IMPLEMENTATION OF THE EPICS DATA ARCHIVE SYSTEM FOR THE TPS PROJECT

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Abstract

The EPICS framework was chosen as control system infrastructure for the new project of 3 GeV synchrotron light source (Taiwan Photon Source, TPS). Various control system prototypes of TPS with the EPICS mechanism have been gradually built and tested. One EPICS archive system is necessary to be developed to record various machine parameters and status information for long time logging. The archive system of CSS (Control System Studio) which named BEAUTY (Best Ever Archive Toolset, yet) was built to be used as the TPS data archive system in 3rd quarter of 2012. An archive engine takes PV data from EPICS IOCs via channel access, and stores them in the data storage. The PostgreSQL RDB (Relational Database) was adopted as the data storage for the BEAUTY. Both the historic PVs data and the archive engine configuration are saved into the same RDB. The archived data can be retrieved in a form of graphical representation using the CSS-based data browser. Taking the performance and redundancy into considerations, the storage servers and RDB table structures are tuned relatively. The efforts will be described at this report.

INTRODUCTION

The TPS [1] is a latest generation of high brightness synchrotron light source which has been under construction at the National Synchrotron Radiation Research Center (NSRRC) in Taiwan since 2010. It consists of a 150 MeV electron Linac, a 3 GeV booster synchrotron, and a 3 GeV storage ring, which is in installation phase. Commissioning is estimated in 2014.

The EPICS (Experimental Physics and Industrial Control System) [2] is a set of open source software tools, libraries and applications developed collaboratively and used to create distributed soft real-time control systems for scientific instruments such as the particle accelerators. Many facilities have good practical experiences for the EPICS and adopt it as the accelerator control systems. Many resources and supports are available as well as numerous applications for accelerator have been developed.

As a result, the EPICS framework was also selected as control system infrastructure for the TPS project. The EPICS platform has been gradually built and tested to control and monitor the subsystems of the TPS. The various database records can be created for accessing the I/O data and setting parameters at the IOC (Input Output Controller) layer. Utilizing the EPICS channel access mechanism with the specific toolkits, the data can be accessed between the IOCs and the clients.

The CSS (Control System Studio) [3][4] is a collection of user interface tools: Archive Engine, Alarm handler, as well as several operator interfaces and control system diagnostic tools. Most of them deal with Process Variables (PV), i.e. named control system data points that have a value, time stamp, alarm state, maybe units and display ranges, but they do this in different ways. One tool displays the value of a PV, one displays details of the PV configuration, while another concentrates on the alarm state of a PV. Each individual tool deserves some attention, and the Experimental Physics and Industrial Control System toolkit, EPICS, indeed offers each function as a separate tool. A key point of CSS is the integration of such functionalities.

One part of CSS is the Archive System, specifically the "Best Ever Archive Toolset, yet (BEAUTY)" that was developed as a replacement for the Channel Archiver. An Archive Engine takes PV data samples from a front-end computer, for example from EPICS IOCs via Channel Access, and places them in the data storage. Archive client programs then access historic data samples from that storage.

The CSS archive system was built to be used as the EPICS data archive system for the TPS project. The Relational Database (RDB) is adopted as the data storage mechanism for recording historic EPICS data. The various operation interfaces for archive data browsing are developed. Taking the performance and redundancy into considerations, the storage servers and RDB table structures are tuned relatively. The efforts for implementing are summarized as followings.

SYSTEM ARCHITECTURE OF THE TPS DATA ARCHIVE SYSTEM

The EPICS related toolkits were chosen as control system framework for the TPS of 3 GeV synchrotron light source. The TPS control system with the EPICS mechanism has been gradually built and in test phase. Utilizing the EPICS channel access mechanism with the specific toolkits, the data can be accessed between the IOCs and the clients. To implement the EPICS support for some subsystems, the control environment of the IOC is set up with the specific EPICS base, modules and extensions at the Linux operation system.

The historic EPICS data need to be recorded during the initial test phase for the TPS control system construction. Thus the EPICS data archive system needs to be established for saving the historic EPICS data of various subsystems. The archive system of CSS was built to be used as the TPS data archive system in 3rd quarter of 2012. Moreover this developed TPS archive system will

be utilizing gradually during the installation and commissioning phases.

To establish the TPS EPICS data archive system, the VNX5300 SAN storage system [5] was set up for saving a large quantity of EPICS related historic data. The system architecture for the TPS archive system is shown as Fig. 1. Now this storage system can be provided about 50TB capacity to store the TPS EPICS archive data. Some mechanisms, such as "Fully Automated Storage Tiering" and "FAST Cache", had been built into this storage system to enhance performance when the data writing and retrieving. Two database severs was set up and built the HA (High Availability) mode to apply the redundant mechanism. As one database server occurs the condition of service halt, the other database server will be replace the service automatically. The 10Gbps Ethernet ports are equipped into the database server for transferring data fast. Several systems are dedicated to perform the Archive Engines for accessing EPICS related data to save into the archive system from various subsystem IOCs. The specific operation interfaces for historic EPICS data browsing can be used in the control consoles.
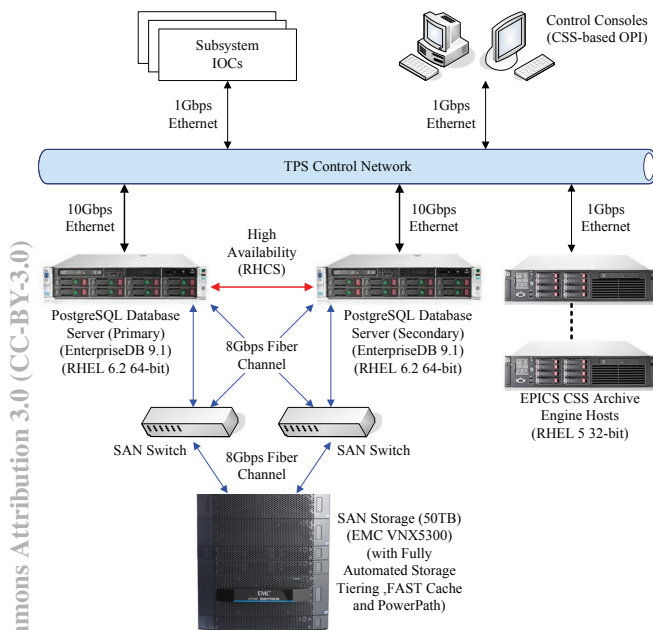
The CSS archive system can store data in a relation database (RDB). The CSS includes JDBC libraries [6] for some databases (MySQL, Oracle, PostgreSQL), and the archive system includes example database definition (DBD) files to create the required tables for the database dialects. The PostgreSQL (EnterpriseDB) [7] RDB was used for the EPICS data archive system of TPS project. The PostgreSQL RDB can be a good compromise and bigger table sizes. Both the historic data of PVs and the Archive Engine configuration are stored in the same relational database. The engine configuration can be imported from an XML file format into the database.

The software architecture of TPS EPICS data archive system is shown as Fig. 2. The storage system is separated into two databases which named RDB1 and RDB2. The RDB1 is mainly used to store into the EPICS historic data from EPICS IOCs via Channel Access. The RDB2 is synchronized to be a duplicate of the RDB1. If the RDB1 causes service halt, the RDB2 will do replication mode for restoring to the RDB1. The RDB2 provides higher reading priority to enhance transmission bandwidth for extracting queried historic archive data.
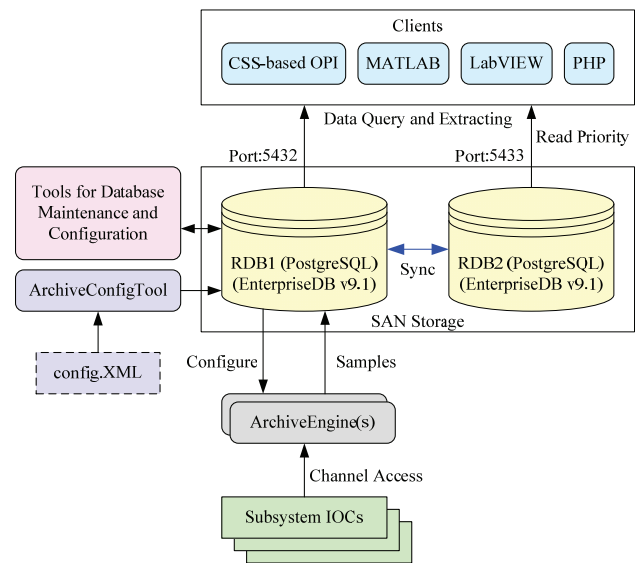

Figure 1: System architecture of the TPS EPICS data archive system.

SOFTWARE ENVIRONMENT OF THE TPS DATA ARCHIVE SYSTEM

For the installation and commissioning phases, one EPICS data archive system is necessary to be developed to record various accelerator parameters and machine status information for long time observation. The archive system of CSS was built to be used as the TPS data archive system in 3rd quarter of 2012. An archive engine takes PV data from EPICS IOCs via channel access, and stores them in the data storage.

Figure 2: Software architecture of the TPS EPICS data archive system.

Database Tuning for the TPS EPICS Data Archive System

To easily maintain and manage the archive data in the database, the sample data table will be separated into a lot of sub-tables by days. The new EPICS sample data will be inserted into the specific sub-table which is according to the day in the year. If the older samples will be deleted, the day-named table can be indicated and deleted. Each created sub-tables will be added the table index to enhance performance for data retrieving. Actually the test is that one week historic data (one channel-sample per second) need about 10~20 seconds to be queried out, extracting and plotting. Otherwise, there is about 1~2 minutes at least for retrieving one week historic data

without creating the table index. It is effective to create table index to enhance performance for retrieval.

OPERATION INTERFACE OF THE TPS DATA ARCHIVE SYSTEM

The clients can use the specific toolkits to retrieve the EPICS historic data from the PostgreSQL DB. As a result, several operation interfaces had been built and developed for difference purposes. The operation interfaces are described as following.

CSS-based Operation Interface

The Data Browser [3] is a generic CSS tool that combines Strip Tool and Archive Viewer functionality. It can display live samples as well as archived data in a plot, or export the data to files. Based on plugins for archive data sources, it can currently interface to the Channel Archiver and the EPICS Archive Record. Each PV may have multiple data sources: for example, the Data Browser can merge samples from an archive record for recent history with those from a midterm and long-term archive. It is convenient that the CSS-based OPI can be used in difference operation systems, such as Windows and Linux, and the GUI are shown in Fig. 3.
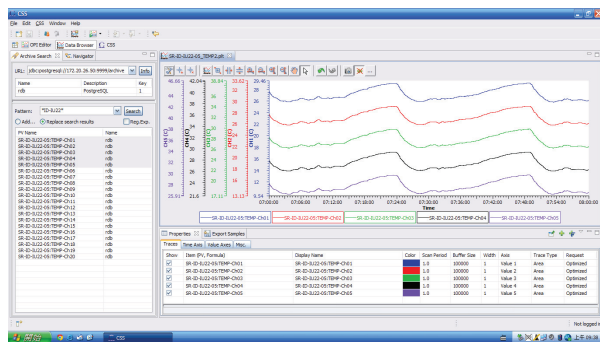

Figure 3: GUI of CSS-based archive data browser.

To easily observe the temperature variation during the in-vacuum insertion device baking, the specific monitor GUI was created by the CSS toolkit. This page can display the latest 30 minutes historic temperature data trend which retrieved from the database. The monitor GUI is shown as Fig. 4.
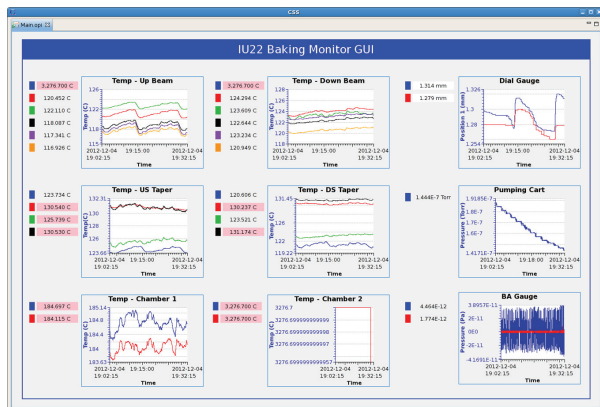

Figure 4: Archive data browsing GUI for ID baking.

Miscellaneous Operation Interfaces

To special purposes, the specific toolkit, such as MATLAB [8] (with JDBC connection), LabVIEW [9], PHP [10] and etc, is used to create the GUI to retrieve the EPICS historic archive data from the PostgreSQL RDB. Fig. 5 shows the retrieved archive data GUI which created by the LabVIEW.
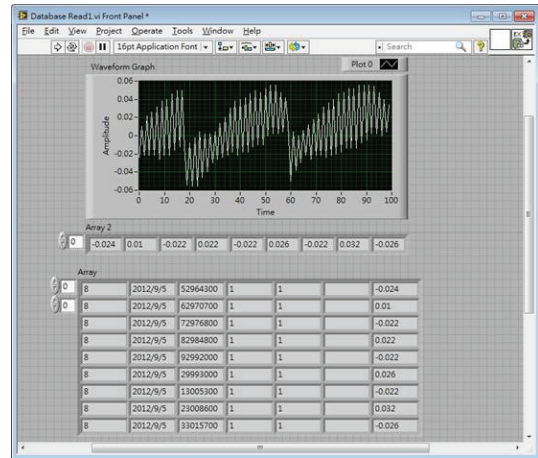

Figure 5: The retrieved archive data GUI which created by the LabVIEW.

CURRENT STATUS

The archive system of CSS (Control System Studio) which named BEAUTY (Best Ever Archive Toolset, yet) was built to be used as the TPS data archive system in 3rd quarter of 2012. The PostgreSQL RDB was adopted as the data storage for the BEAUTY. The archived data can be retrieved in a form of graphical representation using the CSS-based data browser. Taking the performance and redundancy into considerations, the storage servers and RDB table structures are tuned relatively. This developed TPS archive system will be utilizing gradually during the installation and commissioning phases.

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