

A

Seminar report

On

Digital Theatre System

Submitted in partial fulfillment of the requirement for the award of degree
Of MCA

SUBMITTED TO:

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Preface

I have made this report file on the topic **Digital Theatre System**; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude towho assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

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Acknowledgement

I would like to thank respected Mr..... and Mr.for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

Secondly, I would like to thank my parents who patiently helped me as i went through my work and helped to modify and eliminate some of the irrelevant or un-necessary stuffs.

Thirdly, I would like to thank my friends who helped me to make my work more organized and well-stacked till the end.

Next, I would thank Microsoft for developing such a wonderful tool like MS Word. It helped my work a lot to remain error-free.

Last but clearly not the least, I would thank The Almighty for giving me strength to complete my report on time.

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INTRODUCTION

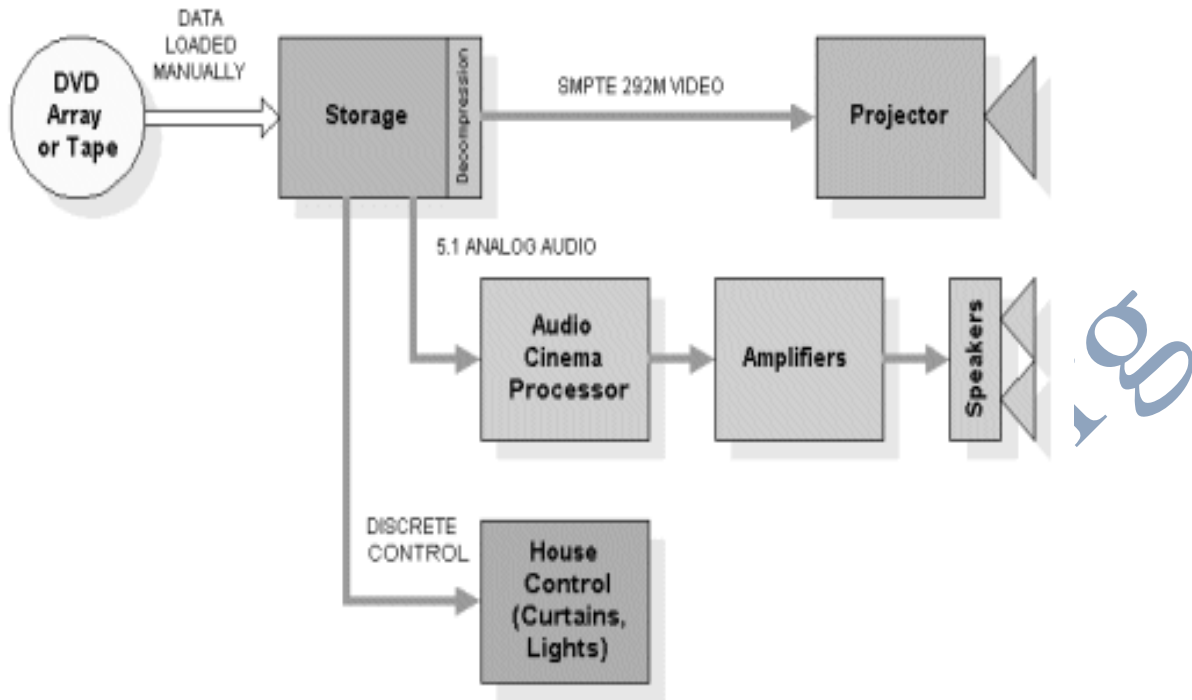
Digital Theatre System (Digital cinema, or *d-cinema*) is perhaps the most significant challenge to the cinema industry since the introduction of sound on film. As with any new technology, there are those who want to do it fast, and those who want to do it right. Both points of view are useful. This new technology will completely replace the conventional theatre system having projectors, film boxes, low quality picture, sound system.

Let's not forget the lesson learned with the introduction of digital audio for film in the '90s. Cinema Digital Sound, a division of Optical Radiation Corporation, was the first to put digital audio on 35mm film. Very, very few remember CDS, who closed their doors long ago. Such are the rewards for being first.

1999 / 2000: MEETING THE CHALLENGE

Various forms of electronic cinema have been around for many years. Public demonstrations of modern day digital cinema, however, began in 1999 as an experimental effort privately funded by major motion picture studios. What better way to learn the many issues of a new technology than to jump in with both feet?

The block diagram below represents the typical trial digital exhibition system in the year 2000. Many of these systems are still in use today.



In the initial trial stage, the server used for storage and play out was a *QuBit* unit, manufactured by QuVis. The QuVis server is loaded with the digital movie from either discs or tape, compressed with a proprietary wavelet compression algorithm. Data is scrambled on the hard drive for protection. But digital image data sent to the projector was not protected. For early trial systems, no one seemed too concerned about the potential security risks of these systems, given that it would take a knowledgeable person and a very expensive recorder to pirate the movie. (As it turns out, no digital thefts from the projection booth have ever been reported, and the patron with a digital camcorder has become the threat.) Security remained an issue, but one for a later phase.

Star Wars Episode I and *An Ideal Husband* were the first motion pictures to be released to the big screen in digital in June of 1999. *Star Wars Episode I* was displayed on four digital systems, two in Los Angeles, and two in New York. Two Hughes/JVC ILA-12K projectors, and two early prototype DLP-Cinema projectors from Texas Instruments were used for the *Star Wars* demonstrations. The digital demonstrations of *An Ideal Husband* were presented only on the Hughes/JVC ILA-12K. The ILA-12K produced a

good looking picture, but was difficult to maintain in a day-to-day theatrical environment. The projector technology of choice quickly became DLP Cinema from Texas Instruments. In the early days, the only projectors available were prototypes built by TI. Today, TI has three licensees: Barco, Christie, and NEC/Digital Projection. TI is the only game in town today, but that could change in 2004.

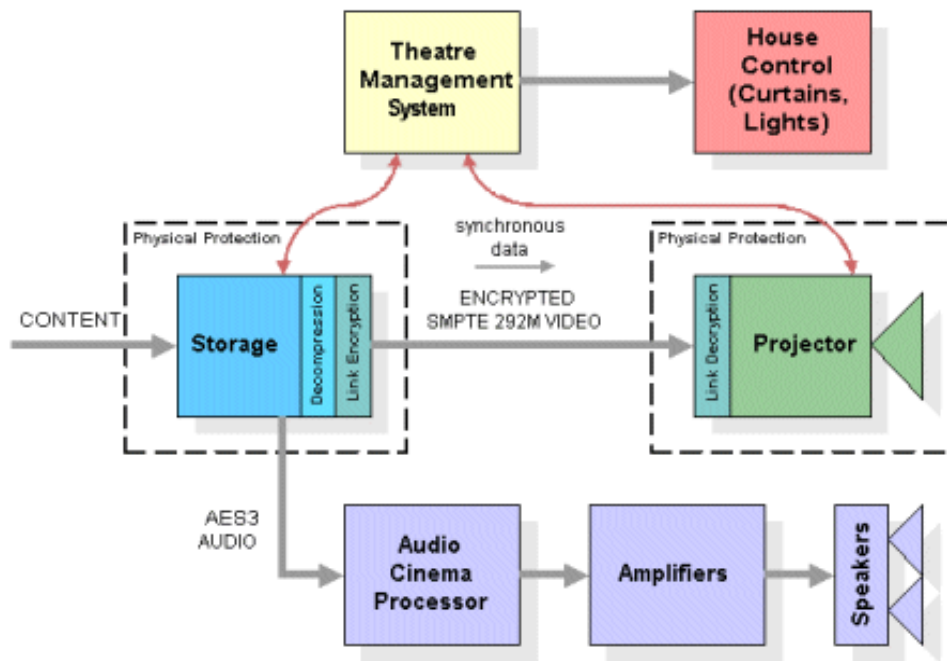
The server provides digital audio as multiple AES/EBU (AES3) streams. Some cinema processors can be configured to directly accept digital audio, and digital audio can be converted to analog for legacy cinema processors. The server also has the ability to command "house controls", i.e., lights and curtains. No improvements were made upon this system until the later half of 2001.

STEPS FORWARD

On July 17, 2001, a digital cinema milestone was crossed with the digital premiere of *Jurassic Park III* in Los Angeles. This particular presentation was compressed with a version of MPEG 2, as developed for digital cinema applications by Grass Valley Group. Called MPEG+, GVG's compression was based upon the MPEG 2 decompression standard, making this the first public digital cinema presentation to use an *almost* standard decompression scheme. Within weeks, a true MPEG 2 presentation was held in New York for Tim Burton's *Planet of the Apes*, this time using an Avica digital cinema server. Together, these presentations marked the beginning of a new phase for digital cinema by bringing new components to the scene.

A third server company, EVS, whose product is also based on MPEG, later jumped in with both Grass Valley and Avica to create interoperable servers. While a noble goal, it did not lead to true interoperability. GVG dropped out of the digital cinema game, and EVS and Avica were not able to demonstrate products that were fully interoperable.

Security got a little boost during this period, though. TI and GVG developed a *link encryption* method, called Cinelink(tm) for the protection of the (SMPTE 292) digital link between server and projector. While promoted by the server companies, it was not implemented in either of the GVG or Avica presentation mentioned above. Link encryption is pictured in the block diagram below.



Cinelink(tm) link encryption was introduced by Texas Instruments in their Mark VII version of the DLP Cinema projector. Link encryption encrypts the image data as it is sent to the projector, offering some security to the system. Full security, however, required encryption of the content stored on the server, which had yet to be introduced.

This phase began with the promise of file interoperability, but failed to deliver. It did produce link encryption, however, which was a step towards addressing the security issue.

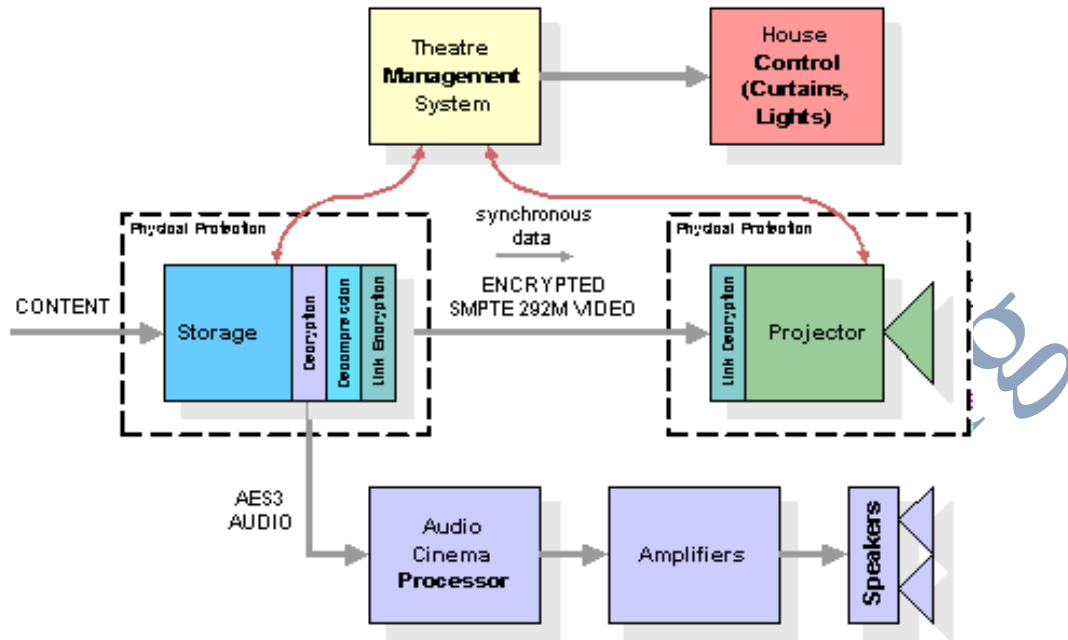
INTRODUCING SECURITY

By early 2002, digital cinema installations were numbered in the 40's. They utilized several types of servers, including the QuBit, Avica, and EVS servers already mentioned, as well as the Technicolor Digital Cinema server designed by Qualcomm. These systems represented three different compression schemes, and four file formats.

On May 16th, 2002, another digital cinema milestone was crossed with the digital release of *Star Wars: Episode II*. Although they didn't financially contribute to the digital presentation of their movie, Lucasfilm heavily promoted that it should be seen as such, and the heyday increased the digital installation count to over 100. The movie was released in all four digital formats -- which proved to be a challenge all of its own.

Episode II broke ground by being the first digital movie released employing content encryption. Not all systems were capable of supporting content security, but those employed by Boeing/Avica/EVS and Technicolor/Qualcomm certainly was. The introduction of fully secure presentation systems was a major step forward.

Many thought this phase would signal a rollout of digital cinema. But numerous issues remained, the least of which were the many incompatibilities in data packaging, encryption, key management, and compression. Exhibitors now had enough experience to know that they had operational issues, too. To add to the problems, not all cinematographers, studios, and exhibitors thought the quality level was good enough to replace film. And the overriding issue remained: there wasn't a sound business model. Studios stood to save significantly each year by not paying for film distribution, and exhibitors stood to pay significantly for the new digital equipment. While 3rd parties attempted to intermediate as system and service providers, none were successful. The business partners needed to talk.



Talking, however, wasn't a simple task. A studio collective was needed to negotiate with exhibitors. For this reason, in early 2002, Digital Cinema Initiatives LLC was created. At first known as Newco Digital Cinema, DCI is a collaboration of the seven major motion picture studios. Episode II created a digital cinema bubble, and DCI appeared on the scene just as the bubble burst. This led to much unfair blame placed on DCI for the "slowdown" of digital cinema -- a slowdown which was inevitable for all of the reasons mentioned above. Today, in 2003, DCI is busy sorting out many of the details of digital cinema, both technical and financial. In the meantime, let's take a look at some of the technical issues of digital cinema.

SYSTEM-LEVEL INTEROPERABILITY

The technology problem imposed by digital cinema is non-trivial. The goal is to replace a very mature film presentation system, upon which an entire industry is based, with a not-so-mature digital one. Obviously, if we want our ticket prices to remain low, we want the digital system to be not-so-immature upon rollout of the technology. The technology for projecting digital images onto screens, however, will not stand still once rollout is begun. Thus, the concept of "interoperability" is important, as it encapsulates an aspect of system maturity that can be addressed.

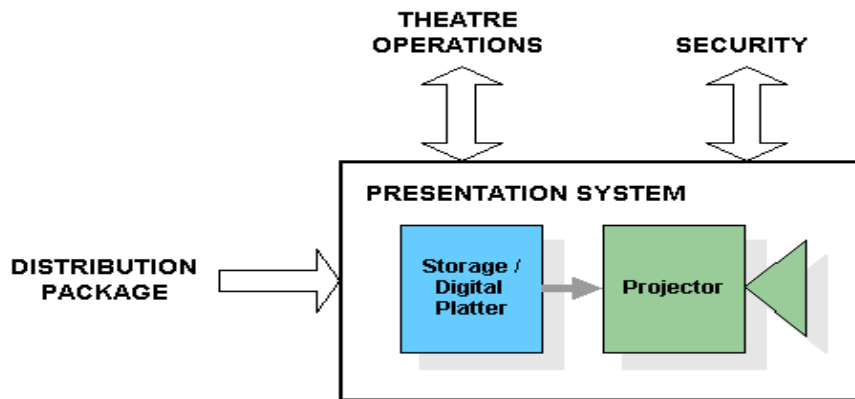
Interoperability can mean different things to different parties. Let's take a look at the practical need for interoperability from an exhibitor's point-of-view.

Digital cinema will not be introduced in the 35,000 cinema auditoriums that exist across the US in months, or even in a year. It will take many years, possibly 10 or more, to build and install a digital cinema system for every US auditorium, and this is not taking into account the over 100,000 auditoriums around the world. An international rollout of digital cinema could take a very long time.

The long rollout period has significant impact on the concept of interoperability. For example, a system installed in Year 1 will have little resemblance component-wise to a system installed in Year 10. This could be due to advancements in projection technology, data storage, networks, and/or the digital link (if any) between storage and projector. In addition, we can expect there will be clever and competitive ways of designing and building systems that we have not yet seen. The progress made by these advances will likely out-pace the on-going work of standards-making.

Obviously, it is not desirable to impede advances in storage and projection technology, particularly if they have a beneficial impact on cost. But equally so, it is not desirable to obsolete the investment in digital infrastructure that will be made in the exhibition booth. To address this problem, a model for system-level interoperability has

been introduced, originally through work produced by the National Association of Theatre Owners. This model is presented below.



The model reduces the interoperability problem to only three Presentation System interfaces: Distribution Package, Theatre Operations, and Content Security. The Distribution Package requires a common file interchange format. Theatre Operations suggests common APIs or protocols for managing the equipment in a multiplex theatre. Security also requires common APIs or protocols for the delivery of security keys to the Presentation System.

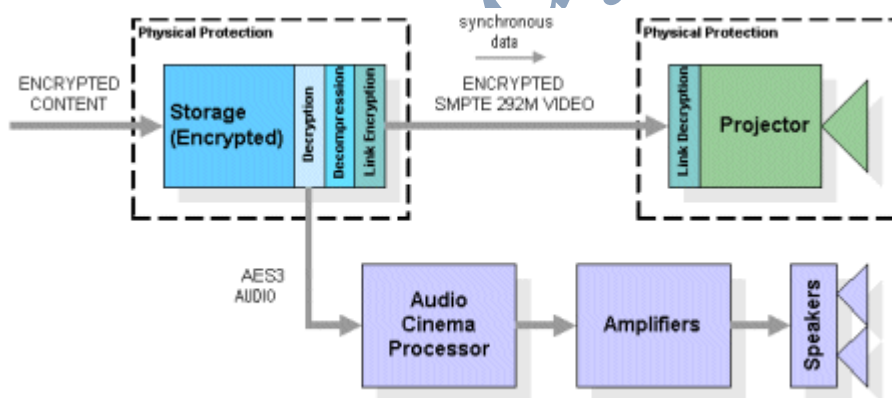
If the focus for interoperability is placed on these three areas of theatre system infrastructure, then the Presentation System is free to evolve, as it naturally will. This concept can simplify the immediate work of standards committees, but more importantly, it can allow differentiation in the design of the presentation system and still gain the confidence of the system investor. It also sets the stage for manufacturers of complete digital cinema presentation systems, much as there are manufacturers of platter and 35mm projector presentation systems today. Building from this concept of system-level interoperability, we'll explore some of the issues behind each point of interoperability: Presentation, Theatre Operations, Security, and Distribution Package.

PRESENTATION SYSTEM:

THE BROADCAST SERVER MODEL

There are two models for the secure storage and play out of digital cinema content: the Broadcast Server model, and the Data Server model. Within the realm of the Presentation System, there is no need find a winning model -- the market place is very efficient for determining winners and losers. (Which leads us back to the importance of *interoperability* as described.)

The Broadcast Server model is based on broadcast-style servers, where image content leaves the server as a decompressed, real-time stream. The server must decrypt the content sent by the studio, decompress it, and stream it to the projector. Naturally, link encryption is needed to make the link between server and projector secure. Focusing on the image and audio paths, the block diagram below depicts the Broadcast Server model.



The Broadcast Server model has the advantage of being readily available. More than one manufacturer of broadcast server products has adapted their commercial product to the cinema market. But the model also has the problem of not being efficient. The broadcast server must be an integral part of the security system, since it decrypts the strong encryption used by the studios. The projector by default must also be in the secure

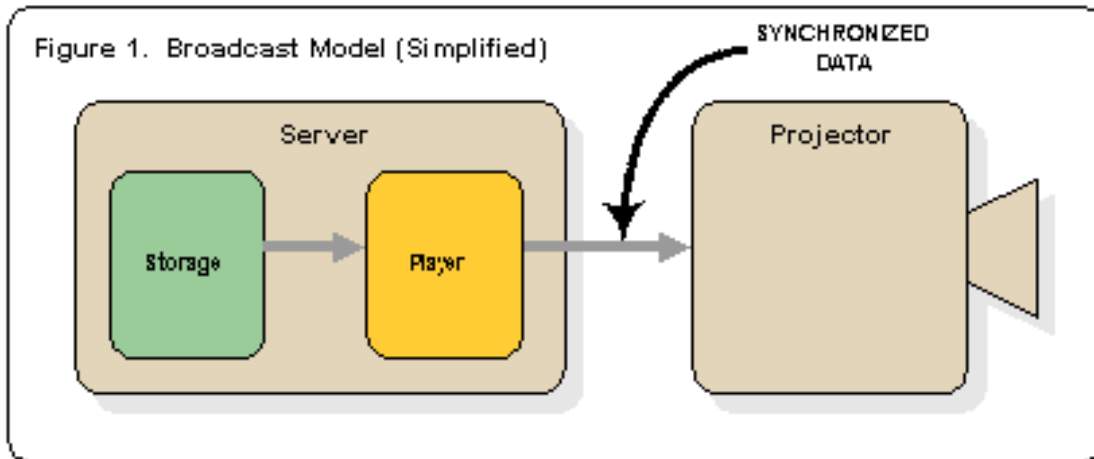
boundary, and thus both server and projector must be physically secure. The overhead presented by this design will ultimately add to the overall system cost.

The Broadcast Server model requires a secure link between server and projector. Currently, encrypted SMPTE 292M links are used, providing a little over 1Gb/sec bandwidth. (SMPTE 292M was designed for broadcast HDTV applications.) Since decompressed image data must travel through this link, the bandwidth must support the maximum needed for digital cinema. SMPTE 292M works well for 2K, 10-bit-per-color image data, but not so well for higher color bits or higher resolution images. Thus, for the Broadcast Server model to migrate to a 4K world, a new secure synchronous transport has to be developed, which will add significantly to the cost of this approach.

The broadcast model gets its name because it has its root in broadcasting. It relies heavily upon a device called server. We are familiar with the term 'server'. But in the broadcast world, server takes on different meaning in that this server also contains a player. The player is the device that accepts digital data and produces a synchronous stream of video and audio.

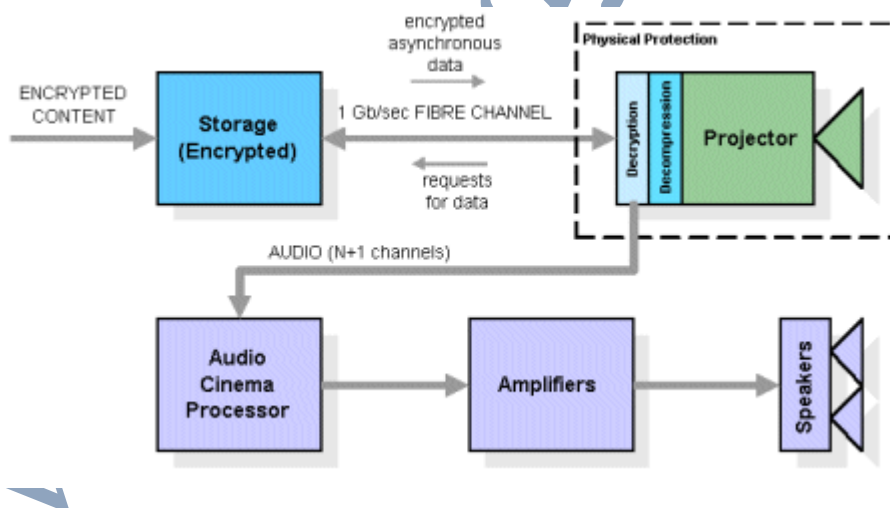
The 'projector' also has its own specialization, it is entirely different from conventional projector.

In the broadcast model of digital cinema, a synchronized image stream leaves the broadcast-style server and goes to the projector, while a synchronized audio stream goes to the audio processor. See the figure given below.



THE DATA SERVER MODEL

The Broadcast Server model for digital cinema systems is realistic but does not take advantage of Moore's Law. A more efficient design is possible that utilizes existing standards in the data industry. Again focusing on only image and audio paths, the Data Server model is presented in the block diagram below.



The Data Server model distinguishes itself from the Broadcast Server model by using the server only for asynchronous data transfer. In fact, the "server" is really nothing more than storage. As with the Broadcast Server model, the stored content is strongly encrypted. Unlike the Broadcast Server model, data is only served from the storage array upon the

request of the projector. Thus, the Data Server model projector "pulls" data from storage, a major distinction from the Broadcast Server model server, which "pushes" data to the projector.

Since the storage array does not decrypt the strongly encrypted data, it is not part of the security system, so does not require physical protection. Further, the link between server and projector also does not require protection, since the data traveling across it retains the original strong encryption provided by the studios. Thus, link encryption is not needed. The system becomes simpler, while also inherently more secure.

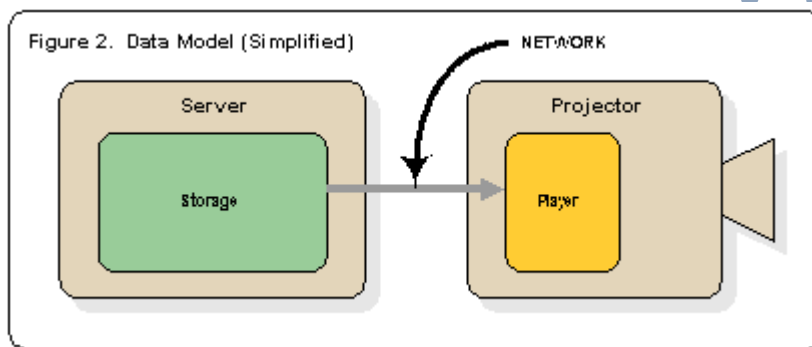
Most importantly, the link between the server and the projector can now be a standard link from the SAN (Storage Area Network) industry. The storage can also be shared among different screen systems. In the block diagram above, Fiber Channel is shown. Fiber Channel currently supports bandwidths up to 1Gb/sec, but a standard is in process that will support 10Gb/sec. However, 1Gb/sec can be sufficient, since the transported data remains both encrypted and compressed. 2K image data, at 24fps (frame per second), with a very conservative 10% compression and 16-bit words per color, requires a bandwidth of 250 Mb/sec. 4K image data, again with a conservative 10% compression and 16-bit words per color, requires a bandwidth of 1Gb/sec.

The use of shared standards-based SAN networks can be a plus for those exhibitors who want the ability to instantly move shows from screen-to-screen. Since no physical movement of data is required, multiple screens can be scheduled from a single unit of shared storage, up to the bandwidth limitations of the SAN. SANs also offer a degree of scalability, allowing the storage system to grow as the number of digital screens grows.

Shared SAN storage may not be for everyone, though. The cost of a SANs network must be weighed against the benefits gained. However, the Data Server model is not

limited to a SANs implementation, and some vendors are pursuing Data Server designs that utilize low-cost storage (but not necessarily shared storage).

And, with the data model of digital system architecture, the server does not include the player. Instead, the player is located at the receiver end, typically in the projector as given in the figure below. The data server will produce a stream but unlike it is synchronous. A data server in a digital cinema system will not work with an ordinary video projector. A projector with an internal or outboard player is required.



SECURITY

Security is perhaps both the most important and least understood aspect of digital cinema. Certainly, the encryption and decryption of content is not a major challenge. There is general agreement that movies will be symmetrically encrypted using a strong, public encryption algorithm such as AES (Advanced Encryption Standard) with very large keys. But there are as many ways of getting that symmetrical key securely to the theatre as there are security vendors. This is where things get difficult.

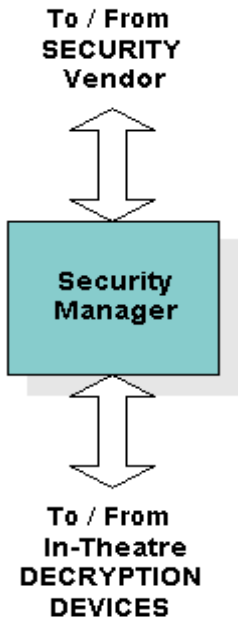
The simplest approach for managing keys is for the decryption device inside the theatre to have a secret private key, whose public key is held by a trusted certificate

authority, sort of a "public key bank". The content key is encrypted with the decryption device's public key, which can only be decoded using the private key held securely within the device.

Another method employed does not rely on a trusted certificate authority, and instead destroys the key used to encrypt the symmetrical movie key immediately upon encryption. The key is later reconstructed using a proprietary method at the theatre, allowing the movie key to be decrypted only by authorized devices.

While not absolutely required, good practice generally requires that a 3rd party is employed to manage the keys. Thus, the technology used by the 3rd party key manager defines the security technology used in the theatre. In a competitive environment where multiple security vendors co-exist, interoperability becomes a concern.

Solutions for interoperability have been proposed, most notably within the SMPTE DC28 Digital Cinema Content Security Working Group. Among the solutions offered is the introduction of a Security Manager device within the theatre environment. In one concept, the Security Manager employs a proprietary means unique to the security vendor for receiving and handling keys, while using a link-encryption method for transmitting keys to the decryption device. Other concepts are also being considered.



Both content owners and exhibitors have business requirements to impose on security systems. Content owners want to know that only authorized devices have successfully retrieved keys, and thus have a need to track key usage. Exhibitors, in turn, require the ability to freely move equipment around per maintenance and business requirements. They do not want the movement of a decryption device to prevent the playing of a movie, and likewise, they do not want the movement of the movie to a different screen within their complex to prevent the playing of the movie. Ultimately, if the movie doesn't play, neither studio nor exhibitor makes money. Thus, flexibility in the management of the security system is important to both studio and exhibitor.

The challenge that lies ahead is to allow the desired flexibility while maintaining the desired level of security. Ultimately, this is both a technology issue and a business issue, for which a satisfactory solution has yet to be agreed upon.

THEATRE OPERATIONS

Theatre operations in the film world are fairly straight-forward. A show is made up by joining policy trailers, ads, movie trailers, and the feature movie together on a single

platter. This operation is called "make-up". The platter, in turn, feeds the 35mm projector with a contiguous show. Automation cues, such as those needed to control house lights, move curtains and/or screen masking are physically tagged to the print and read by the automation system. Thus, once a show is "made-up", its platter can be physically moved to any projector in the house for presentation to an audience.

In the digital world, it is necessary to maintain the same level of functionality as provided by modern-day film systems. Other features are also possible, however, which should not be overlooked. These features can affect how the theatre of the future is operated, right down to the systems used for booking content. Exhibitors have asked for basic features of their digital theatre operations systems:

- Show Scheduling
- Show "Make-Up"
- Asset (Content) Management
- Show Logs
- Equipment Monitoring

Software is already being discussed by at least one vendor that will combine the booking of ads, trailers, and movies with the ability to create system play lists at the time the content is booked. In this way, the creation of play lists becomes centralized, and can be downloaded by the exhibitor to the theatre for operational use. Likewise, system management software can log the play of the content, so that the exhibitor's central office can efficiently oversee operations. This capability is compelling, and it is not available today. It demonstrates the importance of defining interfaces for theatre operations that empower the use of new business tools.

The ability to monitor the health of equipment, particularly from remote locations, is an important tool for maintenance crews. While remote monitoring is not uncommon in the IT world, there is nothing like it today in the cinema. Like the IT world, SNMP has become the most widely discussed protocol for use in system monitoring.

DISTRIBUTION PACKAGING

Distribution packaging is the means for enabling a common interchange format for content. While this can be thought of as the "DVD" of the cinema world, it is far more complex in nature. The basic requirements of a packaging method are:

- Allow any make of system to read the packaged content,
- Allow defective files to be replaced by segment, without replacing the entire movie,
- Provide a flexible means for including additional language sound tracks, subtitles, etc.,
- Provide a means to communicate the synchronization of files.

Through work in the SMPTE DC28 Packaging ad hoc group, the schematic of a packaging scheme has been outlined and circulated among industry participants. In early 2003, it was the recommendation of the DC28 ad hoc group that MXF (Material Exchange Format) be employed as the packaging technology for digital cinema. MXF is a technology originally proposed by the Pro-MPEG group, and currently in process for standardization within the SMPTE W25 Technology Committee for broadcast applications. A digital cinema "operational pattern" has yet to be proposed for standardization at the time of this writing.

CONCLUSION

As you might expect, there's more to the digital cinema story than we have covered here. Digital cinema is not television -- it is much more complex, flexible, and quality-oriented. While not always visible to the public, there are a lot of people working to move this technology forward. In time, you'll be able to enjoy the fruits of their labor!

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