

Digital Cinema – A preliminary review



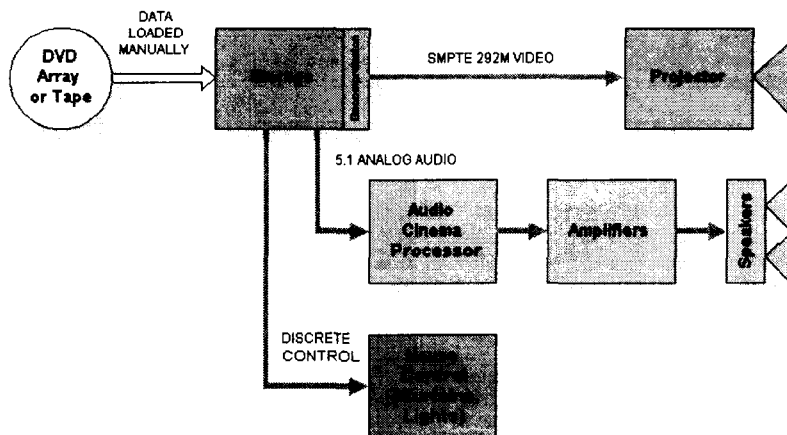
Why D-Cinema?

- Cost
 - \$1 billion per year for making prints and delivery
 - cost of 35mm film takes large portion of producing cost
- Flexibility
 - breaking the limitation of number of prints
 - alternative contents for non-busy hours

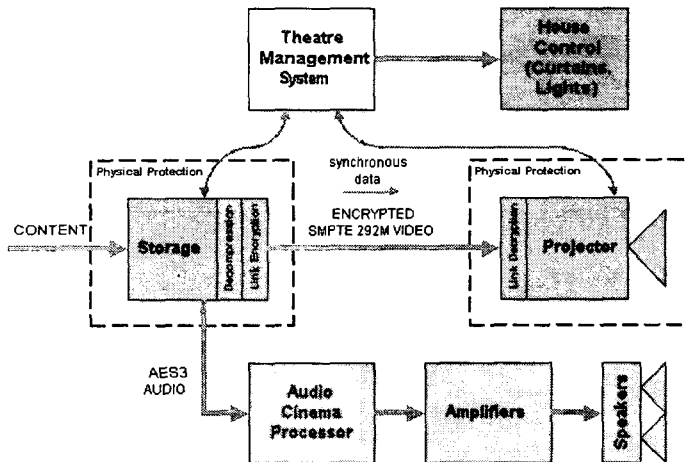
What's in Digital Cinema

- Digitally produced cinema
 - Shooting in Digital
 - 1920x1080@24P
- Digitally delivered cinema
 - mastering
 - distribution
- Independent films
 - low cost solutions

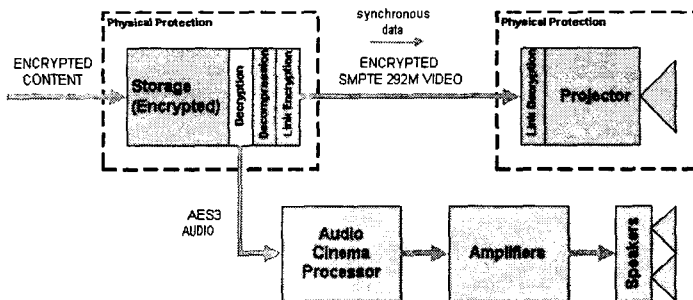
Phase I



Phase II



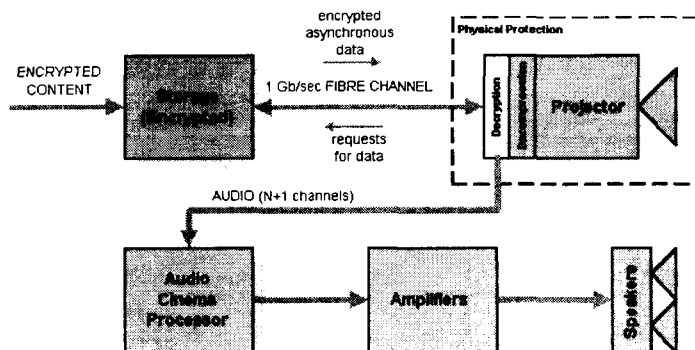
Broadcast server model



Broadcast server model

- problem of cost
 - both server and the project must be physically secure
 - higher maintenance costs
- problem in link between the server and the projector
 - SMPTE 292M was designed for HDTV applications, 1Gbps
 - approximately 7.5Gbps is required for D-Cinema

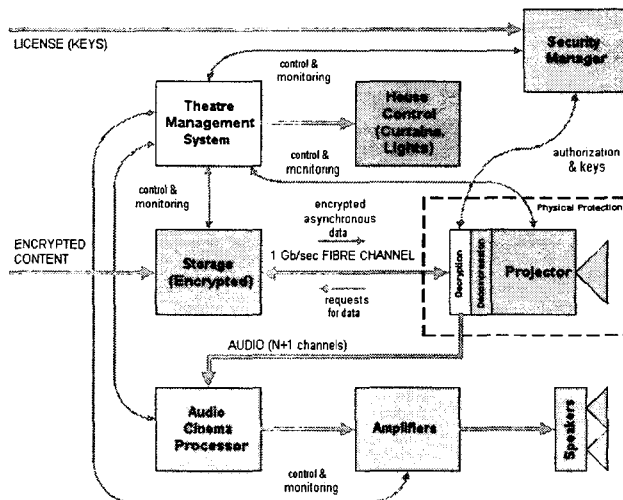
Data Server Model



Data Server Model

- Pull model
 - asynchronous transfer from storage to projector
 - server only serves data on the request of projector
- Server is not part of security system
- 1Gbps link is enough
- no capability of supporting streaming content

Full Rollout Model



Full rollout model

- TMS
 - operator's user interface to the digital cinema system
 - terminal where system faults and status can be monitored
- Security manager
 - receipt of content decryption keys
 - local source of authority in the exhibition system

SMPTE DC28

- DC28.2W Mastering
- DC28.3W Compression
- DC28.4W Conditional Access
- DC28.5W Transport
- DC28.6W Audio
- DC28.7W Theatre Systems
- DC28.8W Projection

NATO

■ Goal

- To encourage the development of fully interoperable, competitive products that can be maintained at relatively low cost, in the manner of today's film projection systems.
- We need to accomplish this while providing a minimum digital presentation quality that exceeds that of film, and that meets the quality needs of the creative community.
- To achieve this goal, international cooperation is needed.

NATO

■ We need

- Minimum presentation standards for image projection, including color gamut, contrast ratio, and pixel count.
- International standards for digital image and audio data representation, storage, and play out.
- System support for more than one method of movie data delivery (e.g., physical, satellite transmission, fiber, etc.)
- International acceptance of a single encryption algorithm.
- Rules for digital rights expression and for electronic methods of exhibitor authorization that duplicate the current rights and facilities existing in 35mm technology.
- International acceptance of a single image compression algorithm.
- International standard for a single audio compression, if implemented.
- International standards for electronic interfaces, networks, and protocols used on all equipment, including secure interfaces.

User requirements from NATO

- Overall
 - The system architecture shall insure the lowest cost of ownership.
 - Normal maintenance procedures shall not compromise the security of valued content.
 - The system shall make use of, wherever possible, existing and established standards to govern system interfaces and processes.
 - Content shall be playable with uniform results on different makes and technologies of playback and projection equipment.
 - In order to promote product competition, proprietary technologies shall be standardized and fairly licensed.

User requirements from NATO

- Content Packaging
 - Digital content shall be packaged for efficient store and forward distribution, so as to minimize the use of the facility's data storage.
 - The system shall allow the Exhibitor to have full discretion over presentation of ads, trailers, and features.
 - Exhibitors request the ability to select language, rating version, etc.
- Distribution
 - The system shall employ "single inventory" distribution of content, such that the same set of digital files can play with uniform results on different makes of equipment.
 - Content shall be distributed such that completeness and integrity of data is validated automatically upon receipt, and can be validated manually after receipt.
 - Digital content that is encrypted prior to distribution shall retain the original encryption throughout the distribution process.

User requirements from NATO

- Content Protection
 - The mechanisms and processes that support content protection shall not interfere with normal business operation within the facility.
 - The content protection and right management system shall support a policy of "No Dark Screen". When a facility is authorized to play content, then usage of that content may be logged in an audit trail by the exhibitor, and no effort is made to prevent the content from playing within that facility.
 - Content decryption keys or licenses shall be delivered to exhibition sites based on the identity of the facility, and not on the identity of specific projection equipment.
 - Keys or licenses shall be delivered to the facility in a non-repudiate manner.
 - Content shall only be decrypted, whether of the original encryption or a link encryption, in components that pass an authentication process, where authentication is defined as a secure process that determines the legitimate nature of the component. (E.g., .I am a projector..)
 - Digital image streams or files shall not be available in clear text form in unprotected components, networks, or links of the playback system.
 - It is desired that playback systems provide either an image or audio watermark that encodes sufficient information for forensic evaluation.

User requirements from NATO

- Encryption
 - Cryptographic content security shall be based upon strong, established, tested, non-proprietary encryption algorithms.
 - If decryption algorithms and link encryption algorithms are to be renewable, they shall be renewable without obsolescence of hardware.
- Audit Logs
 - Audit logs shall be securely retained by the exhibitor.
 - Audit logs, or portions of audit logs, shall only be available to the exhibitor and by parties who have contracted with the exhibitor for access. Parties who have contracted for access shall only have access to data that is material to that party.
- Control and Monitoring
 - The system shall have networked supervisory controls and monitoring that can be remotely accessed by means of secure networks.

EDCF

- **European Digital Cinema Forum**
 - Formed at June 13th 2001
 - Founding members
 - Swedish Work Group for E-cinema (Swedish Film Institute)
 - the DTI/DCMS Group on Digital Film Production and Distribution (UK)
 - Groupe de Travail Cinéma Numérique (CNC/CST, France)
 - Three modules
 - Technical
 - Commercial
 - Content

EDCF

- **Objectives**
 - To function as a network for European co-operation on e- and d-cinema activities.
 - To identify key issues, gather information and create models to encourage private investments and public support schemes.
 - To liaise with other relevant bodies to assist in the establishment of appropriate world-wide standards for e- and d-cinema.
 - To co-ordinate and establish European user requirements for standards for all parts of the e- and d-cinema chains.
 - To initiate and co-ordinate R&D relevant to European digital cinema.
 - To stimulate European production with a broad scope of quality content for e- and d-cinema.

EDCF-C User Requirements

- Better Quality than Current 35mm Projection
- Universal, (Movies or Alternative content)
- Interoperable between manufacturers
- Multiple transport mechanisms
- High Security of content and access tracking
- Upgradeable Systems
- Reasonable cost
- Quality Tiers

Technology Levels

- Level 1
 - matching or exceeding the capabilities of existing 35mm film in terms of color, contrast and resolution.
 - Used for digital cinema presentations.
- Level 2
 - equivalent to standardized high definition television (HDTV) specifications (for example : 1920/1080/24P after visually lossless compression).
 - Used for current digital cinema and electronic cinema presentations.
- Level 3
 - equivalent to enhanced standard definition (EDTV) specifications.
 - Used for electronic cinema presentations.
- Level 4
 - equivalent to standard definition (SDTV) specifications.
 - Used for electronic cinema presentations.

EDCF-T Topic Groups

- Mastering
- Image Compression
- Transport and Delivery
- Security
- Theater systems
- Audio
- Projection systems
- Server systems

Pending Studies

- Projector Technology Evaluation
- Compression System Evaluation

D-Cinema in MPEG

- AHG from March 2000
- Produced
 - Requirements
 - Evaluation plan
 - Call for proposal
 - Workplan
- Pending...
 - DCI is examining these factors and will determine a set of requirements for a Digital Cinema system. The requirements for the video codec have not been determined to date and will be developed over the next six months. The first order of business is to determine the financial issues, which is currently being done.
 - Several experiments are being planned to determine the impact of several key issues on the HVS. Among these issues are resolution, chroma sampling, pixel bit depth, and the sensitivity of the HVS to artifacts on large screens

DCI

- Joint venture
 - Disney
 - Fox
 - MGM
 - Paramount
 - Sony Pictures Entertainment
 - Universal and Warner Bros.
- formed in March 2002
- to establish and document an open architecture for digital cinema components that ensures a uniform and high level of technical performance, reliability and quality control.

D-Cinema Req.

■ Focus

- Archive
 - intended for storage of the highest quality version of a motion picture.
 - An archive is the source from which all release material is generated.
- Distribution
 - includes the process of delivering motion pictures to movie theatres and their subsequent projection.
 - Compression ratios are expected to be higher than for the archive by permitting visually lossless compression

Requirements on Visual

- Archive
 - The standard shall support efficient mathematically lossless compression of moving pictures.
 - The standard shall support coding of pictures containing up to 16 million pixels. The typical operating range is expected to be between 2 and 13 million pixels.
 - The standard shall support coding of moving pictures in progressive format only.
 - The standard shall support coding of moving pictures with frame rates ranging between 12 and 150Hz.
 - The standard shall support coding of moving pictures containing up to 16 bits per pixel component (linear and logarithmic).
 - The standard shall support coding of moving pictures in RGB and YUV formats. For the YUV format, 4:4:4, 4:2:2 and 4:2:0 samplings shall be supported only if the source is in this format. Furthermore, coding of colorimetry information, e.g., color primaries, shall be supported.
 - The standard should support means to facilitate transcoding to a wide range of lower resolution distribution formats, such as theatre resolution, HDTV, SDTV, mobile applications.

Requirements on Visual

- Distribution
 - The standard shall support efficient visually lossless compression of moving pictures. Visually lossless is understood to mean that the reconstructed moving pictures after decompression shall not be distinguishable from its original by a human observer when exposed to typical viewing conditions in a theatre set-up. This applies to different kinds of material, such as natural scenes, animation, and computer generated.
 - The standard shall support coding of moving pictures containing up to 16 million pixels.
 - The standard shall only support coding of moving pictures in progressive format.
 - The standard shall support coding of moving pictures with frame rates ranging between 23.976 and 75 Hz.
 - The standard shall support coding of moving pictures containing a minimum of 8 bits per color.
 - The standard shall support coding of moving pictures from a gamma corrected RGB source.
 - The standard shall support limited random access capabilities, e.g. restarting the system after a crash and scene replacement. A scene may consist of a single frame.
 - The standard shall support variable bit rate coding. A maximum bitrate constraint shall be supported.

Requirements on Audio

- The standard shall support lossless representation of audio.
- A minimum channel count of sixteen full-bandwidth channels, not all of which need to be used. Two of the channels will be used for hearing impaired and visually impaired narratives.
- The standard shall support only 24 bits per sample.
- The sample rate shall be fixed at forty-eight thousand samples per second irrespective of the associated image frame rate or rates.
- Digital reference level shall be -20 dBFS.
- Analog reference levels of +4 dBu and -10 dBv.

Requirement on System

- Archive
 - The standard shall support synchronization of moving and still pictures, subtitles, captions, audio, and metadata streams.
 - The standard shall support efficient carriage of multi-lingual captions.
 - The standard shall support efficient carriage of metadata.

Requirement on System

- Distribution
 - Composition
 - The standard shall support composition of moving and still pictures and subtitles.
 - The standard shall support synchronization of moving and still pictures, subtitles, audio, captions, and metadata streams.
 - The standard shall support multiple streams of moving and still pictures, subtitles, audio, captions, and metadata, to be played back in a sequence.
 - The standard shall support scrolling of graphical information
 - The standard shall support efficient carriage of metadata.
 - The standard shall support efficient carriage of multi-lingual captions.
 - The standard shall support independent management and protection (IPMP) of moving and still pictures, subtitles, captions, audio, and metadata objects.
 - File transfer
 - The standard shall support point to multi-point (one to many) transfer.
 - The standard shall support error recovery.
 - The standard shall support independent transfer of moving and still pictures, subtitle, captions, audio and metadata streams.

DALSA

- L3 = Lossless, Low-complexity, and Layered
- Mathematically lossless - decompressed images are bit-for-bit and pixel-for-pixel identical to the original
- Higher compression than any other lossless scheme, including JPEG 2000, JPEG-LS or any MPEG standard
- Scalable, wavelet-based, allowing lower-resolution views to be extracted directly from compressed images
- Suitable for parallel hardware implementation (required by camera's throughput)
- DALSA will develop reference hardware design for third party use
- Royalty-free algorithm for cameras and workflow in digital movie production

Hurdles for transition

- Standards (interoperability)
 - Digital sounds : DTS, Dolby,...
- Quality (performance)
 - something better than current 35mm
- Financial
 - 35mm projector : \$30,000 for 20 years
 - D-Cinema projector : \$100,000 for 2 years
 - cost saving for distribution : \$800 million

Conclusion

- DCI
- SMPTE DC28
- MPEG