UPGRADING THE PROSCAN CONTROL SYSTEM TO EPICS: A SUCCESS STORY

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Abstract

At the Paul Scherrer Institute the High Intensity Proton Accelerator (HIPA) as well as the new biomedical facility (PROSCAN) use an in-house developed control system called ACS. The SLS and future XFEL on the other hand use EPICS. With a view to standardizing the software and hardware equipment the decision was made to replace the ACS system with EPICS. Two years ago we started the migration of the PROSCAN control system, which has already from the beginning been built with a high degree of hardware standardization, using VME components only. The migration was finished at the end of last year, but we did not perform the definitive switch over due to time constraints coming from the patient treatment. In the coming years we also expect to migrate the ACS control system of the high intensity proton accelerator to EPICS, taking advantage of the work and experience we gained with the PROSCAN migration. We will present here the goals that have been followed and the way we have proceeded for the very successful migration of the PROSCAN control system.

INTRODUCTION

ACS history

ACS control system is the result of continuous development over at least 20+ years. The first version was implemented in late 1980s as a control system library with applications running on PDP-11 computers. Hardware was entirely CAMAC based. In the beginning of 1990s, the control system library was simply made remote procedure callable, and the applications part was migrated to VMS workstations. The underlining communication level "protocol" has basically not changed since, although, it has been extended with additional functionalities. Simultaneously, the PDP-11 replacement project was started. PDPs have been gradually phased out (ca 1993-1995) with HP rt743 real-time VME single board computers running the HP-RT operating system (HP's LynxOS version). The diversity of the CAMAC equipment resulted in 50+ CAMAC "module handlers" (drivers). Over the last ten years, VME equipment drivers and PLC drivers have been added. All the necessary information has always, from the beginning, been stored in a relational DB, which was developed concurrently. The resulting DB structure and tools are a result of the emerging needs. It covers all aspects of IOC and client workstation configuration. In the beginning of the third millennium a project of replacing the rt743/HP-RT with MVME51xx/LynxOS was initiated. Today, all IOCs run on this new platform. The PROSCAN control

system (started in 2003) is also based on the ACS control system.

PROSCAN ACS CONTROL SYSTEM

PROSCAN Overview

PROSCAN (Fig. 1.) is the new biomedical facility at PSI. It is comprised of a 250 MeV superconducting proton cyclotron (COMET), and four beam-lines: the Gantry1 (Existing Gantry on Fig. 1, that was already used with the old facility) and new ones, the Gantry2 (New Gantry), Optis2 (OPTIS) and Experimental Area (PIF).
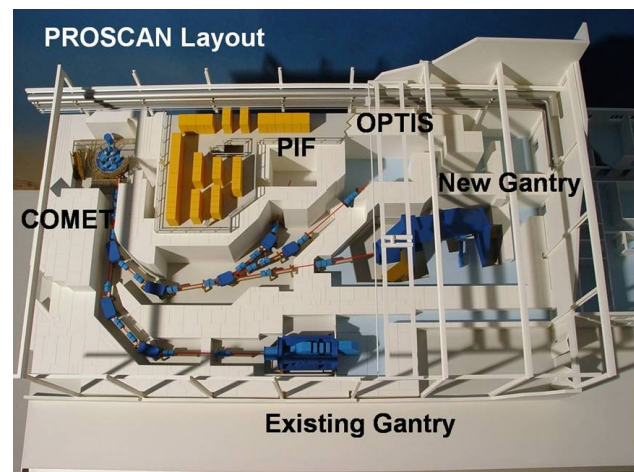

Figure 1: PROSCAN layout.

Hardware

Prior to and in the scope of the "Standardisation of the PSI Accelerator Control Systems" [1], the PROSCAN control system hardware was built in order to reduce the diversity of components. Only VME equipment and PLCs have therefore been allowed. Some CAMAC equipment has been used initially, but was replaced with VME components as soon as they became available. The MVME51xx is the new standard board for the IOCs.

Software

The initial PROSCAN control system design started years before the standardisation proposals were made, and is therefore based on ACS. During the implementation process and after the proposals for standardisation, the decision was made to proceed with ACS control system until regular operation on Gantry1 had commenced, and only then start with the migration to EPICS. The switch-

over to EPICS would have to take place before Optis2 and Gantry2 regular operations start.

Present status

Gantry1 is actually in regular patient cancer therapy operation since Jun 2007. Development of Optis2 and Gantry2 is progressing. The first Optis2 (eye cancer therapy) patient is expected in December 2009, and Gantry2 should follow in 2010. PIF (Proton Irradiation Facility) is also regularly used. One of the difficulties for the EPICS migration project is that the PROSCAN facility is constantly in use and there is not much time left for ACS to EPICS migration testing, except, occasionally, on weekends or late evenings.

MIGRATION TO EPICS

Preparations

On project start we made an inventory of used components: naming conventions; IOCs, hardware boards and PLCs; drivers; client applications; infrastructure; database. The similarities and differences of ACS and EPICS were evaluated. Most important use-cases (primarily the medical applications) and potential implications have been analyzed. It gave us a rough estimate on migration scenarios and required resources. These steps are presented in the following chapters.

Naming conventions

Process variable (PV, also "device" in further text) names had to remain unchanged. Documentation, cable labels and applications use them widely. Documentation and cable labels deal only with device names, but applications also deal with properties ("attributes"). An important issue was to provide an easy method for applications to translate ACS names to EPICS channel access PV names. That ACS recognizes device, attribute and conversion-level (C: number 1, 2 or 3), in a form:

$$DEVICE.ATTR;C$$

It was an obvious and simple solution to translate it to:

$$DEVICE:ATTR:C$$

as EPICS PV name.

IOCs, hardware and drivers

The PROSCAN control system uses 24 IOCs (few still to come), all of the same type, MVME51xx. There is already VxWorks/EPICS support at PSI for it. The hardware components used at PROSCAN are mostly not used in other EPICS based facilities. Driver reuse was minimal, and we had to implement eleven new drivers. In order to provide EPICS PV functionality, look and feel identical or similar as in ACS we have additionally implemented three new record types and four "genSubs". These had simplified our template and substitution files and provided for faster implementation.

Client applications

After identifying 30+ available applications, and discussing with users, we came to some 20+ applications that are essential. The most important is the Beam Allocator (BALL) application. It is the only gateway between medical applications and the machine control system. For the synoptic view of the whole machine MEDM is used. MEDM was adapted in ACS to support ACS communication protocol by the means of the Cdev connectivity module (medmCdev.c). Unfortunately some changes have also been introduced because of ACS specific naming conventions. Although the MEDM availability as an EPICS extension, numerous (70+) adl files had to be adjusted for the changed naming conventions. The TuneHandler and Interlock (the Machine Run Permit System (MRPS) viewer and configurator), the BALL companion applications, are besides the BALL the most important applications. Generally speaking, the BALL, Interlock and TuneHandler are the only applications actually needed for patient therapy. The rest is mostly needed for system overview and troubleshooting purposes. In any case, all 20+ applications have been ported for EPICS.

Infrastructure

We identify three categories: IOCs, workstations and servers, database server. As ACS is completely database driven, we have tried to propagate the same idea to EPICS. The new database server with database schema is in place and all the data inserted. We generate complete IOC configurations (startup scripts, driver configurations, templates and substitution files) from database. Besides the new EPICS file and development servers we have also to provide client workstations, too. For those we have decided to configure additional hard-disks with EPICS environment. When testing, we simply have to shutdown the workstations, replace the hard-disk and boot. For the IOCs, which are network bootable diskless machines, we took the advantage of the dual boot ROM available in MVME51xx. One boots the LynxOS and starts ACS, the other boots VxWorks and starts EPICS. On each IOC we have built in a hardware switch (connected to boot ROM selection jumpers). When switching between the two systems, we have to turn off each IOC, toggle the boot selection switch position and switch the power on again. The whole switching between two systems (IOCs and workstations) is easily done in less than 10 minutes.

Testing

As already mentioned, we rarely get time to test and even then only in small timeslots. The first test was done on March, 1st 2008, 9 months since project start, which was already reported at the "Shanghai EPICS collaboration meeting 2008" [2]. It was quite successful, with almost 100% records in place. Then, and later on, we have had to correct a few wrongly addressed channels or similar small configuration errors. We had a total of 8 days (weekends) until October 2008. We were quite confident that even at

that time a switch-over to EPICS could be finally done, provided that we had one week of continuous testing, together with our medical users, to do the integration tests. That was impossible, because it would mean one week without patient therapy, which is totally unacceptable. Since then we did no more testing until August 2009. In August and September we had 5 full day tests (on weekends) and six times a short, 2 to 3 hours (evening) tests.

Miscellaneous

Concurrent to our activities, the medical user group have had to adjust their therapy software. Namely, they use three IOCs as Patient Safety System (PaSS), which are implemented identically as our MRPS. These IOCs are configured by us, using our hardware and our control system software (EPICS version, too), but is not a part of our machine control system. Due to a tight schedule and an aggressive timetable for getting Optis2 and Gantry2 into operation, they did not have any time to adapt the system. In August we have decided to implement ACS to EPICS communication gateway (simplified version, supporting only features they need) directly on EPICS IOCs. With gateway in place, the medical group did not have to do any modifications on the therapy software, and we were able to continue with integration tests.

Statistics

The implementation has been mostly done in a period between Jun 2007 and October 2008. Four persons have been involved, mostly part-time. Table 1 presents the approximate output achieved in that time.

Table 1: Numbers

Name	Approximate value
Man Months	18
IOCs	24 (21 + 3)
Driver configurations	470
Templates	66
Template substitutions	1300
Records (PVs)	44000

Conclusions

Porting the whole (accelerator and beam lines) control system to EPICS (or any other control system) highly depends on architectural similarities of both systems. In our case, with ACS having a thin-server/thick-client architecture and EPICS allowing for all combinations of either thin- or thick- -clients and -servers, the migration was quite easy. It is just hard work to port the drivers and to provide a set of new record types and helper functions (genSub in our case) to simplify the migration process. The next important point was to generate the IOC startup configurations. We have profited a lot by all data in the ACS database. More than half information was directly imported from an ACS database to the new EPICS database. The effort, though, had to be invested in preparing import SQL scripts, and, of course, verifying that it was imported properly. Unfortunately, having tens of thousands of records, it is virtually impossible to check all by hand, or checking each individual PV. Therefore, during almost each of our test days we found a few wrongly addressed records.

The time for testing on a real machine is a very critical point. Our estimate was that one week of continuous and exhaustive tests would have been sufficient. Because we could not obtain it, the process will take longer with respect to the days used and will be much longer in the time span.

Our migration project is progressing, and we expect to switch to EPICS before the end of this year.

REFERENCES

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[2] D. Anicic, "Converting PROSACAN CS to EPICS", EPICS collaboration meeting 2008, SSRF, Shanghai, China, March 2008