

Real-Time Transcoding and Advanced Encryption for 360 CCTV Streaming

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요 약

Recently, according to the rapid development of surveillance information, closed-circuit television (CCTV) has become an indispensable component in security systems. A lot of advanced technologies of encryption and compression are implementing to improve the performance and security levels of the CCTV system. Especially, 360 video CCTV streaming is promising for surveillance without blind areas. However, compared to previous systems, 360 CCTV requires large bandwidth and low latency. Therefore, it requires more efficiently effort to improve the CCTV system performance. In order to meet the demands of 360 CCTV streaming, transcoding is an essential process to enhance the current CCTV system. Moreover, encryption algorithm is also an important priority in security system. In this paper, we propose a real-time transcoding solution in combination with the ARIA and AES algorithms. Experimental results prove that the proposed method has achieved around 195% speed up transcoding compared to FFMPEG libx265 method. Furthermore, the proposed system can handle multiple transcoding sessions simultaneously at high performance for both live 360 CCTV system and existing CCTV system.

1. Introduction

Nowadays, CCTV is widely deployed in the video surveillance systems and video analysis is a key factor to provide intelligent services. To adapt the necessity of digital CCTV video analytic, enhancing quality of service (QoS) of video is one indispensable element. Especially, the existing CCTV system cannot provide high-resolution Ultra-HD, or hard deploy efficient video codec High Efficiency Video Coding (HEVC) [1]. The video transcoding is necessary to adapt the various requirements of CCTV systems.

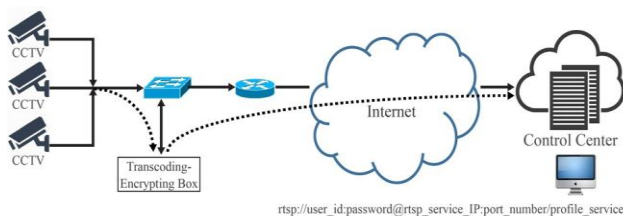


Figure 1. Conceptual architecture of live CCTV System with real-time transcoding.

Compared to the H.264 Advanced Video Coding (AVC) [2], the HEVC video encoding has achieved approximately twice the compression [3][4]. Due to a large amount of existing video content encoded by H.264/AVC codec, transcoding H.264/AVC to HEVC is very necessity. Thus, an efficient HEVC transcoder is helpful to upgrade the AVC CCTV system at the lowest cost. However, the computational complexity of H.265/HEVC coding was very high compared to the H.264 standard. This leads to it too

hard for implementation a real-time high-quality HEVC encoder software in multimedia encoding systems.

To implement the security feature for CCTV system, the encryption method can be implemented at the Network Abstract Layer (NAL) unit level to affect all NAL units of HEVC bitstream file. The performance of the encoder is not significant as it will increase the complexity of the encoder and the transcoder. Therefore, in this paper, we propose a transcoding method for multi-cores platforms. Moreover, the proposed system encrypts the Video Parameter Set (VPS), Sequence Parameter Set (SPS) and Picture Parameter Set (PPS) NAL units of the HEVC bitstream during transcoding process to reduce the computational complexity. The experimental results proved that the proposed system provided significant speed corresponding to a bit rate for H.264 to HEVC real-time transcoding. The conceptual architecture of the proposed system including various CCTV cameras is illustrated in Figure 1.

2. Real-Time Transcoding and Encryption

Video transcoder study can be reviewed in [5]. Regarding the transcoding, there are some concepts commonly discussed in multimedia area such as transcoding codec (for example: MPEG-2 video source to H.264/AVC video and AAC audio, AVC to HEVC etc.), trans-rating bitrate (4 Mbps to 2 Mbps, etc.) or trans-sizing the resolution (3840x 2160 to 1920x1080 etc.). Commonly, transcoding is the combination or one of them of all the above methods. The video conversion requires intensive computational power, so transcoding often requires acceleration capabilities of CPUs/GPU.

2.1 Real-Time Multiple Transcoding

Instead of using a multiplexer to aggregate various video streams, the proposed method provides a parallel-processing mechanism for transcoding. As shown in Figure 2, each video transcoding session was handled by a CPU-core within one or more threads. One thread can process several video frames as a batching or all frames of a video stream. By using advanced technologies from Intel such as pipelining and multi-threading technique, the proposed system can handle the input streams as parallel processing. Each input stream could be attached to one session. Then, all sessions will be joined together to work simultaneously as shown in Figure 3.

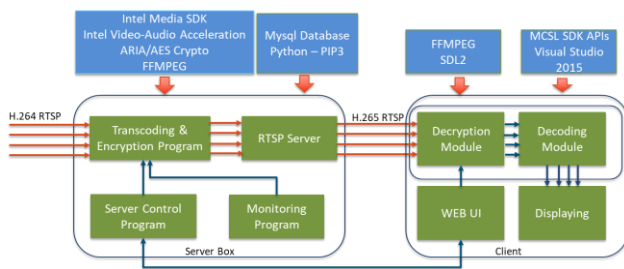


Figure 2. System architecture of CCTV streaming with real-time transcoding.

The FFmpeg library [6] can handle transcoding sessions by providing a muxing mechanism to multiplex video streams. However, it may not use all available core simultaneously. Even though, Intel Quick Sync Video technology [7] integrated into FFmpeg can handle several sessions, but it just supports two sessions of 1080p video streams at the same time with very high latency. Therefore, the proposed method aims directly using Intel video/audio processing acceleration APIs to build the parallel processing mechanism for transcoder. As shown in Figure 2, to optimize CPU cores usage, the proposed method uses Intel Media SDK API to implement acceleration transcoding applications. The main architecture of Intel Media SDK can be reviewed in [8].

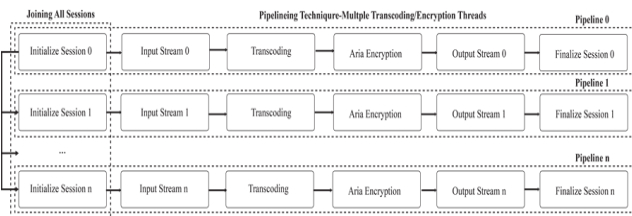


Figure 3. Transcoding and encryption for video streaming on multi-core platforms

2.2 ARIA and AES Encryption

To achieve the real-time transcoding and encryption, the proposed system used ARIA and AES algorithms to encrypt each output HEVC video stream from the transcoder as shown in Figure 3. Instead of encrypting whole output video stream, ARIA/AES crypto library [9] was used to encrypt a several special frames such as VPS, PPS and SPS. Additionally, the encryption mechanism also

allows the transcoder encrypting a part of the video stream as the length of the multiple of 16 bytes to avoid the padding issue. The ‘padding’ can lead to hard work of decryption in client side. In this paper, we applied the encryption mechanism for both video and audio stream. The encryption key and other necessary components were stored at both server and client.

3.3 RTSP Streaming

In order to provide real-time streaming service, the proposed system used the real-time transmission protocol (RTSP) [10] within two components as follows:

- RTSP server: Get input RTSP H.264, then transcodes it and write out packet to output RTSP. Proposed System can provide multiple real-time RTSP streams at the same time.
- RTSP client: Client uses our MCSL SDK APIs to decrypt and decode HEVC RTSP stream from server.

3. Performance Evaluation

To verify the performance the proposed method in a real environment, we implemented an effective testbed to verify the ability of real-time transcoding and encryption. We set up a server transcoder box with an Intel Core i7-7500U 2.70GHz processor, 16 GB of memory and Linux Centos 64-bits version 3.10.0-862.9.1.el7.x86_64 OS. We also used a Window 10 desktop PC as client. Additionally, we installed two Hanwha CCTV cameras as 2D cameras and a Samsung 360 camera as 360 CCTV camera. We also use both 2D and 360 video test sequences which were released by JCT-VC [4] to perform experiments of the proposed method.

As shown in Figure 4, the average transcoding time for the six sessions is approximately 7.05 seconds within input video duration 10.03 seconds. In 6 transcoding sessions, there are 3 sessions (1,3,5) enabling encryption and 3 sessions without encryption (0,2,4). The transcoding time of encrypted sessions are approximately equivalent to none-encryption sessions. Moreover, proposed system can provide two Ultra-HD sessions or six 1080p sessions. The transcoding procedure only takes around 70-75% of the video duration. The average transcoding rate is 36.4 frames per seconds for 1080p and 33.6 frames per seconds for Ultra-HD resolution video.

As shown in Table 1, a comparison between proposed method and x265 have been processed to measure 360 video transcoding. We used libx265 FFmpeg [11] to perform all sessions. Then, we can confirm that the proposed method can speed up the transcoding up to 195% compared to libx265. The highest achievement is 7.03 seconds for 360 transcoding time with a speed of 42.8 frames per second, and 2D video transcoding speed can be achieved up to 42.88 frames per seconds.

As shown in Table 2, WS-PSNR [12] values show the performing unsatisfactory compared to other quality metrics when it comes to estimating the quality of images

and videos as perceived by humans. We performed the comparison for both 1080p and Ultra-HD videos. All WS-PSNR of Y, U and V channels are higher than 38 dB. These values confirmed that the quality of 360 videos at client are reasonable to feel fully immersed in 360 videos.

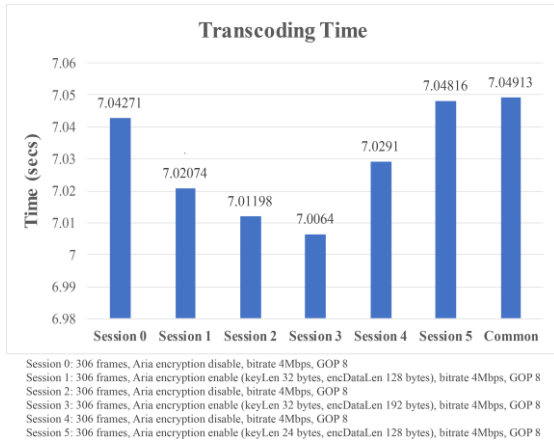


Figure 4. AVC-HEVC: Six 1080p sessions.

Table 1. 360 Video Transcoding Comparison.

Test_sequence	x265	Proposed
<i>DrivingInCity</i> 1080p	20.78s (14.48 fps)	7.03s (42.8 fps)
<i>GasLamp</i> 1080p	22.12s (13.56 fps)	8.45s (35.5 fps)
<i>Harbor</i> 1080p	22.45s (13.37 fps)	8.58s (34.9 fps)

Table 2. The WS-PSNR Comparison

Test sequence	WS-PSNR Y channel	WS-PSNR U channel	WS-PSNR V channel
<i>DrivingInCity</i> _1080p	39.36	45.14	44.52
<i>DrivingInCity</i> Ultra HD	38.68	45.33	44.63
<i>GasLamp</i> _1080p	41.47	46.74	46.08
<i>GasLamp</i> Ultra-HD	42.19	47.34	46.61

Table 3. Processing time comparison between ARIA and AES algorithms.

Test sequences	ARIA total time	ARIA time	AES total time	AES time
ParkScene_240 Frames 25FPS	5.596s (42.88 fps)	3.16%	5.07s (47.33 fps)	2.82%
Kimono_240 Frames 25FPS	5.61s (42.7 fps)	2.53%	5.39s (44.5 fps)	2.07%
Basketball_240 Frames 25FPS	11.89s (42.05 fps)	2.28%	11.55s (43.29 fps)	1.14%

In order to perform the encryption efficiency, the proposed system was taken experiments with both AES and ARIA algorithms. The result proved that the AES algorithm can provide the encryption speed up to 33.4 times when compared to the ARIA algorithm. As shown in Table 3 AES encryption process can reduce the total processing time around 10% when compared to the ARIA algorithm. The percentage time of AES encryption over the total time will be more and smaller when the CCTV video duration time increasing. The ARIA encryption gives the result in the same way with higher percentage than AES

encryption. Finally, we can conclude that AES encryption is one of the best choices to secure live video streaming.

4. Conclusion

The development of 360 video technology is promising to motivate the development of current CCTV systems. In the scope of this paper, we proposed the transcoding and encryption method for real-time CCTV video streaming. The proposed system optimized real-time transcoding AVC-HEVC and ARIA/AES encryption for two Ultra-HD sessions and six 1080p sessions with speeds of 33.6 FPS and 36.4 FPS, respectively. In the future, we will apply cubemap projection extensively into 360 cameras to improve the quality of input CCTV video. Regarding encryption, applying cryptographic attack and plaintext attack are planning to take testing the secured ability of the proposed system.

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Reference

- JCT-VC, High Efficiency Video Coding (HEVC). [Online]. Available: <https://hevc.hhi.fraunhofer.de/>
- T. Wiegand and Gary J. Sullivan, Overview of the H.264/AVC Video Coding Standard, IEEE Transactions on Circuits and Systems for Video Technology, Vol.13, No.7, July.2003; p.p 560 – 576, IEEE.
- J.-R. Ohm, G. J. Sullivan, H. Schwarz, T. K. Tan, and T. Wiegand, Comparison of the coding efficiency of video coding standards— Including High Efficiency Video Coding (HEVC), IEEE Trans. Circuits Syst. Video Technol., vol. 22, no. 12, pp. 1669– 1684, Dec. 2012.
- JCT-VC – Joint Collaborative Team on Video Coding. [Online]. Available: <https://www.itu.int/en/ITU-T/studygroups/2013-2016/16/Pages/video/jctvc.aspx>
- H. Kalva, “Issues in H.264/MPEG-2 video transcoding,” in Proc. 1st IEEE Consum. Commun. Netw. Conf., 358 Jan. 2004, pp. 657– 659.
- FFmpeg software. [Online]. <https://www.ffmpeg.org/>
- Intel, Quick Sync Video Technology. [Online]. <https://www.intel.com/content/www/us/en/377-architecture-and-technology/quick-sync-video/quick-sync-video-general.html>
- Intel Media SDK. [Online]. <https://software.intel.com/en-us/media-sdk>
- Crypto++ Library. [Online] <https://www.cryptopp.com>
- H. Schulzrinne, A. Rao, R. Lanphier, M. Westerlund, and M. Stiemerling, IETF RFC: Real-Time Streaming Protocol Version 2.0, Dec. 2016 . [Online]. Available: <https://tools.ietf.org/html/rfc7826>
- VLC x265 library. [Online]. <https://www.videolan.org/developers/x265.html>
- ERP WS-PSNR software. [Online]. Available : http://mpegx.intevry.fr/software/MPEG/Explorations/3DoFplus/ERP_WS-PSNR