STATUS, APPLICABILITY AND PERSPECTIVE OF TINE-POWERED VIDEO SYSTEM, RELEASE 3

Stefan Weisse, David Melkumyan (DESY, Zeuthen)
Philip Duval (DESY, Hamburg)

Abstract

Experience has shown that imaging software and hardware installations at accelerator facilities needs to be changed, adapted and updated on a semi-permanent basis. On this premise, the component-based core architecture of Video System 3 was founded. In design and implementation, emphasis was, is, and will be put on flexibility, performance, low latency, modularity, interoperability, use of open source, ease of use as well as reuse, good documentation and multi-platform capability. Special effort was spent on shaping the components so that they can easily fit into small-scale but also into area-wide installations.

Here, we describe the current status of the redesigned, almost feature-complete Video System, Release 3. Individual production-level use-cases at Hasylab [1], PITZ [2] and Petra III [3] diagnostic beamline will be outlined, demonstrating the applicability at real world installations. Finally, the near and far future expectations will be presented.

Last but not least it must be mentioned that although the implementation of Release 3 is integrated into the TINE control system [4], it is modular enough so that integration into other control systems can be considered.

OVERVIEW

The origin of the featured Video System 3 (VSv3) is the Photo Injector Test Facility Zeuthen (PITZ). It is a test facility at DESY for research and development on laser driven electron sources for Free Electron Lasers (FEL) and linear colliders [5, 6].

Currently, VSv3 is almost feature-complete. Since 2008, it has emerged out of its predecessor [7], now known as Video System 2 (VSv2). The current software is a result of more than 10 years experience on video controls at particle accelerators.

As the lifetime of an accelerator facility can be a few years or decades, in contrast to the fast-pace IT world, a few design criteria should be kept in mind. Some API or operating systems can be potentially obsolete just a few years after commissioning. Both environmental considerations (radiation level) and customer demands can require frequent exchange of components and/or software evolution and upgrades. Thus there is a strong motivation to incorporate flexibility, modularity and interoperability in the design.

VSv3 was designed and implemented to meet all of these requirements, as well as those general requirements any video system must meet. These include high performance and low latency.

Selection of key characteristics/capabilities:

- raw greyscale images up to 16 bits per pixel
- raw colour images (24 bit RGB)
- integrated JPEG compression/decompression (grey and colour)
- production-level interfaces and experience in operation of: Prosilica GigE cameras, analogue cameras, JAI GigE cameras, JAI/Pulnix GigE cameras and equipment possible to attach using MS Directshow interface (Webcams etc.)
- high-bandwidth possible [8]
- low latency possible (what you steer is what you get)
- production-level 1.4 megapixel transfer, 16 bit grey, at 10 Hz update rate
- up to 30 frames per second can easily be reached
- Area of Interest (AOI)-only transfer
- shared memory interconnection of server-side components
- multicasting of video images

COMPONENTS

The video system comprises of several different components, selected ones are described in details below (see Figure 1).

The **VSv3 Transport Layer** (VSv3 TL) specifies the layout of a well-defined flexible image data type (header and bits) plus ways of transport which is integrated but not limited to TINE control system. Structure, header fields and pixel data formats are well documented.

Small Grabber Part (SGP) is the central front-end server-side component to acquire video images. To keep the C++ code simple, one SGP process will deal with only one camera at a given time. Various editions of SGP exist. Edition means it supports exactly one API to interface image sources / hardware. Most important editions at the moment are Prosilica, JAI and MS Directshow SDK, all on Windows platform. The C++ source code is kept platform independent as much as possible and references only widely available open source libraries. Thus, migration to other operating systems is expected to be on the order of hours or days. This of course depends on the availability of SDK for the chosen platform.

The connection from image source to SGP can be switched from one image source to another remotely. For example, if only two video streams are wanted in parallel, 20 cameras can be supported with just two SGP server processes. SGP provides one TINE control system output interface with VSv3 TL and one interface to shared memory (SHM).

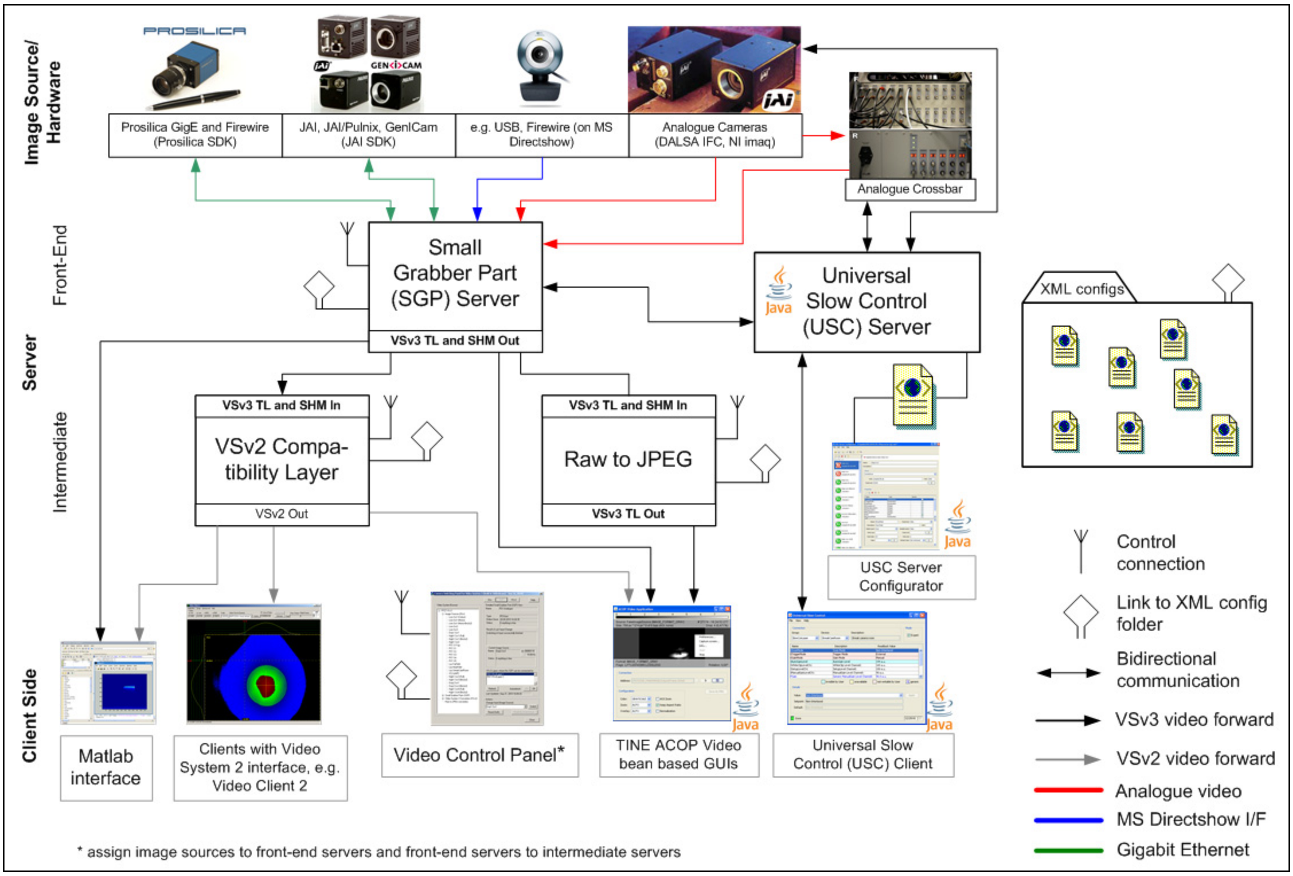

Fig. 1: Simplified layout of VSv3 components are their interaction

VSv2 Compatibility Layer is an intermediate C++ server-side component dedicated to provide backward compatibility. Its purpose is to receive image stream via VSv3 TL (using TINE or shared memory), convert the image to VSv2 format and provide VSv2 output connections (TINE and pure TCP sockets) to legacy VSv2 clients.

Raw to JPEG intermediate C++ server-side component was designed to provide easy translation of raw uncompressed images to JPEG images, with a tuneable compression factor. Input is possible via VSv3 TL (TINE or SHM), output is provided as TINE VSv3 TL. Supported are greyscale and colour images. Near-real time operation is possible. The CPU load required for this needs to be considered but resources are *easy* to provide on today's powerful commodity PC hardware.

TINE ACOP Video bean is a fundamental client-side component which displays video streams and provides basic functionality for image enhancement as well as integrated analysis made by Cosylab [9]. As Java has been selected as the target platform for future control system client-side at DESY, native Java has been used as the programming language. This gives the immediate benefit of platform independence. One might expect Java to reduce the code execution speed of the software. However, even if this does play a role (for example in low-level networking functionality), overall performance figures so far are satisfactory. With the high processing power of today's PC hardware and the periodic increases in power, Java can be considered a real alternative to native code in video system client software. As a Java bean integrated into the ACOP framework [10], it is easy to include along with other ACOP beans in Java clients (from rich clients to simple panel clients). In lieu of a dedicated client application, ACOP beans also provide a generic Video Application, which is designed to work out-of-the-box.

A well-defined **Universal Slow Control (USC) Solution** found within VSv3 provides abstraction and mechanisms to control slow parameters of hardware devices. The server part contains various connections to interface hardware, layout of parameters in hardware and well-defined TINE property interface. The USC client uses this to present hardware parameters to operators in a convenient, platform-independent Java GUI.

A **MATLAB client-side image acquisition interface** provides a simple, easy to use interface for users of Matlab. The interface supports all image features of VSv3 as well as a VSv2 input which is provided for backward compatibility. Operators are currently making good use of this interface, writing their own scripts and clients.

USE CASES

As of September 2010, most components necessary for a full-scale operation have been finished and are already installed in stable production environments at PITZ (DESY Zeuthen), Hasylab and Petra III (DESY Hamburg). The process of rolling out components at EMBL Hamburg has recently been started.

The Hasylab installation is focused on having many Prosilica Gigabit Ethernet (GigE) cameras all running in parallel at slow update rate (~2 Hz). Currently about 45 server processes are distributed across two machines. Images are acquired at defined positions on user beamlines in the newly built Petra III experimental hall [11]. Imaging is used for online beam centering and position monitoring. On the client side, the ACOP Video Application is used as video display. USC is used for tuning of camera's image acquisition parameters (gain, shutter speed, etc.). A special challenge has been transporting data on the 1 Gbit network interface at the server machine which is shared with the general mixed Gbit/100-Mbit controls network.

The Petra III installation consists of a VSv3 Prosilica GigE camera installation at Petra III diagnostics beamline [12] as well as an already existing VSv2 analogue camera readout which provides images of beam positions at pre-accelerators and beam distribution paths in-between. Cameras are driven with a slow update rate of about 2 Hz. On the client-side, the ACOP Video bean has been integrated into rich Java clients custom-made for Petra III control. The earlier mentioned Java-based video analysis collection of components (made by Cosylab) is a vital part of the controls setup. A special challenge at Petra III was that due to limitations in the existing control network bandwidth, certain mechanisms had to be implemented / configured in order not to exhaust limited network resources.

The PITZ setup consists of various camera types. At the moment analogue JAI cameras (M10 RS, M10 SX), Prosilica GigE (GC-1350, GC-1350C) and JAI/Pulnix GigE (RM-1405GE) are installed. Foreseen are installations of more JAI/Pulnix (RM-2030GE) and JAI GigE cameras (JAI BM141GE). In contrast to Hasylab installation, PITZ has about 25 cameras but only about 10 server processes. A camera assignment/switching panel has been provided to the operators, who use this to route video signals from source to destination. On the client side, PITZ is mainly using VSv2 software, which interfaces with VSv2 Compatibility Layer component that has been installed at server-side. VSv3 software is used directly with the VSv3-based Universal Slow Control solution for camera setup (e.g. adjusting gain and shutter in order to tune image quality at place of acquisition). Special challenges here are the demands of PITZ regarding imaging: loss-less image quality, near-realtime and low latency. Furthermore constant changing of hardware and software requires a robust and flexible setup in order to avoid significant investment of time to keep it all up and running.

EMBL Hamburg has used VSv2 for sample changer monitoring and control to great satisfaction. As step by step EMBL user beamlines are commissioned at Petra III, VSv3 components are foreseen to be installed there. As a first step, an interface for Labview readout of VSv3 TL outputs has recently been provided. This is used to monitor video from Hasylab screens, which is very useful for EMBL operation.

ON THE HORIZON, PERSPECTIVE

Effort in the next months will be put on finishing intended features at the server-side. For example, applying a unique trigger event number obtained from a central source to each video frame is foreseen. Likewise, the integration of recording and playback of video sequences to Archive or DAQ installations is foreseen. At the client side, an image import/export API with stable methods to load/save the transport layer's image data type to/from a PNG file will be released, followed by an extension to sequences of images to PNG files in a ZIP container.

Over the coming years, the extension and upgrade of currently existing installations will transpire. Apart from documentation and Video System website updates, the client libraries will provide a range of APIs so that a user, no matter his software experience will be able to interface the Video System with his own tools (e.g. ROOT, MatLab, Labview, C/C++ library, Java, or .NET). VSv3 and ACOP video tools already comprise a collaboration spanning several institutes. At the same time, new collaboration partners are very welcome and are encouraged to contact us.

ACKNOWLEDGEMENTS

We would like to thank Markus Degenhardt and Gero Kube for on-site support, valuable feedback and beta-testing.

REFERENCES

[1] http://hasylab.desy.de
[2] http://pitz.desy.de
[3] http://petra3.desy.de
[4] http://tine.desy.de
[5] F. Stephan, C.H. Boulware, M. Krasilnikov, J. Baehr et al., "Detailed characterization of electron sources yielding first demonstration of European X-ray Free-Electron Laser beam quality", PRST-AB, Vol. 13, No. 020704 (2010)
[6] S. Rimjaem et al., "Measurements of Transverse Projected Emittance for Different Bunch Charges at PITZ", FEL 2010, Malmö, Sweden
[7] S. Weisse et al., "Status of a versatile Video System at PITZ, DESY-2 and EMBL Hamburg", ICALEPCS 2007, Knoxville, TN, USA
[8] S. Weisse et al., "TINE Video System: Proceedings on Redesign", ICALEPCS 2009, Kobe, Japan
[9] J. Bobnar et al., "TINE/ACOP state-of-the-art video controls at Petra III", PCaPAC 2010, Saskatoon, Canada
[10] J. Bobnar et al., "The ACOP Family of Beans: A Framework Independent Approach", ICALEPCS 2007, Knoxville, TN, USA
[11] M. Degenhardt et al., "CVD Diamond Laser Alignment and X-Ray Fluorescent Screens for Petra III", SNI 2010, Berlin, Germany
[12] G. Kube et al., "Petra III Diagnostics Beamline for Emittance Measurements", IPAC 2010, Kyoto, Japan