# Digital Cinema Today and Future Business Developments

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**Abstract**

The standardization of digital cinema by Hollywood in July 2005 is expected to lead to widespread use of digital cinema, bringing advantages in the production, distribution, and exhibition of movies as well as benefits to viewers. This article describes the current status of digital cinema and discusses its expected popularity. It also considers how it may change in the future and discusses possible technical and business contributions by the NTT Group.

## 1. Digital cinema equates to "dream movies"

The movie industry is facing a major turning point based on the fusion of movies and digital technology. The current method of screening movies began in 1895 with the development and publication of the "cinematograph" by the Lumiere brothers in France. Analog film technology has supported the movie industry for more than 100 years since then, but a transition to a digital cinema format was accelerated by a standard set in 2005 by DCI (Digital Cinema Initiatives, LLC), a joint venture established by seven major Hollywood studios [1]. Digital cinema refers to using a digital data format in all three processes of movies: production, distribution, and exhibition. Since movies can be shown every time with exactly the same "highest quality" level of the master print while achieving efficient theater operation at the same time, digital cinema can be called the realization of "dream movies" for the industry.

## 2. Hollywood and NTT collaboration in standardization

The digital format has already made inroads into the process of movie production and most major films are now made from digital source masters. Actually, 60 to 80% of all movies, almost all major Hollywood movies, are edited by a digital process called Digital Intermediate (DI) [2]. However, the previous lack of global standard specifications for digital cinema prevented it from extending to the intermediate and final processes: distribution and exhibition. That situation motivated Hollywood studios to take up the cause of standardization, and NTT contributed to that effort from the technological perspective [3], [4]. DCI specified the standard with the objectives of (1) allowing audiences to watch movies in theaters at a higher quality level than HDTV broadcasting, (2) implementing strong security functions that can protect premiere cinema video content, and (3) securing long-term compatibility of the digital movie format and its presentation equipment to replace the 100-year-old film-based processes.

Hollywood's forward-looking attitude combined with NTT's "4K digital cinema technology" (4096 horizontal pixels by 2160 vertical pixels, an 8-million-pixel video specification referred to as 4K representing the horizontal resolution) resulted in the DCI standard specifications for the distribution and exhibition of digital cinema.

NTT Network Innovation Laboratories presented the 4K digital cinema distribution system at SIGGRAPH 2001 with the support of the Digital Cinema Consortium of Japan (DCCJ). At that time, a vigorous discussion on the digital cinema image format was unfolding in Hollywood between one group that favored reproduction of 35-mm film quality with a resolution of 2K (horizontal resolution of about 2000 pixels for a 2-million pixel image), an image quality

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nearly equivalent to high-definition television, and another group that considered such a resolution to be inadequate. When the Hollywood people saw NTT's 4K ultrahigh-resolution video at SIGGRAPH, they said, "This is the quality we want for the digital presentation of actual movies". An evaluation experiment was performed at Hollywood's Paramount Theater in June 2002. In October of the same year, another public evaluation experiment was conducted at ETC (Entertainment Testing Center), the evaluation theater of DCI's technical evaluation organization, using contents prepared by Hollywood studios for a full evaluation of image quality. More than 100 persons involved in video production from the seven major Hollywood studios participated in that experiment. With the comment by DCI's chief technical officer, "standardization should proceed with 4K digital cinema", 4K video quality came to be recognized as essential for digital cinema. A formal decision to use 4K digital cinema as the DCI standard was subsequently made.

## 3. How digital cinema will change the movie industry

In digital cinema, the conventional film projector must be replaced by a digital projector and a secure media box (SMB) [5] that reproduces the movie from encrypted data in real time. That involves an initial investment cost for introducing the system into theaters, but it brings several benefits, especially for flexible screen operation in cinema complexes with multiple screens (**Fig. 1**), as detailed below.

**1) Better video quality:** The movie is presented with the image quality equal to a master print, which is the quality level in the production stage in the studio (i.e., the quality of the 35-mm answer print (the initial complete positive film made from the master) rather than the 35-mm release print (the positive film used for showing in theaters)). Conventional film suffers from gradual damage with repeated showings that degrades the video image over time. Digital cinema, however, always provides a high-resolution image that has exactly the same quality as the master.
**2) No film copies:** Conventional film involves high costs for distributing a copy print for each cinema screen, using highly secure film transportation, and destroying the medium after the showing as an antipiracy measure. Secure distribution in digital format via a network greatly reduces all of these costs.
**3) Greater operating flexibility:** The transmission

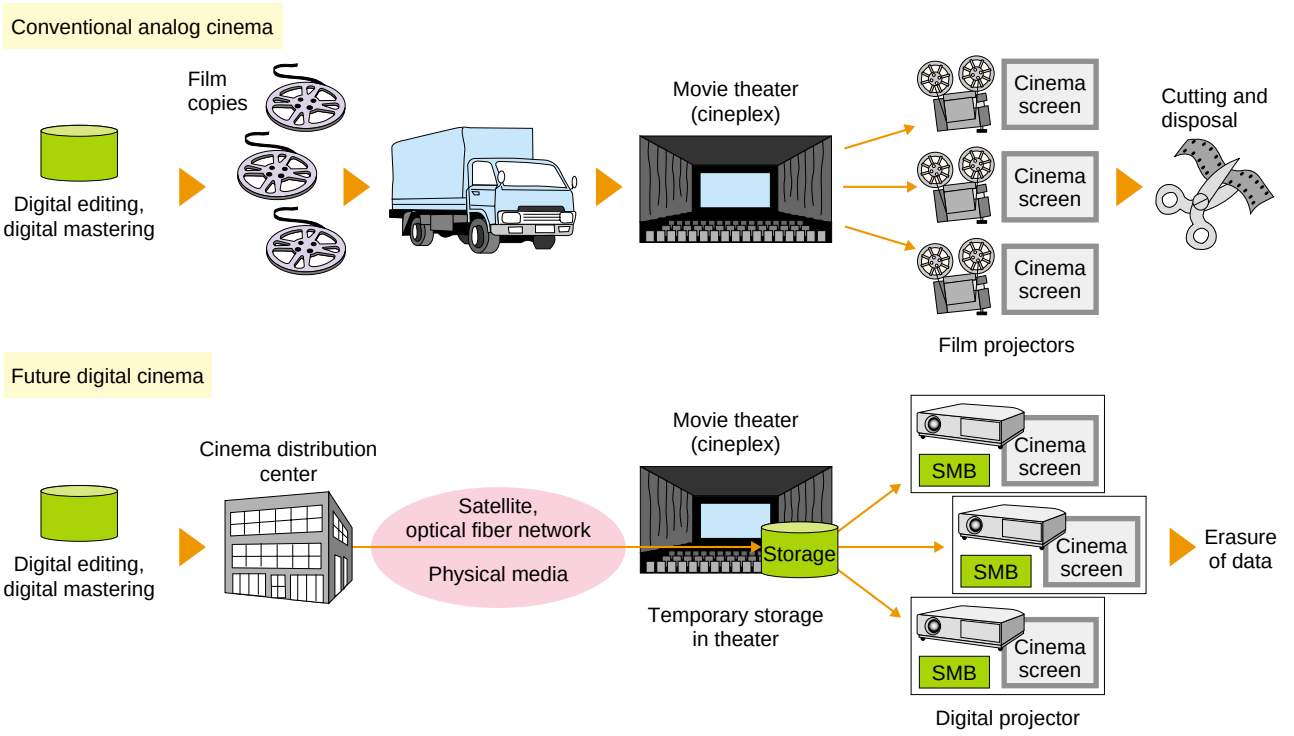
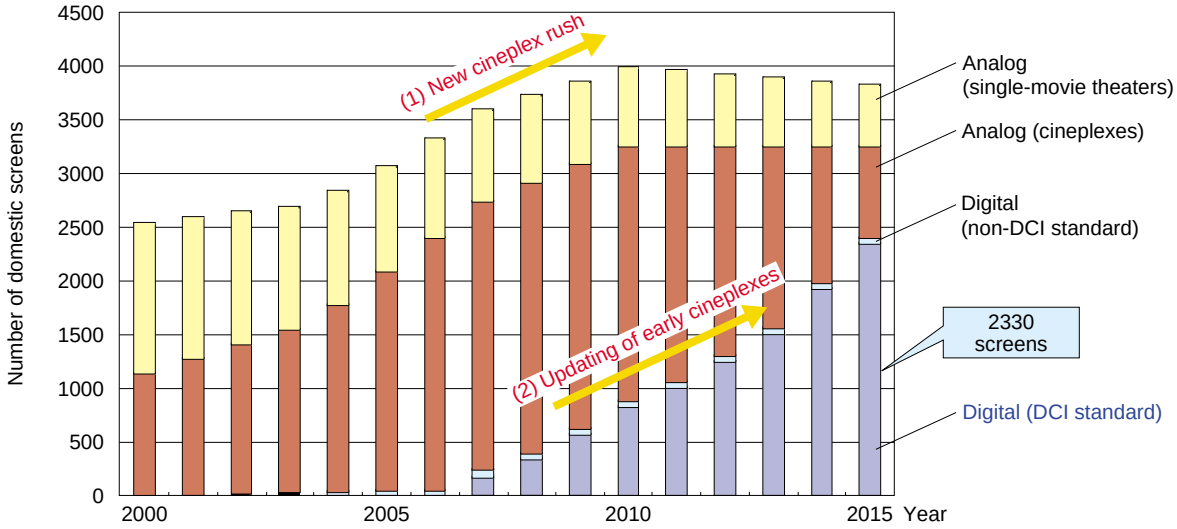



Fig. 1. Changes brought by digital cinema.




Source: Created with data from "Japanese Movie Industry Statistics" by the Motion Picture Producers Association of Japan (2005) and "Information Media White Paper 2003" by the Dentsu Communication Institute (2003)

Fig. 2. Digital cinema market forecast.

of a single movie file increases the flexibility in operating a cineplex by allowing a movie to be shown on multiple screens simultaneously, allowing subtitles and dubbing to be changed freely, and allowing the selection of a screen size appropriate for the movie's popularity in a particular location.

A forecast of the number of cinema screens in Japan is shown in **Fig. 2**. The "new cineplex rush" that will continue for the next few years and the replacement of early deployed cineplex systems that began in 1993 are two reasons for predictions that complete switchover to digital cinema will proceed over the coming 10 years. It is predicted that in 2015, most cineplexes will be digital and the number of screens conforming to the DCI standard will equal about 80% of the total number of screens in 2005.

## 4. Toward digital cinema

Progress toward digital cinema faces technical, operational, and economical challenges.

**1) Technical challenges**

NTT has developed a pioneering SMB prototype for theater exhibition of 4K digital cinema in accordance with the DCI standards, which provide technical specifications for movie image quality and security. Our ultrahigh-speed signal processing technology achieves realtime processing at the 4K image resolution, which makes data theft extremely difficult. Conventional equipment performs the processing for displaying ordinary images in a step-by-step manner (**Fig. 3)**. That creates opportunities for data theft during temporary storage, which is not permitted by the DCI specifications. NTT solved this problem by using extremely fast realtime signal processing that performs AES 128-bit decryption and motion JPEG2000 decoding without using a data buffer (AES: advanced encryption standard).

**2) Operational challenges for the movie industry**

The transition from film projection to digital cinema will change the work flow of distribution and exhibition, including tasks such as dubbing, subtitling, quality control, key management, and response to failures. To investigate how to cope with such work flow changes, NTT began a joint digital cinema distribution field trial called "4K Pure Cinema" [6] with Warner Bros. and Toho, which started in October 2005 and is scheduled to last for about one year. In that trial, digital movie content is transferred from the Warner Bros. servers in Hollywood via an experimental international communication line to the Dojima (Osaka) and Yokosuka distribution centers in Japan. From those centers, it is then distributed to theaters in Roppongi, Takatsuki, and other places via a domestic optical fiber network. After all of the movie data has been received at the theaters, it is decoded and presented in real time by the SMB device.

This trial is the world's first attempt at normal, long-term distribution and exhibition of digital movies in conformance with the DCI standard. The

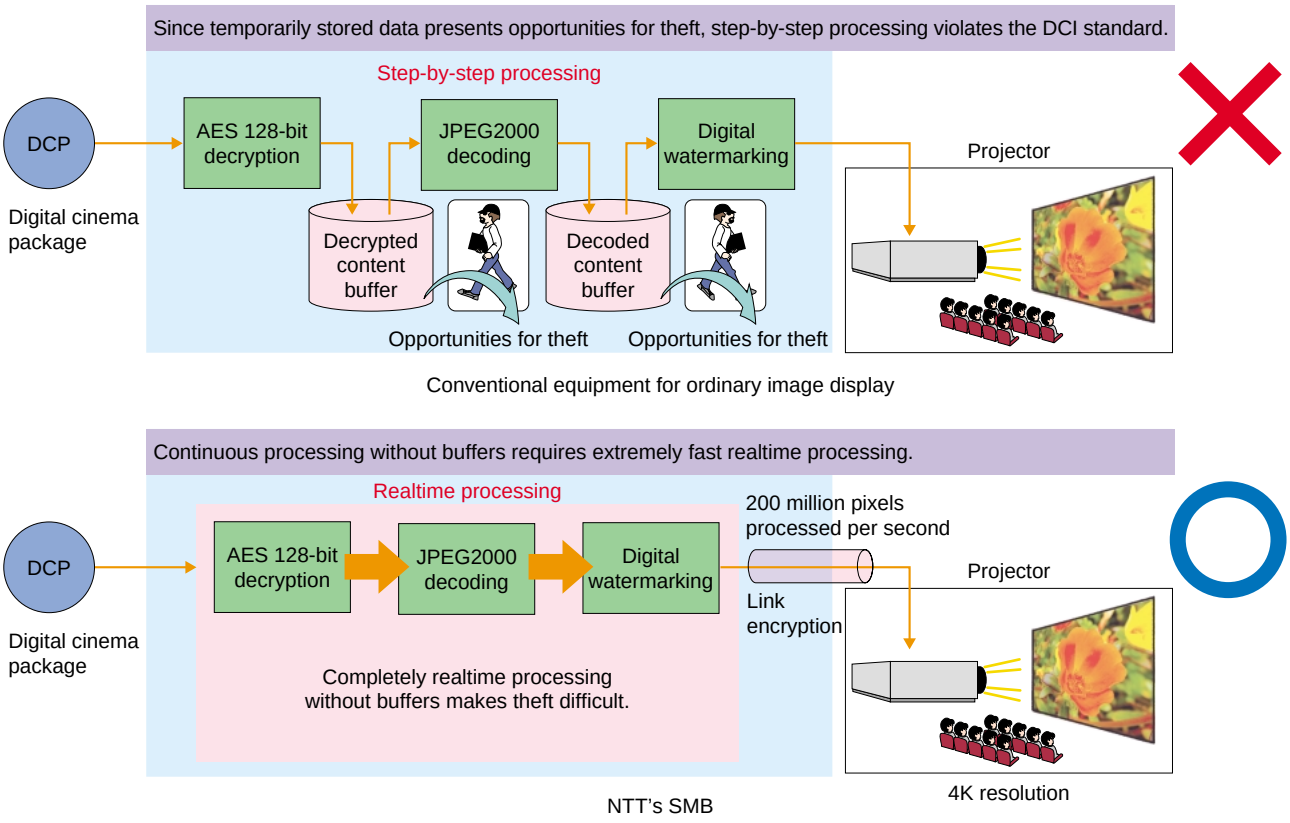



Fig. 3. NTT digital cinema system technology conforming to the DCI standard.

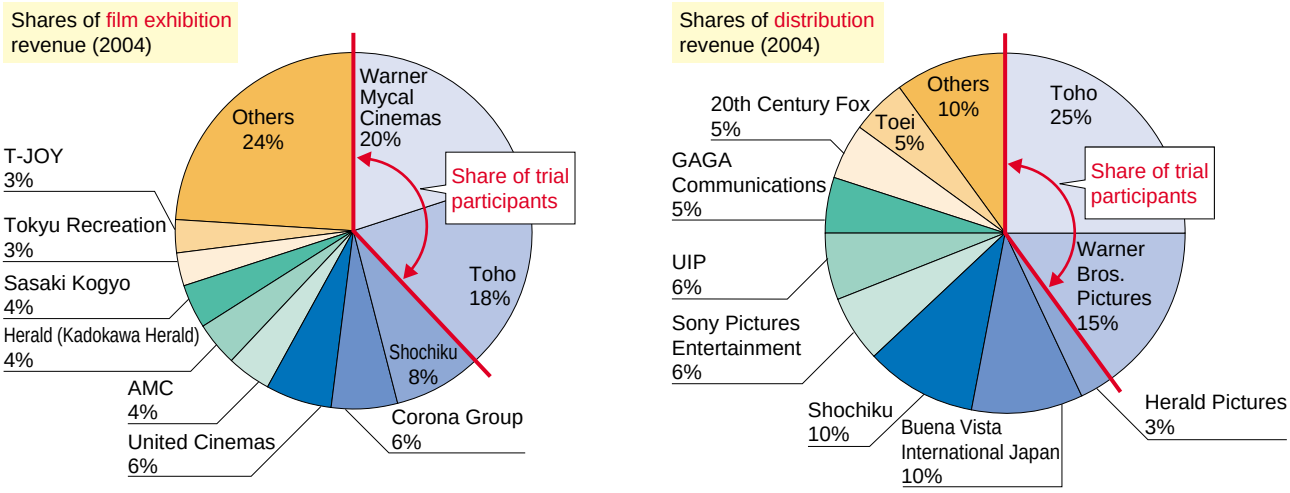



Fig. 4. Exhibition and distribution shares in Japan.

Toho and Warner groups, which have the industry's top two shares for movie exhibition and distribution, will proceed as partners in this trial (**Fig. 4**). The trial's goals include verification of various aspects from both technical and business perspectives, including viewers' evaluations, system operation, security, network distribution, and theater operating costs. The trial is described in the second article [6] in

this Special Feature and the technology that NTT contributed to the trial is described in the third article [5].

**3) Economical challenges**

Implementation of the DCI standard opens up the possibility of attaining economies of scale in the future. For major Hollywood films, progress in computer graphics has resulted in the post-production stage of filmmaking being almost entirely digital now. With Hollywood's support for digital distribution solidifying, our current priorities are (a) reducing digital theater equipment (projector and SMB) costs and (b) establishing a platform for distribution to theaters (i.e., distribution centers and distribution network services) .

In the USA, where there is a complete separation of capital relationship between theaters (exhibition) and the distribution channel, the virtual print fee (VPF) model has been proposed as a method of overcoming the barrier of initial investment by theaters, which is recovered from the reduction in distribution-side costs (film copying, transport, and disposal costs). First, VPF operating companies, established by video equipment manufacturers and others, will use external funds and VPFs from distribution companies to install digital cinema presentation equipment in theaters. The distribution companies engage in ordinary film distribution contracts with film exhibitors, and if the screen defined in the contract is equipped for digital cinema presentation, the distribution company pays a VPF, equivalent to the normal print fee, to the VPF operating company. This form of funding model is accelerating the introduction of theater presentation equipment by thousands of units. In Japan, on the other hand, the exhibitors and distribution companies usually belong to the same capital group, so suitable ways of accelerating digital cinema equipment introduction to the Japanese movie industry need to be investigated.

## 5. Issues for future work

Through the "4K Pure Cinema" digital cinema distribution trial, the NTT Group will contribute to the following three points to encourage the migration of the movie industry as a whole toward a fully digital format.

(1) Cinema distribution center operation

Building on experience gained from the "4K Pure Cinema" trial, we can support the construction and operation of systems for secure digital cinema centers with respect to movie distribution management, packaging, key management, etc.

(2) Network distribution

We will take advantage of the next-generation IP (Internet protocol) network to support the distribution of large volumes of data, ranging from 70 GB (for 2K) to 280 GB (for 4K) per movie, to movie theaters rapidly and at a reasonable cost while maintaining security and quality.

(3) System integration for theaters

The exhibition of films at movie theaters involves more than simply turning on the projector. In addition to preparatory work such as the start buzzer, curtain operation, and control of the room lights and emergency lighting, various tasks must be performed after the start of a showing, such as the presentation of screen advertisements and previews. NTT West has developed a theater control box [7] for the "4K Pure Cinema" trial to allow the operation of a digital cinema to proceed in the same way as conventional theater operation. We are supporting the construction of a system that will allow flexible cineplex operation through the interworking of digital devices such as the digital projector and SMB and existing theater facilities.

The conversion of cinema to digital format goes beyond simply replacing film for movie exhibition; it also creates a paradigm shift that presents opportunities for using the digital cinema platform to create new business. We can anticipate a reformation of the production and editing processes, including movie materials distribution and remote editing collaboration. Furthermore, we can expect new forms of exhibition in addition to the existing movie framework, including ODS (other digital stuff) content such as live concerts, sports events, lectures, and various kinds of screening contents. Furthermore, the screen advertisement business can be expected to expand through the digital conversion of movie theaters. In the USA and the UK, the digital format is causing a restructuring of the screen advertisement industry, and screen advertisement markets in those countries are expanding rapidly. We will also continue to focus NTT R&D technology on the new business generated by these paradigm shifts and to promote medium- and long-term demands for these related services.

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