

Remote Productions with Lower Bandwidth Requirements

Introduction

Remote production, also known as REMI (Remote Integration Model), allows production teams to manage events from central control rooms, minimizing the need to transport staff and equipment to venues. The choice of workflow depends on the infrastructure, budget, quality requirements and specifics of the event. Many remote production workflows require significant bandwidth to transmit image signals between the venue and the production site. However, high-performance IP connections, necessary for transmitting many uncompressed signals, are not available at many locations.

Even with sufficient bandwidth, high compression rates can lead to unacceptable signal delays. An alternative approach is to process signals on-site and send only selected high-bandwidth signals to the production center, reducing overall bandwidth requirements.

Various options for decentralized production are presented and analyzed, including their advantages and disadvantages. Innovative solutions such as low-latency codecs and edge computing, which enable more on-site processing and less data transmission, are discussed. Cloud-based solutions for scalable remote production are also explored. Case studies highlight successful low-bandwidth remote productions,

providing insights and best practices for adapting workflows to different scenarios and ensuring high-quality broadcasts despite limited infrastructure.

Retrospect

Remote broadcast productions have been used for many years to increase efficiency or to enable production at the desired location.

An early example is a television studio on the 53rd floor of the Main Tower in Frankfurt's city center, operational since January 2000. This studio, situated 200 meters high and equipped with four digital cameras, was connected via fiber optic cable to a control room in a broadcasting center in the north of the city. From this control room, the entire production was managed for many years.

The Triax signals between the cameras and base stations were converted to signals that could be sent over dark fiber cables. In these setups, each camera required a separate dark fiber cable, with the maximum cable length limited to approximately 40 kilometers due to the technology used. While the specific technology from that era is now outdated, the challenges faced by production teams in decentralized productions remain the same. This early approach was an important first step in the evolution of remote broadcast productions.



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High-bandwidth Remote Production Workflows

DirectIP

Today's technologies allow for much more extensive remote productions over larger distances. For example, during the 2019 World Skiing Championship in Åre, Sweden, 50 television cameras, including 13 operating in Super-slow-motion mode, were used to cover the event [1]. These cameras were remotely connected via a DirectIP connection to their camera base stations at Swedish Television (SVT) approximately 600 km away.

All signal processing devices and the production team were based at SVT's headquarters in Stockholm. The camera signals were transmitted completely uncompressed over two 100 Gb/s IP connections, resulting in minimal delay. This showcases the significant advancements in remote production capabilities, enabling high-quality, real-time broadcast productions over vast distances, even for extremely demanding applications.

NativeIP

In addition to the uncompressed transmission of signals between cameras and their base stations at the event location and the production center, as used with DirectIP,

the required SMPTE ST 2110 video signal streams can also be compressed using methods optimized for live applications, such as JPEG XS, in a NativeIP connection. This compression typically reduces the bandwidth requirement by a factor of 10 without negatively affecting image quality or signal latency.

For instance, JPEG XS compression was utilized in an international sports production in China, where several cameras were connected to a production center in Europe. This allowed for the integration of cameras from two very distant areas of the world into a single production. Due to the extended preparation time for such an international sports event, a redundant IP connection with the required bandwidth could be organized. This would likely be more challenging with a shorter preparation time.

Despite the efficiency of JPEG XS compression, securing the required IP bandwidth for multiple cameras remains a significant challenge and is not always feasible.

Bandwidth-efficient Remote Production Workflows

Since powerful IP connections are often unavailable or prohibitively expensive at many production sites, alternative workflows for remote productions have been developed in recent years. These new options have made it possible for remote productions to become a viable and practical alternative on a larger scale.

Cloud-based Remote Productions

Cloud-based production solutions, combined with SaaS-based production equipment, offer significant increases in flexibility and efficiency. A notable example is the production of LegaPro, the third Italian football league, by the production company NVP [2]. Within a few weeks, NVP established a cloud-based production platform, enabling the production of over 1,100 games within 10 months.

This demonstrates how cloud technology can overcome the limitations of traditional high-performance IP connections, providing scalable and cost-effective remote production solutions.

Since only a few NDI or SRT signal sources need to be transmitted to the cloud for LegaPro productions (Fig. 1), the required IP bandwidths in each football stadium are manageable.

However, if a larger number of signal sources are needed, the bandwidth requirement increases proportionally, potentially leading to higher signal latency. Each additional source requires a specific amount of bandwidth, and if more signals must be transmitted within a limited bandwidth, the compression rate for each signal must be increased. This increased compression rate subsequently results in greater signal delay.

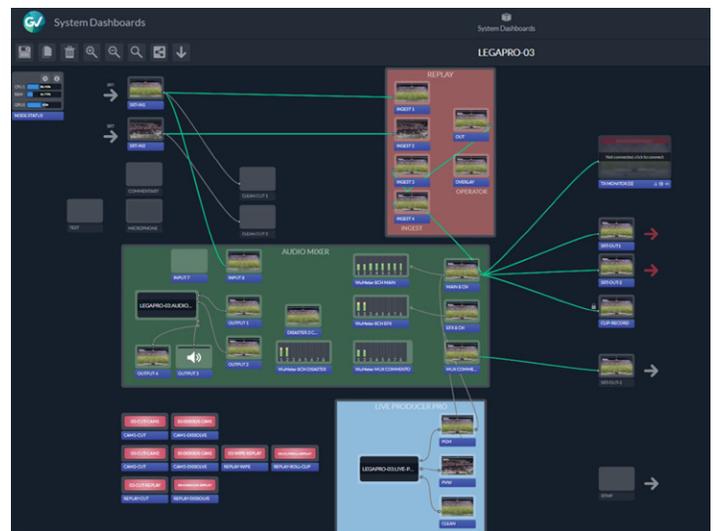


Figure 1 – AMPP system dashboard for LegaPro in Italy.

Remote Productions with On-premises Processing

With a workflow based on SaaS applications processed on-premises using COTS servers, additional SaaS applications can be activated as needed without incurring extra costs for cloud processing. If the existing hardware can handle the additional applications, they can be seamlessly integrated. However, if the hardware's processing capacity is exceeded, additional hardware must be installed, or specific functions may need to be outsourced to the cloud.

This approach enables a customizable balance between on-premises and cloud processing. For regular requirements, maximizing on-premises processing can offer cost advantages, while cloud resources can be leveraged for peak demands. Some installations manage the entire production and playout of several programs entirely with SaaS applications on on-premises processing. Compared to traditional proprietary hardware solutions, this results in significantly lower investment costs and greatly improved flexibility.

However, as with cloud processing, there is still a need to transmit all camera signals from the production locations to the production center. Depending on the number of sources, this can result in a high bandwidth requirement and/or significant signal latency.

Remote Productions with On-venue Processing

Given the limited IP bandwidth at many event locations, a new alternative has emerged. The production of the RallyX series by the Scandinavian company DMC

exemplifies this shift [3]. Previously, this racing series was produced using OB trucks and large production teams across various Northern and Central European locations. Starting this year, a SaaS-based production solution has been implemented, utilizing COTS servers for on-venue signal processing. This approach requires transferring only selected high-quality signals to the production centers in Stockholm and Oslo, where all users, except camera operators, are located (Fig. 2).

Typically, two high-quality image signals are sufficient: one from the main production switcher output and a multiviewer feed with all available sources. On-venue signal processing means the number of input signals does not impact the required IP bandwidth for the connection to the production center(s). This method enables remote productions from locations with limited IP bandwidth while maintaining the possibility to use many signal sources, especially uncompressed, low-latency camera feeds.

This innovative workflow helps minimize production costs and significantly reduces the ecological footprint. However, a slight disadvantage compared to cloud-based processing, or on-premises processing at the production center is the increased need for processing equipment at the event location and a slightly reduced scalability. Despite this, the benefits of reduced bandwidth requirements and environmental impact make this approach a compelling option for modern remote productions.

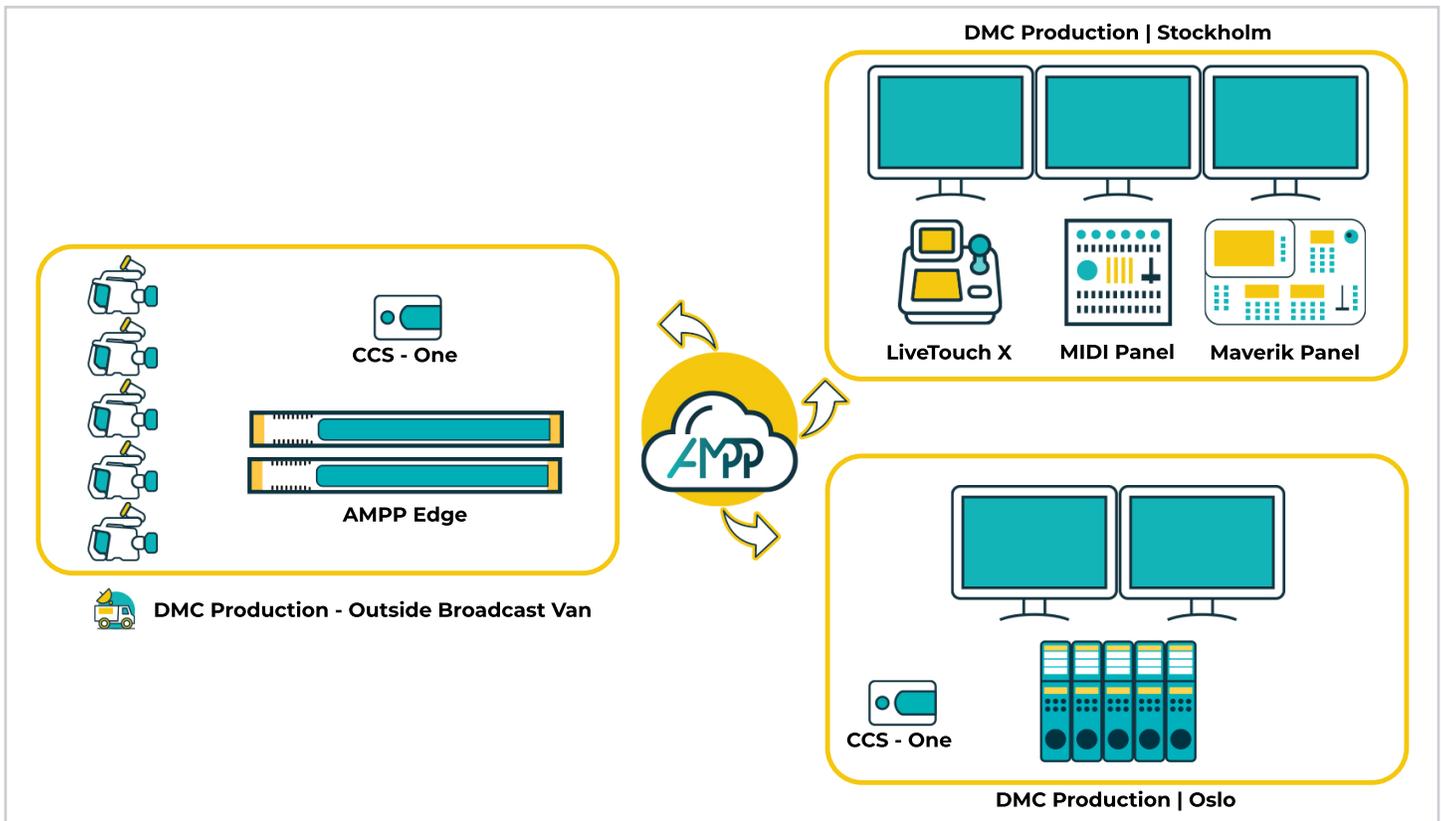


Figure 2 – Overview DMC production workflow of RallyX

Summary

Remote productions have been used for many years, offering significant benefits in cost savings and reducing the environmental footprint. However, achieving widespread use required overcoming various technological hurdles, and advancements in available IP bandwidth have been crucial.

Even today, there is no single solution that meets all conceivable requirements. Different options have emerged to optimize use depending on specific needs. Early applications relied on dark fiber connections to link cameras directly to the infrastructure, while later

implementations utilized IP infrastructures to connect devices. The advent of cloud processing and SaaS-based broadcast products has further enhanced the practicality of remote productions by introducing new possibilities.

Depending on the available bandwidth at the venue, different solutions can achieve the best possible results. Particularly when bandwidth is limited, workflows with signal processing on COTS servers located at the venue can be the most effective solution.

References:

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