SC23 Network Research Exhibition: Demonstration Preliminary Abstract

Uncompressed 8K video processing using SRv6-based service function chaining between Japan and the U.S.

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Abstract

We aim to establish a video processing platform for uncompressed 8K ultra-high-definition videos that can freely link transmission, storage, and processing functions, and automatically configure the required video production workflow using computing resources distributed among data centers and edges in the cloud.

In the previous year's SC22 NRE, a demonstration experiment was conducted to display edited and processed 8K video at the venue remotely using the edge devices of a video processing platform with 400 Gbps video processing capacity installed in Japan from the venue. In this year's NRE, in addition to the edge devices with a processing capacity of 400 Gbps in Japan, 100 Gbps edge devices were installed at multiple locations in Japan and at the venue by chaining them with service functions using Segment Routing over IPv6 (SRv6); 8K uncompressed video was edited and processed in real time and displayed at the venue. This experiment will be conducted to verify that an 8K uncompressed video can be edited, processed in real time, and displayed at the venue. Video traffic will be visualized using two types of real-time monitoring systems.

Overview

8K ultra-high-definition (UHD) videos (8K videos) require 16 times more pixels than those available in HDTVs and are expected to be utilized in various industrial fields such as video production and medicine. To enable 8K videos, it is essential to process and edit video materials. However, uncompressed 8K videos are difficult to handle in real time, owing to limitations in network bandwidth and device processing capacity. Therefore, we currently use a nonlinear editing machine that processes videos stored in local storage rather than in real time.

Our goal is to realize a video processing service that utilizes cloud and edge computing to enable real-time editing and distribution of 8K videos whenever needed, without requiring users to have special equipment.

Cloud-based UHD video processing uses a large amount of data that require management and resource contention, making it difficult to guarantee high performance. Therefore, in this study, we propose a video processing platform architecture that can overcome these limitations and process large amounts of uncompressed 8K UHD video data with low latency by introducing an edge device between the terminal and the cloud. The proposed video-processing platform realizes a series of video-processing workflows by linking virtualized video-handling functions (VVFs), as shown in Figure 1.

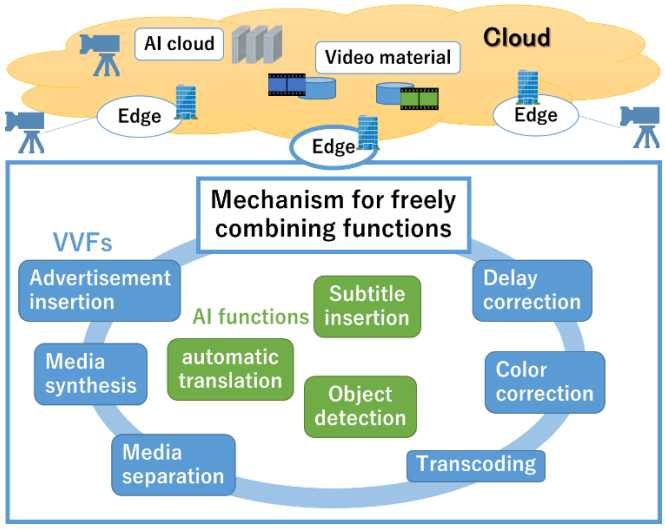


Figure 1 Cloud-based UHD video processing platform

Implementation of VVF

A VVF is an application of the data plane development kit (DPDK) framework used in software router switches for video processing to achieve basic video processing functions, such as video switching, video format conversion, and color correction. Delay adjustment and video switching functions that process video data at the packet level can process four real-time streams (96 Gbps) of uncompressed 8K video data at 24 Gbps.

In addition, the use of Single Instruction/Multiple Data (SIMD) extension instructions, such as streaming SIMD extensions (SSE) and advanced vector extensions (AVX), together with the DPDK framework and increasing the number of memory

slots (channels), enables real-time processing of transcoding and color selection.

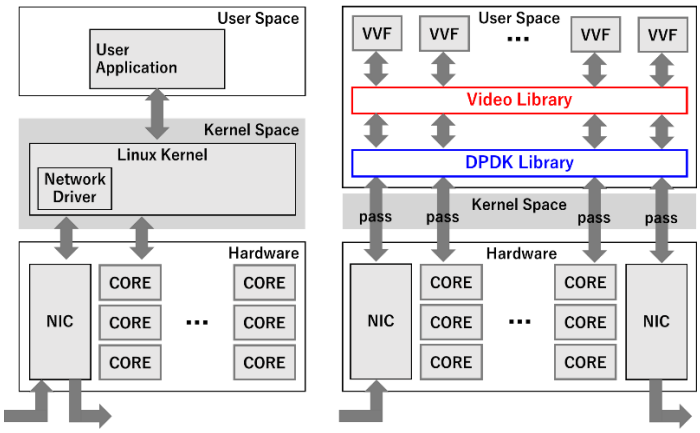


Figure 2 High-speed VVF using DPDK (right) and normal DPDK usage (left)

Service function chaining of VVF

To realize a series of video-processing workflows by linking multiple VVFs, we applied SRv6 in-network service function chaining (SFC) for VVF service chaining.

SRv6 "In-network SFC" is a technology that enables SFC at any point in the SRv6 domain by placing SR-aware network service functions in the SRv6 service function nodes. To achieve SRv6 In-network processing, the data plane uses End.AN, which natively processes SRv6, to process SR-aware network service functions, as shown in Figure 3.

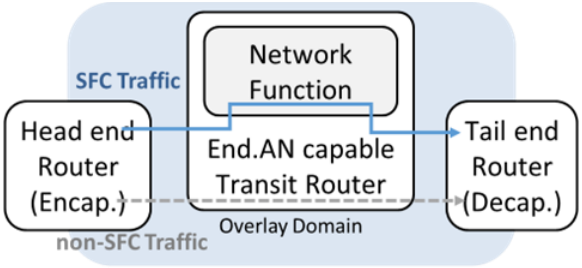


Figure 3 Packet forwarding process of End.AN

As an example of the processing speed of the VVF executed by End.AN, the switching speeds of four uncompressed 8K videos at 24 Gbps per stream can be processed in less than one frame.

Prototype of the video processing platform and testbed

The video processing platform realizes a series of video processing workflows by linking the VVFs that provide primitive video processing functions. We built a prototype edge device comprising three PC servers and a 400 Gbps switch at the Sagamihara Data Center (DC) of SINET6, as shown in Figure 4. The "Next-generation high-reliability NFV equipment" of the Osaka and Hokuriku DCs of the "Beyond 5G Reliable Virtualization Infrastructure" provide by NICT, is also being used.

Furthermore, a testbed was constructed using 8K cameras at SINET6's Ginoza DC, Kanagawa Institute of Technology, and JGN's SterBED 8K video server as video sources to develop and verify the new VFF and SRv6 In-network SFC.

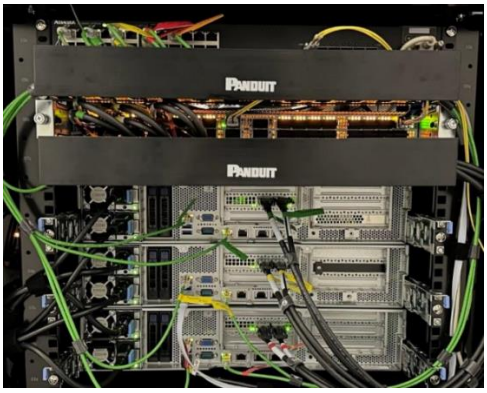


Figure 4 Edge devices at the Sagamihara DC

In June 2023, the SRv6 network built within JGN and SINET6 was extended to the Interop Tokyo 2023 venue, and a video-switching experiment was successfully conducted using a VVF connected by service chaining, as shown in Figure 5. This experiment was a verification of the data plane, and studies are currently underway to include a control plane.

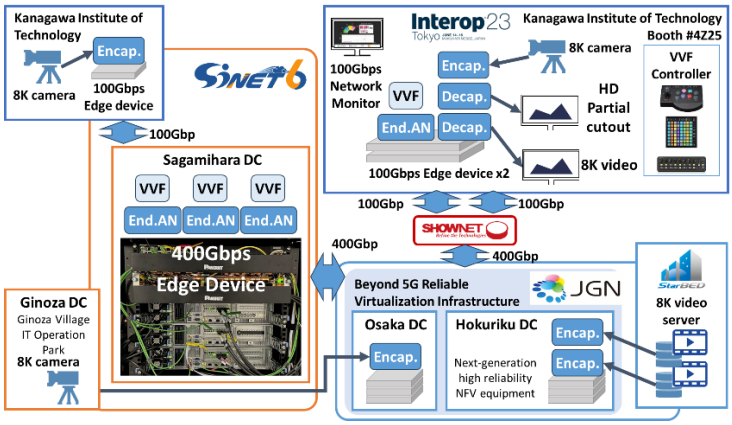


Figure 5 Experiments on 8K video processing with the SRv6 in-network SFC at Interop Tokyo 2023

Monitoring

Traffic monitoring is important for the stable transmission of large-capacity real-time video streams such as uncompressed 8K videos. We are also developing two real-time monitoring systems at over 100 Gbps for multiple uncompressed 8K video streams, as shown in Figure 6.

The first system is the Traffic Meter, which visualizes the amount of traffic in real time with a resolution of less than 1s. Momentary video disturbances can be captured as changes in packet spacing (bursts). The second is the Stream Monitor. Our stream monitor displays the delay difference, reversal frequency, and missing rate of the multiple substreams that

compose the 8K video stream at 1s intervals so that problematic substreams can be identified.

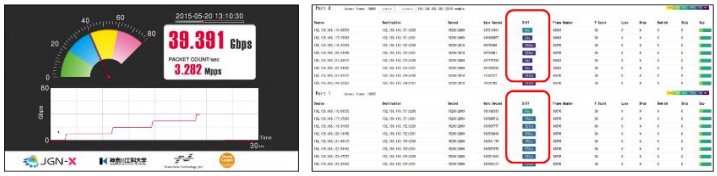


Figure 6 Screen captures of Traffic Meter (left) and Stream Monitor (right)

Both of them are implemented in the VMs and are planned to be provisioned with service function chaining, similar to VVF.

Demonstration

In this demonstration, we show how a video creation workflow is obtained by the SRv6 In-Network SFC of VVFs distributed at JGN and SINET6 in Japan, and at the NICT booth at the venue using SRv6, as shown in Figure 7. Specifically, by remotely operating the VVFs from the venue, multiple 8K video sources in JGN and SINET6 will be edited in real time and shown on the venue's display.

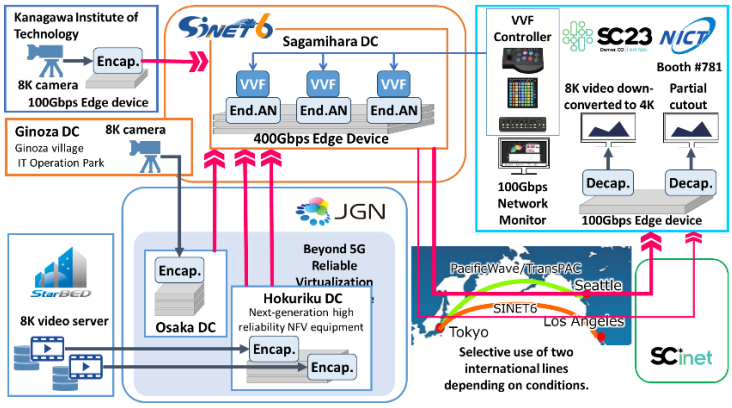


Figure 7 Network topology and traffic flow of the demonstration

One of the display monitors shows the color-corrected VVF selected by the video-switching VVF from the four video sources with the color correction VVF. On another display monitor, an HD video image of an arbitrary portion of the 8K video image is shown.

The four video sources can be switched using the buttons on the MIDI Pad, which can be used to adjust the colors to red, blue, and green; the joystick can be used to change the location of the cutout.

The video traffic will be monitored in real time using the Traffic Meter and Stream Monitor. With these monitoring tools, if there is a disturbance in the received video, the traffic behavior can be checked using the Traffic Meter, and the status of the substreams of the video layer can be checked using the Stream Monitor.

Goals

1. Simultaneous transmission of 8K-DG video (25.6 Gbps) before or after VVFs processing and HD video (3.2 Gbps) derived from 8K video using the SRv6-based VVF service chain established between Japan and the U.S., and visualization of video processing speed.
2. Remote control of VVFs in Japan from the U.S.
3. Monitoring of the processing resources using a high-precision network-monitoring device.

Resources

- Stable connection of 9,100 MTU between Japan and the U.S. with 30 Gbps bandwidth and IPV4 multicast traffic.
- Tapping points or monitoring for debugging and troubleshooting.

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