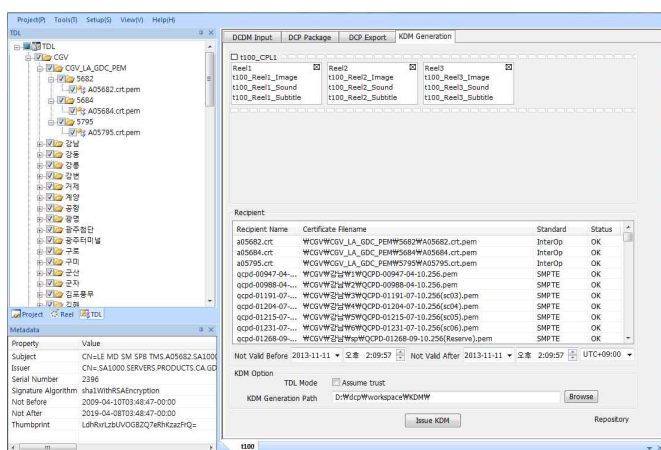


Figure 7. KDM Issue module

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.

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.

ACKNOWLEDGMENT

This work was supported by MSIP(Ministry of Science, ICT and Future Planning) (10041539 High Compression, Low Loss Content Creation /Distribution /Display Technology Development for 8K-Video Service).

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