Revelations on the Coming of Digital Cinema

By Hugh R. Heinsohn

Digital cinema has finally become a real possibility due to recent advances in electronic projection technology. Various industry organizations, equipment manufacturers and studios are working to develop practical systems that will be used to replace film as the primary distribution medium for feature productions. This paper presents one person's observations and perspectives on the potentials and pitfalls of digital cinema for the technical community involved with producing and distributing movies.

The subject of digital cinema has generated enormous interest in theatrical distribution, movie production, and post-production industries over the past year. There have been a number of highly publicized demonstrations; studios are actively funding development programs; and major equipment vendors are presenting solutions to problems and looking for their first big customers. This paper is a personal perspective on digital cinema. It attempts to describe the state of the business as well as point out some advantages and problems likely to be faced when digital cinema eventually becomes a bonafide industry.

The Good News and the Bad News

It is generally agreed, even among the "golden eyes" in our industries, that a digital cinema system will be capable of at least duplicating typical moviegoers' experience of today. In the digital future, people will no longer pay good money to watch scratched up, dirty, film prints with washed out inconsistent color and gate weave. Instead, they will pay to experience system crashes and software bugs.

The Big Questions

At this time, there is no general agreement about the central question for digital cinema. Are we trying to:

A. Create a system that duplicates or even incrementally improves on the best quality 35mm theatrical film experience?

B. Create a system that goes well beyond today's experience and show movies with substantially improved visual fidelity that provide a much more absorbing, realistic environment for feature films? (Obviously, a system like this might ultimately change the way movies are made and promoted and perhaps even raise the expectations of the audience.)

Several people have pointed out something resembling Option B. has been available for about 50 years and yet is hardly ever used: 65mm film. And the primary reason 65mm isn't widely used today is cost. The movie business is, after all, a business. The studios, distributors, exhibitors, and audiences have made a collective decision that the improvements in image quality available from 65mm film aren't worth the extra money. Based on this, can we expect that moviegoers will be willing to pay even one extra dollar to see a movie in a digital format?

We must give cost major consideration in any system. Most of the money will be spent on equipping theaters with the necessary new digital equipment, of course, but we cannot forget the expense of mastering, archiving, handling, moving, and protecting digital versions of feature films. In addition, the movie distribution system will have to support 35mm film, as well as its digital equivalent, for a long time. Many thousands of 35mm film projectors will still be operating when we're all happily retired.

Additional questions need to be asked as well: Do we want a system that allows filmmakers to send different versions of the movies to different regions of the country, or to send out slightly different versions over time in order to attract larger audiences? Should the system allow filmmakers to continue their creative work until the day (or hour) before the scheduled release? And perhaps the biggest question of all: Who's going to pay for all this?

Major Public Demonstrations

The public demonstrations that have taken place so far have primarily been projector demonstrations. That is, they have proven that the state of the art—both in terms of cost and image quality—for electronic projection systems has evolved to the point where we can finally seriously consider all the other bits that need to be put together to develop truly successful systems.

Most readers are probably aware of the digital showings of LucasFilm's *Star Wars Episode I: The Phantom Menace*, Miramax's *Ideal Husband*, and Disney's *Tarzan*. These showings used specially created HDTV master tapes playing back on Panasonic D-5 VTRs or Pluto servers using Panasonic D-5 compression. Hughes/JVC and Texas Instruments (TI) cinema projectors were used. In all cases, the master tapes were carefully color corrected specifically for the digital cinema presentations. All in all, these tests involved a substantial amount of special handling and extra costs and were designed primarily to prove that audiences will accept the quality available from the current generation of projection systems.

Late in 1999 and in early 2000, Disney also showed *Toy Story 2*, *Bicentennial Man*, and *Mission To Mars* in several theaters in the U.S. and in Europe. Again, these tests used TI prototype projectors but this time with a wavelet-based compression sys-

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tem supplied by QuVis. *Toy Story 2* was the first major motion picture to be premiered digitally. It opened at the El Capitan Theater in Hollywood on November 13, 1999. (The film version premiered on November 20.)

None of the demonstrations carried out so far have used any significant encryption or security technology nor have they demonstrated a practical means for distributing compressed movie files to the theaters. However, they have been a good start and have definitely proven that not only is projection technology sufficiently advanced, but also that high levels of image compression are a reasonable component to add to the mix of a digital cinema system.

These demonstrations have not proven that:

- Digital movie masters can be safely distributed and exhibited without being exposed to the threat of piracy.
- Digital cinema systems will be any more reliable than existing 35mm film systems.
- Customers will seek out a theater showing a digital presentation of a movie over one showing the same movie the traditional way.

The demonstrations have also definitely proven that lots of companies, including equipment manufacturers, movie studios, film distributors, movie theaters, and various start-ups are interested in trying to make money on digital cinema.

The Conventional Wisdom

The conventional wisdom at this point indicates that digital cinema in the theater will involve a system that includes a projection device, a system to decompress the movie file, some sort of local storage system (probably using hard disks), and a method for delivering the movies to the venue. The whole package will be protected by sophisticated security and encryption systems that will eliminate the possibility of movie piracy (or at least make it highly inconvenient). In addition, the system will be absolutely reliable, robust, and easily maintained and controlled by the theater chains' existing personnel. It will indeed be a wonderful thing.

The movies themselves will be produced as they are today, although this continues to evolve as well. Eventually, films may be produced entirely in the digital domain and celluloid need never be involved. But for the purposes of a digital cinema discussion, it doesn't matter whether the movie was shot on a borrowed 16mm camera, a consumer camcorder, or with a major cinematographer behind a million dollars worth of cameras and lenses.

The film will be finished and converted into a digital master either through a telecine process or some digital-to-digital process. This digital cinema master will then be compressed by a system that will reduce the file size by several orders of magnitude. The compression is necessary to make it cost effective and practical to move the compressed movie file around to thousands of theaters. Compression isn't necessarily an evil thing. A properly designed compression system will produce pictures that are virtually indistinguishable from the original.

In addition to all of this, a digital cinema system might allow exhibitors to show live events, including pay-per-view programs like fights, NASCAR races, or professional wrestling, as well as provide venues for multiplayer high tech video games. Presumably, promoting these types of events might prove to be more profitable than showing feature films, since the movie theaters would have to share less box office revenue with the software provider than in the case of feature films.

Digital cinema systems should substantially reduce the incremental cost of distributing movies, making it more attractive for filmmakers, including independent studios, to distribute "smaller" films to a larger audience. The experience of the *Blair Witch Project* is still fresh in everyone's mind; what if such a movie could have been distributed at a cost similar to its production costs? Another idea is to use digital cinema to put restored classic films into wider release.

These are all good ideas and might help the exhibitors survive and grow in the coming years. It's even possible that the studios will get on-board with these alternative uses for the theaters, since many of them either own, are owned by, or in alliance with the independent studios, games companies, and events promoters whose software will be shown on all of those digital screens.

There's the Rub

This all sounds fine and most industry people seem to agree (at least in principle) on the basic technical ingredients and architecture of the system. The problem is that a lot of choices have to be made if we are to establish a standard. No matter how carefully designed the standard is, these choices will by their very nature impose certain limitations on the capabilities of the system. Getting all of the creative and technical people in the business to agree on one set of standards is no mean task. The even bigger task, of course, is getting the people who control the purse strings at the theaters, the distributors, and the movie studios to agree on a business model.

Triangle of Business Interests

There is a triangle of business interests involved in digital cinema: the studios, the distributors, and the exhibitors. (The audience is left to view the new digital technology with awe and open wallets.) These major players must agree on the business model for a digital cinema system to survive and grow. Among other things, this model will determine how money is distributed to pay for the capital equipment needed at the theaters (over 37,000 in the U.S. alone at least count); how fees are charged to pay for the distribution of digital masters; and how revenues generated by the system are shared among the players. There are at least three major requirements that a successful business model must meet:

- No one gets hurt.
- Everyone keeps their job.
- Everyone makes more profits, except for the other two entities in the triangle.

At this time, it seems clear that the major obstacles to the adoption and implementation of a digital cinema system are mainly political and economic and not technical.

Major Promoters of a Business Model

Today, this author is aware of three major companies that are actively promoting business models for digital

cinema. It's probably best for these firms to speak for themselves, but let's say that each has a unique, although essentially similar, take on the correct technical implementation and divergent ideas on the business model. Presentations of one sort or another were made by these companies at the recent ShoWest2000 Convention in Las Vegas in June 2000.

AndAction Corp. promotes its secure media network concept and states on its web site that, "Through its Secure Media Network (SMN), AndAction applications and services enable secure distribution and management of a limitless variety of big screen digital entertainment. AndAction's Digital Entertainment Infrastructure spawns new revenue generating opportunities including digital cinema, multiplayer video games, pay per view events, corporate presentations, distance learning, and e-commerce."

Real Image Digital's focus is "on developing, integrating, and maintaining the digital distribution network using the flexibility of electronic distribution technology. The company's view is that it is a "behind the scenes service provider managing the back and forth link and information flow between distributors of content and exhibitors."

Qualcomm has a group developing an end-to-end solution. Their site states that Qualcomm is, "combining its expertise in advanced image compression, electronic security, network management, integrated circuit design, and high-speed digital communications to provide a completely electronic delivery system for distribution of motion pictures to cinema theatres around the world."

All of these companies are offering a complete technical solution as well as a business model.

Industry Groups Grapple with the Problem

Several industry groups are working to study the various business and technical aspects of digital cinema and are hoping to develop practical proposals and ideas to sell to the other industry groups, as well as to the studios, distributors, and exhibitors.

- The Motion Picture Association (MPA) has formed a study group that is primarily concerned with preventing piracy of digital cinema files.
- NATO, the National Association of Theatre Owners, has formed a committee to look at the subject from the exhibitors' perspective.
- SMPTE has formed the DC28 Study Group, which is broken up into several subgroups to examine the technical aspects of the various approaches to digital cinema.

Projection Technology Being Considered for Digital Cinema

The centerpiece of digital cinema is of course the projector. There are endless discussions going on right now about which technology is best suited for a rollout. It should be pointed out that, while projectors are the focus of this discussion, other solutions involving flat panel displays or similar technologies that work even better may eventually become available.

The most popular projection technology today for digital cinema applications is based on the Texas instruments Digital Light Processing (DLP) system. TI itself has produced a prototype projector based around its special DLP Cinema technology, which represents an enhancement of its standard DLP products. DLP technology is based on digital micromirror devices (DMDs) and can produce SXGA resolution (1280 x 1024 pixels).

The JVC Professional Products Co. offers a system based on a reflective liquid crystal technology developed by Hughes and JVC. This Image Light Amplifier (ILA) technology resolves up to 1500 TV lines. At this time, JVC is the only vendor of cinema-quality ILA-based projectors.

A new company called Silicon Light Machines has described a laser-based projection system that could prove to be very useful for digital cinema, although they have yet to make a public demonstration of this technology.

Other technologies are coming into the market that may also prove themselves useful for digital cinema applications, but the ones listed above are the most popular today.

Compression

Most people in the digital cinema business today agree that feature films will have to be compressed in some way to make transporting and storing them economical. Compression technology has evolved to the point where there is little or no penalty in terms of visual quality. There are several basic technologies being seriously considered for digital cinema applications:

MPEG-2 is an established worldwide standard that supports 4:2:2 video formats all the way up to HDTV. The standard is very flexible, well understood by legions of engineers around the world, and supported by a large number of relatively inexpensive chipsets, software, and other off-the-shelf technology. There is also a worldwide organization that supports and maintains the standard. There is some resistance to the use of MPEG-2 due to certain dynamic range, resolution, and colorimetry limitations; MPEG-2 may also be too closely linked with the idea of "television" to be accepted as a standard for true "cinema-quality" applications.

Wavelet compression is often discussed in digital cinema circles. Wavelet systems are currently proprietary and have been developed by a number of different companies.

One company has developed a proprietary variant on MPEG-2 that utilizes adaptively scaled macroblocks. This may improve compression efficiency and therefore allow better looking pictures to be reproduced at lower bit rates than standard MPEG-2 algorithms.

Other compression schemes are being discussed, including MPEG-4, Motion-JPEG, and various lossless systems.

Encryption and Security

Piracy is, of course, a major concern for the studios and other organizations that may supply content to digital cinema exhibitors. A successful system must protect the assets entrusted to it and do everything possible to defeat the pirates. The system must make it extremely difficult to directly copy an unencrypted file of a movie and ideally must also make it difficult or at least very inconvenient to use a camcorder to capture a movie from the screen.

It's important to understand the difference between encryption and security. Think of encryption as the method used to scramble a file so that it

becomes unreadable without the correct key (or keys) and decryption algorithm. Security is how you handle the files and the equipment necessary to store, encrypt, decrypt, and transmit the files so as to prevent theft. For example, a perfect encryption scheme is completely valueless if a worker in a theater knows a password that allows him to decrypt and copy or project a movie without the proper authorization. A well-thought-out security system must protect the hardware and wiring in a theater with tamper-proof housings; protect the passwords and keys required to decrypt a movie so that only authorized personnel have access to them; and make it extremely difficult even for authorized people to decrypt, copy, or project a movie except as authorized by the content owners.

Part of a good security model will involve "watermarking," which will imprint a time and location stamp in each showing of a movie. This watermark must be invisible to the moviegoer and still be capable of being decoded and displayed by the content owner should a pirated copy of a movie be found. The watermark will have to be capable of surviving multiple digital and/or analog copy generations and not interfere with the normal scheduled screening of the movies.

There are a number of very well established encryption and security systems in daily use all over the world by banks, governments, and other big institutions. These systems guard our cash and our investments and allow us to move money around in a reasonably convenient, easy to use, and extremely secure way. Digital cinema should build on these established and well-understood technologies and systems.

A number of companies are now publicly suggesting different encryption schemes and security models for digital cinema. Studios lawyers are seriously discussing these.

Servers

Any digital cinema system will involve relatively large data storage requirements, and a number of companies have demonstrated server technologies for this application. Most of these systems are adaptations of computer systems used as video servers; some use the Windows NT operating system, others use UNIX, and some, proprietary operating systems. They generally utilize RAID technology to safeguard the data from hard disk crashes and also offer a variety additional failure protection, including redundant power supplies and so on.

It's expected that servers will be

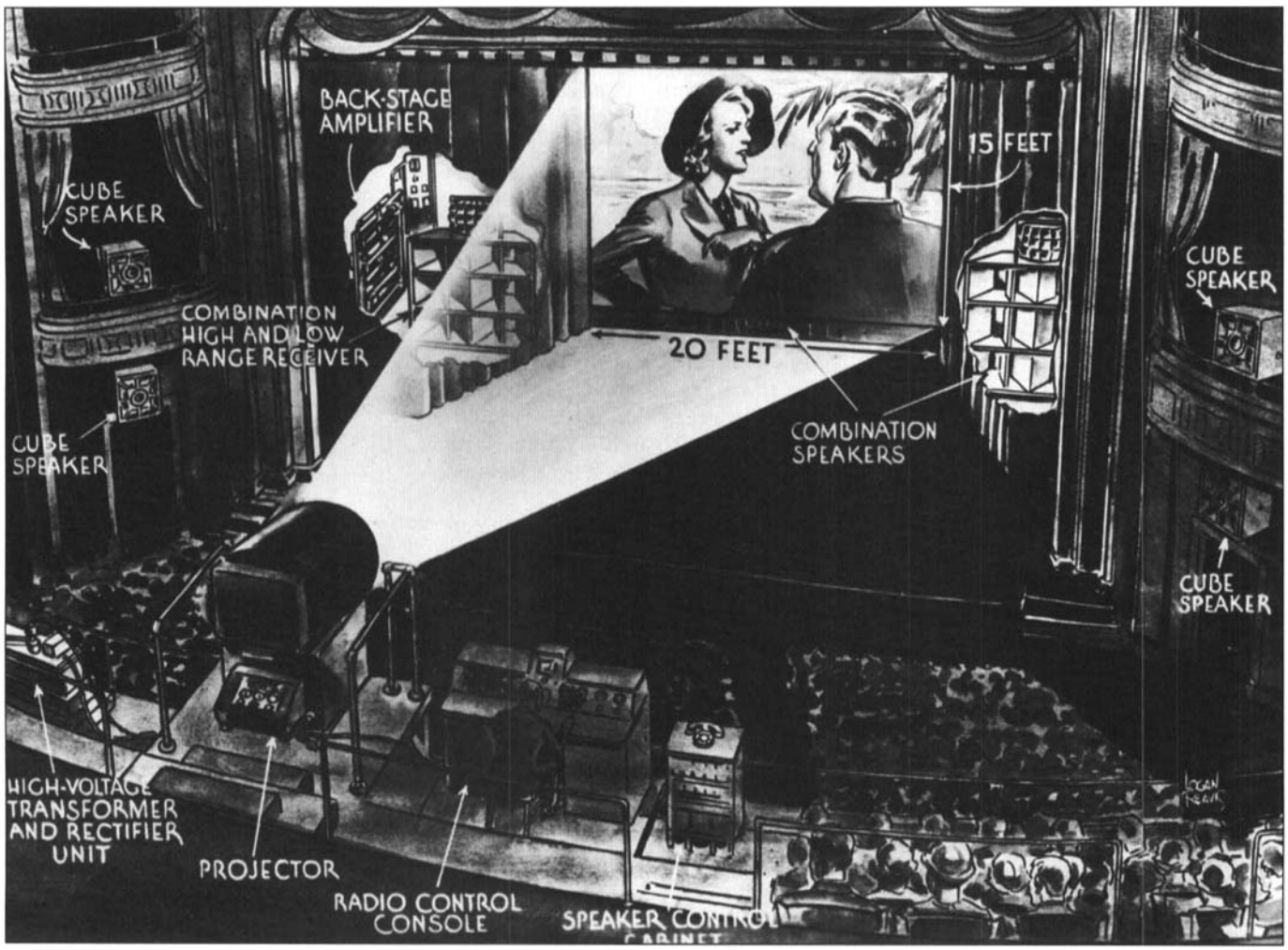

Figure 1. A drawing of of an actual demonstration conducted at the New Yorker Theater in New York City, 1941. (Photo courtesy of the David Sarnoff Collection, Princeton, NJ.)

located at each theater and that movies will be downloaded into them a day or two prior to the first scheduled screening. Some companies have proposed that each projector get its own server in addition to a central server feeding all of the screens in a multiplex.

Hardware technology for fileservers is extremely advanced and it can expect that the servers used in a digital cinema system will be robust, reliable, and even fairly inexpensive. The software required to run the movies may be a different matter.

Software

This author believes that the single greatest technical weakness in any digital cinema system will be the software that schedules, handles, moves, and plays the movies. This software will have to be very easy to use and will have to work almost completely automatically with very little operator intervention. It must be part of a networked system that may accept commands and schedule changes from remote (hopefully properly authorized) locations. It will have to log errors, successful showings, and possibly even track audience numbers for each showing. It may even have to communicate with the theaters' cash register and ticketing systems and the movie distributors' accounting systems. It must be perfectly robust and fault-tolerant and it must never crash.

Moving the Movies

The movie files will have to be moved around from central distribution points to the theaters. A successful system must support at least two delivery methods:

- Physical delivery. The movies might be stored on optical disks of some type or other physical media that can be sent to the theaters by normal courier services.
- Telecommunications networks. The files can also be transmitted to the theaters over fiber-optic, copper wire, or satellite communications links.

Not every theater will be able to accept delivery over satellite, fiber, or wire networks. We must be able to get movies delivered safely and efficiently to all screens, including those located in rural areas, in the basements of urban skyscrapers, or in the outskirts of a third world metropolis. At present, standard 35mm motion picture film can be presented on any 35mm projector worldwide.

Forward, Into the Past

Digital cinema has definitely become a "when" question and not an "if" question. Electronic projection systems are the basic enabling technology and they have finally become good enough for us to consider putting together a system that will replace film as the primary medium for distributing feature films. The ancillary equipment, software, and systems necessary to complete a workable solution, are either available off-the-shelf or can be developed relatively easily.

The primary hurdles that the industry must overcome are economic and political. Who benefits? Who wins? Who loses? Who makes money? And who pays?

These are not trivial issues. The industry has been playing with this concept for a long time and is still in the talking stages. Figure 1 is based on an actual demonstration conducted at the New Yorker Theater in Manhattan in 1941. RCA collaborated with 20th Century-Fox on projection television systems for showing special events.

We must remember that new technology alone will not necessarily bring more people into the theaters. One notable industry wag has stated that only one technical innovation has brought more people to the movies over the past 75 years. It wasn't sound. It wasn't color. It wasn't multichannel digital sound systems with 5000-W sub-woofers. It was stadium seating.

We must keep the technology in perspective. Theatergoers will indeed pay for a good time away from the house, not merely for dust-free pictures. Digital cinema, will redefine the way they experience the second most popular form of entertainment in the world. Whether the movies get any better or not is, of course, a separate question.

For More Information

Here is a partial list of web sites about various organizations and companies active in digital cinema. This is by no means a comprehensive list of digital cinema resources but should provide the interested reader with a starting point for more research.

AndAction Corp.: www.andaction. com
Barco: www.barco.com
Christie: www.christiedigital.com
Cinea: www.cinea.com
Digital Projection: www.digitalprojection.com
Digital Vision: www.digitalvision.se
Electrosonic: www.electrosonic.com
Grass Valley Group: www.grassvalleygroup.com
JVC: www.hughesjvc.com
MPEG: http://drogo.cselt.stet.it/mpeg/
NEC: www.nec-pj.com
Panasonic: www.panasonic.com/presentations
Pluto Technologies: www.plutotech.com
Qualcomm: www.qualcomm.com/digitalcinema
QuVis: www.quvis.com
Real Image Digital: www.realimagedigital.com
Silicon Light Machines: www.siliconlight.com
SMPTE: www.smpte.org
Star Wars Episode I: The Phantom Menace: www.starwars.com/episode-i/news/1999/24/digital_ei.html
Texas Instruments: http://www. ti.com/dlp/products/cinema/

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The opinions expressed in the article are his personally and not necessarily those of Xytech Corp.