THE UNIFIED ANKA ARCHIVING SYSTEM – A POWERFUL WRAPPER TO SCADA SYSTEMS LIKE TANGO AND WINCC OA

D. Haas, S. Chilingaryan, A. Kopmann, D. Ressmann, W. Mexner, KIT, Karlsruhe, Germany

Abstract

ANKA realized a new unified archiving system for the typical synchrotron control systems by integrating their logging databases into the "Advanced Data Extraction Infrastructure" (ADEI). ANKA's control system environment is heterogeneous: some devices are integrated into the Tango archiving system, other sensors are logged by the Supervisory Control and Data Acquisition (SCADA) system WinCC OA. For both systems modules exist to configure the pool of sensors to be archived in the individual control system databases. ADEI has been developed to provide a unified data access layer for large time-series data sets. It supports internal data processing, caching, data aggregation and fast visualization in the web. Intelligent caching strategies ensure fast access even to huge data sets stored in the attached data sources like SQL databases. With its data abstraction layer the new ANKA archiving system is the foundation for automated monitoring while keeping the freedom to integrate nearly any control system flavor. The ANKA archiving system has been introduced successfully at three beamlines. It is operating stable since about one year and it is intended to extend it to the whole facility.

INTRODUCTION

ANKA is a third generation synchrotron light source operated by the Karlsruhe Institute of Technology (KIT). ANKA is operating seventeen beamlines and three more are under construction.

The control system of the ANKA beamlines is based on two independent components. The beamline instrumentation like the pressure, temperature or vacuum system is integrated in the SCADA system WinCC OA [1]. The experimental control, which includes movement of motors, triggering detectors et cetera is managed by Tango [2].

At ANKA the number of analogue sensors for long term archival per beamline can be estimated to 175 in WinCC OA plus 100 in Tango. Considering all 20 beamlines, these results to a number of approximately 5500 sensors, which have to be logged and archived at ANKA. Both systems have a separate solution to visualize the data for the user.

The main goal for the new unified ANKA archiving system is an easy and flexible configuration tool to select the data points for archival. And secondly to provide an unified fast graphical data browser [3]. Therefore this project splits in two parts. The first part was to interface the existing separate archiving solutions and the second part is to access all logged data of a beamline and the experiment. This data should be presented and retrieved in a modern, state-of-the-art web interface with fast data access. This offers the user a convenient way to analyse the data. ADEI [5], a web based interface for database query, developed by the Institute for Data Processing and Electronics (IPE) at KIT, fulfils exactly these requirements. Using ADEI as a viewer, respectively analysis tool and connecting it to the databases of the Tango archiving system and the WinCC OA Archiver plugin creates a platform to track and monitor the status of a beamline.

Due to the structure and available tools of this project, the main challenge was to combine and connect the three different parts, consisting of the Tango Archiving system, the WinCC OA History Database and ADEI.

INTEGRATION OF CONTROL SYSTEM HISTORY ARCHIVES

The integration of all separated archiving system in an overall distributed archiving system requires a TCP/IP based database interface of all sub systems, preferably SQL.

The Tango archiving system [4] allows logging of all Tango-attributes in a MySQL database. In 2014 this archiving system was already evaluated and implemented at ANKA to log the data of the experiment. The database of the SCADA part based on WinCC OA has no TCP/IP based SQL interface and is only accessible via a proprietary programming interface (API). Therefore ANKA developed a WinCC OA archiver plugin to record the logging data of preselected WinCC OA data points into a common SQL database. As the Tango Archiving System has been stored its logged data already into a MySQL database, we decided to use MySQL for the whole project. We found that the effort for the second option, to implement a new SQL interface to the existing C++ History API of WinCC OA, was too high.

The existing Tango Archiving System provides different advantages for logging the data points of the Tango control system. This system is a well-known and maintained archiving tool, which also includes with Mambo an easy to use graphical user interface.

Archiving the data-points of the SCADA system WinCC OA in a MySQL database required a new development. As the internal C like script language of WinCC OA is quite powerful, it was possible to use it to write all updated values directly to MySQL. For a convenient graphical user interface to configure archiving of the analogue values to be logged (Figure 2) a WinCC OA panel was developed. This GUI also allows different modes of logging. The data can be archived in different time periods or can be logged only if the value is changing.

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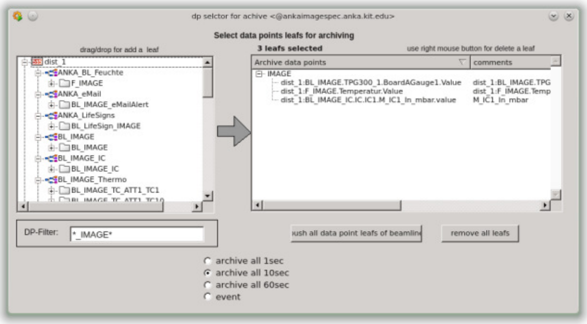

Figure 1: Screenshot of the Archiver plugin of WinCC OA. The sensors, can be added to the list of archived data-points by drag-and-drop.

ADEI

The “Advanced Data Extraction Infrastructure (ADEI)” has been developed to provide ad-hoc data exploration capabilities to a broad range of long-running scientific experiments dealing with time series data. Such experiments have varying characteristics and are often composed from multiple subsystems developed by different vendors. As a result, the underlying storage engines and the data formats often differ even between subsystems of a single experiment. On the other hand, the users want to get uniform access to all the data. Easy correlation of data produced by any components of the system is desirable. Beside this, operators need a tool providing the possibility to examine all collected data, checking the integrity and validity of measurements. The ADEI architecture shown in Figure 2 is modular. New data sources can easily be included. The back-end provides the desired uniform access to the data. The web-based front-end allows quick inspection of data archives. The communication between front-end and back-end is realized using the AJAX (Asynchronous JavaScript + XML) paradigm.

The back-end consists of multiple components organizing the data flow from the data source to the client application. The “Data Access Layer” hides details of the underlying data sources and provides other components of the system with uniform access to all types of data. This is realized using independent source drivers implementing ADEI data access interface. Furthermore, the data is passed through the chain of the configured data processing plugins which analyze the data, control the data quality, and optionally apply correction coefficients or filter out bad values. Hence, the rest of the system can fully rely on approved data quality.

ADEI is designed to deal with data sampled at high data rates and stored for long periods of time. It is still impossible to access large volumes of data interactively. Therefore, newly recorded data is continuously preprocessed. The data is aggregated over several predefined intervals, so called cache levels. For each cache level statistical information is calculated and stored in the caching database. The higher ADEI subsystem, then, can request the raw data, or to reduce the amount of received data, any statistical information from the selected cache level. To illustrate the concept, the rendering module can request the mean values from 60 seconds cache level effectively receiving minute averages instead of the raw data.

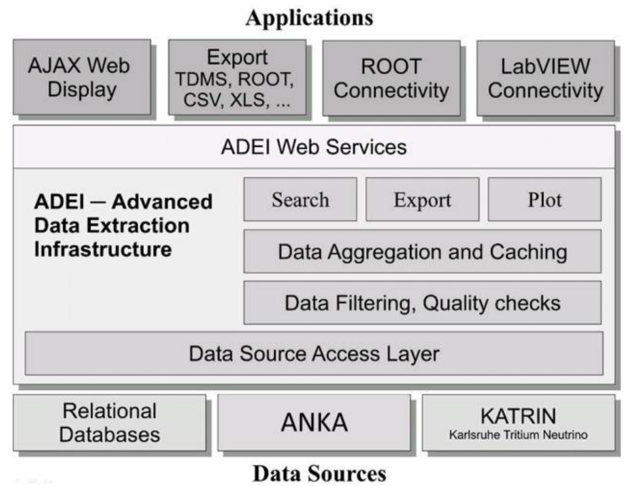

Figure 2: Architecture of the “Advanced Data Extraction Infrastructure ADEI”. The “Data Source Access Layer” unifies the access to the time series data stored in different formats. After filtering and quality checks the data is aggregated and stored in intermediate caching databases. Access to the data is provided by the ADEI web display; web services are used to communicate with client applications.

ADEI provides several interfaces to access the data. The export module provides direct access to the data in a variety of formats implemented as plugins. The search module allows to quickly finding required data channels or time intervals where certain channels possessed the specified characteristics. The plot module is used to quickly generate preview charts. All modules are interfaced by a web service interface.

The ADEI front-end facilitates fast and intuitive (Google maps-style) navigation. Based on the caching subsystem described above, the users can request overview plots over long time intervals interactively. Since the quality checks were executed during the data preprocessing, the problematic intervals are highlighted in the overview charts. A user then can easily navigate to the interval of interest and zoom-in using the mouse only. The complete plot-generation time does not normally exceed 500 ms for any type of requested data.

The ADEI web service interface allows platform and programming language independent design of application-specific data management solutions. To bring an example, we have developed a WebGL application that shows the temperature distribution on the provided 3D model based on the specified mappings of the ADEI data channels onto the model. Also, we developed software libraries to use ADEI data within the National

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Instruments LabVIEW environment and CERN's ROOT data analysis suite.

THE ANKA ARCHIVING SYSTEM

It is essential that the ANKA Archiving System is a stable, reliable and convenient overall system for archiving analogue data-points of a complex control system. To install and configure the different tools a certain hardware structure is needed. Figure 3 shows the efficient modular hierarchy. At every beamline there is a dedicated small server, which is responsible to archive the data of this certain beamline into a database. All these archiving servers are connected to one server where the web front-end ADEI is running. It was sufficient to build the servers from standard PC-parts, which make it cost effective. For the archiving servers standard Intel Xeon 8 core boards with 8 GB RAM and 3 TB disk space are used. The ADEI server differs in the disk space with 12 TB and a memory of 32 GB.

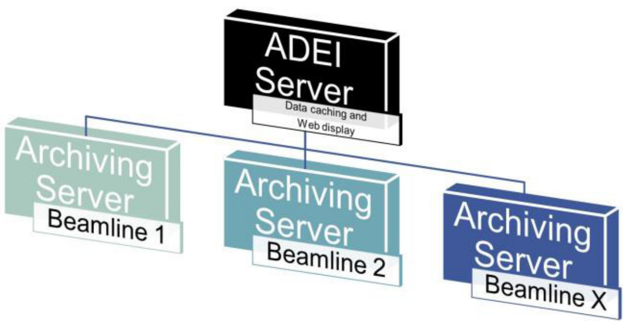

Figure 3: Structure of the different servers and their function in the ANKA Archiving System.

To connect the different software layers a well-structured concept was introduced.

As described in the previous chapters the user has two graphical user interfaces where he can configure the logging data-points of the two main control systems (see Figure 4). To configure the archiving data for Tango the user can use the GUI Mambo and for the SCADA system WinCC OA there's the developed Archiver Plugin available. Both of these GUIs are saving data into independent MySQL databases. Finally these two databases are connected to an ADEI instance which is pre-processing and caching the data and providing the web-interface to the user.

This software concept can be introduced at every beamline to provide the unified ANKA Archiving System. The complete ANKA archiving system is currently been embedded and implemented into the control system at three beamlines, Topo-Tomo [6,7], Image and NANO.

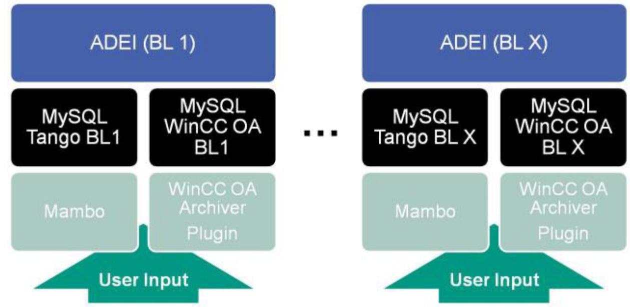

Figure 4: The different software layers of the ANKA Archiving system. The user configures the logged data, which is afterwards saved in a MySQL database and finally presented by ADEI.

THE WEB INTERFACE

The web interface of ADEI (Figure 5) is intuitive and self-describing. There is a list of data sources existing where you can choose the beamline from which you want to retrieve the archived data. The available logged data is shown in a tree structure. In this tree the user can easily select the data to plot and evaluate. The plot is shown in a big window where a zoom-in, save or export function is available. As export function mainly the excel- and cvs-file export is supported.

CONCLUSION & OUTLOOK

The unified ANKA archiving system was implemented and tested at three beamlines. It is a powerful combination of different interconnected tools providing a convenient, state-of-the-art and user friendly way to log, archive and represent data of a synchrotron beamline. The system is easy to setup and does not required deep programming knowledge. The test system is in operation since nearly one year and turned out to be stable and reliable. It can be easily extend by further history database sources. The next steps will be to extend our system to mobile devices like smartphones and tablets and to roll out the unified archiving system to the remaining ANKA beamlines.

The sources will be available under GNU GPL2 on the official Tango website www.tango-controls.org.

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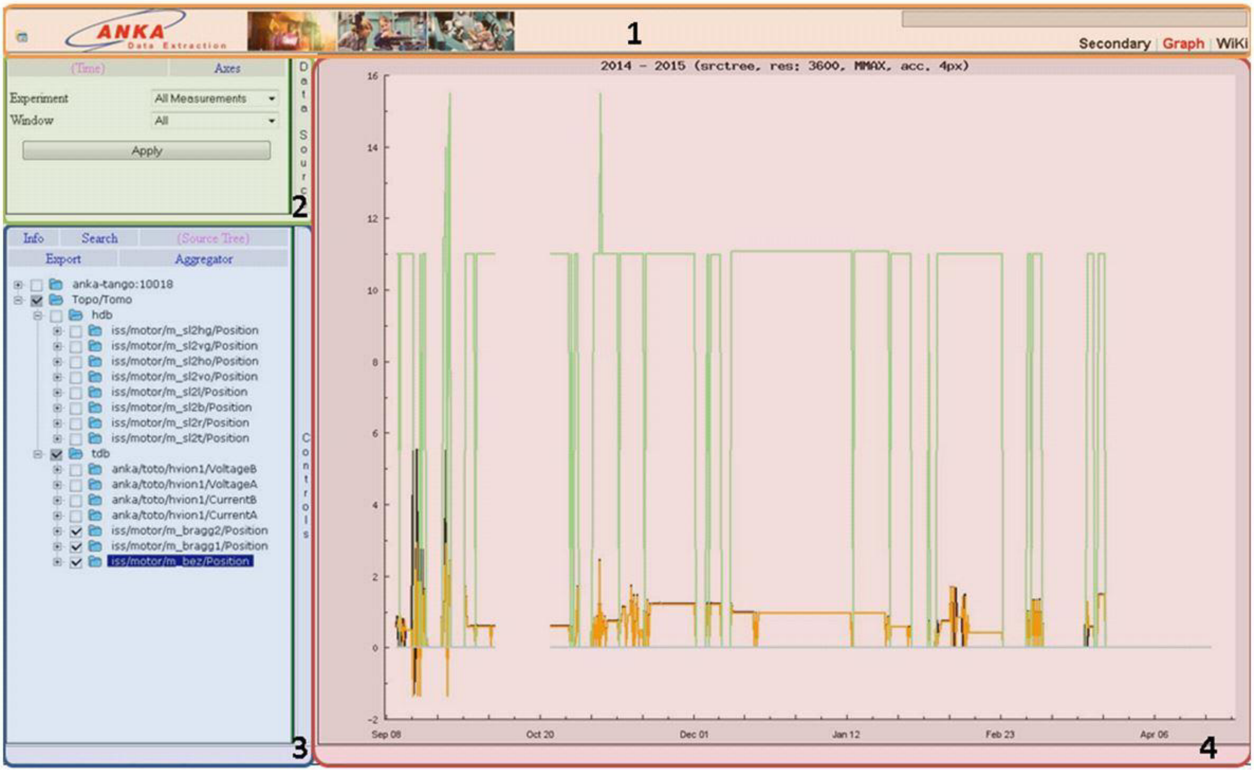

Figure 5: Screenshot of ADEI Web Front-end for the ANKA Tango Archiving System. (1) header bar with main menu, (2) dropdown-menu for selecting server respectively beamline, (3) data selection, (4) plot of the selected data.

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