Compression Technologies Supporting Next Generation Broadcasting Services - Ultra-HD Digital Video Compression Technology and Real Time HEVC Compression Unit Corresponding to 4K HD Images

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Abstract

Advances in image recording/playback device technologies have made it possible to provide next-generation broadcasting services that deliver ultra high definition video that surpasses terrestrial HD (High Definition) broadcasts. The ultra high definition digital video of 4K comprises a pixel count that is 8 times higher than HD, enabling it to convey a scene's depth and presence more effectively to the viewer. However, since the amount of image data that must be processed is enormous, a highly efficient digital video compression technology becomes necessary for image transfer. And since the ultra high definition digital video will be used for sports and other live broadcasts as well, real-time compression is a necessity. In this paper we discuss NEC's ultra high definition digital video compression technology and real-time HEVC compression unit corresponding to 4K, as well as our future activities.

Keywords

UHDTV, 4K broadcast, ultra high definition digital video compression, real-time compression unit, HEVC

1. Introduction

Today's world is witnessing the commercialization of UHDTV (Ultra High Definition Television) services utilize ultra high definition images such as 4K. These 4K image feature eight times the number of pixels as HD images, increasing visual expression capabilities dramatically and enabling the presence and depth of a scene to be conveyed to the viewer more effectively. However, since the size of the image data becomes enormous, a digital video compression technology offering a high compression ratio is necessary to transmit the images. For this reason, activity is high in the research, development and commercialization of ultra high definition digital video compression technology that is compliant with HEVC (High Efficiency Video Coding), the world's standard for video encryption that achieves higher compression performance than conventional technologies.

In this paper, we will introduce NEC's ultra high definition digital video compression technology that supports the 4K broadcasts that are being adopted worldwide, and the VC-8150 Real Time HEVC Compression Unit corresponding to 4K HD images.

2. Requirements for Ultra HD Digital Video Compression Technology to Realize 4K Broadcasting

With the goal of achieving next generation broadcast services such as 4K/8K as early as possible, the Next Generation Television & Broadcasting Promotion Forum (NexTV-F) was inaugurated in 2013 with a membership of 21 companies including broadcasters, telecommunications carriers and equipment manufacturers. From June 2014, NexTV-F has begun the first 4K test broadcasts in Japan as "Channel 4K" via CS digital broadcasting.

Achieving this required that 4K video data be compressed to approximately 1/200th its original size in order for transmission over CS digital broadcast bandwidth to be possible. However, the compression rate of existing technology being used in Japanese one-segment broadcasts and overseas terrestrial HD digital broadcasts was insufficient, as it afforded only about 1/100th compression. NEC therefore developed its own ultra HD digital video compression technology compliant with HEVC, which offered approximately twice the data compression ratio of conventional technologies, and incorporated it into the world's first Real Time HEVC Compression Unit, the VC-8150. Currently a device possessing the same encryption

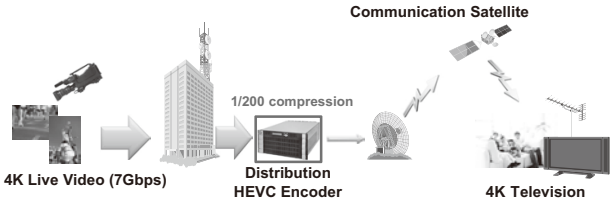

Fig. 1 4K Broadcast using HEVC Encoder.

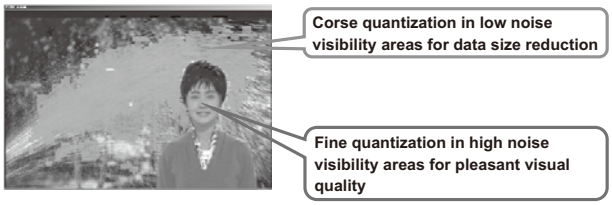

Fig. 2 Noise visibility adaptive quantization technology.

core as the VC-8150 is in operation as the 4K digital video compression unit for "Channel 4K" (**Fig. 1**).

3. Element Technology for Ultra HD Digital Video Compression

NEC possesses original key technologies needed to realize the high compression ratio, low processing load, high quality image, real time compression, and high-performance software compression that are required for products and services that address the high technological requirements of broadcast services through compliance with HEVC standards. The following is a summary of those key technologies.

(1) High compression

- **Noise visibility adaptive quantization**
  Based on the image's complexity and color, quantization granularity is adapted region by region depending on how noticeable the quantization noise visibility appears due to compression. By adapting coarse quantization granularity and therefore reducing data size in areas with complicated patterns where degradation is not so noticeable, it is possible to maintain overall image quality while greatly increasing compression performance (**Fig. 2**).
- **Elimination of movement adaptive changes over time**
  This detects the changes in pixels over time that are difficult for the human eye to recognize and eliminates them. By eliminating changes over time that are inconsequential for human viewing, it is possible to greatly reduce data size[1)] in scenes where the camera or subject is moving gradually (**Fig. 3**).

(2) Low computation burden

- **Multistage optimal compression parameter estimation**
  Based on advance multistage analysis, the optimal block partitioning shape is analyzed per each portion of the image. This makes it unnecessary to decide on block partitioning shape after trial-running all presumable block division patterns as is done with current methods. Therefore the computational load is greatly alleviated[2)] while high image quality is maintained (**Fig. 4**).

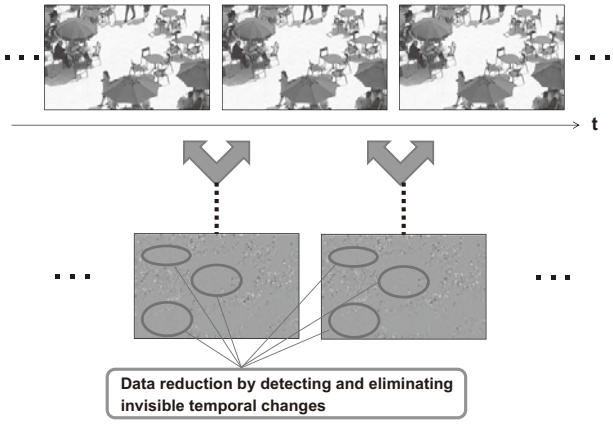

Fig. 3 Movement adaptive time change elimination technology.

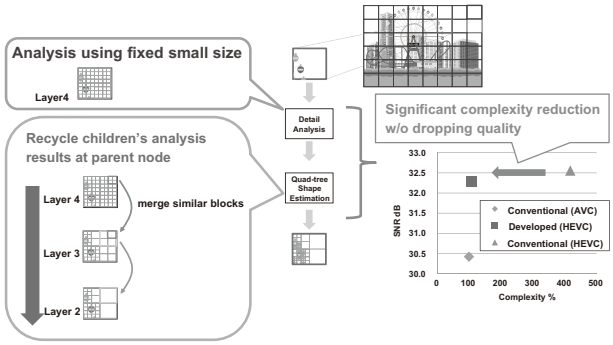

Fig. 4 Multistage optimal compression parameter estimation technology.

(3) High quality image

- **Screen image boundary overlap motion analysis technology**
  When segmenting and compressing ultra high definition video data, this technology bridges the boundaries of adjacent image segments and overlaps the analysis regions to detect the motion vectors of the subject and the camera. So even in scenes where a video frame is split into different image segments and the objects move across the adjacent boundaries, reproduction of a high quality image is possible (**Fig. 5**).

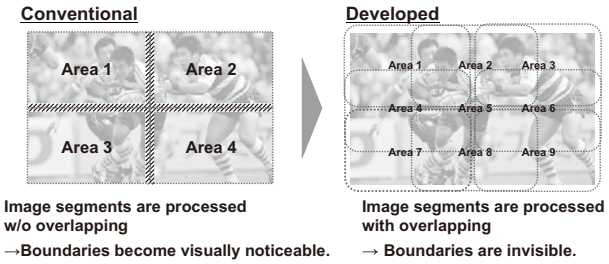

Fig. 5 Screen boundary overlap movement analysis technology.

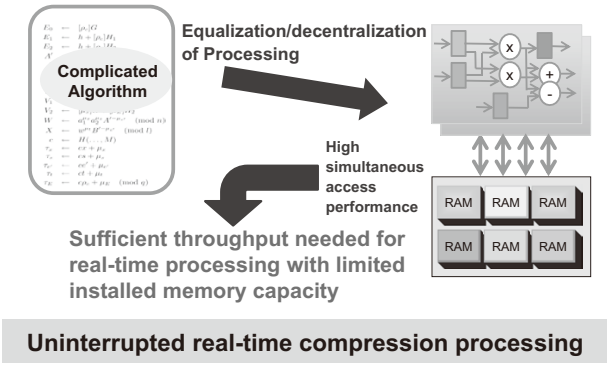

Fig. 6 Distributed memory architecture.

(4) Real-time processing

- **High throughput parallel processing**

Through the implementation of high throughput parallel processing based on the following elemental technologies, advanced HEVC compression processing was realized in a hardware platform.

(a) A distributed processing framework was adopted to guarantee the necessary processing time for peak load handling of HEVC compression processing, in which the processing load fluctuates depending on the image, by distributing the maximum load over multiple specified elemental processes.

(b) A data bottleneck was avoided by adopting distributed memory architecture to improve simultaneous access performance, thereby addressing each of the above issues individually.

As a result, we were able to achieve the necessary throughput performance with limited on-board memory capacity, thereby enabling real-time compression without interruptions in video as required by broadcasters (**Fig. 6**).

(5) High-performance software compression

- **GPU highly parallel processing**

A broadcast station's video management system, as well as VoD (Video on Demand) service, necessitates a software encoder capable of flexible operation. Whereas an ordinary software encoding on CPU takes dozens of hours to compress 1 hour of 4K video, the highly parallel processing technology developed by NEC utilizes a GPU (Graphics Processing Unit) equipped with over 1,000 cores to accelerate processing speed by dozens of times[3] (**Fig. 7**).

4. Features of VC-8150

The VC-8150 incorporated various elemental technologies including the aforementioned multistage optimal compression parameter estimation, visually adaptive quantization, and screen boundary overlapping movement analysis, thereby providing for the first time in the world, real-time HEVC compression that satisfies the quality requirements for 4K images being broadcast via narrow-band communication satellite. Shipment of the VC-8150 started in April 2014, and it has been implemented not only for 4K test broadcasts in Japan, but also for 4K broadcasts and public viewing facilities in Europe and South America during the World Cup in Brazil, therefore contributing greatly to the launch of next-generation broadcast services the world over.

Main specifications of VC-8150 are described in **Table** below. **Photo** shows the outer cabinet of the apparatus.

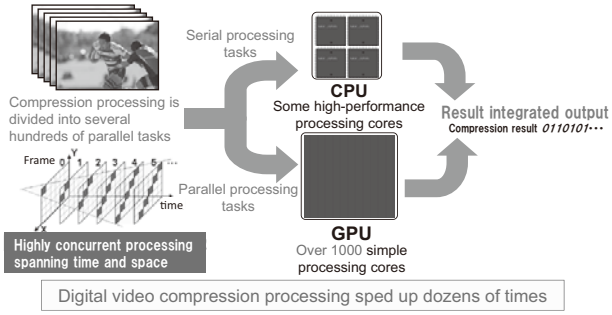

Fig. 7 GPU highly parallel processing technology.

Table Main specifications.

Item	Details
Video input	Format : 3840(H)×2160(V), Progressive I/F : 3G-SDI×4 (SMPTE-424M) Frame frequency : 50Hz, 59.94Hz, 60Hz
Audio input	Embedded audio BTA S-006B,SMPTE 299M
Video Encoding	ITU-T Rec.H.265¦MPEG-H part2/HEVC Main, Main10@Level 5.1[Main tier] Coding resolution : 3840(H)×2160(V)
Audio Encoding	MPEG-2 AAC-LC,MPEG-4 AAC-LC 1/0,1/0+1/0,2/0,3/1,3/2,5.1ch
Output signal	MPEG-2 TS, DVB-ASI
Size	5U, 220(H)×430(W)×500(D)mm, Approx. 50kg

Photo Outer cabinet of VC-8150 apparatus.

5. Conclusion

This has been an introduction to NEC's ultra high definition digital video compression technology which supported the public viewing at the World Cup in Brazil as well as 4K test broadcasts, and also the VC-8150 real-time HEVC compression unit corresponding to 4K. In the future it is our intention to develop an LSI for the HEVC encryption section, and contribute to the improvement of 4K broadcast services by miniaturizing our equipment and pursuing higher image quality.

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