DWT Based Robust Watermarking Embed Using CRC-32 Techniques

Sadi Vural, Hiromi Tomii, Hironori Yamauchi

***Abstract*—**As far as the latest technological improvements are concerned, digital systems more become popular than the past. Despite this growing demand to the digital systems, content copy and attack against the digital cinema contents becomes a serious problem. To solve the above security problem, we propose "traceable watermarking using Hash functions for digital cinema system. Digital Cinema is a great application for traceable watermarking since it uses watermarking technology during content play as well as content transmission.

The watermark is embedded into the randomly selected movie frames using CRC-32 techniques. CRC-32 is a Hash function. Using it, the embedding position is distributed by Hash Function so that any party cannot break off the watermarking or will not be able to change.

Finally, our experimental results show that proposed DWT watermarking method using CRC-32 is much better than the convenient watermarking techniques in terms of robustness, image quality and its simple but unbreakable algorithm.

***Keywords*—** Decoder, Digital content, JPEG2000 Frame, System-On-Chip, traceable watermark, Hash Function, CRC-32.

I. INTRODUCTION

WITH the rapid spread of the Digital world in the field of Movie Industry, some companies are starting to develop equipments for digital cinema systems. *Olympus Corp* developed digital video camera (SH-880TM) with 8Million pixels [9] and *Victor Corp* developed D-ILA projector (DLA-HD2K) with 8million pixel compatible [10].

NTT also continues its R&D via fiber optic networks for Digital Cinema networks and systems [11]. Digital Cinema initiatives in US work on specifications for digital cinema and the usage of the specifications [8]. In recent days the encoding specifications have been fixed as ISO/IEC 15444-1:2000 Information Technology-Jpeg2000, a superior algorithm [4][5].

Since far, many digital watermark techniques have been proposed for digital cinema as a protection method [1][2][3] and many papers have been published and are still continuing as a solution to security at Digital cinema [6][7]. However, none of those can be said to be satisfactory for the digital cinema subscriptions. So, we propose our traceable watermarking method. We put watermark into transmitter and Receiver using completely new algorithm "CRC-32 traceable watermarking".

In this research, we put the watermark twice to trace the image not only during the play at projection but also during the data transmission and download from Digital Cinema System.

The brief digital cinema architecture will be discussed at [II]. The [III] gives the further details on proposed watermarking techniques including concrete design of encoder, decoder, traceable watermarking technology, consequently.

The chapter [IV] gives the experimental results of our research.

The following chapter [V] will give a simple conclusion of the entire research and the last chapter is reference chapter.

S. V. is with the Science and Information Technology of Ritsumeikan University BKC Campus Kusatsu/Japan (phone: +81-90-1958-8949; fax: +81-72-675-4806; e-mail: svv21002@se.ritsumei.ac.jp).
H. T. was with Science and Information Technology of Ritsumeikan University BKC Campus Kusatsu/Japan. She now works for Konica Co. Ltd (phone: +81-775-671-1111,, email: tomii@hotmail.com.
H. Y. is with the VLSI Center of Ritsumeikan University BKC Campus Kusatsu/Japan (e-mail: yamauchi@se.ritsumei.ac.jp).
He is now the director of Rohm Plaza where LSI design and FPGA circuit design are done for educational as well as business purposes

II. DIGITAL CINEMA SYSTEM ARCHITECTURE

A. Entire Digital Cinema Stage

Digital Cinema is a complete hardware system to provide full-length noise free moving pictures, in addition to the other visual "cinema-quality" programs to users throughout the world using some digital technologies over the high-speed networks.

The Digital Cinema system delivers digitized, compressed, and encrypted movie contents to its users using some Electronic transmission methods. In Japan, High-bandwidth fiber optic cables are being sprout every day which makes digital cinema signal transmit faster so that digital cinema clients play movie, learn news from live broadcasting clearly and securely.

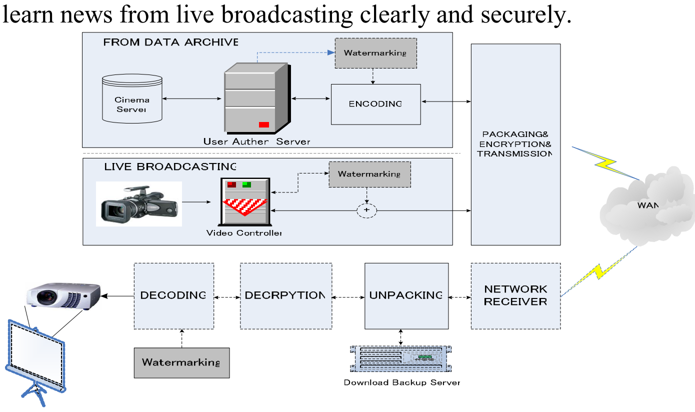


Fig 1 Digital Cinema system

There is a Cinema Server, which keeps the contents. This server must have some large storage where movie contents must be stored. The service, which is offered from Cinema Server can also be renamed as VideoOnDemand (VOD). Another service which digital cinema system provides is live broadcasting service. Live broadcasting is done from Digital Video Camera placed outside or inside at a location. Using it, the broadcasting data from a high-resolution digital video camera is directly transmitted to the client side. The data is controlled by a digital video data controller which provides an I/F between the digital camera and the encoder & transmitter I/F as seen at Fig 1(above). Authentication server authenticates user.

The transmitter is LSI, which encode, embed watermark, encrypt and any other sub-process for transmission.

The Receiver is LSI built in receiver circuits and it uncompresses, decodes, decrypts, and re-embeds the traceable watermark. It is at the user side and connected to a server to save downloaded data and to the projector. The content data at local disk is not possible to play prior to decoding. Because playing the data requires a series of authentication, evaluation, decoding. For each play of the content, a new authentication with the server has to be taken.

III. Our proposed watermarking solution

The Encoder SoC primarily handles on several works such like the embedding watermark to the encoded content, Encoding, encryption, compression, synchronization, packaging, network authentication. The watermark embedded in encoder side is done to protect the content from the network attackers or hackers during the content transmission to the user side.

Watermarking data consists of the Content Administration ID, company name of the content supplier's and the content owner.

Watermark is inserted to the sub bands of the content frames using DWT. Since the watermark embed does not vary for each user, the operation of encoder LSI is done quickly and speedy.

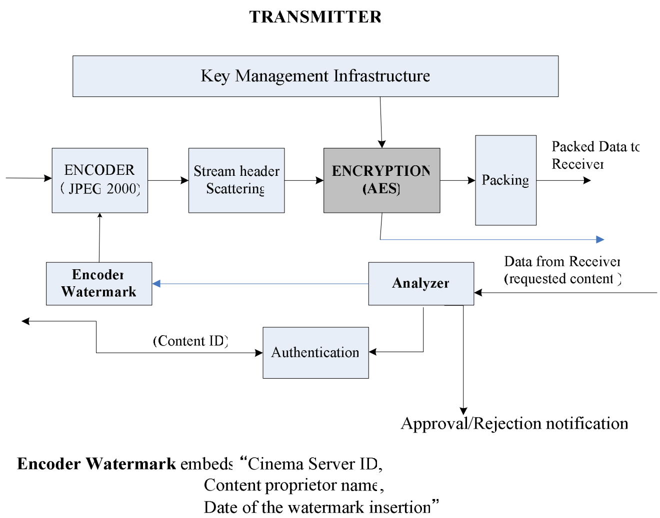


Fig 2 Transmitter LSI with encryption method

JPEG2000 compatible transmitter is responsible for inputs from both the digitalized data from the Cinema server and watermarking data at the same time. The plain content and Watermark data are added inside the Encoder by our Crc-32 traceable watermarking method, which will be further explained at chapter "3" (fig 2). Transmitter makes an output for watermarked content. The watermarked content is made an input to a SHS (stream header scattering) so that frames are randomly distributed on the entire contents. Data for watermarking to embed at transmitter is restricted into cinema server's ID number, Proprietor name, and Date. It is possible as large as 256-byte per each frame.

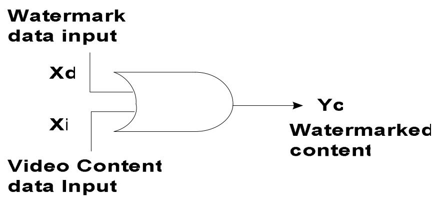


Fig 3 Logic of the Watermark embed

1 *Proposed traceable Watermarking*

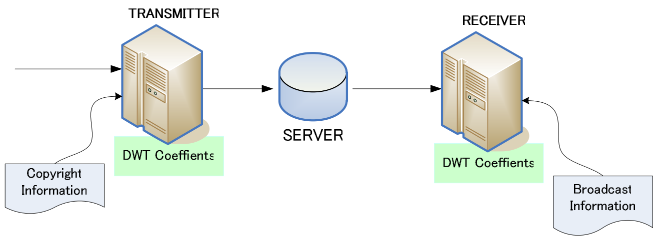


Fig 4 Traceable watermark application

The basic structure of traceable watermark is shown at Fig 4. The content of watermark is copyright information at transmitter and broadcast info at receiver. We embed the watermark into LL subbands and divide embedded subbands into code blocks using the DWT at transmitter. Receiver side is useful to embed due to the illegal recordings during play. The basic algorithm for embedding it is shown at Fig 6-(a), (b) and its embedding method is given at Fig 5

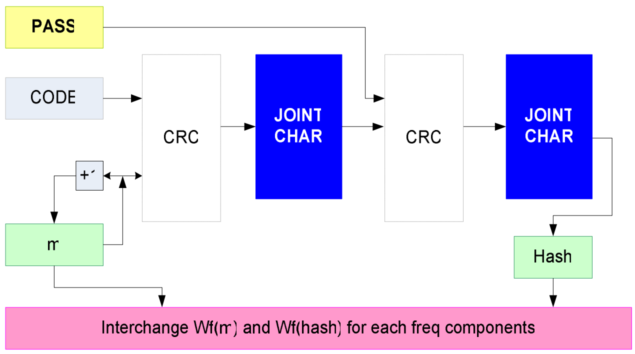


Fig 5 Transverse using CRC-32 Hash function

At Fig 5, by using the hash function, we execute the additional watermarking. Hash Function generates constant length data from the input data. Obtaining the original data from hash data is almost impossible so showing its robustness against any attack. SHA and MD are also robust but they need a series of complicated calculations. We use CRC32 of the RFC1662. The input for CRC32 is called as "strings", which has a variable string length and generated 32-bit hash is called "CRC (string)"

1.2 RNG Based watermarking embedding

At Fig 6-(a) RNG generates random numbers to be a basis of automatic frame selection. While Fig6-(b) shows the frame in terms of sub-band position. The frame is embedded after its 2nd division into the subbands. The second level is LL_2, LH_2, HL_2, and HH_2 because of a wavelet transformation.

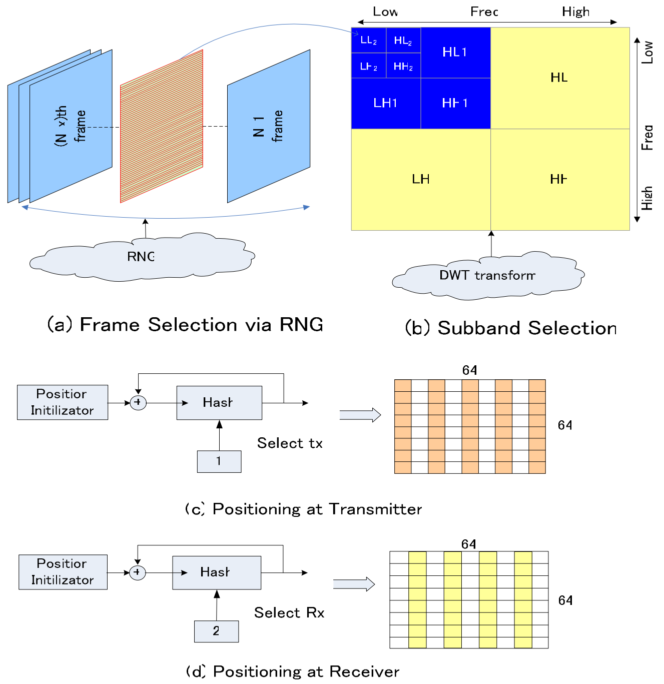


Fig 6 Watermarking Algorithm

[A] Positioning for the embedding

Fig6-(c) right side is the method of embedding watermark into the content. The left side of the (c) is the position of the watermark. First, a 4-16 digit Hash key is decided and it is re-drawn to the left box in one-dimension like 4x4 representation of the box. For each hash key, the 4x4 data cell is interchanged. To recover it, the hash key is assigned in reverse. At above Fig 6, position initializator determines the coordinate (x_e,y_e) for encoder and (x_d,y_d) for decoder. It is the position of where to embed the first data at content frame depending on the Hash function. 64x64/2=2048 dot (256byte) can be embedded for both Dec and Enc. It is 128 byte for encoder and 128 byte for decoder part, which gives a total 2048 dots as given above.

[B] Embedding Strength

Encoder is embedded into the odd numbers of the sub-band and decoder is done into the even numbers. This is given as below

$$L=(N_x \times N_y)/2^{2n},(0 \le x < N_x/2^n),(0 \le y < N_y/2^n) \quad (1)$$

Where L is the maximum number of dots to be embedded.

A simple formulation of the above hash function used for traceable watermarking is also given at 2. To compute it,

First, we have to decide the position using the threshold value T. As a given value T, below threshold condition must be satisfied.

$$norm(m) \ge T \quad (2)$$

Where

$$norm(m) = \sqrt{W_{HL}{}^2(m) + W_{LH}{}^2(m) + W_{HH}{}^2(m)} \quad (3)$$

And using

$$tmp = (\text{int})[W_{LL}(m)/Q] \quad (4)$$

Where (int) is cut-off integer and Q is embedding intensity. Here we use the following concept;

Set tmp "old number" if Watermark information is 0,

Set tmp "even number" if Watermark information is 1.

Then $W_{LL}(m) = tmp \times Q$ (5)

and using the equation 5 in addition to the 4,

$$m = m + Num, Count += count \quad (6)$$

Embedding string array to the frame is done as shown at Fig 6-b. By Positioning of the each component using the hash key from the reverse order of the method at Fig 6-(d), we get l watermark.

2 *Architecture of encoder*

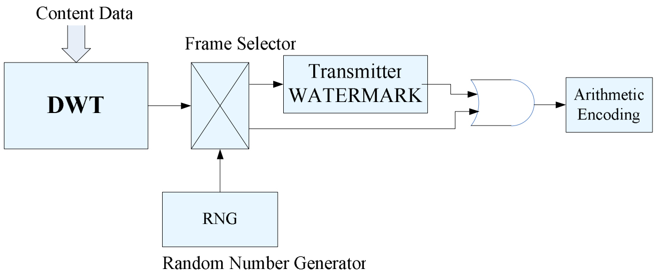


Fig 7 Watermarking at Transmitter

Fig 7 is shows encoding process. DWT coefficients are separated into the code blocks and each frame sub-band is divided into the same size (64x64). Multiplexer (Frame selector) simply decides the content frames whether to insert watermark. RNG decides if watermark must be put into the frame. RNG randomly generates a series numbers with its high calculation algorithms. Finally, the result is applied to the AE (arithmetic encoding).

From Fig 7, we only embed watermark to random frames using RNG information not only for playing but also for the user or client is authenticated user.

3 *Architecture of Decoder*

After the watermarked content has been downloaded, it is either saved into the user server or directly applied to the Decoder LSI for projector.

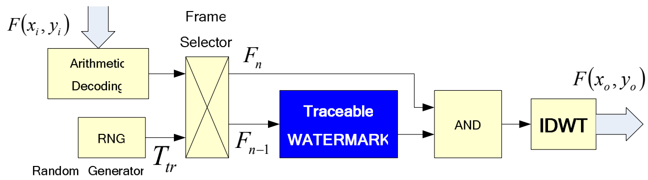


Fig 8 watermarking at Receiver

The content inputs to the Arithmetic Decoding (AD) block. RNG must be synchronized with transmitter RNG. So, we have to use a trigger for synchronization. Finally, Mux decides if frames will be watermarked. Should watermarked frames be detected, traceable watermark is inserted. If no watermarked frames are found, it is bypassed to IDWT to recover the frames.

$$\begin{cases} Hash(F(x,y) \times T_{tr} \times (n-1)) & if \ldots F_n \\ Hash(F(x,y) \times T_{tr} \times (n)) & if \ldots F_{n-1} \end{cases} \quad \text{Eq 7}$$

According to the Eq 7, if it is even frame, F_n th frames are embedded with watermark. Else, watermark is embedded to the F_{n-1} th frames.

Receiver LSI gets the Hash key and inserts 2nd watermark. So, embedding process is fully handled with HW implementations.

IV. Experimental Results

Experimental results show that proposed method is robust against any image processing.

Tile size of 2048x2048 Digital Cinema is used. For the simplicity, we used 512x512 image and divided into 5 subband levels via DWT. The Lowest subband is 16x16. The total character size is 256byte to embed, which means entire subband is used. The resulted image is shown in Fig 10-b:

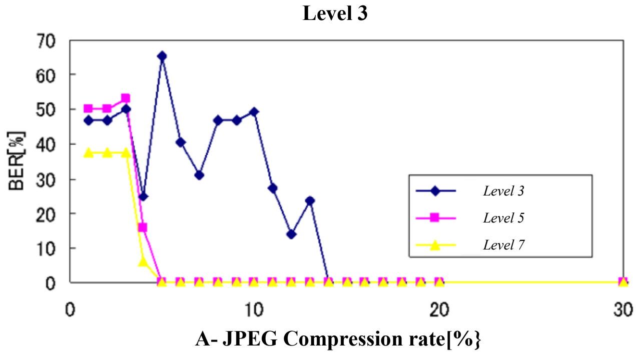
(A) ORIGINAL IMAGE (B) WATERMARKED IMAGE [4· 40db]

Fig 9 Lena Image (512x512)

Table-1 BER values with Intensity

JPEG	Comp rate[%]		2	4	6	8	10	12
	(PSNR[DB])		24.37	29.23	31.77	32.84	33.64	34.41
	Q	3	46.87	25	40.62	46.87	49.21	14.06
		5	50	15.62	0	0	0	0
		7	37.5	6.25	0	0	0	0
JPEG2000	Comp rate[%]		5	7	9	11	13	15
	(PSNR[DB])		33.51	35.00	36.06	37.20	38.14	38.80
	Q	3	42.96	21.87	19.53	14.84	9.375	3.906
		5	25.06	3.906	3.125	1.562	0	0
		7	41.40	0	0	0	0	0

Above table shows the experimental results for JPEG and JPEG2000 compression in accordance with PSNR and Quantization Level (QL). It has been approved at digital cinema experiments that 5% compression rate for an image is satisfactory enough for the quality of digital cinema [11]. Hence, the results for QL≥5 satisfy the digital cinema requirements. Our experiments shows Jpeg2000 compression gives better results and there is almost no error for QL=5 and 7.



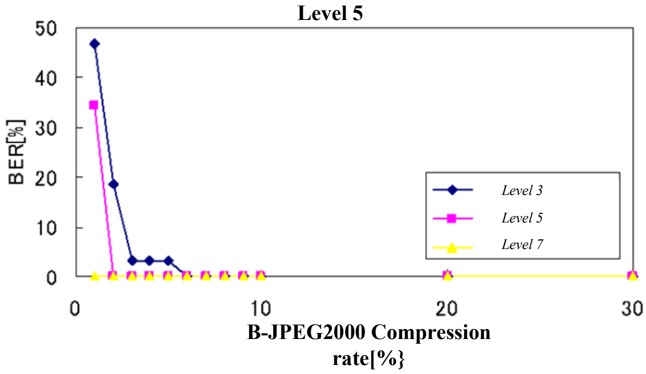


Fig 10 Embedded Data under Compression

At Fig 10 A-B, it is clear that when compression rate is increased, BER is decreased It means watermarking data is fully obtained with no BER Especially for JPEG 2000 compression, the result becomes almost zero for further compression rates. Fig 10 gives that 5% of compression rate has an ignorable BER and it is feasible to make it zero by error correction..

V. Conclusion

In this work, we proposed additional watermarking for digital cinema delivery. Our experimental results show that our watermarking method is robust and safe enough. We will further expand our experiments to the digitalized high-vision movie for its further spread out in the industry.

References

[1] Akio, Miyazaki, Digital Watermarking for images.IEEE Trans. Fundamentals, Vol.E85-A,NO.3 March 2002, pp. 2.
[2] N. J. Mathai, D. Kundur and A. Sheikholeslami, "HW Implementation Perspectives of Digital Video Watermarking," IEEE Transactions on Signal Processing, vol. 51, no. 4, pp. 925-938, April 2003
[3] Hisashi. Inoue, "A Digital Watermark method using the Wavelet Transform for Video Data" , *IEICE Trans.Fundamentals*,Vol.E83-A,No.1 Jan2000.
[4] Suzuki, Junshi, "JPEG2000 Technology" by *Ohm Publishing,* Jan 2001.
[5] Rohm Corp, "Jpeg2000 Coder LSI " http://wwww.rohm.com
[6] Xilinx Corp, ".Digital Cinema Applications" http://www.xilinx.com
[7] "Rijndale" http://www.esat.kuleuven.ac.be/~rijmen/rijndael/
[8] Digital Cinema Initiatives " Digital Cinema System Specifications v2.0", 2003 , http://www.dcci.com
[9] Olympus Corp, "R&D Center, IS Division Project , Planning Group"
[10] Japan Victor Corp "ILA Center Division" http://www.victor.co.jp
[11] NTT Telecommunications "Yokotsuka R&D Division" http://www.ntt.co.jp