EDCINE/ARCHIVES

A Summary of the EDCine Project – Archival applications

A Digital Storage and Access System for Film Archives with relevance to other digital borne and film originated, digitally derived content

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www.ledoux.be
www.iis.fraunhofer.de
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1. PROJECT OVERVIEW

The European-funded EDCine project[1] focuses on future enhancement of digital cinema technology within three areas of interest:

- **Networked content streaming to cinemas**
- **Advanced movie experience beyond DCI**
- **Film archives and access to film archives**

EDCine consists of a sixteen partner consortium, which includes four universities and research centres, ten companies, and as end user partners, a film archive and the town of Nancy in France.

The project commenced in July 2006 and lasts to June 2009.

The long-term objectives include practical proposals for future digital cinema standards and film archiving standards.

This report summarizes the proposals for *Film archives and access to film archives.*

Partners in 'archival section' of the project are **Cinémathèque Royale de Belgique** (Brussels, Belgium), **Fraunhofer Institute for Integrated Circuits IIS** (Erlangen, Germany), and **MOG Solutions** (Oporto, Portugal).

2. INTRODUCTION

Film archives, both public and private, play a decisive role in the preservation of cultural heritage of our society. Publicly funded archives include national and regional institutions with a remit to collect, preserve and provide access to collections relevant to their country, region, area or special interest.

Commercial archives are more diverse and include stock-shot licensing companies, newsreel and feature film collections, producers, distributors as well as rights holders. Many film studio collections are in the process of diversifying into digital intermediate and digitally borne input, as well as content destined for digitally projected cinema, home video and home cinema, internet and television distribution.

Public film archives are growingly concerned with the conservation of digital intermediate and digitally borne works, and are exploring new modes of access to their collections, including various digital channels (digitally projected cinema, home video and home cinema, internet and television distribution).

Film archives may store their analogue film collections under strictly controlled low temperature and humidity conditions that can provide a life expectancy of several hundred years for film already in the early stages of decay, and thousands of years for fresh film (this according to the most recent research, mostly by the Image Permanence Institute[2]).

[1] The EDCine– Enhanced Digital Cinema project is funded by the European Commission within the 6th Framework Programme FP6/2004/IST/4.1, contract no. 038454 EDCine.

[2] *See* http://www.imagepermanenceinstitute.org/

However, in the current climate of increasing digital presentation, film display except in cinema's (and this too may become untenable in time) is increasingly considered insufficient to respond to users' demand for broader access to collections.

Moving image collections of all sorts require easy and economical access to digital versions of many different qualities and file sizes both from film in their current collections, and from digital content in the future.

Digitally borne content, whether new or derived from film, will also require a practical, secure and affordable preservation procedure, and film archives, used to the relative independence from obsolescence (of all sorts) they experience with film, would prefer similar reliability for preservation and access to their digital content.

EDCine intends to meet all these requirements by presenting a two-tier storage model that provides a framework for both digital preservation at best quality and uncomplicated access to the stored items. EDCine is not concerned with media though, since it focuses on systems architectures, workflows and file formats.

The EDCine Digital Film Archive System makes use of the OAIS reference model as a fundamental basis for its own system architecture. The Open Archival Information System (OAIS)[3] is a reference model for a conceptual framework for an archive platform for preservation and delivery of digital or digitised content and is standardised by ISO.

A modular implementation assures scalability and provides interfaces to existing systems and the future addition of new functions.

Based on the OAIS reference model, the EDCine Digital Film Archive System Architecture presents two different file formats to store image, audio and metadata. Each is able to store archived items in the best possible quality (at this time), and to facilitate the access to the archived items into many different distribution formats.

The proposed architecture consists of two packages, the Master Archive Package (MAP), for long-term preservation, and an Intermediate Access Package (IAP) designed to make the access to the stored items faster and simpler. Following OAIS reference model, both MAP and IAP are designed as information packages where the content (image, sound, texts, etc.) is stored jointly to its technical metadata (and optionally its cataloguing information), to ensure that the content is correctly displayed when accessed.

3. ARCHIVAL REQUIREMENTS

Digitisation for preservation and access being a costly and labour-intensive, archives acknowledge that viable solutions must allow for high-quality preservation so that digital content can be easily distributed on multiple platforms, ranging from very low (streaming) quality to high end distribution (broadcast, D-Cinema). In other words, all moving image film, video and digital archives need solutions that can store all or most of their images (and related sound) while providing access to them in an increasing variety of formats and qualities, with a multi-channel, multi-platform approach.

[3] *See for ex.* http://nost.gsfc.nasa.gov/isoas/

EDCine has a specific brief and cannot provide the total package of concepts, routes and software for public archives, commercial collections and rights holder archives. The project's principle focus is on Digital Cinema, and on cinema quality images, although its overall concept and architecture are designed to serve a wide variety of image and sound content, including analog and digital video, and film images at lower quality than film.

No new concept or process can ever be "future proof", but at least we should try to make what we devise relevant to the users needs, and that will fit, or can be adapted to fit, within an eventual working system.

As the expected decline in film projection in the cinema occurs, archives, cinematheques, specialist art house cinemas, and any cinema planning to show archival films will increasingly need to display a digital version. In most instances, this will require to be compliant with an eventual world standard, possibly similar to DCI specification, currently under consideration by SMPTE's DC28 Committee. Other digital cinema display methods are already a reality across the world and may need to be taken into account in time.

Film for cinema has always generated its own unique experience in the audience, which has varied with time, location and technology for over 100 years. Archives, cinematheques and specialist cinemas require that the cinema projection of heritage films (best defined as films shot and released prior to digital projection becoming used or standardized) be authentic and as faithful a representation on the screen of the projected original film as possible (a requirement already observed in the restoration of old films).

The following list (a summary of the details provided by the User partner, the Cinémathèque Royale de Belgique in consultation with the Fiaf Technical Commission, to the research partners) records some of the characters that provide this authenticity, but is not exhaustive:

1 The resolution of the projected screen image should not be visually lower than that of the original film image (it is appreciated that this requirement is difficult to quantify).

2 The frame rate of a digital cinema projection should be the same as that of the original film.

3 The aspect ratio of the image should be that of the original film

4 If appropriate to the original period, a film programme of mixed aspect ratio content should be shown using common height principles.

The basic requirements of a digital storage system for film, in brief and as proposed to the research partners are:

1 Ingest should be from both film images, film sound, and any analogue or digital video or data version of a programme, images or sound.

2 For purposes of access, the intermediate access package IAP must be capable of producing the wide range of current formats and media output (from D-Cinema quality to HD and standard definition television, to Internet-browsable versions), defined as Distribution Access Packages (DAP) in the EDCine Digital Film Archive System.

3 The MAP, the long term digital storage format, which will in time be economically and practically viable, must store data in a lossless format.

4 D-Cinema output versions, film output versions and any other high quality output versions of the future that are generated from long term digital storage formats should be as close to the original film, or digital version, as possible. Hence conversions of colour space, resolution and frame rate, etc., are to be avoided, or if unavoidable should be losslessly and accurately reversible. It is recognized that a "DCI-type" Digital Cinema Package may also be required (i.e. at 24fps when the MAP, and the original film, was at a different frame rate) and this should be possible.

5 Film images will not always be in a restored form when ingested for long term storage as the MAP, and therefore if restoration is deferred if must still be possible subsequently. This has several implications, the main concerning the bit depth of archived images.

6 A single "ingest standard" would also be widely welcomed by all archives facing the problem of managing and conserving content deposited in a wide range of different formats, as for example archives that manage a legal deposit obligation.

4. PROPOSED SYSTEM ARCHITECTURE AND FILE FORMATS

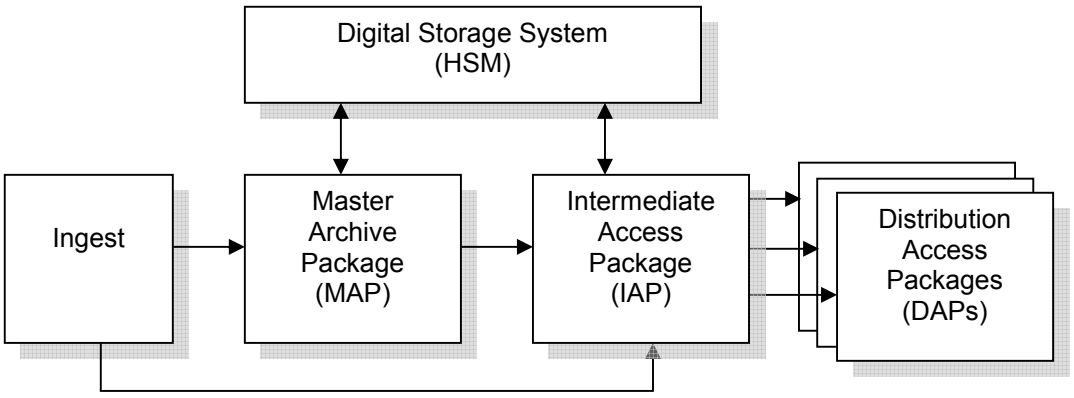

Figure 1: Overview of the EDCine Archive System Architecture

An archival system architecture for preservation and multi-format access of high quality moving image content must provide a solution for two major use cases with partly oppositional requirements.

On the one hand these are the long-term archival, with the requirement to store the source images and sound without any loss of information. This practice usually requires lossless compression and results in large amounts of data, due to the high spatial resolutions used in cinematic production.

On the other hand there is the requirement of frequent access to archived items. This practice usually does not require the original lossless quality of the source images and data.

Instead the focus lies on easy and standardized access through local and remote channels. This results in the requirement for a significant (and often extreme) reduction of the original amount of data and the restriction of certain coding parameters to ensure maximum compatibility with a wide range of decoding and playback equipment.

To illustrate this point, the following table illustrates the requirements in terms of data rate, and consequent compression rates, for some of the formats managed by the EDCine Archive System, from ingesting the digital master of a digitally produced film (Digital Intermediate) to an HDTV distribution format.

DATA RATES IN PRODUCTION AND ARCHIVE WORKFLOW

Type	Data rate	Compression Rate
Digital Intermediate 4096x2160@24fps uncompressed 16Bit, 3 comp.	1.2 GByte/s	1:1 No Compression
MAP 4096x2160@24fps 2:1 compressed	600MByte/s	2:1 Compression
IAP (4096x2160) @24fps 500MBit/s data rate	500Mbit/s	12 Bit per Comp. + 19.2:1 Compression
HD DVB-S2 (1920x1080) @24fps 10MBit/s data rate	10MBit/s	Downscaling + 420 Subsampling + 8 Bit per Comp + 80:1 Compression

Furthermore, medium or long term digital preservation inevitably implies the implementation of timely media and format migrations. To counter media and format obsolescence, as well as to allow effective access and optimize storage costs, any digital repository must migrate its content to new media on a regular basis and it must also migrate from formats which have become obsolete, to new ones. Format migration entails costly and time consuming transcoding, possible loss of quality, and might incur in problems due to proprietary formats. Clearly, the complexity and the costs of this process are directly proportional to the number of formats used in the archive.

Moving image and other media archives have been experimenting with different approaches aimed at simplifying this process by reducing the number of formats used in the archive; unfortunately, these approaches are hindered by the growing complexity deriving from the evolution and proliferation of access formats.

In order to respond to the strong need of simplifying the management of modern, large moving image repositories the EDCine Archive System proposes a solution that allows archives to convert digital borne content as well as digitized analogue films and videos to one common archiving format at the ingest phase (MAP and/or IAP), and to derive from this all required access formats (Delivery Access Packages - DAPs), as shown in the above schematic diagram.

All the above requirements lead to defining a two-tier system architecture with different file formats and JPEG 2000 profile specifications for long-term storage and for frequent access (for distribution, browsing or display). Archived material may be stored in either one of the two formats or in both formats simultaneously depending on the type and usage scenario for the material.

The long-term storage format should be used if cinematic material needs to be preserved digitally in all of its aspects. The access format shall be used if access to the material is the main concern. The latter can be generated through transcoding from the former. The access

format is close to the formats standardized by SMPTE DC28, for simplified distribution of digital content to cinemas. It can also be used to transcode to other formats for delivery to end users. For more information, see section 3.

Cinematographic content usually consists not only of image sequences but also additional data of various types. Typically, these are one or more sets of single or multi-channel audio data, timed text for subtitles and technical as well as descriptive metadata of different details levels. All of this data should be stored together in one place as described by the asset store approach standardized within the Open Archival Information System (OAIS) Reference Model standardized as ISO 14721:2003.

In order to meet all the above requirements, as well as those of using only standardized and non-proprietary formats (a key requirement to ensure long term conservation of data), JPEG 2000 was chosen for both lossless and lossy compression, and MXF was selected as a wrapper to package together all data streams and metadata in the MAP and IAP.

JPEG 2000

In any large moving image archive, compression of the image data is required to reduce the enormous amount of data required by cinema content to more manageable levels. The choice of JPEG 2000[4] was driven by several considerations:

- it is an open standard (ISO standard 15444-1:2004)
- it allows mathematically lossless as well as visually lossless compression,
- it has the advantage of allowing a scalable representation of image data,
- it shows a significant improvement in visual quality when compared with other compression standards,
- compression is performed on an intra-frame basis only, thus allowing editing and processing also after compression,
- the use of wavelets and a special arithmetic entropy encoder called EBCOT produces a hierarchical code stream that can be scaled in terms of quality and resolution, thus allowing to encode images at the desired maximum resolution and quality.

Besides, having been developed by the JPEG committee, JPEG 2000 is not the product of one single vendor. Although parts of the technology used are protected by patents, the known patent holders agreed to license them for part 1 of the standard under a royalty-free and non-discriminatory basis to everybody, and this is a prerequisite for any technology or algorithm to be included into a JPEG base standard, and this is monitored by the committee.

Some of the applications in which JPEG 2000 is widely used today include medical imaging, natural sciences and digital cinema distribution. In digital archives JPEG 2000 is used to preserve scanned newspapers and digital video. Since all the information required to create and read JPEG 2000 code streams is very well documented (so much that open source implementations are available now available), from an archival standpoint the life expectancy of JPEG 2000 can be considered to be long.

MXF (Material eXchange Format) wrapping

The EDCine Archive System adopted MXF (Material eXchange Format[5]) as a wrapper format. MXF, standardized by SMPTE and EBU as a file format intended for the interchange of audiovisual material and related metadata. In the EDCine Archive System MXF is used to store the JPEG 2000 compressed image sequences together with any accompanying data (audio, text, etc.) and metadata providing the synchronization between the separate

[4] http://www.jpeg.org/jpeg2000/index.html
[5] See SMPTE 377M and others at http://www.smpte.org

elements of the essence: images, sound tracks, data, etc. MXF is also widely recognized in the broadcast industry and will be increasingly used within the digital cinema industry since has been chosen by SMPTE for D-Cinema distribution[6].

Audio formats

Audio data shall be stored in a lossless manner in both MAP and IAP. For this purpose RAW audio format shall be used. As an option audio data can also be represented as MPEG-4 Scalable Lossless Coding (SLS) specified in ISO/IEC 14496-3:2005/Amd 3:2006 as a compressed but lossless audio format. All audio channels shall be organized as discrete channels. All channels of a multi-channel representation shall have the same properties. In the MAP, the number of channels is unrestricted, while it is limited to up to 16 in the IAP. The mapping of the audio channels is described in the metadata section and is independent of the order of the channels.

Metadata formats for Master Archive and Intermediate Access Packages

A key concept in the OAIS model is that all the metadata needed to interpret the content correctly in the future (i.e. to render the image on a display or reproduce the soundtrack) must be stored together with the essence (in our case, the image and sound code streams).

Also “historical” technical metadata (i.e. technical metadata describing the processes the image and audio underwent within the archive) can be very important to trace processing and conversion steps, both in the digital and in the analogue domain. This type of metadata makes it possible for example to judge where in the processing chain quality loss might have been introduced, to differentiate between different versions (as restored vs. un-restored), and to identify the source of the digitized content.

The adoption of the MXF format in the EDCine Archive System permits the storage of all the necessary metadata together with image and other media data in the same file, while it is still possible to mirror metadata in an external database to simplify search and retrieve functions, and in this case synchronisation of metadata will be guaranteed.

Structural metadata shall be stored in a format appropriate for the chosen file format. In all cases there shall be a minimum set of structural metadata stored.

For image data this shall consist of all information relevant to the employed JPEG 2000 profile and contain at least image size, frame rate, colour space, sub-sampling information, number and meaning of components and bit depth.

For audio data this shall consist at least of bit depth, sample rate, number and meaning of audio channels for each multi-channel audio representation and audio encoding standard.
Descriptive and historical metadata shall be stored as human readable text in a UTF-8 XML representation or using the metadata storage mechanisms provided by the file formats.

The EDCine Archive System is designed to accommodate the metadata schemes used by any individual archive, and to allow as much as possible a precise mapping from one schema to another.

5. KEY SPECIFICATIONS FOR MAP AND IAP

The key specifications of the **MASTER ARCHIVE PACKAGE** are within the limitations of JPEG 2000 and AES recommended practices:

- Image resolution up to 16K (16384 x 8640)

[6] SMPTE 429.3M and others, http://www.smpte.org

- Any image frame aspect ratio
- Any image bit depth (only limited by JPEG 2000 maximum bit depth, which is for practical implementations 32 bits per component)
- Any colour space
- Any frame rate
- Image components up to 8
- Mathematically lossless compression for image content (can also be lossy if required, e.g. when archiving an already compressed DCP)
- Audio data in RAW format (optional MPEG-4 SLS)
- No audio sampling restrictions (at least support of recommended values as in AES-5[7])
- No restrictions for word length in audio (at least 16 bit or 24 bit)
- Discrete (i.e. no matrix encoding) audio channels (unrestricted number)
- MXF wrapper. No limitations on the Operational Patterns, implementation is currently restricted to Op1a and Op1b.

The key specifications of this **INTERMEDIATE ACCESS PACKAGE** are within the limitations of JPEG 2000 and AES recommended practices:
:

- Image resolution up to 2k (2048 x 1080) or 4k (4096 x 2160) (depending on adopted profile)
- Any image frame aspect ratio
- Image bit depth up to 12 bits
- Any frame rate
- Image components: up to 3
- Compression aimed to produce a maximum bit rate to match the highest requirements for distribution (at the moment those for D-Cinema, whose standards are currently being finalized)
- Audio data in RAW format (optional MPEG-4 SLS)
- 48kHz or 96kHz audio sampling frequencies
- 16 bit or 24 bit word length for audio
- Discrete (i.e. no matrix encoding) audio channels (up to 16 channels)
- MXF wrapper. No limitations on the Operational Patterns, but implementation is currently restricted to Op1a and Op1b.

6. SYSTEM IMPLEMENTATION

In order to ensure a modular and upgradeable system, the EDCine Archive System adopts a SOA (Service-Oriented Architecture), which allows a flexible number of processing and encoding/decoding modules. A SOA client allocates tasks to SOA services/modules, which can then process the tasks on single or multiple computers. Thus, a scalability and extensibility of processing modules and computing processors is made possible: new source and output formats can be handled in the future by adding new services; tasks can take advantage of enhanced performances provided by hardware accelerators, GPUs or multicore processors, whenever these are available.

Currently the EDCine Archive System is in its implementation phase, with several key modules already completed (as transcoding modules for JPEG 2000 to H264, generation of

[7] *See http://www.aes.org/publications/standards/*

MAP and IAP formats, conversion from MAP to IAP and vice versa), and others still in progress. These modules will be integrated in a first demonstrator (scheduled for the second quarter of 2009) designed to illustrate the functionalities of the system as well as some of the many workflows the system can support.

As mentioned earlier, the EDCine Archive System' modular architecture was designed to accommodate a wide range of workflows to meet the needs of archiving and distributing both archival content and current, digital productions.

The workflows identified in EDCine's initial phase (with the contribution of archives and digital post-houses) indicates the need for the system to ingest, manage and preserve a wide range of input formats (digitized analogue film and video, digital video and Digital Cinema products) and to transcode them on demand for distribution and access via different digital formats.

As an example of the many possible workflows, Figure 2 shows how the system handles the ingest of digitally post-produced film (a Digital Intermediate), its conversion in an MAP and subsequently in an IAP, and from this the production of three delivery formats, an Internet-browsing format, a Digital Cinema Package and an HDTV master. As the figure shows, the System will handle the necessary compressions, transcoding, colour conversions, as well as management of the relevant metadata.

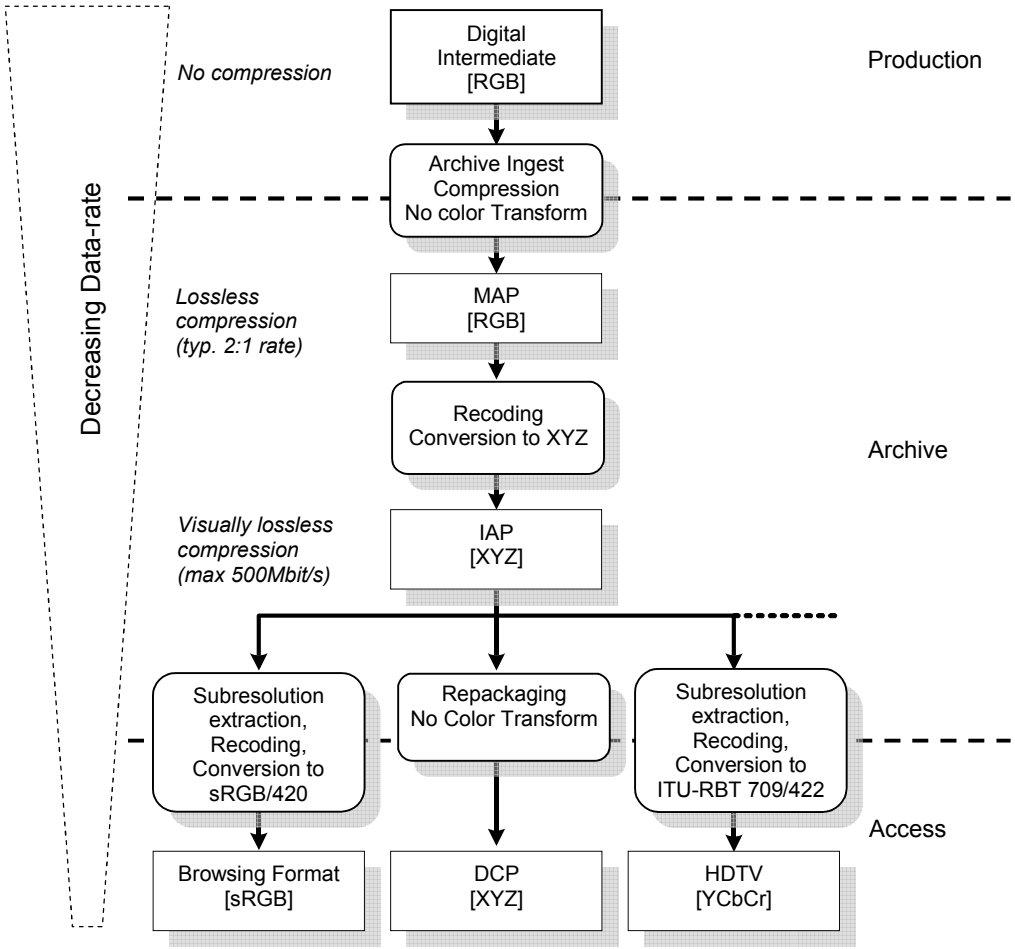

Figure 2: Workflow for ingest, archiving and access for a digitally post-produced film

7. STANDARDS PROPOSALS

It is part of EDCine-Archive's mandate to undertake all the necessary actions to ensure that all the relevant parts of the EDCine Digital Film Archive System either utilize existing standards or whenever this is applicable, standardization processes are undertaken.

JPEG 2000 is a comprehensive standard with many parameters and possibilities, resulting in a rather high complexity for hardware and software solutions supporting all of its features. In order to reduce this complexity, and to minimize the efforts required to implement encoders or decoders for a specific application, several JPEG 2000 profiles were defined, which effectively limit the choice of parameters and features for a specific application. For example, two profiles are currently defined and in use for D-Cinema cinema distribution[8]: respectively for 2k and 4k image resolution, both using lossy (but visually lossless) compression. For archival applications, three new profiles have been proposed and are currently in the ballot process to be standardized as amendments to the JPEG 2000 part 1 standard.

Other standardisation initiatives, e.g. in the MXF and in the metadata areas, are currently being assessed.

8. OBJECTIVES FOR EDCINE/ARCHIVES

Objectives for EDCine/Archives include:

- the design of the proposed digital route for film archives
- the research, preparation and presentation of a Demonstrator, a PC based software package that demonstrates a selection of the proposed files, formats and routes for Ingest, archive master and access outputs including, if applicable, a projectable digital format for heritage and current cinema film formats.
- A program of symposia (to be organised in several European locations) to illustrate and discuss the EDCine approach to moving image archiving, divided in:
    - an initial programme covering the basic issues facing moving image archives and the technology utilized by EDCine.
    - a series of presentations demonstrating the technology researched via the Demonstrator.

[8] ISO/IEC 15444-1, AMD1: Profiles for Digital Cinema

9. SUMMARY OF THE FUNCTIONS AND SYSTEMS IN THE DEMONSTRATOR

The following diagram illustrates what the project is considering as a workflow to be used in the demonstrator. Specifics of the demonstrator are currently under evaluation, so what shown here can change in the coming months.

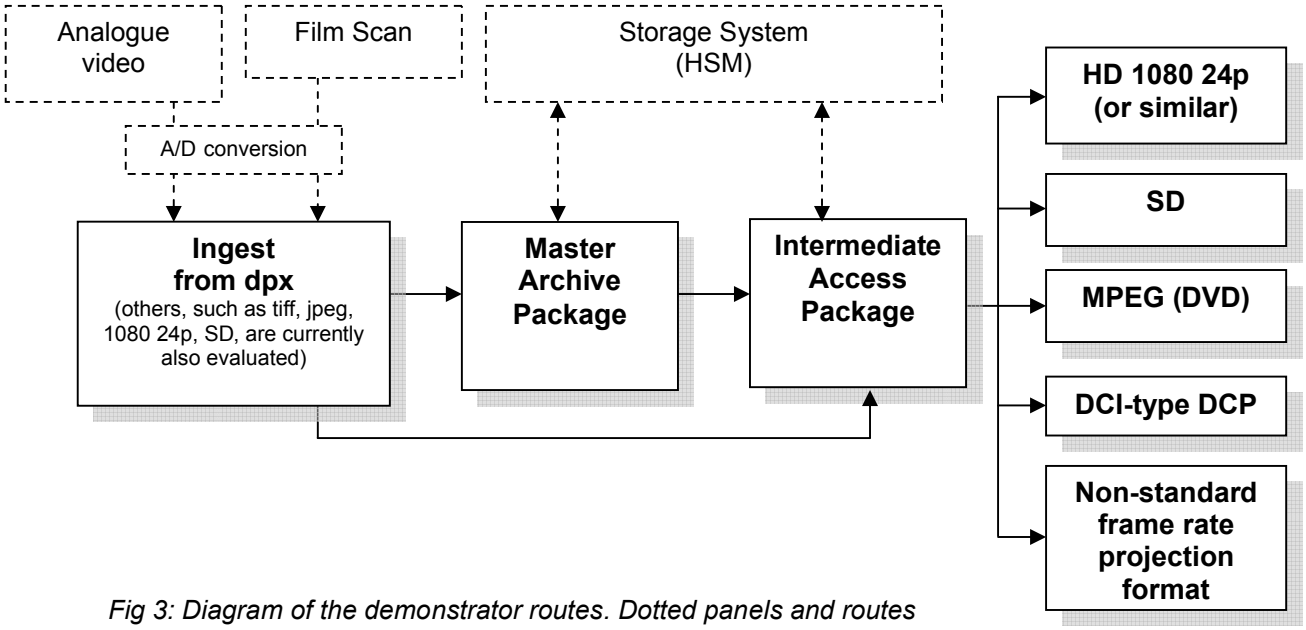

Fig 3: Diagram of the demonstrator routes. Dotted panels and routes are shown for context but are not part of the Demonstrator.

10. FUTURE PROSPECTS

EDCine does not set out to replace film with digital content, except to extend and speed access into a wider availability.
Film is the best preservation format for film at this time. However film is already being replaced by digitally borne content and this lacks film's more affordable and more certain future.
Furthermore, all archives worldwide are facing the issue of how to ingest, store, manage, conserve and preserve efficiently and effectively film content in digital form. EDCine is working to respond to these needs both in terms of a practical solution, a system ready to be implemented at the end of the project, and as an overall approach and model.

APPENDIX A: PROPOSAL FOR NEW STANDARDIZED JPEG 2000 PROFILES FOR ARCHIVAL APPLICATIONS

The following table contains a description of a proposal for new standardized JPEG 2000 profiles. At present, the proposal is being discussed and reviewed, so details can change.

Codestream restrictions for Archive applications			
	Scalable 2k digital cinema profile (Intermediate Access Package)	**Scalable 4k digital cinema profile (Intermediate Access Package)**	**Long-term storage profile for cinematic content (Master Archive Package)**
SIZ marker segment			
Profile Indication	Rsiz=5	Rsiz=6	Rsiz=7
Image size	Xsiz <= 2048, Ysiz <= 1080	Xsiz <= 4096, Ysiz <= 2160	Xsiz <= 16384, Ysiz <= 8640
Tiles	one tile for the whole image: YTsiz + YTOsiz >= Ysiz XTsiz + XTOsiz >= Xsiz	one tile for the whole image: YTsiz + YTOsiz >= Ysiz XTsiz + XTOsiz >= Xsiz	One tile for the whole image or minimum tile size: YTsiz + YTOsiz >= 1024 XTsiz + XTOsiz >= 1024
Image and tile origin	XOsiz = YOsiz = XTOsiz = YTOsiz = 0	XOsiz = YOsiz = XTOsiz = YTOsiz = 0	XOsiz = YOsiz = XTOsiz = YTOsiz = 0
Sub-sampling	$XRsiz^i = YRsiz^i = 1$	$XRsiz^i = YRsiz^i = 1$	No restriction
Number of components	Csiz = 3	Csiz = 3	Csiz<=8
Bitdepth	$Ssiz^i$ = 11 (i.e., 12 bit unsigned)	$Ssiz^i$ = 11 (i.e., 12 bit unsigned)	No restriction
RGN marker segment	Disallowed, i.e., no region of interest	Disallowed, i.e., no region of interest	Disallowed, i.e., no region of interest
COD/COC marker segments	Main header only	Main header only	Main header only
Coding style	Scod, Scoc = 0000 0esp, where e=s=0, and p=1 Note – e=0: EPH marker shall not be used s=0: SOP marker shall not be used p=1: precincts defined in $SPcodI^i$ / $SPcocI^i$	Scod, Scoc = 0000 0esp, where e=s=0, and p=1 Note – e=0: EPH marker shall not be used s=0: SOP marker shall not be used p=1: precincts defined in $SPcodI^i$ / $SPcocI^i$	Scod, Scoc = 0000 0esp, where e=s=1, and p=0 or 1 Note – e: EPH marker shall be used s: SOP marker shall be used p: precincts with PPx=15 and PPy=15 or defined in $SPcodI^i$ / $SPcocI^i$
Progression order	CPRL	CPRL	CPRL
Number of layers	L=2	L=2	L<=5
Multiple component transform	No restriction	No restriction	No restriction
Number of decomposition levels	N_L <= 5 Every component of every image of a distribution shall have the same number of wavelet transform levels.	1<= N_L <= 6 Every component of every image of a distribution shall have the same number of wavelet transform levels.	No restriction, with respect to: (Xsiz-XOsiz)/D(*I*) <= 64 (Ysiz-YOsiz)/D(*I*) <= 64 and D(*I*)=pow(2,N_L) for each component *I*
Code-block size	xcb = ycb = 5	xcb = ycb = 5	xcb <= 6, ycb <= 6
Code-block style	SPcod, SPcoc = 0000 0000	SPcod, SPcoc = 0000 0000	SPcod, SPcoc = 00sp vtra where r = v = 0, and a, t, p, s = 0 or 1 NOTE — a = 1 for selective arithmetic coding bypass t = 1 for termination on each coding pass, p = 1 for predictive termination s = 1 for segmentation symbols

Transformation	9-7 irreversible filter	9-7 irreversible filter	No restriction
Precinct size	PPx = PPy = 7 for N_LLL band, else 8	PPx = PPy = 7 for N_LLL band, else 8	PPx >= xcb, PPy >= ycb
Tile-parts	Each compressed image shall have exactly 6 tile parts. Each of the first 3 tile parts shall contain all data necessary to decompress one 2K color component compatible to 2k digital cinema profile. Each of the next tile parts shall contain all additional data necessary to decompress the rest color component. The resulting codestream structure is diagramed in Figures A-29	Each compressed image shall have exactly 12 tile parts. Each of the first 3 tile parts shall contain all data necessary to decompress one 2K color component compatible to 2k digital cinema profile. Each of the next 3 tile parts shall contain all additional data necessary to decompress one 4K color component. Each of the next 3 tile parts shall contain all additional data necessary for the rest of one 2k color component. Each of the next tile parts shall contain all additional data necessary to decompress one the rest of the color component. The resulting codestream structure is diagramed in Figures A-25, A-27 and A-28.	Each compressed image shall have exactly Csiz tile parts. Each tile part shall contain all data from one component
Other markers			
Packed headers (PPM, PPT)	Disallowed	Disallowed	Disallowed
Tile-part lengths (TLM)	TLM marker segments are required in each image	TLM marker segments are required in each image	TLM marker segments are required in each image
Packet length, tile-part header (PLT)	For each tile-part a complete list of packet lengths shall be provided	For each tile-part a complete list of packet lengths shall be provided	For each tile-part a complete list of packet lengths shall be provided
QCD, QCC	Main header only	Main header only	Main header only
SOP, EPH	Disallowed	Disallowed	Each packet in any given tile-part shall be prepended with a SOP marker segment and each packet header in any given tile-part shall be postpended with an EPH marker segment
POC marker	There shall be exactly one POC marker segment in the main header. Other POC marker segments are disallowed. The POC marker segment shall specify exactly two progressions having the following parameters: First progression: RSpoc = 0, CSpoc = 0, LYEpoc = 1, REpoc = N_L+1, CEpoc = 3, Ppoc = 4 Second progression: RSpoc = 0, CSpoc = 0, LYEpoc = 2, REpoc = N_L+1, CEpoc = 3, Ppoc = 4	There shall be exactly one POC marker segment in the main header. Other POC marker segments are disallowed. The POC marker segment shall specify exactly four progressions having the following parameters: First progression: RSpoc = 0, CSpoc = 0, LYEpoc = 1, REpoc = N_L, CEpoc = 3, Ppoc = 4 Second progression: RSpoc = N_L, CSpoc = 0, LYEpoc = 1, REpoc = N_L+1, CEpoc = 3, Ppoc = 4 Third Progression: RSpoc = 0, CSpoc = 0, LYEpoc = 2, REpoc = N_L, CEpoc = 3, Ppoc = 4 Fourth Progression: RSpoc = N_L, CSpoc = 0, LYEpoc = 2, REpoc = N_L+1, CEpoc = 3, Ppoc = 4	Disallowed

Application specific restrictions			
Error protection	Disallowed	Disallowed	The use of marker segments defined in ITU-T Rec. T.810 | ISO/IEC 15444-11 for the detection, correction and protection against errors that may result from aging media is not mandatory but optional and strongly recommended.
Max compressed bytes for any image frame (aggregate of all 3 color components)	1302083 bytes	2604166 bytes	No restrictions
Max compressed bytes for any single color component of an image frame	1041666 bytes	2083332 bytes	No restrictions
Max compressed bytes for quality layer 0 of any image frame (aggregate of all 3 color components)	1302083 bytes for 24 fps 651041 bytes for 48 fps	1302083 bytes for 24 fps	No restrictions
Max compressed bytes for layer 0 of any single color component of an image frame	1041666 bytes for 24 fps 520833 bytes for 48 fps	1041666 bytes for 24 fps for 2K portion of each component.	No restrictions

Main header	Tile-part header	c0p*r*l1	Tile-part header	c1p*r*l1	Tile-part header	c2p*r*l1	Tile-part header	c0p*r*l2	Tile-part header	c0p*r*l2	Tile-part header	c0p*r*l2

Proposed codestream structure. Assuming N_L wavelet transform levels (N_L+1 resolutions), the rectangle labelled c*i*p*r*l1 (*i* = 0, 1, 2) contains all packets for color component *i*, all precincts, resolutions 0 through N_L and layer 1. The rectangle labelled c*i*p*r*l2 (*i* = 0, 1, 2) contains all packets for color component *i*, resolutions 0 through N_L and layer 2.

APPENDIX B: EDCINE/ARCHIVES' SYMPOSIA

EDCine organises a series of symposia specifically addressed to archivists and professionals responsible for the archiving, digitizing and distribution of archival materials.

The symposia are organised in different locations in Europe in collaboration with local Archives and Institutions.

The program is divided in two parts.

Part One is designed as an in-depth introduction to the fundamental issues related to archiving and accessing film content in a digital environment, and it is addressed to all archivists and cinema professionals concerned with the application of digital technology to cinema archiving.

Part Two symposia focus on a practical demonstration of the results of the EDCine Project, as concrete applications for storing, managing and distributing digitized archival films.

Although at this time (October 2008), the complete program of events is being finalised, some appointments can already be announced. The following list is not yet complete, and we hope that other locations will be added in the coming weeks.

EDCINE SYMPOSIA PART ONE:
DIGITAL TECHNOLOGY FOR MOVING IMAGE ARCHIVES IN DIGITAL INGEST, STORAGE, ACCESS AND DISTRIBUTION

Bologna, July 3rd & 4th, 2008, in collaboration with the Cineteca di Bologna, the Festival Il Cinema Ritrovato, Mostra Internazionale del Cinema Libero.

London, November 24th & 25th, 2008, in collaboration with BFI Southbank

Copenhagen, January 22nd and 23rd, 2009, in collaboration with the Danish Film Institute

Valencia, March 5th and 6th, 2009, in collaboration with the Valencia Film Archive

CONTENT

The content covers all the background and introductory understanding needed for archivists, technicians and technologists to appreciate the choices, alternatives and possibilities available in this area. The programme will be structured around D-Cinema distribution routes but will include the many lower bit-rates, formats and quality versions relevant to TV, internet, home movie etc.

AUDIENCE

The program will be beneficial to:

- Directors and managers of moving image archives, who have, or plan to have, digital projects.
- Film and TV Archive technical staff concerned with cinema display and digital preservation and access.
- Technical and management staff of digital facility and post houses intending to provide film and digital services to archives.
- First and second degree students of film and TV archive programmes.
- Industry: exhibitors, distributors, producers, post-houses

DURATION

Two days (12-14 hours) of presentations and information content: lectures, demonstrations, discussion and tutorials.

TOPICS COVERED IN THE INITIAL TRAINING PROGRAMMES

THE CHALLENGES

Archives and cinémathèques facing advent of Digital in preservation and exhibition

FILM FOR DIGITAL CINEMA TODAY

Cinema film becomes digital film becomes digital cinema. Explaining cinema archives to film makers, and modern film making to archivists.

DIGITAL FORMATS FOR MOVING IMAGES AND AUDIO FOR ACCESS.

An archival perspective on of digital file formats and media, hardware and software current and medium term overview

DIGITAL TECHNOLOGY, DCI, SMPTE AND DIGITAL CINEMA PACKAGES,

The proposed digital cinema systems and the need for simplified creation of digital projection formats.

DIGITAL DILEMMA FOR ARCHIVES AND THE OBJECTIVES FOR EDCINE.

A two-need system: access and preservation. Maintaining a filmic image from film originals in the cinema and fast, simple, easy access to lower qualities.

JPEG 2000

An introduction to JPEG 2000, its application in D-Cinema and its advantages in the context of digital preservation of moving image content (film, video)

MXF, JPEG 2000 AND EDCINE.

An introduction to MXF from the perspective of its application in the archival workflow, and in EDCine/Archives proposed architecture

THE FILM (AND VIDEO) ARCHIVE AND ITS DIGITAL POLICY

Policies and strategies for digital preservation of film collections; EDCine proposed system in a real archival environment; the areas needing further research.

LOOKING AHEAD ANOTHER HUNDRED YEARS.

A look into the future from the perspective of film archives.

EDCINE SYMPOSIA PART TWO: THE EDCINE ARCHIVE PROJECT – RESEARCH, PROPOSALS AND PRACTICE.

London, May 28th, 2009, in collaboration with BFI Southbank
Brussels, June 2009 (date to be confirmed) – EDCine/Archives closing event

CONTENT

A final deliverable of the project will be a demonstration of the use of JPEG 2000 and MXF, and of open standards as means to provide film (and other moving image) archives with methods of ingesting, storing, providing access, creating versions in various format and qualities to both content and its associated metadata. The session will be provided in context, with real archive content and at a real scale.

AUDIENCE

The symposia will be beneficial to:

- Archivists, technicians, technologists, and students that have attended Part One of the programme.
- Technology managers from archives and digital facility houses familiar with film archive requirements.
- Senior management of film and TV archives.
- University academic staff, influential movers within the archive world and the entertainment industry.

DURATION:

One full day – 6hrs approx.