UPGRADING THE ESRF ACCELERATOR CONTROL SYSTEM AFTER 10 YEARS OF OPERATION

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Abstract

The ESRF accelerator control system was developed more than 10 years ago and has been running continuously since 1993. At that time the state of the art, in accelerator control, were front-ends based on VME technology and UNIX workstations. Our client server model was written in C with an object-oriented approach and using RPCs on the communication layer. GUIs were based on X11 and Motif.

Since several years we had to address problems on different levels. On the industrial market VME technology was largely overtaken by PC technology. Due to lack of evolution and support we had frozen the OS/9 real-time operating system on our VME front-ends in 1996. The upcoming Web and Java technologies did not integrate easily with our C programming framework.

We decided to upgrade the control system on all layers. On the front-end layer compact PCI crates running Linux are now the workhorses. But, following the industrial market, Windows based front-ends and PCI hardware are gaining more and more ground. On the communication layer CORBA was chosen for its multi language support and its high level of integration. The new control software allows servers and clients to be written in C++ (speed), Java (GUI + Web) and Python (prototyping + sequencing). To ease GUI programming a Java based toolkit and an integrated synoptic editor were developed.

The new control software was designed based on 10 years of experience with a running system. Emphasis was put on control system administration and configuration, code generation, standard data formats and application structuring.

The control system modernisation will take several years and started in 2001. The actual status is given and conclusions are presented.

INTRODUCTION

The ESRF is a 6 GeV synchrotron radiation source and was constructed in the early 1990s. Since 1993 the ESRF is running continously. Today 40 beamlines are available for users, providing more than 5500 hours of beam time per year. The beam availability for users is at 96.8%.

The ESRF control system was designed more than 10 year ago and is based on:

- VME technology running OS/9 and UNIX workstations
- A client server model to implement distributed objects written in C and using RPCs for communication (TACO)[1],[2].
- The graphical user interface (GUI) uses X11 and the Motif toolkit.

During the years several independent sub-systems have been added around the basic control system kernel (data cache, archiving, events, security etc.) with their own configurations, APIs and tools. But, the control system design ends with the client API. Control and machine physics applications have been developed independently using the API.

MOTIVATION

During the last 10 years the technology landscape changed considerably.

- PC hardware dominates the market and industrial control systems.
- New operating systems dominate the market.
- New object oriented programming languages have appeared.
- Internet is becoming a driving force.

These changed boundary conditions brought us to the following conclusions:

- The VME technology of our front-ends is largely overtaken by PC technology on the market. Off the shelf PC hardware offers a big choice. Adapted software is often available on the market, but forces the choice of the operating system.
- The operating system OS/9 on our VME front-ends was frozen in 1996 due to a lack of evolution and support. A replacement with a modern operating system has to be found.
- The Java programming language and Web technologies do not integrate easily in our C programming framework. The integration of C libraries is always platform dependent.
- Specific and unstructured applications written in C with X11 and Motif don't allow the export of information on the Web.

In a research environment like the ESRF it is quasi impossible to freeze the control system because the needs are constantly evolving. If there is no strategy behind the modernisation it will lead to an uncontrolled process that will eventually result in a piecemeal control system of a collection of incompatible parts. To avoid this scenario we decided to start upgrading the ESRF control system on the front-end layer, the communication layer and the application layer to be modern for another 10 years.

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THE FRONT END LAYER

Due to the domination of PC hardware on the market we have chosen it as the base for all our new developments. Compact PCI crates running Linux are now the workhorses. But, following the industrial market, Windows based front-ends and PCI hardware are gaining more and more ground.

During the next years we foresee a replacement of 70% of our VME front-ends with PC hardware. For the remaining 30% the replacement cost cannot be justified. We will replace the old CPUs running OS/9 with an Intel based CPU running Linux. This solution allows us to run compatible software for the machine control system and the beamline control systems, which use a PCI-VME bus coupler to replace OS/9 [5].

On the front-end layer we foresee an increasing use of dedicated intelligent controllers directly connected to the network. In this perspective we decided on a network upgrade to increase the network speed, the number of sub-networks and the number of possible network connections.

Table 1: Front End Layer Upgrade

1993	2003
Ethernet 10Mbps-shared	Ethernet 100Mbps-switched
VME	cPCI and PCI Dedicated Controller
OS/9	Linux and Windows

TANGO

TANGO [3],[4] is developed as the successor to TACO in collaboration with the synchrotron SOLEIL in Paris, France [6].

On the communication layer we have chosen CORBA for its multi language support and its high level of integration. TANGO allows servers and clients to be written in C++ (speed), Java (WWW + GUI) and Python (prototyping + sequencing).

Designed with 10 years of experience on a running control system, the emphasis was put on:

- Coherence: Every service is implemented as a standard TANGO server.
- Configuration: configuration off all services from one central point.
- Control system administration: remote startup and stop, surveillance, black box, startup levels, etc.
- Code generation: To allow faster development and to enforce documentation.
- Standard data formats: To write generic applications and to display data in a coherent way.
- Application structure: Reuse of application code, standard look and feel and rapid application development up to the synoptic level.

TANGO is available for Solaris, Linux and Windows. Its application toolkit is developed in Java and contains basic application building blocs as well as an integrated synoptic editor.

Table 2: Control System Core Upgrade

TACO	TANGO
OS/9, Solaris	Linux, Windows, Solaris
RPC	CORBA
C	C++, Java, Python
Core contains: Server API Client API Database Service Test Applications	Core contains: Server API (multi language) Client API (multi language) Database Service + Appli Administration Service + Appli Logging Service + Appli. Event Service Application Toolkit Code Generator + Appli. Generic Applications

STATUS

The ESRF control system modernisation is programmed over several years and started already two years ago.

Network

The network upgrade to a fully centralised, switched 100Mbps network was finished last year. The installation of a large number of multimode fibre optic cables allows now a multiplication of network nodes.

The wired network was complemented with a wireless network based on the 802.11b (WiFi) standard (11Mbps) for local hardware configuration and diagnostics.

Frond End Layer

On top of the installation of new front-end PCs, the replacement of VME crates is in progress. At the end of this year about 30% of our VME front-ends will be replaced with new hardware.

For 30% of our VME front-ends the replacement cost cannot be justified. For those front-ends we have chosen a new Intel based CPU and started the porting of hardware drivers and control software from OS/9 to Linux. During the winter shutdown OS/9 will be replaced on a first font end of the RF system.

Table 3: Upgrade Statistic

Hardware	Action
Compact PCI Racks	22 racks installed 19 running Linux 3 running Windows
Industrial PCs	39 PCs installed 35 running Linux 4 running Windows
VME Racks	92 racks initially in place 27 racks replaced 1 rack ported to Linux
Networked Controllers	25 new controllers connected in 2002 and 2003

TANGO

The TANGO core runs reliably at the ESRF and at SOLEIL. A packaged source code release is available and can be downloaded [3]. The structure and the features supported by TANGO are constantly discussed and improved.

Deployment of servers and applications is progressing. At the ESRF, 80 servers are controlling hardware and about 15 applications have been developed with the TANGO application toolkit.

Ongoing developments for this year are:

- Finish the integration of Python. The client API is available, but the server API is still under development.
- The first version of the archiving service is under test. It is based on an Oracle or a MySql database. Configuration and extraction applications are also under development.
- New services are requested for security, scanning, sequencing or taking snapshots.
- The interoperability of TACO and TANGO needs to be improved. This will ease the continuous migration at the ESRF, but will also open the way for TANGO into the TACO collaboration with the new neutron source FRM-II [7] in Garching, Germany and the HartRAO [8] telescope in South Africa.

CONCLUSION

The upgrade process is on its way and will continue for the next years. Coming from a homogenous system (VME, OS/9 and C) our preference would be an upgrade to another homogenous system using new technologies. Unfortunately, the actual situation on the hardware market and the constant evolution of IT technologies doesn't allow this choice without heavy restrictions. All choices made need to be constantly re-evaluated over the next years.

Some lessons we learned during the modernisation are:

- With the increasing number of devices connected to the network, network structuring and diagnostics become very important
- The support of different hardware platforms with fast evolving technology and fast evolving operating systems is a challenge for system administration and a problem for spare part management.
- Another critical issue is the training of support people. The complexity of the system increases when using multiple programming languages and two different communication layers on top of several operating systems. Automatic surveillance and diagnostic applications for hardware and software are important to ensure quality.
- To integrate new control software into a running system needs a very high level of backward compatibility. The evolution of the control system must be transparent to the users.
- When upgrading a reliable control system, an effective quality control procedure is necessary, to insure the quality of software developments.
- A clear gain of functionality is important to motivate users and developers and can compensate for some instability induced when upgrading a sub-system.
- The balance between a homogenous control system, money, manpower and the benefits of fast evolving IT technologies has to be found

But, in spite of all problems, opening-up the way for new technology and new features motivates developers and users. A simple upgrade often leads to a complete redesign of a sub-system.

REFERENCES

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