Managing User Interface Complexity and Usability in Computer-Supported Film Sets

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Abstract

In this paper we discuss the usability requirements and practical design solutions for an advanced real-world computer-supported film set (CSFS). A CSFS provides highly-interactive production support for many roles (e.g. director, director of photography) on the film set during the shooting of commercials and feature films. Recently the performance and functionality of such systems could dramatically be improved over earlier CSFSs by introducing real-time asynchronous software architectures that control a network of cameras, hard disk video recorders, and I/O devices. To keep the user interface complexity for such distributed systems under control, novel UI design and usability solutions had to be found. A contextual design approach was applied to combine advanced software engineering techniques with user-centered design practices and to produce highly usable software and hardware for the resulting target systems.

1 Introduction

With an eye to attracting ever larger audiences Hollywood customarily puts huge *post-production* efforts into creating spectacular visuals and animations for feature films (Macedonia, 2002). The *production*-related IT-aspects of movies and commercials on the film set, however, are only now beginning to find the interest of the HCI-community and computer scientists. One reason for this new interest in IT solutions for the film set is the wish to lower the enormous production costs. Another reason is the migration from pure optical and electronic filming equipment to digital and software controlled systems for the film industry.

This paper studies some novel HCI-related aspects of a real-world project effort (Märtin & Prell, 2003) that has used a contextual design approach (Beyer & Holtzblatt, 1999) and an iterative project life-cycle in order to develop a highly-usable software/hardware environment, called the *CSFS (computer-supported film set)*. The project has successfully lead up to a set of commercially available soft- and hardware products (Vantage Film, 2004).

1.1 Computer-Supported Film Set

In the last couple of years digital video-assist systems have entered the production process of high-budget feature films and commercials in order to support the tasks of directors, directors of photography and camera operators directly on the set. Hard disk video recorders store the video-assist signal received from the finder of conventional electronic film cameras (e.g from ARRI, Panavision) and thus allow for easy playback of takes and better administration of the recorded takes, long before the developed celluloid film becomes available.

A computer-supported film set (CSFS) combines these video recording features with intelligent software functionality for on-the-set effects simulation (slow-motion, time-lapse, ramping, filtering, mix-and-overlay of takes, blue-, green-screen effects, editing etc.), shooting day organization, rehearsal support, and hard- and software-support for active camera control and communication. A CSFS significantly lowers production costs and at the same time raises the working quality of the people on the film set. With the arrival of really usable high-resolution digital film cameras, in a couple of years, future CSFSs with parallel media processing capabilities could also serve as multi-terabyte storage environments for the shot master takes. Early examples of such digital cinematography cameras (DALSA, 2003; Khanh & Koppertz, 2003; Panavision, 2004) show that the recorded material of only a few minutes is already too large to be stored directly with the camera, even when only HDTV resolution is used.

A CSFS can be organized as a network of computer and film equipment devices (fig. 1) which are controlled by a high-performance film server component, e.g. the Vantage Film PSU® (pre-screen unit, based on high-performance computer hardware and CSFS server software). Other devices are configured as *passive I/O devices* (e.g TV-out monitors) or as *active clients* (Vantage Director´s Pads® based on tablet PC hardware and CSFS client software) that interchange video data with the film server via (wireless) LAN, and can independently support the tasks needed on the film set.

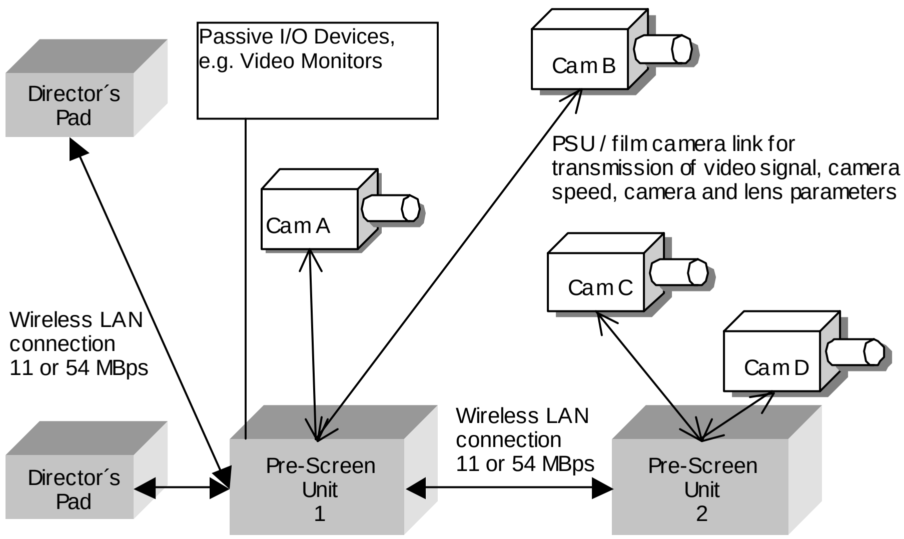

Fig. 1: Distributed CSFS environment

1.2 HCI Challenges

Apart from the enormous hardware performance needed for such complex functionality, the usability requirements constitute a grand challenge for the involved software engineers, user interface and interaction designers. A typical characteristic of movie people, e.g. directors, DoPs, or camera operators is their dislike of mouse and keyboard interaction or applications with the look-and-feel of desktop-oriented business applications. Film equipment that looks like a computer would not be tolerated on the set. Rather a user interface similar to the user interfaces of consumer electronics devices might be accepted (Petersen, Madsen & Kjaer, 2002).

However, there is much more to a CSFS user interface than making it look similar to a DVD player interface. For instance, the administration of the recorded takes and edited sequences (storing video data with or without sync-sound, searching, editing single takes, combining/editing multiple takes, deleting video data) requires efficient and usable ways to easily and quickly find the needed takes or sequences. The organization of the overall film project that could last up to several months, e.g. when a major feature film is shot, should not require a database-like storage and query interface, but rather allow the retrieval of takes in an intuitive, visually supported way. Nevertheless, it must be possible to store with the film takes also relevant textual shooting information (e.g. lens parameters, lighting conditions, location information etc.) that may later also serve for the content-based retrieval of specific film material.

The design of a CSFS that is accepted by professional film crews has to adapt to their contexts of use and to their view of equipment devices as aiding tools that practically do not require any learning effort. Advanced CSFS software brings unprecedented functionality and flexibility to the film set. However, the rich software features and the complex interaction behavior of the different CSFS devices requires highly usable and self-explaining interfaces. Like for any software-controlled system, new software releases for the CSFS offer additional or advanced functionality for the users. It was a design guideline to enable a smooth migration for CSFS users from the well-known features of a current CSFS software version to the broader functionality of each new release.

The CSFS hardware and software is embedded into the overall environment on the film set, e.g. a network of cameras with mounted lenses, video screens, studio equipment, lighting etc. User-centered design for such an environment means that the control of the communication between computer-based CSFS components (e.g. PSUs, Director´s Pads) with the rest of the equipment (e.g. movie cameras, video monitors) follows the traditional shooting workflow for standard filming situations. For situations where CSFS hard- and software technology allows intelligent new methods of interaction of users with their equipment, flexible new ways of equipment control or completely new action sequences should already be represented in the underlying task models. For the interaction designers and software engineers this requires the availability of powerful new task-modeling approaches (Dittmar & Forbrig, 2003).

CSFS hard- and software both adds new productive functionality and various new interaction modes to the process of shooting a film. As a result overall production time can be shortened significantly. More important, however, is the fact, that such advanced capabilities of interacting with their equipment (see chapter 2 for examples) adds slack and several new degrees of freedom to the work of film professionals and may lead to more creative results.

2 Software Design and Functionality

This chapter first gives an overview of the design process and the major hard- and system-software characteristics of the CSFS components. It then discusses in more detail some of the most interesting interactive features of the asynchronous software found in the latest version of the CSFS main component, the PSU®-2. Finally, the overall software architecture of the CSFS and the architecture enhancements that allows the integration of active (W)LAN client components are briefly discussed.

2.1 CSFS Design

2.1.1 Design Process

In order to arrive at a CSFS solution that fulfills functional, usability, and reliability criteria, the system was developed by a joint team of computer scientists and film professionals using a contextual design approach (Beyer & Holtzblatt, 1999). The applied life-cycle produced a series of HW/SW prototypes that were tested under real-world production conditions by directors and DoPs around the world (Märtin & Prell, 2003).

Most usability problems resulting from a lack of communication between software engineers and user-centered design (UCD) experts (Seffah & Metzker, 2004) could be avoided by having the film people (our UCD experts) evaluate each new interactive feature on the CSFS prototypes immediately after the feature was available. The results of these tests were carefully examined and integrated into the first product version of the system main component, the PSU®-1 (fig. 2).

The latest product version, the PSU®-2, that is housed in the same aluminium chassis, comes with slightly modified hardware and a completely restructured asychronous software architecture. The PSU®-2 software structure is mainly responsible for the flexible new interaction modes.

Fig. 2: Vantage PSU-1

2.1.2 CSFS Functionality

The specific requirements of the film-set-context lead to the following set of system-level hard- and software features. Note that usability aspects are not restricted to the user interface or software functionality, but also concern the system-level:

- touch-screen based user interface for the PSU®-2 main unit
- high-performance dual hyper-threaded Intel Xeon processor hardware and high-speed SCSI RAID disk system for take data storage
- stable operating system (Linux Kernel Version 2.6) with advanced multiprocessor and multi-threading support
- special HW- and mechanical support for robustness against rough environmental conditions (temperature, humidity, power breakdown, transport handling) including twin-ATA operating system disks with self-healing HW/SW support for stable booting after file system defects
- active dynamic fan-speed control for enabling high-quality sync-sound recordings
- straightforward and efficient UI development environment using Trolltech´s Qt, OpenGL code and Intel´s Performance Primitives library as well as the C++ programming language
- asynchronous multi-tasking CSFS system control software for PSU®-2 main unit, active clients, and passive I/O devices
- highly-usable and adaptable CSFS user interface software for interaction with different on-set roles and internationalization support
- intelligent, adaptable tool tips that dynamically appear from time to time as learning aides for new PSU®-2 users and for introducing advanced users to new features. Their behavior is controlled by the frequency of use of the interaction objects and is also guided by user profile settings, e.g. help levels. Tool tips can also be completely deactivated.
- compatibility mode that hides functionality and UI modifications introduced in a new software release. All new features can be activated step by step through user profile settings.
- highly-usable, take-icon-menu based visual retrieval of recorded film material and project administration features (including on-screen keyboard for typing individual take comments)
- optional (W)LAN-based interfaces to active tablet-PC client systems (fig. 3).

Fig. 3: Prototypical Director´s Pad® tablet PC client

- flexible Lector® HW/SW interface to electronic high-performance movie cameras. The video signal of two cameras can simultaneously be recorded by one PSU®-2.
- standard connections to additional passive I/O devices, e.g. TV-out monitors

2.2 CSFS User Interface Design

Though many of the widgets included in the PSU®-2 main interface show similarities to consumer electronic products, various new interaction modes and widgets were created for navigational and CSFS-specific purposes. With a disk capacity of up to 60 hours using JPEG compression in order to still allow access to any single image, it is possible to store several production weeks of shot film material or thousands of takes on the disks. Access to single images is advantageous for real-time slow-motion or speed-ramp simulation up to 500 frames per second (fps) by rendering intermediate images out of the original 25 fps of the video signal. Having access to single images also allows take editing, effects simulation and mix and overlay techniques to start and end on exactly one specific take image. This feature is used by directors on the set to create artistically satisfying scene templates for the post-production process. To easily locate a specific take in the take menu browser out of sometimes several thousands of takes, the takes are organized in a per shooting day mode. An image from the middle of the take serves as the take´s icon (Märtin & Prell, 2003).

To demonstrate the asynchronous multi-tasking nature of the CSFS software for the PSU®-2, which was released as a product in early 2005, figure 4 shows the PSU®-2 main screen. In the following two sections some advanced features with complex functionality and rich interaction behavior are demonstrated in detail.

2.2.1 Automatic Take Recording with Lector®

Lector® is a hardware/software device attached to a professional movie camera. It is responsible for asynchronously sending the camera status information (camera start, stop, camera speed for controlling slow motion and ramping simulation) and the video signal to the PSU®-2 with which the camera is coupled. As shooting time is expensive, no shot can get lost, because Lector® lets the PSU®-2 automatically begin to record the take in the background (fig. 4). However, sometimes a camera is started only for test purposes and recording does not make sense. Thus, the exact definition of the recording behavior and of the interaction modes of the PSU®-2 when a Lector®-device is in place (right diode of the lector button for CAM A shows light green color or is blinking in red) had to be found in an intensive discussion between film professionals and software engineers.

The right one of the two Lector® diodes of the CAM A button in fig. 4 is blinking in red and indicates that this camera is receiving a control signal from Lector®, while the left diode displays light green indicating that in fact a true live image is sent by the camera. At the same time the touchscreen operator works on a take she had recorded on disk earlier. The PSU®-2 operator is informed by the comment in the center of the touchscreen display that an automatic recording of camera A has started in the background. If Lector® is configured for manual mode (fig. 5), the operator now has the option to either confirm the shooting by pressing the `rec` button in the comment field or to suppress the recording by pressing `NO RECORDING`. If the former option is chosen, the PSU®-2 continues the recording, creates a take number and makes the take visible in the take menu. With the latter option chosen, the recording is interrupted, the already recorded images are removed from the disk and no take number and menu entry are generated. The operator continues her work. If the operator choses to press no button at all, the recording stops after an adaptable time limit and the take and all related information is discarded. If Lector® is configured for automatic mode the takes will always be recorded. In the user profile, however, it can be selected, whether the PSU®-2 display will switch to live mode to display the active camera input or remain in the mode it was, before the recording was started.

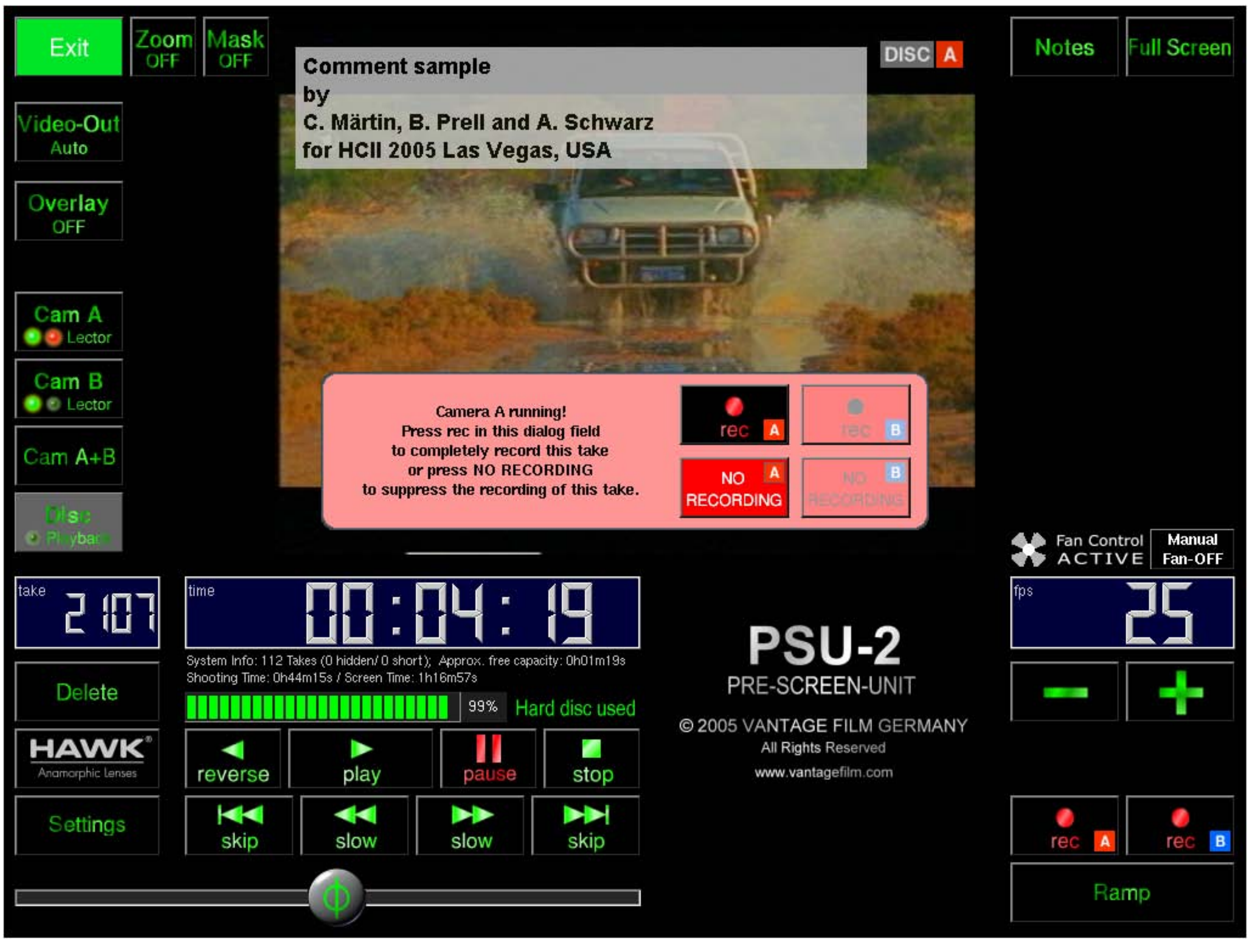

Fig. 4: PSU®-2 touch-screen interface with active CAM A Lector® button

2.2.2 Support for Multiple Display Modes

Two electronic cameras can be coupled with one PSU®-2 at a time and the video and speed signals of these two cameras can be recorded simultaneously. In addition TV-out monitors can be connected with the system. The asynchronous nature of the PSU®-2 software architecture allows that recordings of one or two live video streams and the replay of a stream recorded earlier can be executed at the same time. It is also possible for the operator to change into editing mode, in order to work with several recorded takes on the display, with the live recording of up to two takes still running in the background. In this case it makes sense, not to disturb the user in his or her editing task, but to display the recorded live streams on the connected TV-out screen.

Fig. 5: User profile settings for Lector® recording

The flexible combination of several simultaneous tasks, however, raises the user interface complexity. Guided by user-centered design, the video-out selector widget (on the right side of fig. 6) was developed to allow the easy configuration of the video-out display mode. In `Auto`-mode the TV-out monitor mirrors the touch-screen display. In the other modes the TV-out screen shows one or two live cameras, the current disk playback, a test signal or the TV-out screen is switched off. On the left side of fig. 6 the current configuration is shown: the TV-out screen is in `Auto`-mode and displays the currently active playback from disk. In the background the live video signal from CAM A is recorded.

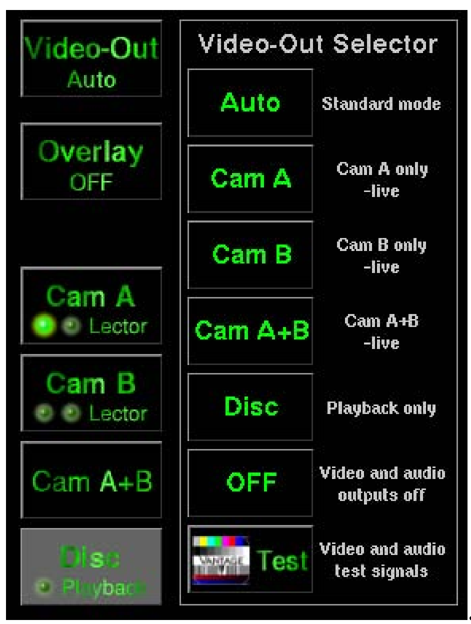

Fig. 6: TV-out configuration interface

2.3 CSFS Design from a Software Engineering Perspective

During our contextual design process we used UML use case diagrams (Booch, Rumbaugh & Jacobson, 1999) for the early phases of requirements analysis. Because of the highly interactive structure of the CSFS components the design of the overall communication flow between the software-components of the PSU®-2 and of other CSFS devices had to be planned in close coordination with the user interface architecture. For the detailed design of the communication aspects between the various classes and layers of the distributed CSFS environment, we found UML collaboration models (fig. 7) very helpful. Some details of the first product version of the communication structure are discussed in (Märtin & Prell, 2003). We also used several well-known design patterns for specifying the communication and interaction behavior of the system (Gamma et al., 1995). For the PSU®-2 we added the asynchronous multi-tasking functionality described in chapter 2.2 to the software architecture. Some of the design solutions in our first product version (PSU®-1) could be exploited as communication patterns for designing the multiple asynchronous display modes of the PSU®-2.

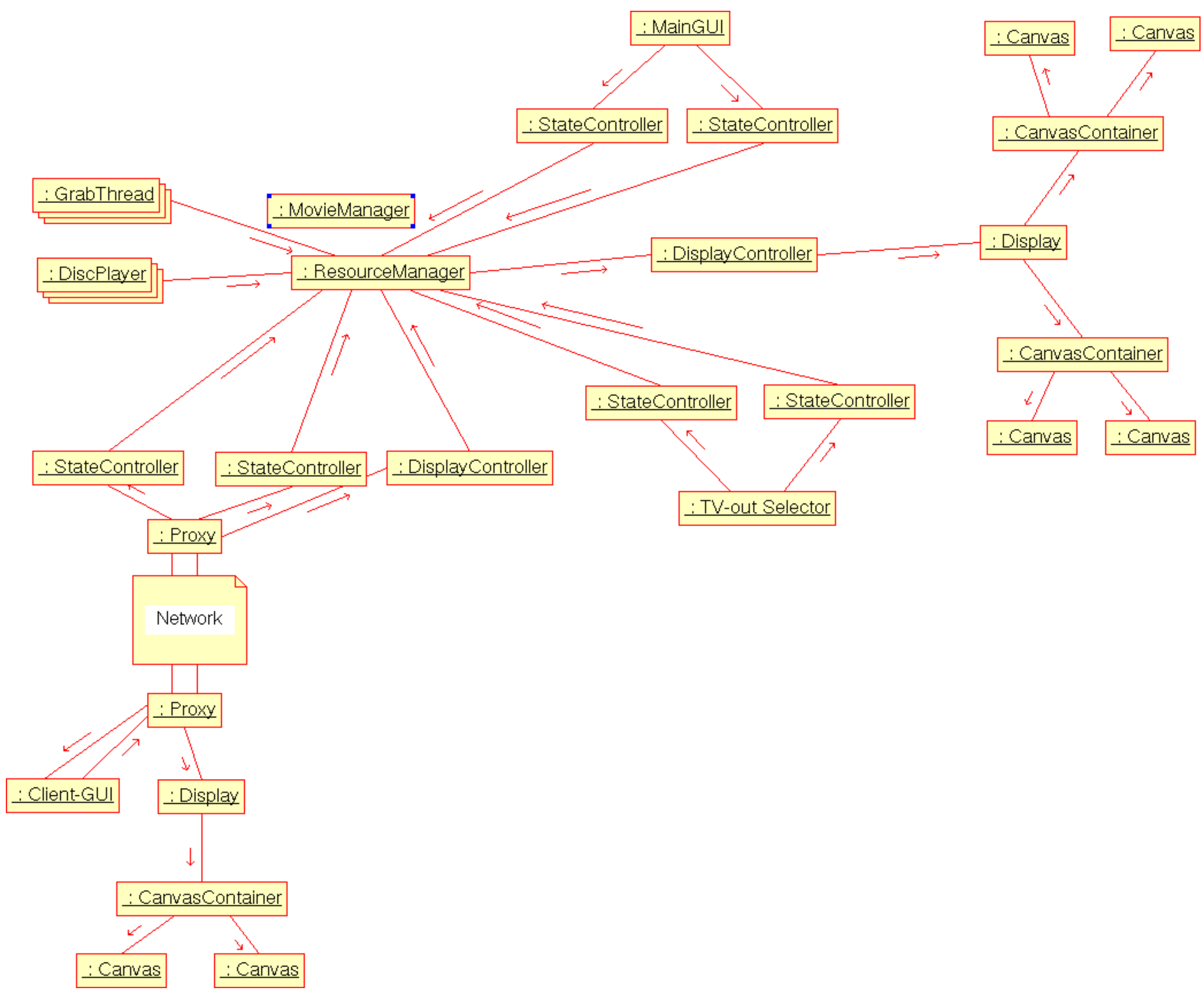

Fig. 7: CSFS collaboration model including active client communication over WLAN

This architectural extension for asynchronous multi-tasking not only supports multiple display modes as discussed in section 2.2.2, but also allows us to couple active clients like the tablet-PC-based Director´s Pad® with the PSU®-2 via a (wireless) LAN. An active client is able to access the PSU®-2 like a server and to asynchronously communicate with it. An active client allows the user to work independently of the PSU®-2 main unit and to watch the live recordings or recorded takes from other perspectives in a distance of up to 30 meters from the main unit. The active client therefore must be able to receive JPEG-compressed live video data from the PSU®-2 and to decode and display them on the tablet PC in real-time. In addition it must be possible for the active client to asynchronously download film data (take videos or edited sequences) from and upload edited sequences to the PSU®-2. This communication and disc access traffic must not disturb the other tasks running on the PSU®-2. The implementation of these advanced multi-tasking features in a satisfying way for the professional end user required heavy optimization on all soft- and hardware system-levels.

The Proxy-Pattern (Buschmann et al., 1996) helped us to define the additional middleware-layer when communicating with active clients. To support the flexible signal/slot paradigm that is integrated into Trolltech´s Qt UI toolkit not only for communicating with local display devices, but also over the WLAN, an IDL precompiler was developed. This precompiler automatically generates source code for all functions in the network layer, i.e. the communciation flow proxy – network – proxy (fig. 7) .

3 Results

In this paper some important design and implemention aspects of a real world CSFS product and its development process were discussed. The currently available PSU® systems are in use world wide and have served in the production of hundreds of commercials and many major feature films. Their usability is rated extremely high by the film crews. Several directors have reported significant production cost reductions due to the comprehensive and flexible take administration, playback and effects simulation features. Many film professionals also mentioned the new creative possibilities due to the flexible interaction modes and the user-centered design solutions in general.

However, the future of CSFS systems seems to become even brighter: The advent of digital high-performance and high-resolution cinematography cameras will soon bring a great part of post-production efforts directly to the set. Future high-resolution CSFS systems will be one of the key technologies for digital film production. In order to process the high-resolution film data, these developments will require CSFS components with enormous parallel computing power. Recent developments in the field of massively parallel media processors, like the Cell microprocessor (IBM, 2005), that combines one multithreaded PowerPC core processor with eight attached SIMD processing elements on one chip, could be the key technology for future products in this field. The chip that was developed by IBM, Sony and Toshiba supports the Linux operating system and delivers a top performance on multimedia applications of 256 Gflops. A Cell chip can easily be connected with other chips of this type to deliver the necessary computing power for the film industry.

4 Acknowledgements

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5 References

Beyer, H. & Holtzblatt, K.(1999). Contextual Design. interactions, January + February, pp. 32-42

Booch, G., Rumbaugh, J. & Jacobson, I. (1999). The Unified Modeling Language User Guide, Addison-Wesley

Buschmann, F. et al.(1996). Pattern-Oriented Software Architecture. A System of Patterns, John Wiley & Sons, 1996

DALSA Corp. (2003). Compression of Motion Pictures for DALSA Digital Cinema Systems, Whitepaper, http://www.dalsa.com/dc/documentes/L3_Compression_White_Paper_03-70-00164-00.pdf

Dittmar, A. & Forbrig, P. (2003). Higher-Order Task Models. In: Interactive Systems. Design, Specification, and Verification: 10th International Workshop, DSV-IS 2003, Funchal, Madeira Island, Portugal, June 11-13, Revised Papers, Springer LNCS Vol. 2844, pp. 187-202

Gamma, E. et al. (1995). Design Patterns: Elements of Reusable Object-Oriented Software, Addison-Wesley

IBM Corporation (2005). IBM, Sony, Sony Computer Entertainment Inc. and Toshiba Disclose Key Details of the Cell Chip. Innovative Design Features Eight Synergistic Cores Together with Power Based Core, Delivers More Than 10 Times the Performance of the Latest PC Processors, Press Release, Feb. 7th

Khanh, T. & Koppertz, M. (2003). Funktionsmuster einer digitalen Filmkamera auf der Basis eines CMOS-Sensors, IRT-Kolloquium, 10th Nov., http://www.irt.de/IRT/veranstaltungen/irt_vortrag-arri-kamera-1.pdf

Macedonia, M. (2002). Linux in Hollywood: A Star is Born. IEEE Computer, February, pp. 112-114

Märtin, C. & Prell, B. (2003). Contextual Design of a Computer-Supported Film Set: A Case Study. In: Interactive Systems. Design, Specification, and Verification: 10th International Workshop, DSV-IS 2003, Funchal, Madeira Island, Portugal, June 11-13. Revised Papers, Springer LNCS Vol. 2844, pp. 392-405

Panavision Corp. (2004). GENESIS™ Super 35 Digital Cinematography Camera System, Product Description, 2004, http://www.panavision.com/publish/2004/07/01/Genesis.pdf

Petersen, M.G., Madsen, K.H. & Kjaer, A. (2002). The Usability of Everyday Technology – Emerging and Fading Opportunities. ACM Transactions on Computer-Human Interaction, Vol. 9, No. 2, June, pp. 74-105

Seffah, A. & Metzker, E. (2004). The Obstacles and Myths of Usability and Software Engineering. Commun. ACM, December, 71-76

Vantage Film GmbH (2004). PSU-1 HDVR , http://www.vantagefilm.com, Equipment Section, September