UNICOS: AN OPEN FRAMEWORK

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Abstract

In early 2001 a control system called UNICOS (UNified Industrial COntrol System) developed at CERN with the objective of building the LHC cryogenics control system was commissioned for the first time. It deployed the controls layers covering the SCADA (Supervisory Control And Data Acquisition) and the PLC (Programmable Logic Controllers) layers. A possibility of re-targeting the system on other kinds of applications and environments was identified. Since then, the framework proposes a reusable environment composed of a set of components for the SCADA part and several solutions for the front end part (i.e. other than PLC). Together with the description of the UNICOS environment, the paper presents a number of very different applications developed at CERN based on the UNICOS methodology: (1) SURVEY, to align the focusing magnets of the LHC located on both sides of the experiments; (2) Quench Protection System, to display and act on the devices used to protect the superconducting elements of the LHC; (3) Powering Interlock Controller, to manage the powering permissions of the electrical circuits making the LHC.

UNICOS

UNICOS was born at CERN in early 2001 with the development of the LHC cryogenics control system. The goal was to create an industrial control system covering the three layers of the typical automation pyramid: the field layer with field equipment, the control layer with PLC (Programming Logic Controller) and the supervision layer based on a SCADA toolkit (Supervision Control and Data Acquisition). In order to ensure a rapid start-up by easing the manual interventions on the control logic and HMI (Human Machine Interface) views generally required during the commissioning and maintenance, automatic data-driven generation tools were developed.

UNICOS is based on a well-defined set of standard devices covering most of the equipment and the needs of a continuous control process such as the cryogenics control; also it enforces a method for programming the process control logic.

Based on the first implementation of UNICOS and following the needs for other types of control and/or monitoring systems the UNICOS framework was formalized.

THE UNICOS FRAMEWORK

UNICOS is a CERN framework developed to produce control applications for two/three layers control systems. UNICOS provides developers with the means to rapidly develop full control or monitoring applications and provides operators with ways to interact with all the items of the process from the most simple (e.g. I/O channels) to the high level compound devices with little effort. In addition UNICOS offers tools to diagnose problems in the process, the control system and to access and operate the devices without specific development.

The framework proposes a reusable environment composed of a set of components for the supervision and the front-end layers:

- UNICORE where packages can be added.
- A basic package called UNICOS Continuous Process Control (CPC) is offered to develop process control applications.

A package is a set of generic software components combined together and configured to produce a control and/or monitoring application. Tools to create new packages are also provided.

In addition to the CPC package, other packages have been developed to cope with new applications. Such packages cover mainly the development in the supervision layer. Three of these packages will be described here: SURVEY [5], Quench Protection System (QPS) and Powering Interlock Controller (PIC).

UNICORE

UNICORE (Fig. 1) is deployed in two layers: the supervision and the process control layers. It is based on PVSS II® [1] and reuses some of the Joint COntrol Project (JCOP) framework components [2]. At the supervision level, in both Linux and Windows operating systems, the following functionality is offered:

- Application distribution in many SCADA data servers and handling of the connection state.
- Monitoring the integrity of the application (e.g. status of the front-end).
- Interface to the LHC Software suite (LHCLogging, LASER Alarm System and Post-Mortem Data Analysis System).
- Client and Server Controls MiddleWare (CMW) interface.
- Interface to include additional packages.
- Device and file access control, based on the JCOP access control [3] with as many domains as needed and four privileges per domain and with LDAP (Lightweight Directory Access Protocol) feature.

UNICORE was also developed to offer UNICOS application developers a configurable user interface which does not require neither the knowledge of the PVSS scripting language and nor the use of basic PVSS interfaces. In addition it offers operators a homogenous user interface that is entirely customizable with features such as navigation capabilities between panels and trends (WWW browser like, contextual buttons, pop-up navigation), access to the devices without creating a panel (tree device overview), process alarm and event list.

The supervision device hierarchy is based on a *front-end device* containing *process devices* (time stamping in

the front-end is allowed). Typical examples of front-end devices are PLCs, Front-End Computers (FEC), OPC servers; while process devices are Analog Input, Digital Input, etc. A device includes some libraries of code, a set of widgets (summarized view of the device status), a faceplate (detail view of the device) and the device actions interface. A tool is provided to import the front-end and process device configuration into the supervision layer (PVSS).
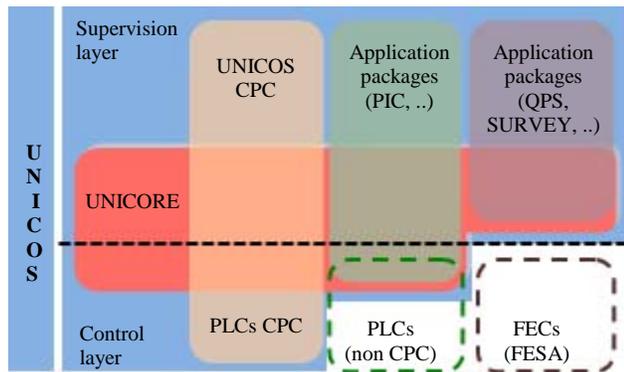

Figure 1: UNICOS framework and applications packages.

At the front-end level the UNICORE implements the communication protocol with time stamping at the source and optionally an event publishing mechanism (TSPP).

Reusing these features allows the developer to focus on the particular package application development.

A developer of a UNICOS supervision application does not need any PVSS scripting knowledge. He has to import the front-end and process devices, to create the panels of the process views with the catalogue of device widgets and to configure the trends.

UNICOS CPC: Continuous Process Control

The UNICOS CPC package proposes a method to design and develop complete process control applications. It is based on the modelling of the process in a hierarchy of devices (I/Os, field and abstract control devices). These devices are used as a common language by process engineers and programmers to define the functional analysis of the process. The package is deployed both in the supervision layer and in the PLCs (Schneider and Siemens). Examples of existing applications using the CPC package are the LHC cryogenics control and the LHC Gas Control System (GCS).

In addition to the methodology, tools have been developed to automate the instantiation of the devices in the supervision and process control layers and generate either skeletons or complete PLC programs. The production of control code with this methodology is generally data-driven and for some projects (LHC GCS and Sector Cryogenics control) a complete model driven software production tool has been implemented. Customized devices can be added to the CPC package to cover new client requirements increasing the functionality of the package.

SURVEY

The SURVEY package is used to build the application to align the focusing magnets of the LHC located on both sides of the experiments. This control system covers the three layers (Fig. 2): the UNICORE and the SURVEY package at the SCADA level, the front-end layer implemented using the Front-End Software Architecture (FESA) framework [4], and the field layer with equipment connected to the WorldFIP fieldbus.
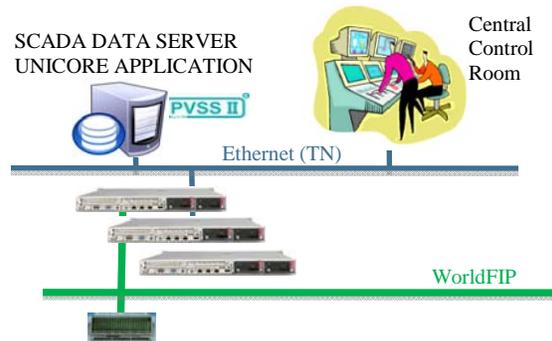

Figure 2: SURVEY architecture.

The SURVEY package contains the PVSS devices: high precision measurement instruments (Fig. 3), actuators (stepping motors), WorldFIP agent, etc. These devices have their counterpart in the front-end layer. The development of the SURVEY package was largely simplified by using the common features provided by the UNICORE component: CMW interface, tree device overview, process alarm, event list, external interface and the basic user interface among others.
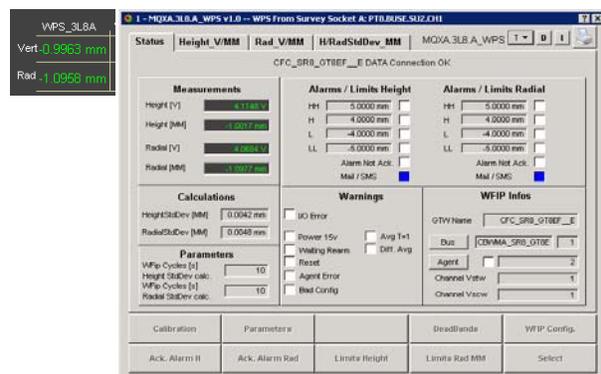

Figure 3: SURVEY device widget and faceplate.

QPS

The QPS package is used to build all the Quench Protection System applications to display and act on the devices used to protect the superconducting elements of the LHC. The control architecture is similar to the SURVEY application (Fig. 2): the UNICORE and the QPS package at the SCADA level, the front-end layer implemented using the FESA framework [4], and the field

layer with radiation-hard equipment connected to the WorldFIP fieldbus. This equipment includes the fast readout and control system to protect the superconducting magnets and the superconducting elements (e.g. current leads) of the powering circuits as well as the control and monitoring system of the energy extraction switches.

The QPS package contains the PVSS devices (Fig. 4) corresponding to the front-end devices in the field. The front end application monitors the QPS process devices; the timestamp of the data is read from the QPS field equipment which is timed synchronized by the front-end. The CMW interface of the UNICORE is used extensively to subscribe to all the front-end devices producing data and for publishing data to different partners: PIC, hardware commission software, etc.
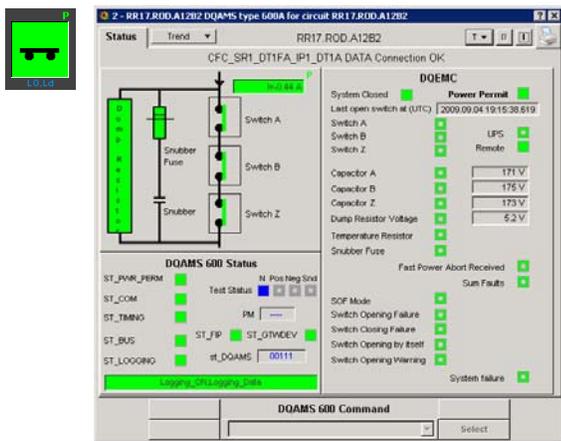

Figure 4: Example of a QPS device widget and faceplate.

The following features of the UNICORE component are also used:
- Access to the device via the tree device overview.
- Grouping of devices by circuit, circuit type, interlock type, etc.
- Trend tools in the device faceplate.
- Application distribution: the QPS application is distributed in 16 SCADA data servers connected to the LHC_CIRCUIT application [6].

PIC

The PIC (Powering Interlock Controller) package is used to manage the powering permissions of the electrical circuits connected to the LHC magnets. The control architecture is a three layers design: the SCADA layer, the front-end layer and dedicated signal conditioners. Due to a 1msec readout constraint, the type of application and the design of the PIC hardware, the UNICOS CPC package could not be used at the front-end level. However the front-end application was developed with the front-end UNICORE TSSP protocol and deployed on standard Siemens PLCs. At the supervision level, it reuses the UNICORE (Fig. 5) features to implement:
- A multi grouping mechanism to group the device by circuit, circuit type, interlocks type, etc.

- Widget interface: circuit widget to show the state of one circuit of the PIC, PIC device widget.
- A device access control with many user configurations.
- A post-mortem interface: to send automatically the history of the PIC data in case of an event.
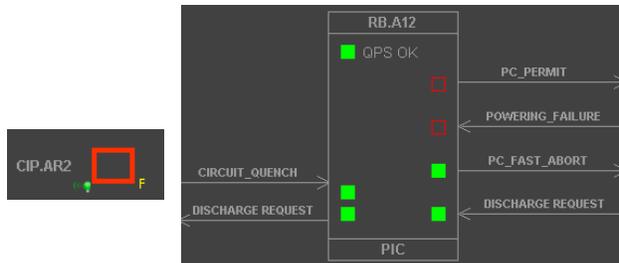

Figure 5: PIC device widgets.

The PIC collects data from many applications: cryogenics, timing, QPS, etc. via the CMW interface of the UNICORE. Many calculations are done with this data mapped to CPC devices to give the summary states of each powering sub-sector.

CONCLUSION

Since a few years, the UNICOS framework is used intensively in different kind of applications dealing with various front-ends like PLCs and FESA front-ends. It has demonstrated its re-usability in many control applications from feedback control to monitoring systems. The list of use cases described here is not exhaustive: many other non CPC-package UNICOS applications have been developed like the Cryogenics Instrumentation Expert Tool (CIET) or the Warm Interlock Control system (WIC). Despite of the size of the applications in terms of connected channels and their apparent diversity, these developments have been done and are maintained by a small team.

REFERENCES

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