Design of Cloud-based remote collaborative system for broadcasting production workflow

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***Abstract*—This paper presents the design of a cloud-based remote collaborative production system with a service platform architecture involving virtualization of the production environment and remote control of equipment. The system mainly includes an IP-based media gateway supporting various media data specifications in a local production domain and a service platform with a video switcher module, a remote control& management module, and an automated production module in the cloud. And for enabling small-scale production and individual content creators as well as professional AV experts to participate easily in remote sites the system will be provided with various interfaces and equipment compatibility to enable to participate in production easily.**

***Index Terms*—Cloud based broadcasting production, Cloud-based video switching, Over-the-top (OTT) platform, Remote live production**

I. Introduction

Recently, the evolution of the broadcasting production environment with IP technology not only resolves the limitations of transmission distance and speed, but also enables resource sharing through networks and facilitates centralized control of systems. Additionally, the shift from hardware-based equipment to software-centric virtualization technology allows for the seamless integration of cloud-based production platform [1] [2].

In this changing trend, broadcaster operators are considering to migrate studio functionality to the cloud-based production platform in order to reduce their operating and maintenance budget, including aspects such as media asset management, transport headend, and production. While many studio facilities have already been deployed for non-real-time production during the transition to the cloud, challenges remain for live production scenarios, particularly in news or sports real-time broadcasts, which require overcoming an end-to-end latency and device synchronization issues as well as skilled human operators. Nevertheless, the transition from on-premises to the cloud in broadcasting production brings the benefits of collaborative production, improved operator efficiency, as well as reduced space and power consumption, leading to substantial savings.

In cloud-based remote broadcast production, providing a unified broadcast production workflow that accommodates various interfaces and satisfies compatibility between devices allows a small-scale/ individual content creator and professional-AV (ProAV) producers to easily participate in production. In this paper, we describe the design of a cloud-based collaborative production system for remote participants involving virtualization of the production environment and remote control of equipment.

II. Overall Structure of Cloud-Based Broadcasting Production System

The current broadcasting equipment connectivity and control have widely utilized the serial digital interface (SDI). However, with the existing physical transmission scheme it has become more difficult to handle the demands for high resolutions (4K/8K) and large-capacity data transmission required for immersive media, and signal quality over long distances cannot be guaranteed [3]. The network infrastructure advancement like giga speed or 5G wireless network has impacted on production workflows to meet these changes. Figure 1 shows the overall structure of cloud-based broadcasting production systems and the functional components proposed in this paper.

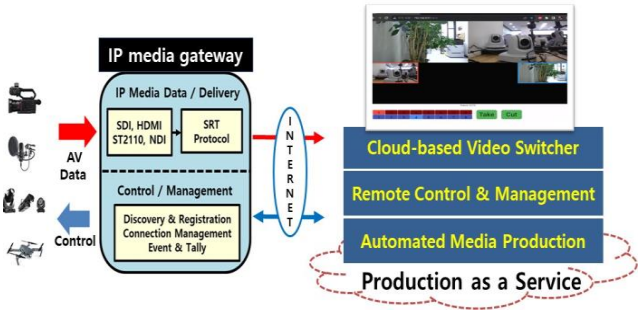

Figure 1. Functional components of the proposed cloud-based broadcast production system

As shown in figure 1, if a workplace for production workflow is newly created as a service for a broadcast production in a cloud, all of A/V media data that can be generated from cameras and microphones in a local area are delivered to the cloud thru an IP media gateway. It converts A/V media sources to IP formats and further processes to send them to the cloud over IP networks. In detail, it compresses A/V sources at a propriate data size and packetizes for error detection and correction during network delivery. It is highly important to feed A/V data remotely to the cloud in maintaining constant bit rate and low-latency transport [4][5][6].

The cloud-based production service platform (cloud-based platform) for high quality live media production is mainly

composed of three modules defined in a video switcher module, a remote control and management module, and an automated media production module. First of all, a video switcher is run on the cloud service platform with software-defined units and manipulates multiple A/V sources. This cloud-based video switcher decapsulates and decompresses multiple A/V source data over the network. And then, it takes preview/program (PRV/PGM) in accordance with a producer's command at a remote location in real-time. Secondly, a remote control and management module discovers and registers remote production equipment to be utilized in a workplace. The control structure between remote equipment and the cloud-based platform is designed by NMOS-expanded open standard in WAN. The participants in remote different sites can work in cooperation with the controlling signals such as a microphone's volume, a lighting, and a tally. Lastly, automated production module recommends a possible PGM shot(s) among candidate camera shots based on AI algorithms. For instances, decision of a preferred camera shot from multiple preview cameras or decision of a cropped shot of interest (program) given a wide shot video like 4K/8K.

III. Design of Remote Collaborative Production in Cloud

A. Remote collaborative production in cloud

As described in previous section, all on-site AV sources are transmitted remotely to the cloud production platform. In order to effectively produce broadcast programs in cloud environment, the cloud-based platform creates a virtual workspace facilitating participation and collaboration among production crews. The production workplace for collaborative activities is dynamically constructed with the virtualized computing resources depending on a scale of production: number of remote participant connection & AV equipment, recordings, video quality, accessories of subtitles & chatting and so forth. In result, the executive producers, announcers (narrators), lighting and audio experts engage in broadcast production through the virtualized work space in the cloud production infrastructure.

From the proposed scenario, various live channel programs can be streamed by using multiple AVs selectively. For an example in figure 2, producer A can stream channel-1 with camera-1&-2, commentary plus subtitle. While producer B can stream channel-2 with camera-1 and audio mixing (ex. music). Therefore, a camera-1 can be commonly used to execute two streaming channels by production separately.

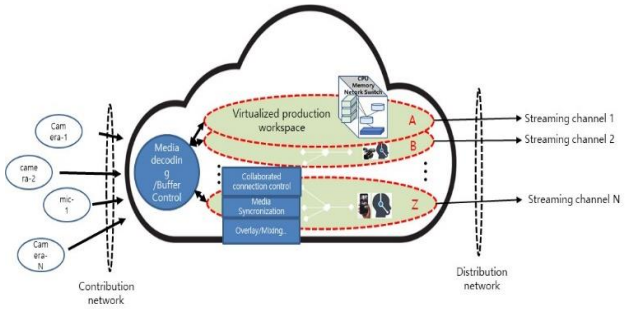

Figure 2. Cloud-based Remote collaborative production workflow

B. Remote multi-view production control in cloud

The proposed cloud platform is designed to seamlessly perform switching control of 6 input videos (more than Full-HD) at frame-level accuracy. For this purpose, all of production in a cloud should be processed in uncompressed audio/video format while A/V data in the ingest stage are decoded and queued in frame buffers separately. Uncompressed videos in frame buffers are aligned with a reference clock, and then they are released from buffers after consuming a needed time for a cloud-based production.

The multiple camera input videos in a production need to be shared to remote participants in real-time. To minimize the transmission delay between a cloud platform and a remote location, PRV/PGM videos are transcoded into one layout screen of multi-view. A multi-view screen is composed of views of a lower video quality (i.e. smaller resolution and frame rates) compared to original videos in the cloud. If a participant in a remote site connects to the cloud-based platform, he/she can check on-going production through a multi-view screen and also immediately order a switching control during watching a multi-view screen. The latency to process real-time switching control is aimed to be achieved within 5 frames at most.

The PGM output by production is packaged for transmitting to OTT platforms and also sent to back channel for monitoring the final production program. Figure 3 shows the functional modules for remote participants with applying proper protocols to each network section in contribution, media access, and distribution network.

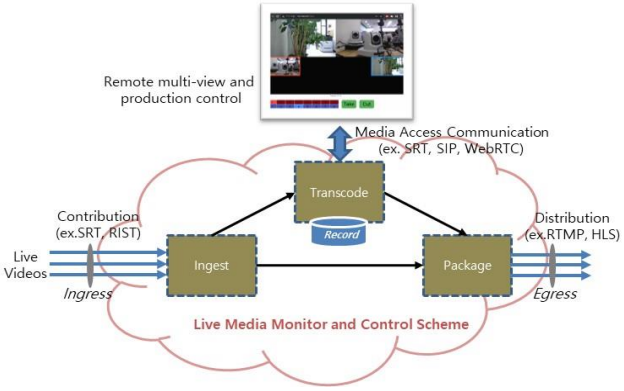

Figure 3. Remote monitoring and control of live media

C. Remote device control and management in cloud

Prior to initiating A/V streams through a low-latency protocol like secure reliable transport (SRT) or (reliable internet stream transport (RIST) [7], the local devices should be registered to the cloud. However, there is currently no standardized scheme to signal control&management between distant devices for remote production. The networked media open specification (NMOS) standard is intended for zero-configuration of devices in local area domain and therefore it cannot be applied to remote domains without modification [8][9]. The cloud-based production control technology extends the NMOS standard to allow broadcast and ProAV to integrate, control, and manage their production equipment by a standardized procedure. In this paper, a MQ telemetry transport

(MQTT)-based scheme is proposed in purpose of NMOS extension to be operated in WAN.

The cloud platform enabled with MQTT Broker (mqtt server) is communicate with IP media gateway (mqtt client) of proxying which forwards the local device's information to the cloud via MQTT protocol. On the other hand, when performing a cloud-based video switching control, the IP media gateway receives a tally signal from the cloud. For the equipment registration in a collaborative production the IP media gateway on startup publishes a mqtt topic "program-id" with the device information of which includes its properties (device_name, node_type, capabilities, status, etc.). And the cloud platform can build a database of remote devices and they are notified to the subscribers that want to utilize a facility related to the topic.

According to the shared topic of "program-id", a participant using cloud-based video switcher can select cameras and initiate video source streaming from the possible devices for a production, and another participant can pan/zoom/tilt a camera remotely.

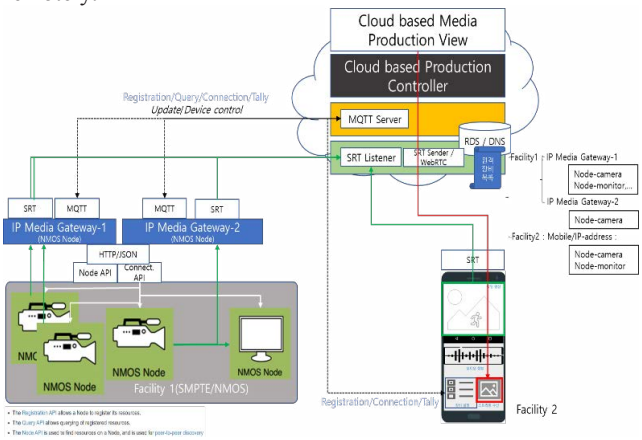

Figure 4. Device control for remote collaborative production

IV. Conclusion

This paper presented the design of a cloud-based collaborative production system for remote participants involving virtualization of the production environment and remote control of equipment. To communicate with distant devices the IP media gateway is also involved in the proposed cloud production system. In near future, the cloud-based production system will be implemented to meet for the switching latency to be achieved within a maximum of 5 frames. With the development of the Internet and OTT technology, broadcast production is no longer the exclusive domain of broadcasters or related companies. This system will enable small-scale producers or individual creators as well as experts to participate in production easily by providing various interfaces and the unified control for equipment compatibility.

Acknowledgment

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