HYDRA - High Resolution Live Streaming

1. Research Team

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Industrial Partner(s):	New World Symphony, Intel, Hewlett-Packard

2. Statement of Project Goals

Presently, digital continuous media (CM) are well established as an integral part of many applications. With High Definition (HD) displays becoming increasingly common and large network bandwidth available, high quality video streaming has become feasible and novel, innovative applications possible. However, the majority of the existing systems for HD quality streaming are based on offline content, and use elaborate buffering techniques that introduce long latencies. Therefore, these solutions are ill-equipped for interactive real-time applications. Also, due to the massive amount of data required for the transmission of such streams, simultaneously achieving low latency and keeping the bandwidth low are contradictory requirements. This project focuses on the design of a system that enables HD quality video and multiple channels of audio to be streamed across an IP based network with commodity equipment. This has been made possible due to the technological advancements in capturing and encoding of HD streams. Our goal was to produce an architecture that integrates live streaming along with multi-stream recording by adapting and extending proven algorithms where applicable, and introducing new concepts where necessary. The project raises practical issues such as loss recovery, buffer management, playback latency optimization and multiple stream synchronization. The recording and playback challenges and design of the HYDRA architecture are described in a second report entitled "*HYDRA - High Speed Immersive Media Stream Recorder*", which can also be found in this Volume II.

3. Project Role in Support of IMSC Strategic Plan

The vision of the Integrated Media Systems Center is the development of immersipresence as the next great breakthrough in our digital era, moving people from the current two-dimensional world of computers, television and film to three-dimensional immersive environments with visual, aural and haptic capabilities [1]. One of its current instantiations is the Distributed Immersive Performance (DIP) [10] effort. It requires live streaming of video at a very low latency. For the system to be widely adopted, high definition quality video and multi channel audio is necessary. We are pursuing the design and implementation of such a streaming system [6.7.10].

4. Discussion of Methodology Used

Figure 1 illustrates the architecture of HYDRA high definition live streaming system. High definition cameras capture the video that is sent over an IP network to the receiver. Audio can be transmitted either by connecting microphones to the camera and multiplexed with the same stream as the video, or transmitted as a separate stream. The transmission subsystem uses the Real-time Transport Protocol (RTP) on top of the Universal Datagram Protocol (UDP). The streams are decoded at the receiver side to render the video. In addition, a feedback based synchronization mechanism is being developed.

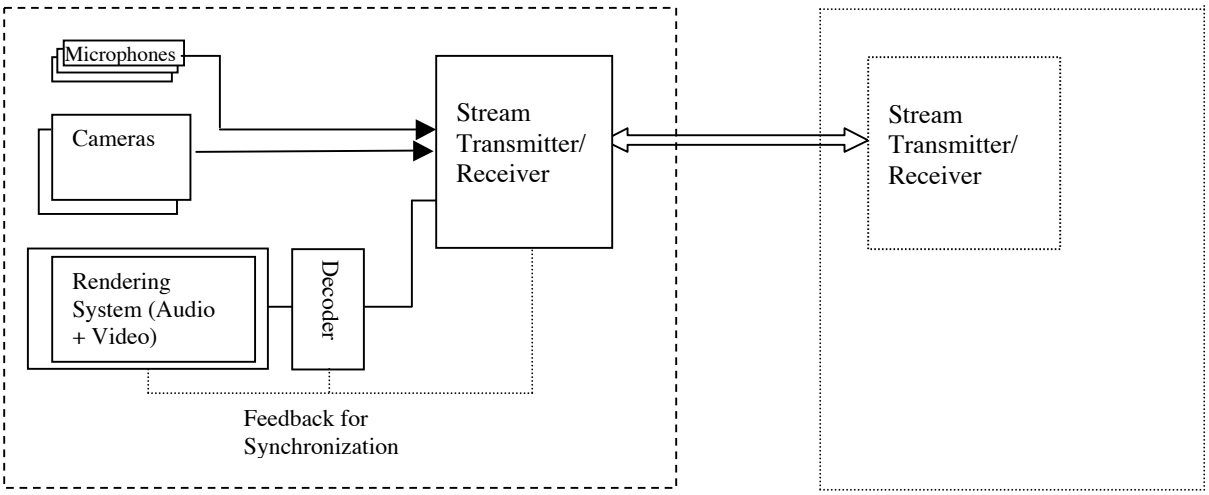

Figure 1: Data Stream Recorder Architecture. Multiple cameras/microphones are connected to the stream generator, which is connected to the other node via an IP infrastructure. Streams received are synchronized using a feedback based mechanism in the decoder.

Our current implementation of this system includes a camera interface that acquires digital video from a JVC JY-HD10U camera via FireWire (IEEE 1394) in HDV format (1280x720 pixels at 30 frames per second). The resulting MPEG transport stream is packetized and transmitted at approximately 20 Mb/s over traditional IP networks such as the Internet with the RTP protocol. At the client side, the received data stream is displayed with a software or hardware decoder on Linux. The software decoder is based on the open source library *libmpeg2*, a highly optimized rendering code that provides hardware-assisted MPEG decoding on current generation graphics cards. When improved quality and picture stability are of paramount importance we use the CineCast HD decoding board from Vela Research.

The system uses a single retransmission algorithm [4.8] to recover lost packets. Buffering in the system is kept to a minimum to maintain a low latency. The system is being designed such that it can be extended to support multiple simultaneous video streams along with multi-channel audio (i.e., immersive 10.2 channel audio). The issues related to synchronization of such streams are currently being studied. This system also integrates with the HYDRA recording system, which focuses on recording of events that produce a multitude of high bandwidth streams. Various

hardware and software options for decoding of streams are considered to achieve the best quality video with minimal latency.

5. Short Description of Achievements in Previous Years

This project was started recently in Spring 2003. The accomplishments in previous year up to date are presented in Section 5a.

5a. Detail of Accomplishments During the Past Year

During the last year we have concentrated on the design and initial prototype implementation and evaluation of the streaming system. Some of the highlights of the past year were as follows:

- We have implemented a prototype for HYDRA high definition live video streaming system. On November 20, 2003, we demonstrated this system during IMSC's semi-annual Board of Councilors/Scientific Advisory Board meeting.
- On Thursday January 29, 2004, we used the HYDRA system to demonstrate a two-way videoconferencing setup between USC and the University of Hawaii (approx. 5,000 km). During the 10-minute linkup, two of Prof. Zimmermann's students in IMSC's data management research laboratory — Dwipal Desai and Moses Pawar — explained the technical details of the system to researchers attending a meeting of the Asia-Pacific Advanced Network (APAN) Consortium in Honolulu. Up-to-date information can be found on our home page at http://dmrl.usc.edu/hydra.html. Figure 2 shows two pictures of the event. (Note that these are screenshots taken from an HD video, not still photographs).

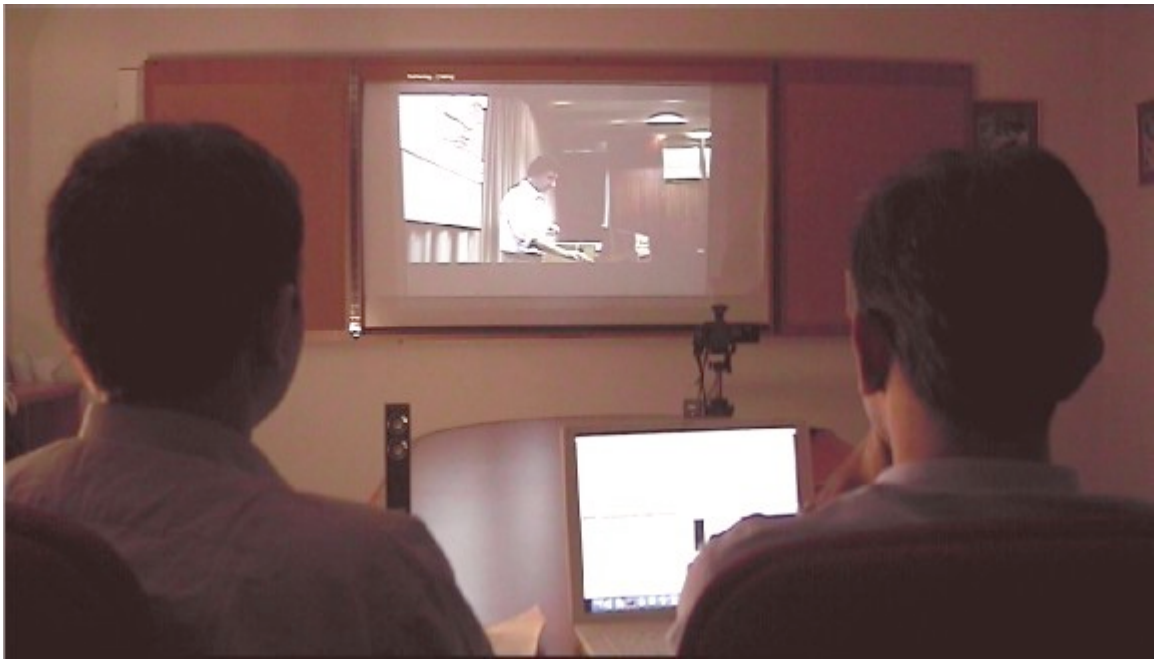

Figure 2: Two IMSC students, Dwipal Desai and Moses Pawar, are watching a live, high definition video stream at USC transmitted from the APAN meeting in Honolulu. They later interacted with the audience in Hawaii through this bi-directional setup.

6. Other Relevant Work Being Conducted and How this Project is Different

The goal of this project is to achieve high quality streaming with minimal latency such that it can be used for interactive applications. There are commercial systems available to stream media content, however, they are either more focused on low resolution or content that is stored offline. Such systems use very large buffers and other mechanisms to reduce the bandwidth requirement that increase the latency and are unsuitable for interactive applications. Microsoft's Windows Media, Apple's Quicktime and RealNetwork's RealOne are examples of such systems. Cable companies currently broadcast high definition videos. However, they have a very limited support for extensions that Internet based streaming can achieve, such as interactivity and high quality multi-channel audio. Our streaming system is specifically designed to integrate with the large-scale HYDRA recording architecture. Hence, the combination of low latency and high quality media streaming offered by HYDRA is not currently available in any other existing systems.

7. Plan for the Next Year

One of the applications that we are exploring for this technology is IMSC's vision scenario of a Distributed Immersive Performance (DIP) where musicians and audiences are geographically disbursed in different locations [10]. In such an advanced many-to-many immersive scenario, musicians located at physically different sites must coordinate their activities. As part of this effort we are studying various synchronization methods to align a separate 10.2 channel audio stream with the video stream. In collaboration with the New World Symphony (Miami Beach, FL) we intend to perform a number of experiments to demonstrate our advanced live streaming and recording technology.

8. Expected Milestones and Deliverables

Next year we plan to continue our work on the high definition live streaming system such that it can support the requirements of the Distributed Immersive Performance project.
Specifically, the following key issues will be addressed:

- **Capabilities extension**. We will continue to investigate additional research issues that are not currently addressed in our initial design. Among them are a more robust transmission protocol, multi-channel audio and support for multiple simultaneous live video streams, reducing the decoder latency and integration with the HYDRA recording system.
- **Performance evaluation**. Together with several other IMSC investigators we will pursue a number of experiments to evaluate our live streaming system. Cross-continental streaming trials together with the New World Symphony will be among the tests.

9. Member Company Benefits

The high-speed immersive media stream recorder prototype is being built partially with equipment donated by Intel. Our streaming experiments also involve the New World Symphony located in Miami Beach, FL. We are pursuing two-way experiments for educational and entertainment purposes that will broaden the appeal of Internet streaming and make new content available in areas that were previously underserved.

10. References

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