Use of Photonic Networks in Digital Cinema Postproduction Dailies Workflow

Michal Krsek[1], Paul Hearty[2], Laurin Herr[3], and Jurgen Schulze[4]

[1] CESNET, z.s.p.o., Zikova 4, Praha 6, 160 00, The Czech Republic
michal.krsek@cesnet.cz
[2] Rogers Communications Centre, Ryerson University, Toronto, Canada, M5B 2K3
phearty@ryerson.ca
[3] CineGRID Inc., 5756 Ayala Avenue, Oakland, California 94609, USA
laurin@cinegrid.org
[4] California Institute for Telecommunications and Information Technology
University of California at San Diego, 9500 Gilman Drive, MC 0436
La Jolla, California 92093-0436, USA
jschulze@ucsd.edu

Abstract. We describe a recent proof of concept demonstration of international, grid-based collaboration in Post Production for Digital Cinema. In the demonstration, very high resolution (4,096 x 2,160 Pixels x 24 Frame per second) Digital Cinema content captured in the Czech Republic was rendered using processing resources in the United States. Editing and color correction were carried out in real time by an editor/colorist in Canada under the artistic direction of a cinematographer in the Czech Republic. Final conforming, product assembly, and exhibition were carried out in the Czech Republic. The creative workflow demonstrated was made possible by a 10 GE fiber networking infrastructure and by grid-like resource management.

Keywords: CineGrid, digital cinema, Post Production, high-speed photonic networks, networked collaboration.

1 Introduction

CineGrid is a non-profit membership organization whose mission is to build an interdisciplinary community focused on the research, development and demonstration of networked collaborative tools, enabling the production, use and exchange of very high-quality digital media over high-speed photonic networks.

One such application is the Digital Cinema. With resolutions of up to 4096 pixels horizontally x 2160 vertically at 24 frames per second, and with each pixel requiring up to 16 bits per Red, Green and Blue color channel, Digital Cinema provides not only exceptionally high quality imagery for exhibition, but also exceptional challenges in Production and Post Production. For example, when 4K x 2K image data is captured and output in "raw", rather than in Red-Green-Blue format, the processing resources required to render the data from the sensor in a time-frame that is viable for Production are both substantial and rare. And, finally, the technical and

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creative resources necessary to edit and color-correct digital cinema content are rare and geographically distributed, particularly given the realities of on-location shooting.

CineGrid members believe that the existence of broadband photonic networks and of grid-based tools for the discovery, acquisition, provisioning, and management of creative and processing resources can facilitate Production and Post Production in Digital Cinema. They further believe that the network management, distributed resource management, and other tools adapted or developed to support such applications will be applicable to other high-demand applications, such as scientific visualization and collaboration.

The importance of high-speed networks in enabling the Digital Cinema applications is evident when one considers the basic parameters of the medium.

2 Demonstration Objective and Concept

The underlying objective of the demonstration was to show that Production and Post Production in Digital Cinema can be facilitated by using high-speed photonic networks and by grid-like management of distributed resources. The demonstration was conceived in two parts:

- Capture in a 4K format at one location with rendering at another, in this case Prague and San Diego, respectively;
- Edit and color correct with the editor/colorist at one location and the cinematographer at another, in this case Toronto and Prague respectively.

3 Approach, Strategy and Basic Technology

For the first part of the demonstration, we captured 4K x 2K digital cinema imagery in Prague using a Dalsa Origin 16 camera and used processing-cluster resources at the California Institute of Telecommunications and Information Technology (Calit2) at the University of California San Diego to render the raw Bayer images[1] to RGB. The

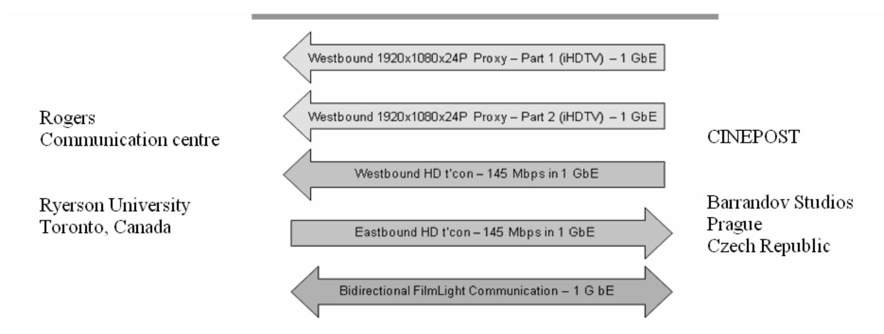

Fig. 1. Link and signal structure used for editing/color-correction demonstration

[1] In the Bayer format used, the image is captured against a target 4096 x 2160 x 24 sampling structure, but the approximately 8.8 megapixel spatial sampling lattice is divided into 4-pixel blocks in which Green is sampled at twice the frequency of Red and Blue.

key factor was to allow transfer of the “raw” 4K x 2K data from Prague to San Diego and of the rendered RGB data back to Prague within a viable time window for full-scale Production and Post Production.

For the second part of the demonstration, we established a near-real-time workflow between the cinematographer in Prague and an editor/colorist in Toronto. The key factor at this stage was to establish a transcontinental interconnect that would support the delivery of workable image data from Prague to Toronto, a two-way telepresence between the cinematographer and the colorist, and bi-directional transfer of control data between the colorist’s control surface in Toronto and the cinematographer’s base processing system in Prague. The link and signal structure were as shown in Figure 1.

3.1 Network Connections

The demonstration described here was presented at the 2007 meeting of the Global Lambda Integrated Facility[2] in Prague. The network connections were established *ad hoc* and were as shown in Figure 2.

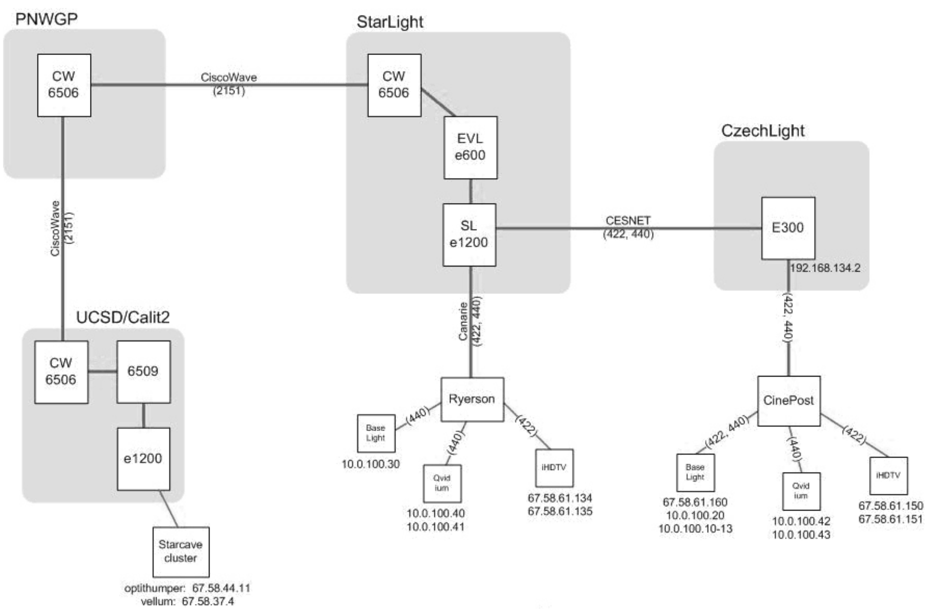

Fig. 2. Diagram of the Network used for the demonstration

4 Challenges and Results

Several challenges had to be solved while preparing this demonstration.

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[2] GLIF is an international virtual organization that promotes standards for fiber optic (lambda) networking, involving dedicated, high-capacity circuits based on optical wavelengths, which terminate at exchange points known as GOLEs (GLIF Open Lightpath Exchanges).

First, tuning up all the network equipment as well as processing nodes to work with very long high-speed circuits was necessary (e.g. jumbo frames had to be set on all the routers and switches and tune-up TCP window size on processing nodes to get maximum throughput).

Second, we needed to render (de-Bayer) raw image data using parallel processing. Processing of one second of image data took about 23 seconds on one machine, so parallel processors were used to get nearly real-time performance. Time distribution of the de-Bayering is shown in Table 1.

Table 1. Time Distribution of de-Bayering from Prague at San Diego cluster

Step	Duration per one second of footage
Transfer Prague -> San Diego	4.4 seconds
Processing on cluster	9.6 seconds
Transfer San Diego -> Prague	9.1 seconds

The processing devices used for this demonstration were Linux based personal computers or servers that had well defined interfaces HD-SDI (SMPTE 292M) and 1000Base-T (IEEE 802.3ab). We tweaked those interfaces for best performance.

Third, it was necessary to set up and maintain telepresence between Toronto and Prague. This two-way connection had to support the exchange of HDTV video as we as audio, with minimum latency and jitter.

And, finally, we needed to tweak console/cluster communication for the color correction system used, a Baselight FOUR[3]. In its design configuration, this system is intended to support of separations of up to 50 meters between the control surface and the base cluster. In our case, we had a separation of approximately 7,500 km, resulting in lengthier communication delays.

5 Conclusions

We demonstrated the feasibility of using of high-speed photonic networks for real-time Post Production of Digital Cinema source material.

Both the colorist in Toronto and the cinematographer in Prague provided positive feedback – insertion of the long-distance photonic network between them had no effect on the collaborative creative activity. The high speed, low latency and zero jitter on the network, combined with the high resolution telepresence, allowed collaboration as if in the same room.

[3] BaseLight FOUR is a cluster-based color correction device developed by UK based vendor FilmLight.