Multi-channel streaming for medical and multimedia industry applications

Keywords: 4K video, 3D video, multimedia industry, robotic surgery, remote collaboration, remote teaching

Abstract— **In this paper we describe the technology that we have developed for multi-channel video streaming and our experience with use cases to support remote collaboration in multimedia industry and remote teaching in medicine.**

I. Motivation

High-definition video transfers are one of the expected driver application areas of the future Internet. In some fields, such as scientific visualizations, film post-production or remote learning, we already work with better-than-high-definition-resolutions (such as 4K) or 3D (stereoscopic) video sequences.

Real-time streaming of such video sequences with low latency can enable effective remote collaboration of distributed teams in these areas, thereby increasing productivity. Two of the main technical issues are high-data volume and time synchronization when transferring over an asynchronous network such as the current Internet.

II. Requirements

Based on requirements of applications in the above mentioned areas that we investigated, we have set the following set of technical parameters to be provided by the technology to be developed:

- transmission of multiple streams with post-HD resolution
- operating over Internet infrastructure (routers, switches)
- low latency (for interactive work)
- lightweight, easy to deploy
- extendable by customer firmware upgrades for flexibility

III. Architecture

The proposed architecture and design options have been described in more detail in [1]. In general, the transmission device has two interfaces, the video & audio interface and the network interface, Fig. 1.

On the video & audio side, we use HD-SDI [2], [3] interfaces, which are most commonly used in professional video equipment. Audio can be embedded in non-visible frame sections.

On the network side, we use a 10 Gigabit Ethernet interface. When a dedicated fibre or wavelength without in-line electric components is available, simple electro-optical converters can be used. Such converters are commercially available for HD resolution. When transmitting over longer distances across routers and switches, the transport technology matters. With a synchronous SONET/SDH network, we can map synchronous video streams directly to synchronous payload, using justification bytes to adjust bit rates. However, SONET/SDH networks are currently being gradually replaced in favor of more cost effective Ethernet networks. When streaming synchronous video data over an asynchronous packet network, such as Ethernet, the receiver does not have direct connection to the sender clock rate and cannot derive its clock from the network. We elaborated several solution options in [1]. The main idea behind the solution used in our architecture are tunable transceivers driving the HD-SDI outputs of the receiver devices, which are controlled based on the /systematic error in the rate of incoming video data.

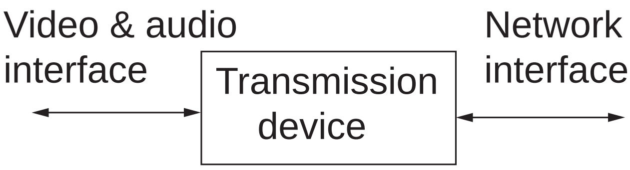

Fig. 1. Device interfaces

The data rate of one HD-SDI channel is 1.485 Gb/s. For 2K resolution without color subsampling, we need two HD-SDI channels. The 4K resolution is then transmitted as four quadrants, each having 2K resolution, thereby requiring eight HD-SDI channels. Uncompressed transmission for minimal latency is then possible over a 10 Gb/s network when some non-visible frame parts are removed.

The data rate to be processed in the device approaches 10 Gb/s, therefore hardware acceleration is generally needed. We use Virtex 5 FPGA board, which takes care of all data processing between HD-SDI interfaces and the physical layer of the 10 Gigabit Ethernet interface in our custom firmware.

IV. Use cases in multimedia industry

At the CineGrid 2009 workshop we demonstrated the use of the described technology for real-time remote color grading of uncompressed 4K video between continents over a distance of more than 6200 miles (10000 km).

The aim of the demonstration was the presentation of remote collaboration during the color grading process, where the grading system and its operator (the colorist) were in Prague, while the Director of Photography (DoP), who instructed the colorist what to do and checked the results, was in San Diego. The current state of the art in the movie industry is to have all persons in the same place. This leads to a non-effective allocation of resources during the post-production phase, where the key people are often highly distributed across continents and spend a lot of non-productive time while traveling.

The demonstration setup is illustrated in Fig. 2. The 4K content was streamed from the Baselight Four at the Cinepost corporation at Barrandov Studios in Prague. This content was transferred using two MVTP-4K devices over the GLIF network from Prague over Chicago to the University of California in San Diego (UCSD), where the CineGrid workshop took place.

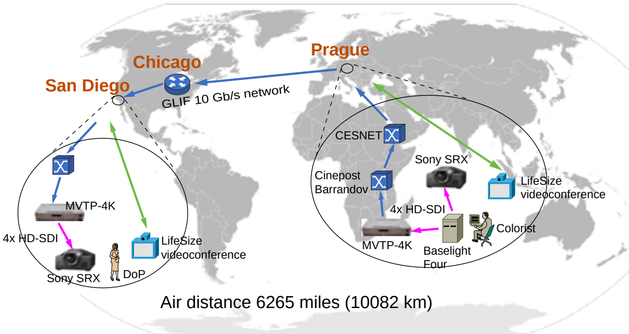

Fig. 2. CineGrid demonstration

V. Use cases in remote learning in medicine

Robotic surgery brings several advantages to modern surgery techniques - precision, smaller incisions, decreased blood loss and consequently quicker healing time.

A stereoscopic camera is used to provide the surgeon with a view of the surgical elements. The signal from this camera can also be used for E-health applications, such as remote medical students training or presentations of surgical procedures on symposia.

We conducted several real-time transfers of 3D HD images from the da Vinci Robotic Surgery system in the Masaryk Hospital in Ústí nad Labem. Particularly, we arranged real-time transmission to the 5th International Congress of Mini-invasive and Robotic Surgery in Brno in October 2010 and to the audience in the KEK research center in Tsukuba, Japan. The 3D HD streaming of the surgeon view was accompanied by a bidirectional HD videoconference for surgeon commentary and audience questions. All operations were lead by M.D. Jan Šraml, head of the Department of Urology. The schematic of the transmission to KEK is shown in Fig. 3. The distance was approx. 17600 km. The data were transferred across the European Geant network utilising the Premium IP service, continuing over the Atlantic to MAN LAN in New York and further to SINET3 network in Japan.

Fig. 3. Streaming robotic surgery from Czech Republic to Japan

VI. Conclusion

We demonstrated on several use cases a practical use of our technology for real-time multi-channel streaming of post-HD resolution video across Internet. Users found the experience realistic and very useful either to increase productivity in remote collaborative work or for distance learning.

Fig. 4. Receiving 3D HD streaming in KEK

References

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Biography

Sven Ubik received his MSc. and Dr. in Computer Science from the Czech Technical University. He is currently with the Research department of CESNET.

Jiří Halák and Petr Žejdl received their MSc. at the Czech Technical University and are working towards their PhD in Computer Science.

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