

An Experimental Architecture of IP-based Network Control of Laser Show Projection Systems

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Abstract — This demo proposal presents continued work of the Laser & Light Lab at the Institute of Computer Science 4 based on an earlier IEEE LCN demo presentation. An architecture and IP-based network control protocol for transmission of laser projection picture frames and remote configuration of important laser projection parameters has been developed. The demo presents the operation in two example scenarios: Firstly, the classical PONG game [3], where the game video graphics are displayed by laser projection. Secondly, laser projected playback of a sequence of laser graphics available in the standardized ILDA Image Data Transfer Format [2]. The demo also outlines the relation of our architecture to proprietary network based solutions and to ongoing laser industry standardization steps towards network controlled laser projection.

Keywords – IP-based network control; laser projection; Local area networks; Multimedia & real-time communication

I. INTRODUCTION & MOTIVATION

Some relevant basic information on laser show systems and their relation to the topic area of computer networks have been given in the IEEE LCN 2009 demo paper of the same author, see [1]. Laser show systems can be considered to be among the most visible applications of lasers and probably the most entertaining ones (cf. [4], [5]). A laser projector emits a laser beam of single color (typically red = R, green = G or blue = B) or a mixed-color beam, where several laser modules emit laser beams of different colors, which are mixed by dichroitic mirrors to a single beam (mixed RGB theoretically allowing the full color spectrum). The single beam will be redirected in X- and Y-orientation by two moving mirrors which are mounted to a galvanometer each (so called “laser scanners”).

The movement of the scanners will be controlled by a hardware driver, typically connected to a laser control interface device, which in turn is connected to a computer (e.g. by USB interface or TCP/UDP/IP based network). The software on the computer controls the X-Y-movement of the laser beam forming a picture projection, as well as the timing of a sequence of “laser picture frames” and as such the sequence of a whole laser show.

Two kinds of laser shows can be distinguished: With a graphic show, the laser beam forming a picture is directed onto a projection screen (or wall). The goal of this kind of show is to present some kind of “content”, e.g. a comic strip, text or logo

display or any other kind of (animated) graphic projection. Figure 1 shows the laser projection of the PONG game (to be further discussed in section 2).

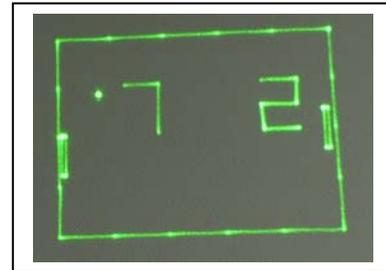


Figure 1. Example of a laser graphic projection – PONG game (picture taken by University of Bonn)

The second type of laser show is a so called beam show. Here, the beam is emitted from the laser projector in the direction of the spectators with artificial fog used to visualize the laser beams in the air. See [1] or [5] for further details.

The International Laser Display Association (ILDA, [2]) has defined several relevant standards for the set-up and operation of a laser show system. The ILDA Image Data Transfer Format defines the way on how to save and transfer laser images and sequences of laser images (useful for laser show software). Furthermore, the ILDA Standard Projector (ISP) defines some hardware configuration, among others the ISP-DB25, a DB25 connector and signal specification for the cable connection between an ILDA-compatible laser projector and a laser control interface (which is connected to a computer). The ISP-DB25 contains the X- and Y-signals used by the laser scanners to generate a laser picture by (mechanical) redirection of the laser beam (further information is also summarized in [1]).

The development of a network-based laser projector interface already started a few years ago, commercial products on this became available in recent years (e.g. the so called NetLase interface, manufactured by [8] for own integration into a laser projector system; the “Infinity ShowLaser” projector manufactured by [7], or the Pangolin QM2000.NET [9] – among others). The advantage of a laser system set-up with network-based control is the digital transmission of the relevant information. The physical network technology might be

Ethernet or Wireless LAN, the Internet Protocol family with IP and TCP or UDP most probably is used as protocol suite for OSI layers 3 and 4.

The Laser & Light Lab [6] of the Institute of Computer Science 4 at the University of Bonn has been set up to support teaching activities of undergraduate lectures of practical computer science. It builds on basic lectures in the area of low-level and machine-oriented computer science, including a one-semester lecture on computer system and network programming with a high degree of practical work.

In the past, student work concentrated on the internals of laser show software (e.g. internal representation of graphical data of laser show frames) and interaction to directly connected laser control interfaces (e.g. via parallel port interface/enhanced parallel port EPP or Universal Serial Bus USB). Recently, the working focus moved to networked environments, as already presented with the IEEE LCN 2009 demo [1].

II. SCOPE AND SIGNIFICANCE OF THE DEMO

The demo for IEEE LCN 2011 presents our experimental architecture of IP-based network control of laser projection systems over a local area network.

Figure 2 shows the functional blocks of the server side of our architecture. The main component is the so called „lapromo“ (Laser Projection Module). This module is written in C++ programming language and receives laser frame data over the network. It opens a listening TCP port with the (internally) well-known port number 6667 and is ready to accept TCP connections for exchange of laser picture frame data from a client connecting to „lapromo“.

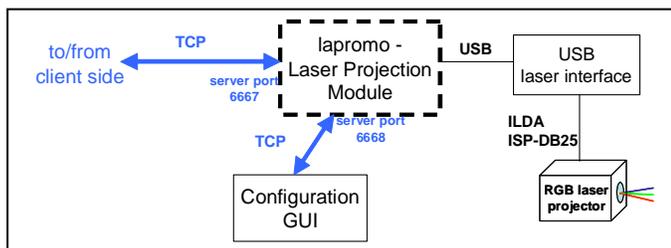


Figure 2. Server side of network architecture for laser projection

In our laboratory setup, „lapromo“ is running on a Linux based PC, an RGB laser projector is connected to the PC via a USB laser interface (so called EasyLase USB, cf. [8]). In future implementations, „lapromo“ could be integrated directly into a laser projector as an embedded system.

Currently, the protocol for exchange of laser picture frame data is quite simplistic: the client/sending side firstly opens the TCP connection to „lapromo“. After connection setup, a sequence of laser frames maybe sent on a frame by frame basis. A data record for each frame consists of the number of points to be projected in the frame, followed by the sequence of records for each point: X and Y coordinate and color values of R, G, B. Each point record has constant size. After receiving a full laser picture frame, „lapromo“ will activate the display of

the laser frame on the laser projector. Future options for change/enhancements of the protocol for data exchange might be compression of the sequence of point data records, encryption of the data stream, or changing from frame by frame basis to a finer granularity for laser projection.

Beside the data connection for laser picture frames (port 6667), „lapromo“ is ready for incoming TCP connection setup on port 6668. Via this connection, important configuration parameters for laser projection might be changed, such as size and offset of the projection (X and Y independently), orientation of projection, RGB color management – among others. A configuration module with graphical user interface (GUI) for interaction with „lapromo“ has been implemented for our demonstration setup in Java programming language. Figure 3 shows a screenshot of the GUI.

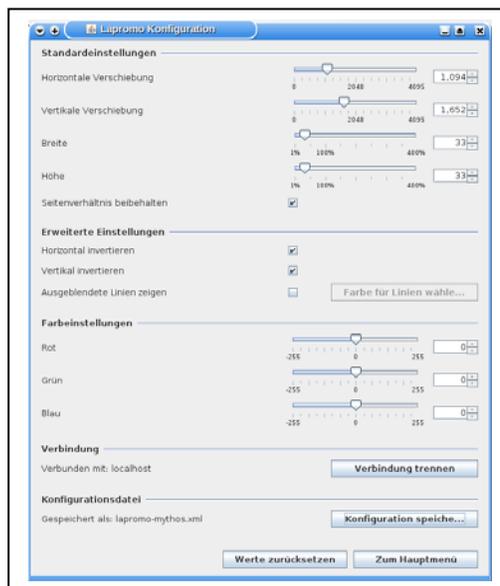


Figure 3. Server side: screenshot of „lapromo“ configuration GUI

Figure 4 shows the client side for our first demo example scenario: The main component is the game logic for the PONG game, which is fully implemented in the Java programming language. It implements a model of the PONG game (cf. [10]) and sends the calculated laser picture frame data via a TCP connection to the „lapromo“ module (port 6667). The dynamic parts in the graphics display are the positions of the ball, the left and right paddle, and the current game score displayed in a single digit 0...9 for each player (cf. Figure 1).

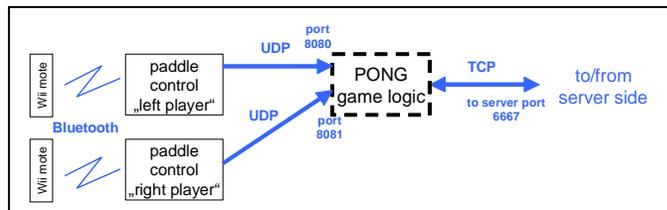


Figure 4. Client side: example 1 – PONG game

The PONG client itself has an internal architecture of several networked components. The players of the game operate the paddle via a Nintendo Wii remote control (Wii mote), which is each connected to a paddle control module via a wireless Bluetooth connection. The paddle control module (as a rapid prototype component) currently is written in Python programming language, using a Python library for interaction with the Wii mote. The paddle control module sends the position of the paddle via the network to the PONG game logic using the UDP protocol, sending to UDP port 8080 (left player) or port 8081 (right player). The modules of the PONG client maybe executed over the network themselves, or may operate within the same host using loopback communication.



Figure 5. Client side: example 2 – screenshot of ILDA-Frame-Player

Our second demo example scenario presents a generic playback functionality of a sequence of laser graphics available in the standardized ILDA Image Data Transfer Format [2]. A client module (ILDA Frame Viewer/Player) is implemented to read an ILDA sequence from a file and send the sequence of laser picture frames frame-by-frame to the „lapromo“ module (port 6667). In addition, the ILDA Frame Player implements a preview functionality of the laser pictures. The module is written in C++ programming language using the Qt4 library for the GUI. Figure 5 shows a screen shot of the GUI of the ILDA Frame Viewer/Player.

To summarize, our experimental architecture presents main building blocks for network based control of laser projection systems in local area networks (Ethernet, WLAN, ...) based on the IP protocol family. The server side projection module allows for remote configuration and uses a (currently) quite simplistic protocol for exchange of laser picture frame data. Two example client side applications are available to demonstrate the networked operation.

Recently (in the last quarter of 2010), the ILDA has taken discussion on network-based laser projection into a technical committee. Long-term goal might be to develop another open ILDA standard for digital transmission of laser projection data over the (probably IP-based) network to allow different types of laser show software and different types of laser projection systems to interact. Our experimental architecture might be extended to consider aspects of ILDA standardization and/or to form an experimental platform e.g. for performance analysis or proof of concept implementation.

III. CONCLUSION

The IEEE LCN 2011 demo presents some practical work carried out in the Laser & Light Lab of the Institute of Computer Science 4 at University of Bonn. The network-based control of a laser projection system is an up-to date topic in the application sector of laser show systems. In relation to the research topics covered at LCN in general, it is an interesting application of real-time communication in a local area network.

The work on network-based laser control has started in our lab right from the scratch, using a simplistic protocol for data exchange on top of a (reliable) TCP connection. The experimental architecture might easily be extended to study several additional challenging issues, e.g. using unreliable UDP, introducing compression or encryption, using real-time protocols like RTP. Furthermore, future work on the experimental architecture may run together with upcoming ILDA work on standardization of a digital networking connection for laser projectors.

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