technische universität dortmund

Poster ID: MOPGF036

Control System Developments at the Electron Storage Ring DELTA

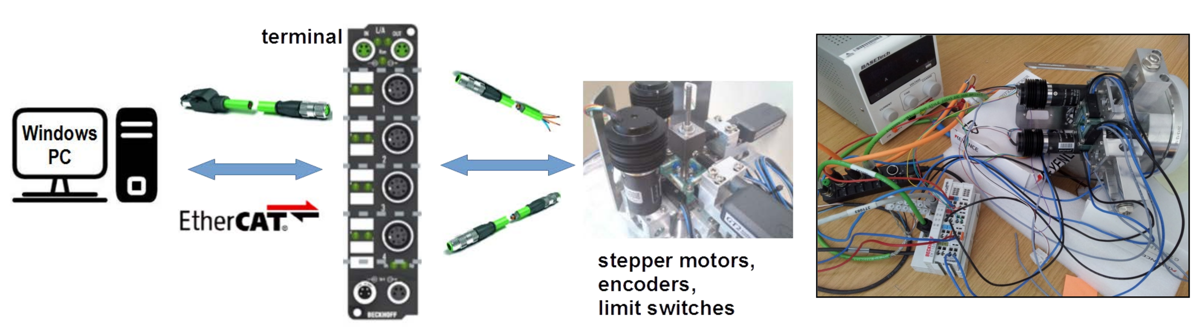
ICALEPCS 2015

D. Schirmer*, A. Althaus, F. Bahnsen

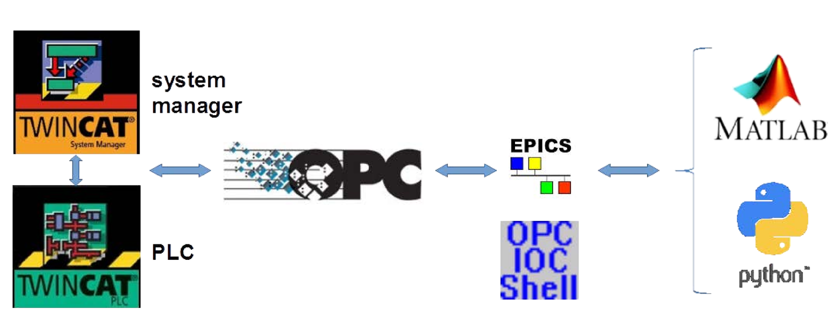
Center for Synchrotron Radiation (DELTA), TU Dortmund University, 44227 Dortmund, Germany

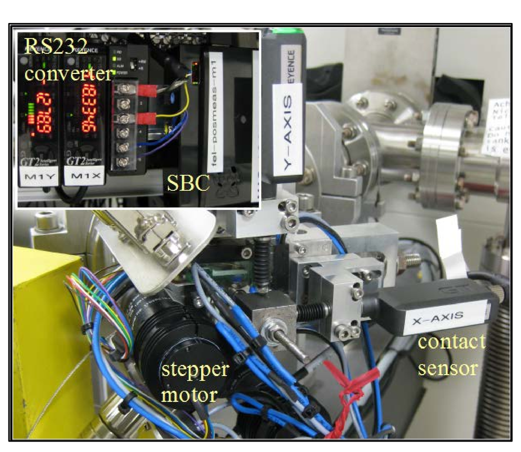
Integration of New Hardware

Special hardware and software is necessary in order to drive mirrors, for example, in the evacuated laser beam lines of the short-pulse facility. Because the current system has been discontinued, a new control unit is being evaluated. Here, stepper motors [26-28] are controlled over EtherCAT [6], a vendor-initialized real-time Ethernet.



The hardware configuration, such as a setup of motor parameters, is managed by the TwinCAT system manager [5], whereas the motor movement logic is programmed on a PLC controller [5]. The link to EPICS is accomplished via a vendor specific OPC-server [29] and an EPICS IOC-shell with OPC driver support (OPC client) [30, 31]. All three software levels are running on the same Windows-PC internally communicating over DCOM [32].

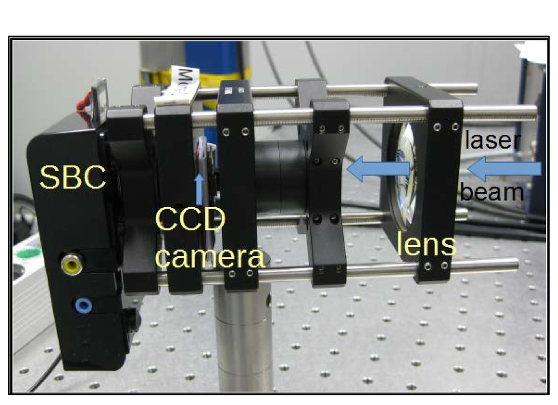




The software encoding of the stepper motors is imprecise due to slippage and x/y motion coupling. Therefore determination of the true mirror position must be realized by high-accuracy contact sensors and additional limit switches [26, 27].

The analog sensor signals are connected to a converter device providing a standard serial (RS232) communication interface. This port can be used again by RS232 EtherCAT terminal or by a single board controller (SBC, Raspberry-Pi) running Linux and PyEpics [18, 26, 33].

Test Benches & SBC Applications



For near-field angle measuring of the beam guidance in the laser laboratory, a SBC, equipped with a standard 5-megapixel CCD camera, is in preparation. A converging lens focuses the beam on the CCD chip. Changes of beam angle yield a shift of the focal point of the Gaussian intensity distribution [33].

A python script [7] quantifies this displacement and writes the measured value to EPICS records. Background radiation can be reduced via a SBC-GPIO triggered slit. This basic cost-saving setup allows angular measurement within very short distances with a resolution of 50 µrad in both transverse directions [33].

All booster magnet power supplies are driven by 16-bit DAC boards. The functionality of these boards is quite crucial and must be checked in advance by a simple SBC-based test bed. A python script on the SBC converts the simulated booster ramping curve to a 16-bit digital I/O signal which is mapped via a photo-coupler adapter card for voltage level matching and finally fed to the DAC-board input.

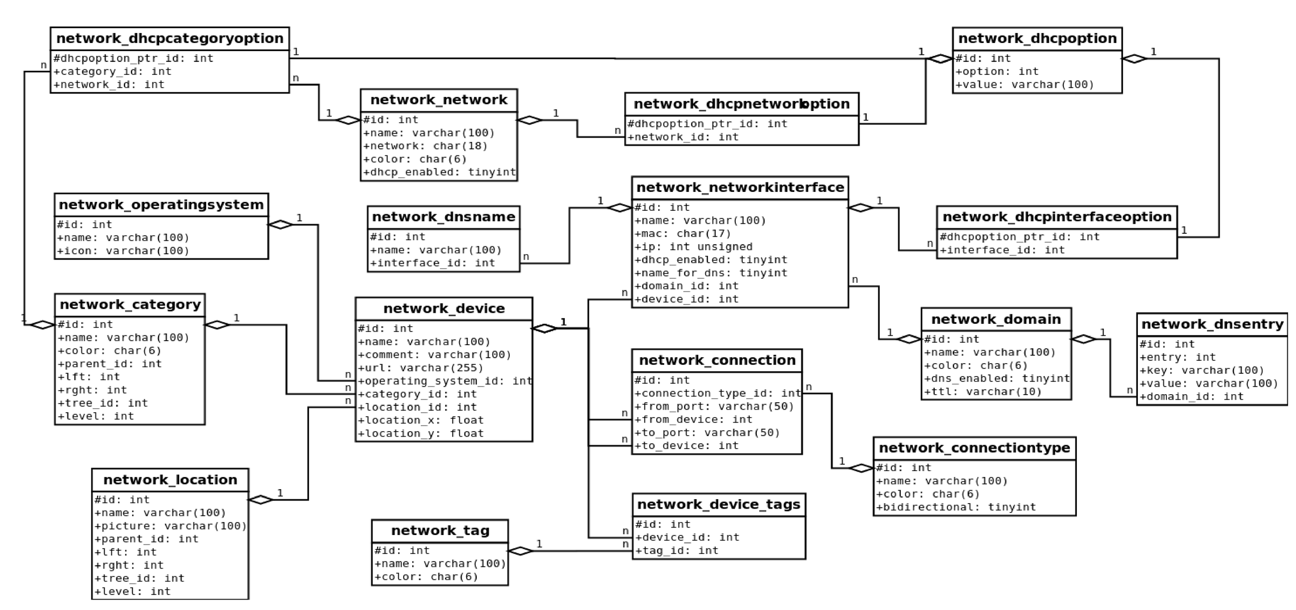
The resulting analog DAC output value is measured and analyzed under several test conditions (e.g. ramp cycle frequency, curve shape, temperature variation) by a oscilloscope or circuit analyser.

Introduction

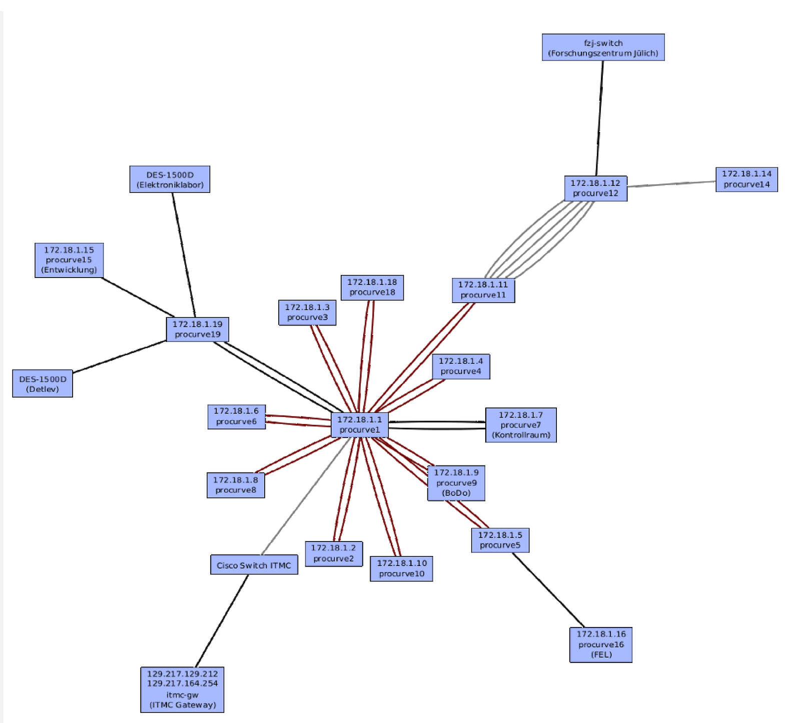
DELTA, a 1.5-GeV electron storage ring, is operated since 1999 by the TU Dortmund University as a synchrotron light source for campus-based, regional and international users. Since 2011 the facility has been extended by a short-pulse source for VUV and THz radiation making use of the CHG (Coherent Harmonic Generation) principle [2-4]. An upgrade to EEHG (Echo-Enable Harmonic Generation) is in preparation [11]. Not only for these reasons the EPICS-based DELTA control system [1] has been revised and complemented in many fields.

Network Administration Tool

Since the number of control system network devices and, thus, the complexity of the network topology increased constantly, it was mandatory to develop a DELTA-specific management tool. With the help of this tool, all individual devices and their connection properties are registered centrally.

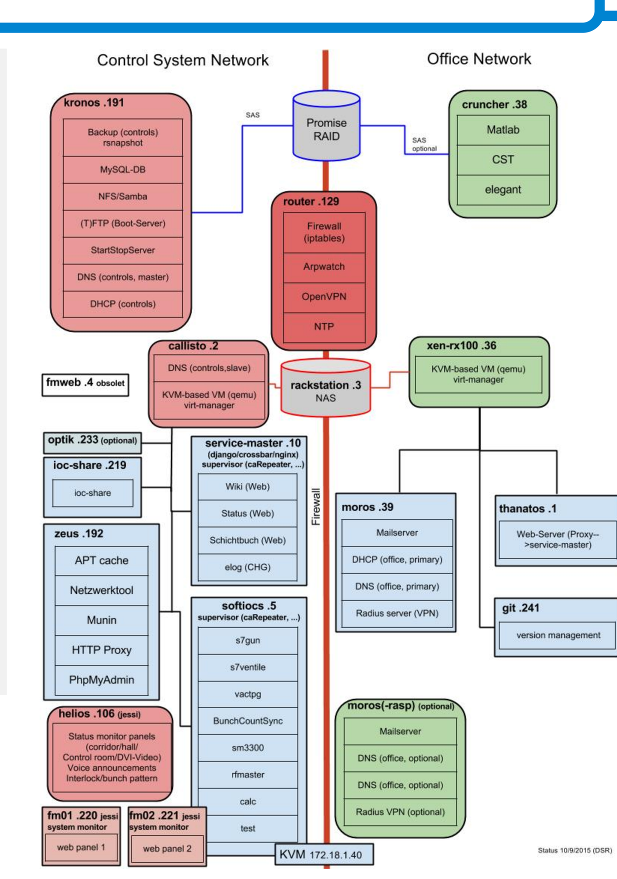


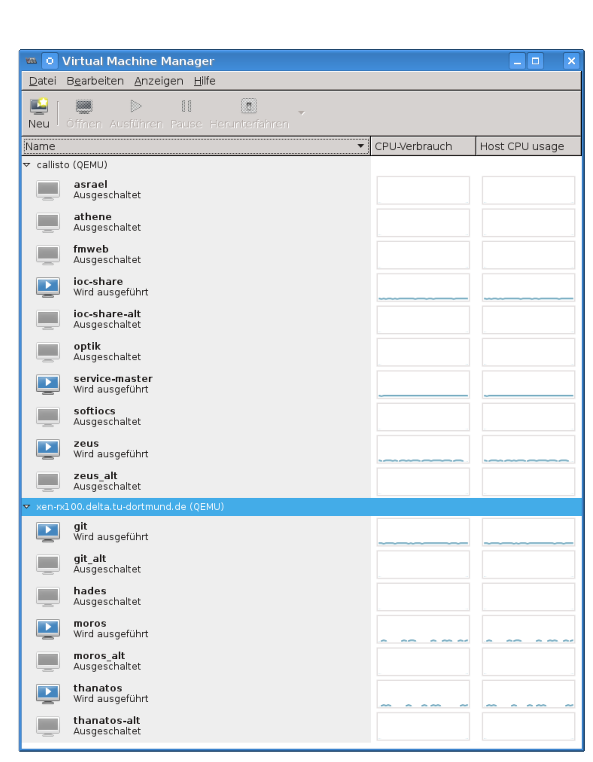
The tool administers network interfaces, IP/MAC numbers and assignments to domains. Furthermore, it generates consistent DNS/DHCP configuration files as well as location and network plans and much more. The program is implemented as a web application and is based on the high-level Django /Python framework [7, 8]. All data and configurations are stored in the DELTA MySQL [12] database.



Server Maintenance & Consolidation

Nowadays, all server-CPUs support hardware-assisted virtualization (VT, AMD-V) and, in addition, kernel-based virtualization (KVM [10]) is by default merged into the standard Linux kernel. The migration from XEN [9, 19] to this kind of full virtualization was required for maintenance reasons. KVM is driven by *qemu* [20] and provides an API to control VMs with GUIs like *virt-manager* [21].



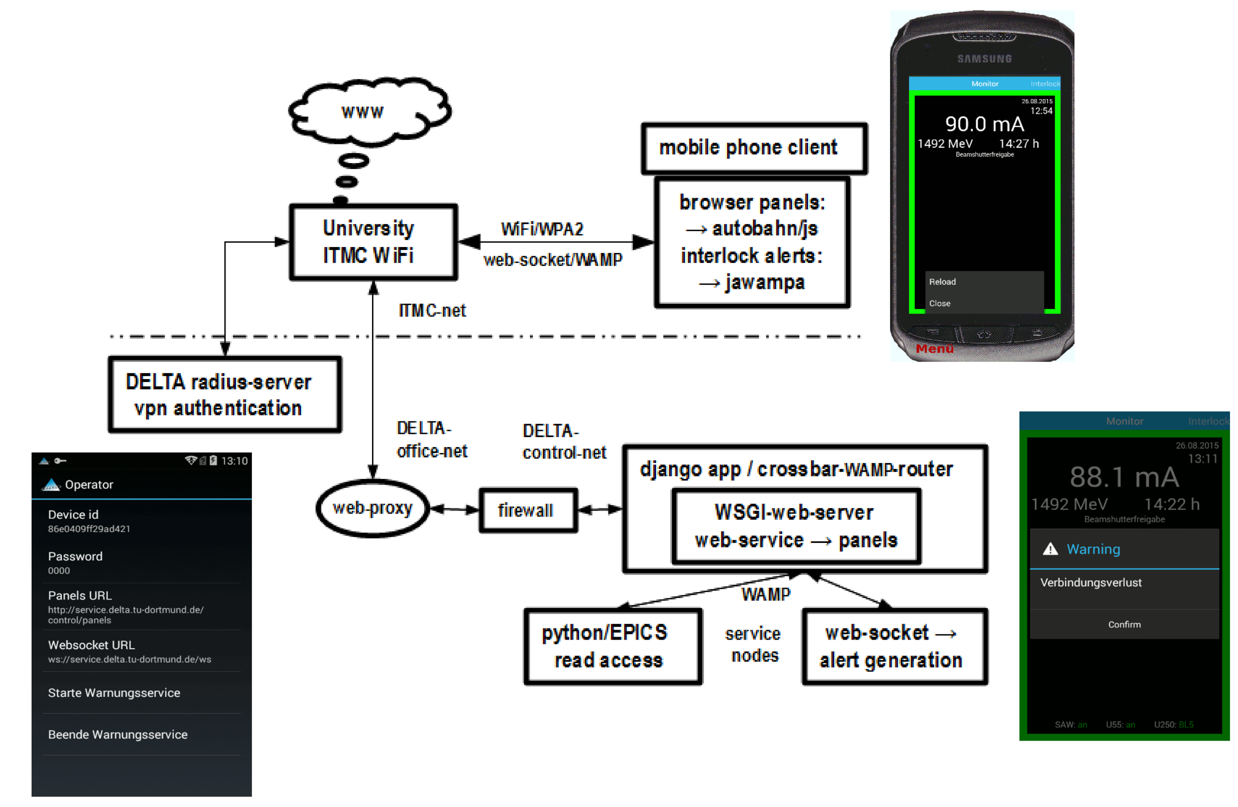


In the course of this migration, all server and virtual machines have been upgraded to the latest operating system (Debian 7/8 [22]). This upgrade implies also the introduction of *systemd* [23], a new system and service manager for Linux-OSs and the successor of *sysvinit* [24]. Thus, even all EPICS soft IOC shells are now centrally managed by this powerful OS-integrated software package.

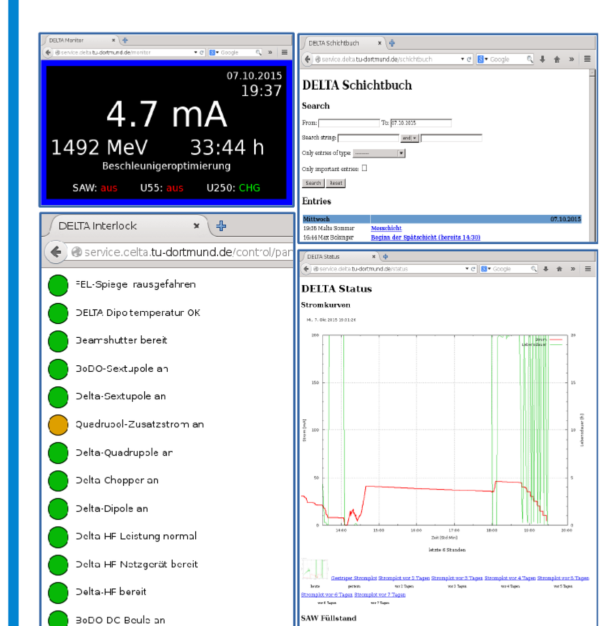
Also for the purpose of maintenance the default installation of all servers is now centrally and automatically managed by the software suite *Ansible* [25].

Web-based Applications

For security reasons, it was necessary to develop an additional alert system, which notifies the operator to machine malfunctions via a mobile phone (**mobile alert system**).



For "real-time" monitoring of the accelerator interlock warnings, a web-socket communication is performed, which keeps a full-duplex communication link between a client (e.g., an Android-based mobile phone) and a server continuously open. The connection uses WAMP (Web Application Messaging Protocol) [13], a web-socket sub-protocol (with RPC and publish & subscribe mechanism).



On the server side, *Crossbar.io* [14] interacts as a message WAMP-router for different so-called service nodes. One node provides the service to read EPICS records another calculates und triggers interlock warnings. In addition, it launches web services that provide panels accessible from various URLs. There are web pages for machine status (e.g., beam current, lifetime, insertion device status), interlock notifications as well as the electronic logbook .

On the client side (e.g., mobile phone), an *Autobahn/JS*-application [15] (an implementation of WAMP in javascript) displays the server-side spawned panels, and a *jawampa*-application [16] (library to support WAMP to Java) indicates the interlock warnings, all in "real-time". The communication is established via WiFi inside the DELTA building. An acoustic and vibration alarm will be activated on the mobile phone in the case of a machine alert or server connection loss.

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*detlev.schirmer@tu-dortmund.de