

Development of a Theater Control Box for Digital Cinemas and Its Effectiveness in Trial Operation

Hiroshi Yamane[†], Hiroyuki Utsumi, Naoki Kihara, Akihisa Ogawa, and Yukihisa Saito

Abstract

NTT West has developed a theater control box for the 4K Pure Cinema trial. It executes the entire procedure of exhibiting a digital movie in a movie theater, which involves more than simply presenting the images on the screen. Our device allows digital cinema operation to be performed in the same way as conventional theater operation. We also present some of the results obtained so far in the ongoing 4K Pure Cinema trial.

1. Background

From July 2001 to April 2002, NTT West collaborated with Toho Company Ltd., a leading Japanese motion picture company, in conducting experiments to establish a new movie distribution model. This work was commissioned by a telecommunications and broadcasting organization (then called the Telecommunications Advancement Organization (TAO)) as part of the “Creative Information Communication Systems Development” project of the Ministry of Public Management, Home Affairs, Posts and Telecommunications (Supplementary Budget of 2000) and was the world’s first experiment involving the use of an optical fiber network for the distribution of movies.

The distribution source was Toho, NTT Smart Connect served as the distribution center, the theaters were Toho’s Kitano Theater and Umeda Sukaraza Theater (later renamed), and the optical network was provided by NTT West. The movies distributed under this setup (**Fig. 1**) included “Sen to Chihiro no Kamikakushi” (“Spirited Away”), which was produced by Studio Ghibli and distributed by Toho. The equipment used in the experiment included a DLP (digital light processing) projector with a horizontal

resolution of 1.3K (1300 pixels) and a QuBit video data storage server produced by QuVIS. The distribution method was file transfer from the data center to the theaters.

At the 17th Tokyo International Film Festival in October 2004, NTT West and NTT East, with the assistance of NTT Laboratories, exhibited the 4K digital cinema version of ‘Shitsurakuen’ (directed by Yoshimitsu Morita and first distributed by Toei in 1997). The exhibition did not involve the use of a network, but was the world’s first public screening of 4K digital cinema in a theater. It was viewed by both members of the general public and industry professionals, many of whom provided positive comments about the presentation quality [1]. For this demonstration, the organizers received the 10th AMD (Association of Media in Digital) Award in 2005.

During its preparation for presenting 4K digital cinema at the Tokyo International Film Festival, NTT Network Innovation Laboratories was planning a trial using its own eight-million-pixel digital cinema distribution system [2] (referred to below as simply the 4K digital cinema system) and was discussing the matter with Warner Bros. Entertainment Inc. (WBEI). WBEI’s position was that the NTT operating companies and Japanese movie companies would want to participate in the trial, so that it would become more than just an R&D project. The Laboratories then sounded out NTT West and Toho, which were conducting digital cinema distribution experi-

[†] NTT West
Chuo-ku, Osaka, 540-8511 Japan
E-mail: yamane.h@west.ntt.co.jp

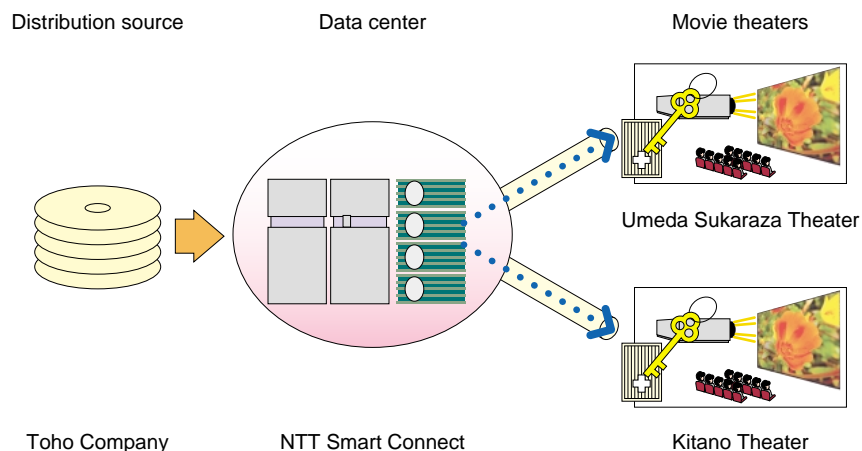


Fig. 1. Setup of the 2002 experiment.

ments, concerning participation in a 4K digital cinema system distribution and presentation experiment. When approached with the idea, Tomoharu Toyoda, Director of Toho's theater division, replied with the strong opinion that, "To push this beyond simple R&D, we should present first-run Hollywood movies as an ordinary exhibition".

2. Aims of the 4K Pure Cinema trial

Following the above-mentioned background, study began on a new trial with WBEI, Toho, NTT's Department III, NTT Network Innovation Laboratories, and NTT West as participating members. This new trial, which was called "4K Pure Cinema" [3], began in October 2005 and is scheduled to run for almost one year, so it is still in progress. In discussing its aims, the participants decided to focus on the kinds of problems that might occur in an actual presentation. These include system problems, content distribution, responses to problems, and operational problems.

One problem concerning operations was how to achieve coordinated control of the various kinds of equipment used in the theaters and the digital cinema system. When conventional movies are shown, equipment for performing various tasks must be operated and it is usually controlled on the basis of marks made on the film and read by the film projection system. The trial has already made clear that a way of doing this in digital theaters is essential.

Other topics discussed included methods of preventing unauthorized copying of content, the desirability of having Hollywood representatives inspect the experimental equipment installation sites, the



Fig. 2. Theater control box.

handling of encryption keys, and other matters related to practical operations.

3. Theater control box development and encryption key management

The responsibilities of NTT West in this trial include the development of a theater control box (TCB), encryption key generation and management, and the operation and management of the network in western Japan. The TCB performs coordinated control of the theater equipment and the 4K digital cinema system to achieve smooth theater operation (Fig. 2).

Running a theater involves the operation of various kinds of equipment for sounding the starting buzzer or announcing the beginning of the presentation, controlling the room lighting and emergency signs, raising the curtains, handling coordination with the sound system, and so on. Recently, some theaters have also been using video projectors or slide projec-

tors to display commercial advertisements. There is also a need for linked operation with a cut-off relay device that controls lighting and switches the audio system to an emergency broadcast message if a fire, earthquake, or other emergency occurs. Because this is a trial system, it is also necessary to coordinate operations with an ordinary film projection system that would take over and continue the presentation in the event of a failure in the 4K digital cinema system.

NTT West developed the TCB around the concept of being able to control all the various theater equipment via a communication link by simply pressing buttons. The TCB has control buttons for theater lighting, a commercial advertisement terminal, a film projection system, the 4K cinema projector, the secure media box, curtain operation, and the audio system. If the need arises, the unit can also receive a signal from a cut-off relay to switch the entire system over to the emergency operation mode. Since the operation of these various types of equipment may vary from theater to theater, the control procedure and timing are determined by a pre-set program.

With the development of the TCB, theater presentation with the 4K digital system became possible. To support maintenance in theaters that operate continuously day and night, the TCB logs the control operations for each device and sends the logs via a network to the Osaka Data Center provided by NTT West's Osaka branch, where device failures can be quickly

diagnosed.

A system for encryption key generation and management was set up at the Osaka Data Center. Because theft of the encryption key would allow the content to be copied and viewed without permission, this system must meet high security requirements. Accordingly, the Osaka Data Center is equipped with security measures that provide a higher level of security than ordinary data centers. These measures include a biometric personal identification system (blood vessel authentication system based on recognition of the pattern of veins in a finger), equipment for preventing the entry of multiple persons after the authentication of a single person, and a surveillance camera system that has no blind spots (**Fig. 3**). After inspecting the facilities, WBEI certificated the Data Center as an appropriate location for the encryption key generation and management equipment that is vital to the 4K digital cinema system.

4. Results to date from the 4K Pure Cinema trial

4.1 Public side-by-side evaluation experiment

The 4K digital cinema presentation of “Tim Burton’s Corpse Bride” at Cinema Mediage (Daiba, Minato-ku, Tokyo) and Toho Cinemas Takatsuki (Takatsuki, Osaka Prefecture) began on October 22, 2005. Audience reaction was favorable, including comments such as “beautiful” and “good image quality”, but some people also noted that it was hard to judge the quality without a comparison. That sentiment motivated a public side-by-side comparison experiment held at Toho Cinemas Takatsuki on November 25, 2005, which was limited to representatives of the mass communication industry.

The ‘side-by-side’ effect was achieved by simultaneously presenting a digital image on the right half of the screen and a corresponding film image on the left half, so that the two formats could be compared in terms of quality. To facilitate comparison, a ‘butterfly’ method was used in which the digital image was reversed left to right to produce exact left-right symmetry of the overall image relative to the center of the screen (**Fig. 4**). This side-by-side evaluation may have been the first of its kind in Japan and may also have been a world’s first in terms of the media and the public nature of the experiment.

The evaluation results revealed three main findings: (1) The 4K image features a sharpness that was considered to be superior in quality to the film image, particularly for text, (2) the grayscale levels of the 4K and film images were judged to be about the same,



Fig. 3. Security at NTT West Osaka Data Center. Top: Biometric personal identification system; bottom left: system for preventing entry by multiple persons; bottom right: blind-spot-free surveillance camera.



© Digital Cinema Initiatives, LLC

Fig. 4. Examples of the images shown in the side-by-side evaluation.

and (3) the film images had some hot-spots but the 4K system provided a uniform overall screen brightness, giving the digital images an overall bright feeling.

The public evaluation experiments proved that there is no great difference between the images presented by the 4K digital cinema system and a film projector, so it greatly contributed to the future advancement of digital cinema.

4.2 Audience evaluation

Because the trial is not yet finished, the true evaluation of audience reaction is yet to come. So far, reactions expressed in comments spoken in the theaters and written in blogs (web logs) mainly indicate that the quality of 4K images is good. Comments such as, “The biggest surprise was the clothing. The texture of the cloth could be sensed, not just at the level of ‘stiff and starchy’ or ‘soft and fluffy’, but down to ‘a velvety feel’ kind of experience. This is the first time I’ve had such a sensation from watching a movie.” and “There was no flicker or blurring.” (from the blogs of ordinary movie viewers), indicate that even ordinary movie-goers can appreciate the improvement in quality provided by the 4K system.

The opinions of people directly involved with movies were expressed in comments such as: “Unlike DLP, there are no jaggies at all in the subtitles.”, “The 4K presentation has good edge balance and does not produce the impression of hardness one gets with

DLP.” (from blogs) and “The mixing in of computer graphics can be clearly seen in places. It will be necessary to change the way in which CG is used.” and “The sound holes in the screen are noticeable.” These comments indicate issues that need to be addressed concerning the conventional theater environment and content production methods.

One comment, “DLP presentation! Viva 8 million pixels!” (from a blog), reveals that some people mistook this trial for the conventional DLP-specification video projection method. This points to the importance of creating correct recognition of “4K Pure Cinema” technology.

5. Plans for the future

NTT West will continue its work on this project, with attention focused on trials promoting 4K digital cinema. At the same time, it will seek new partners and aim for early implementation of digital cinema distribution and presentation over networks. In the current trial, we will continue to investigate methods for supporting encryption key administration and control, theater operation, and other items not prescribed in the DCI specifications, as well as to strengthen cooperation with our trial partners to achieve standardization in Japan.

The provision of network services that meet the needs of distribution companies and theatrical exhi-

bition companies will continue to be stressed, as well as the development of systems for supporting digital cinema services. The objectives will continue to be even more efficient and secure movie distribution and theater operation and higher network security.

References

[1] K. Shirakawa, K. Ishimaru, T. Fujii, N. Kihara, A. Ogawa, H.

Yamane, and A. Akutsu, "Eight-million-pixel Digital Cinema Distribution System—17th Tokyo International Film Festival 4K Digital Cinema Presentation Experiment," NTT Technical Journal, March 2005, pp. 89-92 (in Japanese).

[2] T. Fujii, M. Nomura, J. Suzuki, I. Furukawa, and S. Ono, "Super High Definition Digital Movie System," Part of the IS&T/SPIE Conference on Visual Communications and Image Processing '99, Vol. 3653, 25-27 Jan. 1999 (in Japanese).

[3] H. Sakamoto, K. Minami, K. Shirakawa, T. Fujii, Y. Saito, and H. Yamane, "The "4K Pure Cinema" Joint Digital Cinema Trial," NTT Technical Review, Vol. 4, No. 7, pp. 18-22, 2006 (this issue).



Hiroshi Yamane

Manager, Broadband Application Service Department, NTT West.

He received the B.S. degree in sociology in 1989 and the MBA degree from Momoyama Gakuin University (St. Andrew's University of Japan), Osaka, in 1996. He also received the Ph.D. degree in engineering from Nara Institute of Science and Technology, Nara, in 2001. In 1989, he joined BRAINS R&D Center, NTT Business Communications Headquarters, Tokyo. In 1999, he joined NTT West. He received the 10th Telecommunications Advancement Foundation Award in 1995 and the 10th AMD (Association of Media in Digital) Award in 2005. He is a member of the Institute of Electronics, Information and Communication Engineers of Japan, the Institute of Image Information and Television Engineers of Japan, and the Institute of Image Electronics Engineers of Japan.



Akihisa Ogawa

Chief, Broadband Application Service Department, NTT West.

He received the B.E. degree in electrical and electronics engineering from Nippon Institute of Technology, Saitama, in 1989. After joining NTT in 1989, he was engaged in the business incubation of R&D products of NTT Cyber Solutions Laboratories from 1999 to 2001. Since moving to NTT West in 2002, he has been working mainly in the area of business incubation of digital cinema service. He received the 10th AMD Award for the digital cinema screening of "Shitsurakuen" at the 17th Tokyo International Film Festival.



Hiroyuki Utsumi

Broadband Application Service Department, NTT West.

He received the B.E. degree in mechanical engineering from Doshisha University, Kyoto, in 1997. After joining NTT in 1997, he was assigned to the Multimedia Business Development Department in 1998-99 and worked on business development in the areas of telemedicine and services for senior citizens. After joining NTT West in 1999, he worked in the area of system solutions in 2000-2004. He is now working in the D-cinema project team.



Yukihisa Saito

Senior Manager, Broadband Application Service Department, NTT West.

He received the B.A. degree in law from the University of Tokyo, Tokyo, in 1987 and the M.A. degree in communications management from the University of Southern California, USA, in 1993. Since joining NTT in 1987, he has participated in various business development projects in the multimedia/broadband fields such as the "Ko-net Plan" (promoting ISDN and videoconferencing to K-12 schools in Japan) in 1996-99 and "BROBA" (video-on-demand service over IP network) in 2001-2004. He has also been engaged in strategic planning of NTT West's sales/promotion activities on broadband services.



Naoki Kihara

Broadband Application Service Department, NTT West.

He received the B.A. degree in education from Hiroshima University, Hiroshima, in 1998 and the MBA degree from Kobe University, Hyogo, in 2004. He joined NTT in 1998. After NTT's reorganization in 1999, he was engaged in solutions business at NTT West. He has been working in business development activities since 2002 and is currently working in the D-cinema project. He received the 10th AMD Award in 2005.