Digital Cinema Package

A **Digital Cinema Package** (**DCP**) is a collection of digital files used to store and convey Digital cinema (DC) audio, image, and data streams.

The term has been defined[1] by Digital Cinema Initiatives, LLC in their recommendations for packaging of DC contents. General practice adopts a file structure that is organized into a number of usually multi-gigabyte size Material eXchange Format (MXF) files, which are separately used to store audio and video streams, and auxiliary index files in XML format.

The MXF files contain streams that are compressed, encoded, and encrypted, in order to reduce the huge amount of required storage and to protect from unauthorized use. The image part is JPEG 2000 compressed, whereas the audio part is linear PCM. The adopted (optional) encryption standard is AES 128 bit in CBC mode.

The newer SMPTE standards are used to conform the recommendations among different tool vendors and producers. Interop, the legacy DCP standard, is still required to be supported by DCP players.[2][3]

Technical specifications

The DCP root folder (in the storage medium) contains a number of files, some used to store the image and audio contents, and some other used to organize and manage the whole playlist.[4]

Picture MXF files

Picture contents may be stored in one or more *reels* corresponding to one or more MXF files. Each reel contains pictures as MPEG-2 or JPEG 2000 essence, depending on the adopted codec. MPEG-2 is no longer compliant with the DCI specification. JPEG 2000 is the only accepted compression format.

- Supported frame rates are:
  - SMPTE (JPEG 2000)
    - 24, 25, 30, 48, 50, and 60 fps @ 2K
    - 24, 25, and 30 fps @ 4K
    - 24 and 48 fps @ 2K stereoscopic
  - MXF Interop (JPEG 2000) – Deprecated
    - 24 and 48 fps @ 2K (MXF Interop can be encoded at 25 frame/s but support is not guaranteed)
    - 24 fps @ 4K
    - 24 fps @ 2K stereoscopic
  - MXF Interop (MPEG-2) – Deprecated
    - 23.976 and 24 fps @ 1920×1080
- Maximum frame sizes are 2048×1080 for 2K DC, and 4096×2160 for 4K DC. Common formats are:
  - SMPTE (JPEG 2000)
    - Flat (1998×1080 or 3996×2160), ~1.85:1 aspect ratio
    - Scope (2048×858 or 4096×1716), ~2.39:1 aspect ratio
    - HDTV (1920×1080 or 3840×2160), 16:9 aspect ratio (~1.78:1) (although not specifically defined in the DCI specification, this resolution is DCI compliant per section 3.2.1.2).
    - Full (2048×1080 or 4096×2160) (~1.9:1 aspect ratio, official name by DCI is Full Container)
  - MXF Interop (MPEG-2) – Deprecated
    - Full Frame (1920×1080)
- 12 bits per pixel precision (36 bits total)
- XYZ colorspace

- Maximum bit rate is 250 Mbit/s (1.3 MBytes per frame at 24 frame/s)

Sound MXF files

Sound contents are stored in reels, too, corresponding to picture reels in number and duration. In case of multilingual features, separate reels are required to convey different languages. Each file contains linear PCM essence.

- Sampling rate is 48,000 or 96,000 samples per second
- Sample precision of 24 bits
- Linear mapping (no companding)
- Up to 16 independent channels.

Asset map file

List of all files included in the DCP, in XML format.

Composition playlist file

Defines the playback order during presentation. The order is saved in XML format in this file; each picture and sound reel is identified by its UUID. In the following example, a reel is composed by picture and sound:

```
<Reel>
 <Id>urn:uuid:632437bc-73f9-49ca-b687-fdb3f98f430c</Id>
 <AssetList>
  <MainPicture>
   <Id>urn:uuid:46afe8a3-50be-4986-b9c8-34f4ba69572f</Id>
   <EditRate>24 1</EditRate>
   <IntrinsicDuration>340</IntrinsicDuration>
   <EntryPoint>0</EntryPoint>
   <Duration>340</Duration>
   <FrameRate>24 1</FrameRate>
   <ScreenAspectRatio>2048 858</ScreenAspectRatio>
  </MainPicture>
  <MainSound>
   <Id>urn:uuid:1fce0915-f8c7-48a7-b023-36e204a66ed1</Id>
   <EditRate>24 1</EditRate>
   <IntrinsicDuration>340</IntrinsicDuration>
   <EntryPoint>0</EntryPoint>
   <Duration>340</Duration>
  </MainSound>
 </AssetList>
</Reel>
```

Packing list file

All files in the composition are hashed and their hash is stored here, in XML format. This file is generally used during ingestion in a digital cinema server to verify if data have been corrupted or tampered with in some way. For example, an MXF picture reel is identified by the following `<asset>` element:

```
<Asset>
 <Id>urn:uuid:46afe8a3-50be-4986-b9c8-34f4ba69572f</Id>
 <Hash>iqZ3X7TdAjAqniOxT2/hj66VCUU=</Hash>
 <Size>210598692</Size>
 <Type>application/x-smpte-mxf;asdcpKind=Picture</Type>
</Asset>
```

The hash value is the Base64 encoding of the SHA-1 checksum. It can be calculated with the command

```
openssl sha1 -binary "FILE_NAME" | openssl base64
```

Volume index file

A single DCP may be stored in more than one medium (e.g., multiple hard disks). The xml file `VOLINDEX` is used to identify the volume order in the series.

3D DCP

The DCP format is also used to store stereoscopic (3D) contents. In this case, 48 frames exist for every second - 24 frames for the left eye, 24 frames for the right.

Depending on the projection system used, the left eye and right eye pictures are either shown alternatively (double or triple flash systems) at 48 fps or, on 4k systems, both left and right eye pictures are shown simultaneously, one above the other, at 24 fps. In triple flash systems, active shutter glasses are required whereas optical filtering such as circular polarisation is used in conjunction with passive glasses on polarised systems.

Since the maximum bit rate is always 250 Mbit/s, this results in a net 125 Mbit/s for single frame, but the visual quality decrease is generally unnoticeable.

DCP creation

Most film producers and distributors rely on digital cinema encoding facilities to produce and quality control check a digital cinema package before release. Facilities follow strict guidelines set out in the DCI recommendations to ensure compatibility with all digital cinema equipment. For bigger studio release films, the facility will usually create a DCDM (Digital Cinema Distribution Master).

A DCDM is the post-production step prior to a DCP. The frames are in XYZ TIFF format and both sound and picture are not yet wrapped into MXF files. A DCP can be encoded directly from a DCDM. A DCDM is useful for archiving purposes and also facilities can share them for international re-versioning purposes. They can easily be turned into alternative version DCPs for foreign territories. For smaller release films, the facility will usually skip the creation of a DCDM and instead encode directly from the DSM (Digital Source Master) the original film supplied to the encoding facility. A DSM can be supplied in a multitude of formats and colour spaces. For this reason, the encoding facility needs to have extensive knowledge in colour space handling including, on occasion, the use of 3D LUTs to carefully match the look of the finished DCP to a celluloid film print. This can be a highly involved process in which the DCP and the film print are "butterflied" (shown side by side) in a highly calibrated cinema.

Less demanding DCPs are encoded from tape formats such as HDCAM SR. Quality control checks are always performed in calibrated cinemas and carefully checked for errors. QC checks are often attended by colourists,

directors, sound mixers and other personnel to check for correct picture and sound reproduction in the finished DCP.

DCP encryption

The AES encryption is applied to all MXF files. The encryption keys are generated and transmitted via a KDM (Key Delivery Message) to the projection site. KDMs are XML files containing encryption keys that can be used only by the destination device. A KDM is associated to each playlist and defines the start and stop times of validity for the projection of that particular feature.

DCP delivery methods

The most common method uses a specialist hard disk (most commonly the CRU DX115) designed specifically for digital cinema servers to ingest from. These hard drives were originally designed for military use but have since been adopted by digital cinema for their hard wearing and reliable characteristics. The hard drives are usually formatted in the Linux EXT2 or EXT3 format as D-Cinema servers are typically Linux based and are required to have read support for these file systems. Usually the iNode is set to 128 bits to avoid compatibility issues with some servers. Also, NTFS and FAT32 are occasionally used. Hard drive units are normally hired from a digital cinema encoding company, sometimes in quantities of thousands. Drives are commonly shipped in protective hard cases. The drives are delivered via express courier to the exhibition site. Other, less common methods adopt a full digital delivery, using either dedicated satellite links or high speed Internet connections.

DCP creation tools

DCP creation tools

Name	GUI	CLI	JPEG 2000	XYZ	MXF	XML	Frame size	3D	Frame rate (frame/s)	Sampling rate (kHz)	Multi-threaded	Input formats	Notes	OS	License
2DCP_GUI [5]	Yes	Yes	Yes	Yes	Yes	Yes	2K, 4K	Yes	24, 48	48, 96	Yes	Multiple	Picture scaling	Windows	Freeware
CineCert AS-DCP File Access Library [6]	No	Yes	No	No	Yes	No	2K, 4K	Yes	24, 25, 30, 48, 50, 60	48, 96	Yes[7]	J2K, WAV, XML	Needs separate codec	Windows, Mac OS X, Linux	BSD-like
Doremi CineAsset [8]	Yes	Yes	Yes	Yes	Yes	Yes	2K, 4K	Yes	23.98, 24, 25, 29.97, 30, 47.95, 48, 50, 59.94, 60, 72, 96	48, 96	Yes	Multiple video formats,[9] TIFF, DPX, and others	A Final Cut Pro plug-in has been implemented for Mac users	Windows, Mac OS X	Commercial license

Cinemaslides [10]	No	Yes	Yes[11]	Yes[12]	Yes[13]	Yes	2K, 4K	No	24, 25, 30, 48, 50, 60	48, 96	No	All known image[12] and audio[14] formats	Encryption, KDM generation, Theater Key Retrieval element (TKR[15]), Composition Metadata[16]	Linux	GPLv3
DVS Clipster [17]	Yes	No	Yes	Yes	Yes	Yes	2K, 4K	Yes	24, 48	48		Multiple formats		Windows	Commercial license
CuteDCP [18]	Yes	No	Yes[11]	Yes	Yes[13]	Yes	2K	Yes	24, 25, 30, 48, 50, 60, 72, 96	48, 96	Yes	Multiple formats	Plug-in for Adobe After Effects	Windows, Mac OS X	Commercial license
DCP Builder [19]	Yes	Yes	Yes[11]	Yes	Yes[13]	Yes[20]	2K, 4K	Yes	24, 25, 30, 48, 50, 60	48, 96	Yes	BMP, TIFF, DPX, PNG, SGI, TGA, multiple video formats[9]	No encryption	Windows, Mac OS X, Linux	Freeware, superimposes logo, needs registration
DCPC – Digital Cinema Package Creator [21]	Yes	No	Yes[11]	Yes[12]	Yes[13]	Yes	2K, 4K	Yes	24, 25, 30, 48, 50, 60	48	Yes	Multiple formats	Encryption, Subtitle, MPEG2 DCP, 7.1, 3D HFR	Windows	
Prism DCP Encoder [22]	Yes	No	Yes[11]	Yes[12]	Yes[13]	Yes	2K, 4K	Yes	24, 48	48	Yes	DPX, CIN, TIFF, PNG, BMP, TGA, JPG	Picture scaling presets	Windows	Commercial license
Inition DCP Pro [23]	Yes	No	Yes	Yes	Yes	Yes	2K	Yes	24	48		Multiple formats	Network encoding of JPEG 2000 files	Windows	Commercial license
DCP Tool [24]	Yes	No	Yes[25]	Yes	Yes	Yes	2K, 4K	Yes	24, 48	48	Yes	TIFF, DPX, WAV, AIFF	Two separate tools	Windows	Commercial license
Dietrich [26]	No	Yes	Yes	Yes	Yes	Yes	2K, 4K	Yes	24, 25, 30, 48, 50, 60	48, 96		DCDM, DCP, MXF, XML	Encryption, key management, KDM generation, package validation, subtitles	Linux	
YADEtech DCP encoder [27]	Yes	Yes	Yes	Yes	Yes	Yes	2K, 4K	Yes	24, 25, 30, 48, 50, 60	48, 96	Yes	TIFF, PNG, BMP, DPX, J2K, XML, DCP, DCDM, MXF	Encryption; KDM and key management; Interop/SMPTE subtiltes; uses ultra fast, proprietary jpeg2000 codec (jade2k[28]); highly scalable	Windows, Linux, Web[29]	Commercial license
DVD-o-matic [30]	Yes	Yes	Yes	Yes	Yes	Yes	2K	No	23.98, 24, 25, 29.97, 30, 48	48, 96	Yes	Multiple	Upload to TMS; network J2K rendering	Windows, Linux	GPL

Fraunhofer IIS easyDCP Creator [31]	Yes	No	Yes[25]	Yes	Yes[13]	Yes	2K, 4K	No	24, 25, 30, 48, 50, 60	48	Yes	DPX, TIFF, J2K, JPEG, GIF, PNG, BMP		Windows, Mac OS X	Commercial license
Fraunhofer IIS easyDCP Creator+ [31]	Yes	Yes	Yes[25]	Yes	Yes[13]	Yes	2K, 4K	Yes	24, 25, 30, 48, 50, 60	48	Yes	DPX, TIFF, J2K, JPEG, GIF, PNG, BMP, QuickTime	Supports KDM and encryption with included easyDCP KDM Generator	Windows, Mac OS X	Commercial license
Magna Mana FinalDCP [32]	Yes	No	Yes	Yes	Yes	Yes	2K, 4K	Yes	24, 48	48	Yes (plus parallel network computing architecture)	AVI, QuickTime, Apple ProRes, AVID DNxHD, Edius HQX, RED R3D, GoPro-CineForm, GoPro-CineForm3D, DPC (DPX-C), TIFF, MPEG4, JPEG2000, MXF, etc.	Easy to use drag'n'drop User Interface, automated ISDCF compliant Digital Cinema Naming Convention support, zero configuration massive parallel network rendering architecture, preview editor, cropping, scaling, padding, color preprocessing, audio rate conversion	Windows, Mac OS X	Commercial license
Magna Mana FinalDCP FREE Edition [32]	Yes	No	Yes	Yes	Yes	Yes	2K, 4K	Yes	24, 48	48	Yes (plus parallel network computing architecture)	AVI, QuickTime, Apple ProRes, AVID DNxHD, Edius HQX, RED R3D, GoPro-CineForm, GoPro-CineForm3D, DPC (DPX-C), TIFF, MPEG4, MXF, etc.	Easy to use drag'n'drop User Interface, Automated ISDCF compliant Digital Cinema Naming Convention support, zero configuration massive parallel network rendering architecture, unlimited render nodes, preview editor, cropping, scaling, padding, color preprocessing, audio rate conversion	Windows, Mac OS X	Commercial license Demo, superimposes logo, needs registration
Extron J2KENC [33]	Yes	No	Yes	Yes	Yes	No	2K	Yes	24	48	No	BMP, DPX, PNG, TGA, TIFF		Windows	Commercial license

Marquise Technologies MIST (Media Ingest Stream Transcode) [34]	Yes	No	Yes[35]	Yes	Yes[35]	Yes[35]	2K, 4K	Yes	24, 25, 30, 48, 50, 60	48	Yes	Multiple formats	Interop and SMPTE subtitles. Automated ISDCF compliant Digital Cinema Naming Convention support.	Windows	Commercial license
EVS O^3 DCP [36]	Yes		Yes	Yes	Yes	Yes	2K, 4K	Yes	24, 48	48		DPX, Cin, Tiff 8, Tiff 16, TGA, BMP, SGI, RAW, RGB, YUV, Wave		Linux	Commercial license
opencinematools [37]	Yes	Yes	Yes[11]	No	Yes[13]	Yes	2K, 4K	Yes	24, 48	48	No	TIFF		Windows, Mac OS X, Linux	BSD
OpenCubeDCP [38]	Yes	No	Yes	Yes	Yes	Yes	2K, 4K	Yes	24, 48	48		DPX, CIN, TIFF, TGA, BMP, SGI, RAW, RGB, YUV, WAV	Rack mounted unit	Linux	Commercial license
OpenDCP [39]	Yes	Yes	Yes[11]	Yes	Yes[13]	Yes	2K, 4K	Yes	24, 25, 30, 48, 50, 60	48, 96	Yes	TIFF, DPX, BMP, CIN	XML file generation with digital signatures. Naming Convention support. SMPTE subtitles.	Windows, Mac OS X, Linux	GPL
intoPIX PRISTINE J2K Accelerator [40]	No	Yes	Yes	No	No	No	2K, 4K	Yes	24, 25, 30, 48, 50, 60			Multiple formats	Up to 100 fps in 2K, up to 24 fps in 4K, PCIe board, Accelerate any DCP opensource tool, Direct Interop with EasyDCP Creator	Windows, Linux	Commercial license
QubeMaster Pro [41]	Yes	No	Yes	Yes	Yes	Yes	2K, 4K	Yes	24, 25, 30, 48, 50, 60	48, 96	Yes	Multiple formats DPX, CIN, TIFF, TGA, BMP, AVI, QT, ASF, AUD, WAV, TXT		Windows	Commercial license
Doremi Rapid & RAPID2x [42]	Yes	Yes	Yes	Yes[43]	Yes	Yes	2K, 4K	Yes	24, 48, 23, 25, 29, 30, 47, 50, 59, 60	48, 96	Yes	TIFF, DPX, WAV, J2c	HD-SDI Capture capabilities (licensed option), KDM Generation, Image Sequencing Tool	Red Hat Linux	Commercial license

Dolby SCC2000 [44]	Yes	No	Yes	Yes	Yes	Yes	2K, 4K	Yes	24, 25, 30, 48, 50, 60	48, 96		All common D-Cinema master file formats	Standalone unit, render farm	Linux	Commercial license
CineCert Wailua DCP Mastering System [45]	No	Yes	Yes	Yes	Yes	Yes	2K, 4K	Yes	24, 25, 30, 48, 50, 60	48, 96	Yes[46]	TIF, DPX, J2K, MXF, WAV, XML	DCP testing (individual assets and entire packages), Support for creating partial ("supplemental") DCPs, Encryption, KDM creation, Extensive Python API; Kii add-on module required for JP2K compression, colorspace conversion, and pixel array resizing	Mac OS X, Linux	Commercial License
QuVIS Wraptor [47]	Yes	No	Yes	Yes	Yes	Yes	2K	No	24	48		Multiple formats	Plugin for Compressor in Final Cut Studio. Works well with all versions of FCP and Compressor.	Mac OS X	Commercial license
QubeMaster Xpress [48]	Yes	No	Yes	Yes	Yes	Yes	2K	No	24	48	Yes	Multiple formats		Windows	Commercial license
QubeMaster Xport [49]	Yes	No	Yes	Yes	Yes	Yes	2K, 4K	Yes	24, 25, 30, 48, 50, 60	48	Yes	Multiple formats	Plugin for Compressor in Final Cut Studio.	Mac OS X	Commercial license

Notes

[1] http://www.dcimovies.com/DCIDigitalCinemaSystemSpecv1_2.pdf
[2] http://mkpe.com/digital_cinema/isdcf/transition/2011-3-2-SMPTE-Interop-DCP-Guidelines-with-Accessibility.pdf
[3] http://isdcf.com/papers/ISDCF-Doc2-DCP-TransitionReview.pdf
[4] http://www.digitalpreservation.gov/formats/fdd/fdd000200.shtml
[5] http://www.mik-digital.de/programme
[6] http://www.cinecert.com/asdcplib/
[7] Is thread safe.
[8] http://www.doremilabs.com/products/cinema-products/cineasset/
[9] Using FFmpeg
[10] https://github.com/wolfgangw/digital_cinema_tools/wiki/Cinemaslides
[11] Using OpenJPEG
[12] Using ImageMagick
[13] Using CineCert AS-DCP File Access Library (http://www.cinecert.com/asdcplib/)
[14] Using SoX
[15] http://isdcf.com/papers/ISDCF-Doc8-TheaterKeyRetrieval-TKR-v03.pdf

[16] http://isdcf.com/papers/ISDCF-Doc6-Composition-Metadata-Guidelines.pdf
[17] http://www.dvs.de/products/video-systems/clipster.html
[18] http://www.fandev.com/cutedcp.html
[19] http://www.dcpbuilder.com/
[20] Using *opencinematools*
[21] http://cinema.terminal-entry.de/
[22] http://prismdcp.com/
[23] http://www.inition.co.uk/inition/dispatcher.php?action=get&model=products&URL_=product_stereovis_dcppro&SubCatID_=81&tab=blurb
[24] http://www.hs-rm.de/ing/ueber-uns/personen/personen-im-fb-ing/prof-dr-ing-wolfgang-ruppel/mastering-workflow/index.html
[25] Using Kakadu (http://www.kakadusoftware.com/)
[26] https://github.com/wolfgangw/dietrich/wiki
[27] http://www.yadetech.com/
[28] http://yadetech.com/ns/index-en.html#yadedcp
[29] http://yadetech.com/ns/demo.html#yadeweb
[30] http://carlh.net/software/dvdomatic/
[31] http://www.iis.fraunhofer.de/en/bf/bv/dc/pp/dcpcr/
[32] http://www.magnamana.com/products/finaldcp/
[33] http://www.extron.com/product/product.aspx?id=j2kenc&s=5
[34] http://www.marquise-tech.com/mist.html#tabs-3
[35] M I S T focusSHEET (http://www.marquise-tech.com/downloads/MIST-DCPmastering-focusSHEET.pdf)
[36] http://www.evs.tv/emea/product/o%25C2%25B3-dcp
[37] http://code.google.com/p/opencinematools/
[38] http://www.opencubetech.com/page81/OpenCubeDCP
[39] http://code.google.com/p/opendcp/
[40] http://www.intopix.com/products/index/index/id/17/lang/en
[41] http://www.qubecinema.com/qubemaster.htm
[42] http://www.doremilabs.com/products/cinema-products/rapid/
[43] With license
[44] http://www.dolby.com/professional/products/cinema/digital-cinema/scc2000.html
[45] http://www.cinecert.com/products/
[46] Concurrent operations use OS / Interpreter threading
[47] http://www.quvis.com/?Action=Products&SubAction=wraptor
[48] http://www.qubecinema.com/products/Xpress
[49] http://www.qubecinema.com/products/Xport

External links

- Digital Cinema Initiatives (http://www.dcimovies.com/)
- Digital Cinema Naming Convention (http://digitalcinemanamingconvention.com/)

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