Multi-Party HD Conferencing System for Wired and Wireless Networks*

Beomjoo Seo
Computer Science Department
University of Southern California
Los Angeles, CA 90089
bseo@usc.edu

Roger Zimmermann
School of Computing
National University of Singapore
Singapore 117590
rogerz@comp.nus.edu.sg

Abstract

With High Definition (HD) consumer cameras and displays increasingly affordable and large network bandwidth available, high quality video streaming has become feasible and novel, innovative applications possible. Here we present our work on the HYDRA project (High-performance Data Recording Architecture) which aims to create an overall architecture for the acquisition, transmission, storage and rendering of high resolution media such as HD quality video and audio. Our demonstration showcases HYDRA's live streaming capabilities that enables media streaming across both wired and wireless IP based network with commodity equipment.

1. Introduction

Some novel and innovative applications can benefit from high quality video conferencing. Here we present the live streaming component of our High-performance Data Recording Architecture (HYDRA) [3] project. HYDRA has been motivated by and used in a number of different projects. Our research activities in the *Pratt & Whitney, UTC Institute for Collaborative Engineering* (PWICE) at the University of Southern California have focused on accelerating the workflow for aircraft engine maintenance. In this scenario multiple parties are involved (the local airport, the airline's technical engineering office, and the engine manufacturer's help-desk) to quickly diagnose and resolve engine related issues. Real-time communication with high-quality and portable video transmissions of affected components can speed up the process to return an aircraft to service. The HYDRA live streaming services are part of a larger project scope that aims to provide complete management of video resources (capture, recording, transmission, storage, querying, and playback) [2].

*This research has been funded in part by NSF grants EEC-9529152 (IMSC ERC), CMS-0219463 (ITR), IIS-0534761, NUS AcRF grant WBS R-252-050-280-101/133 and equipment gifts from the Intel Corp., Hewlett-Packard, Sun Microsystems and Raptor Networks Technology. We further acknowledge the support of the NUS Interactive and Digital Media Institute (IDMI) and the National Research Foundation.

2. Related Work

There are only a few systems available that focus on high-quality video conferencing (i.e., with a visual quality beyond standard definition (SD)). Commercially, three systems are available. The *Halo* system from Hewlett-Packard[1] features complete room installations with fully assembled hardware communicating over a private, dedicated network. While the cameras used in Halo are SD, the video streams are up-converted to HD at the display side. Each stream requires about 6 Mb/s and each room generally supports four streams. The Halo system is turn-key and fully proprietary. The *TelePresence* system from Cisco[2] is similar in concept to the Halo system, but features 1080p HD video. A twelve-person and a four-person version are available. For stream transport Cisco's own Service-Oriented Network Architecture is used. The systems from *Lifesize*[3] feature 720p cameras and displays. A proprietary compressor provides very low bandwidth (e.g., 1 Mb/s). While the camera and compressor are proprietary, the display is generic.

A number of research prototypes exist. Well known among them is the UltraGrid system which transmits uncompressed HD at a bandwidth requirement close to or above 1 Gb/s [1]. A number of other prototypes exist, some of which exceed HD quality (for example the Super HD work of the iGrid project). The main differentiator of our system is that it is based on off-the-shelf hardware (e.g., cameras, computers, displays), transmits media streams at a selectable rate between 8 to 25 Mb/s and uses a very modular software architecture hosted on either Windows or Linux (only an earlier version of HYDRA). Its UDP based streaming protocol has been demonstrated across both wired and wireless IP links (e.g., 802.11a/g).

[1] http://www.hp.com/halo/index.html
[2] http://www.cisco.com
[3] http://www.lifesize.com

3. System Overview

Work on the HYDRA live streaming system was initiated with the goal of designing a high-definition capable Internet live, interactive conferencing system. The initial version was developed on the Linux platform and was functional in a two-way, point-to-point scenario. As part of the PWICE project the functionality of the software has been significantly extended and a port to the Windows platform has been undertaken. The current prototype is a multi-point conferencing system that is scalable in video resolution and number of participants. The system comprises of the following components and features.

Figure 1. HD transmission over a wireless, ad-hoc link (802.11a) between two laptops in the laboratory.

Figure 2. HD multi-party conference with two wired (top left and bottom) and one wireless HD transmission (from an aircraft hangar).

Acquisition MPEG-2 compressed HDV camera streams are acquired via a FireWire interface. The acquisition code is encapsulated in a DirectShow filter module. Any camera that conforms to the HDV standard (http://www.hdv-info.org) can be used as a video input device for HYDRA. We have tested multiple models from JVC and Sony. As a benefit, cameras can easily be upgraded whenever better models become available. HDV camera streams are acquired at a data rate of 20 to 25 Mb/s. Recent cameras use the H.264 codec (under the AVCHD name – see http://www.avchd-info.org) to achieve higher compression. However, unfortunately most of the AVCHD branded cameras do not include a FireWire interface. In addition they also do not support live high-quality HD streaming via USB.

Compressed domain transcoding This functionality is achieved via a commercial DirectShow filter module. It allows for an optional and custom reduction of the bandwidth for each acquired stream. This is especially useful when streaming across a wireless link. The minimal bandwidth for HD streams is about 8 Mb/s.

Multi-point communication The system allows the setup of many-to-many scenarios via a convenient configuration file. A graphical user interface is available to more easily define and manipulate the configuration file. Because the software is modular it can naturally take advantage of multiple processors and multiple cores. Furthermore, the software runs on standard Windows PCs and can therefore take advantage of the latest (and fastest) computers.

Rendering MPEG-2 decoding is performed via a DirectShow module that takes advantage of motion compensation and iDCT hardware acceleration operation in modern graphics cards. The number of streams that can be rendered concurrently is only limited by the CPU processing power (and in practice by the size of the screens attached to the computer). We have demonstrated 3-way HD communication on a dual-core machine. We expect the system to scale almost linearly to more processors and cores.

4. Conclusions

This demonstration presents a low-cost and high-quality HD conferencing system that utilizes commodity hardware combined with modular software. Real-time, compressed domain transcoding makes it suitable for different networks, in particular 802.11a/g wireless links.

References

[1] L. Gharai, T. Lehman, A. Saurin, and C. Perkins. Experiences with High Definition Interactive Video Conferencing. In *IEEE International Conference on Multimedia & Expo (ICME)*, Toronto, Canada, July 2006.

[2] R. Zimmermann, K. Fu, and W.-S. Ku. Design of a Large Scale Data Stream Recorder. In *5th International Conference on Enterprise Information Systems (ICEIS 2003)*, Angers, France, April 23-26, 2003.

[3] R. Zimmermann, M. Pawar, D. A. Desai, M. Qin, , and H. Zhu. High Resolution Live Streaming with the HYDRA Architecture. *ACM Computers in Entertainment*, 2(4), Oct/Dec 2004.