# OPENING THE FLOOR TO PLCS AND IPCS: CODESYS IN UNICOS

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*Abstract*

This paper presents the integration of a third industrial programming environment for process control applications with the **UNICOS** (Unified Industrial Control System) framework at CERN.

The UNICOS framework is widely used in many process control domains (e.g. Cryogenics, Cooling, Gas Systems, Ventilation, Vacuum…) to produce highly structured standardized control applications for the two CERN approved industrial PLC product families, Siemens and Schneider. The CODESYS software suite, developed by the **3S** (Smart Software Solution), provides an independent IEC 61131-3 programming environment for industrial controllers [1].

The complete CODESYS based development includes: (1) a dedicated Java™ module plugged in an automatic code generation tool, the UAB (UNICOS Application Builder), (2) the associated UNICOS baseline library for industrial PLCs and IPCs (Industrial PC) CODESYS v3 compliant, and (3) the Jython-based templates to deploy device instances and control logic. The availability of this development opens the UNICOS framework to a wider community of industrial PLC manufacturers (e.g. Beckhoff, ABB, WAGO…) and, as the CODESYS control Runtime works in standard Operating Systems (Linux, W7…), UNICOS could be deployed to any IPC.

## INTRODUCTION

The development of the UNICOS (Unified Industrial Control System) framework started in 1998 for the implementation of the LHC cryogenic control system [2]. One of the goals of this framework was to homogenize industrial process control applications independently of the domain, by sharing a common library and software architecture and also by defining common coding rules amongst all developers. Having a common structure was the base of creating automatic code generation tools. At the control level, the existing implementations are devoted to produce all necessary source code for CERN standard PLCs: Schneider (PL7/Concept) and Siemens (Step 7).

During the last years **PLCs** (Programmable Logic Controllers) have been largely evolving adopting new technological trends. They are not anymore considered as isolated single purpose proprietary machines but rather as open machines being able to be programmed with high level programming languages and to communicate through a variety of standard protocols.

ARC Advisory Group coined a term to differentiate PLCs and others machines with more advanced features: the so-called **PAC** (Programmable Automation Controllers) though nowadays it is difficult to differentiate them.

In parallel, the **IPC** (Industrial Personal Computer) has emerged in the automation world as a general-purpose computer but ready to be deployed in harsh environments with components adequately selected (e.g. industrial protection, ruggedized aspect, redundant power supplies...). These controllers, which are powerful machines, are able to run faster and can handle special tasks requiring more computing capabilities than a classic PLC.

Therefore the scope of the UNICOS framework has been enlarged to deal with this new emerging field where IPCs are used to perform process control duties. Hence, following a technological survey, CODESYS was selected; it complies with the PLCopen XML standard, which specifies an XML scheme for IEC 61131-3 languages and claims to be platform independent.

## THE UNICOS FRAMEWORK

The UNICOS framework is used at CERN from more than ten years for process control applications based on PLCs and also for applications dedicated to monitoring and supervision [3]. The component of the framework specifically dedicated to process control is identified as the UNICOS-CPC (Continuous Control Process) [4] package.

It is used to build process control applications from a well-defined library of generic objects. Those objects model real components of the control system such as inputs, outputs or field devices (analog valves, heaters….). Table 1 gives a detailed list of all of objects with their basic category.

The UNICOS-CPC package provides the means of building process control applications in the two layers of a classical process control pyramid: control and supervision. The communication between the control components of these two layers is also provided by the package:

- The supervision layer is built in a commercial SCADA (Supervision Control and Data Acquisition). The commercial tool employed here is WinCC OA (Open Architecture) by Siemens.
- The control layer is based on PLCs and it is compliant with the two CERN standard industrial programming environments: Siemens Step 7 and Schneider UNITY and a new one platform independent: CODESYS.
- The communication layer implement an in-house event based protocol (TSPP: Time Stamp Push Protocol) over both, Siemens S7 and Modbus TCP/IP protocols.



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Table 1: UNICOS-CPC Objects

| Name | Function | Category |
|---|---|---|
| DI | Digital Input | I/O |
| DO | Digital Output | |
| AI/AIR | Analog Input (Word/Real) | |
| AO/AOR | Analog Output (Word/Real) | |
| xPAR | Digital/Word/Real Parameter | Interface |
| xStatus | Word/real Status | |
| Analog | Valve, Heater | Field |
| OnOff | Valve, Motor, Pump | |
| AnaDig | PWM, slide valves | |
| AnaDO | Pump, Frequency Variator | |
| Local | Local hand valves | |
| MFC | Mass Flow Controller | |
| xAlarm | Analog/Digital Alarm | Control |
| Controller | PID controller | |
| PCO | Process Control Unit | |

The first code generation tool based on Microsoft Access, with dedicated tools for both Schneider and Siemens showed some shortcomings when managing large projects with several thousands of base objects. The importance of the scalability and flexibility has pushed us to produce a new generation tool based on the latest software engineering concepts: the **UAB** tool (UNICOS Application Builder).

## CODESYS DEVELOPMENT ENVIRONMENT

CODESYS (Controller Development System), a 3S-Smart Software Solutions GmbH [5], is a software suite designed to fulfill the requirements of modern industrial automation projects. It turns industrial PCs and compact embedded devices into IEC 61131-3 controllers.

The product has reached maturity proving its reliability and robustness in industry. The 3S marketing policy offering this tool without copy protection licensing has had an additional advantage helping to increase its popularity. Around 300 manufacturers have integrated this product as the development environment for their hardware. The integrated compiler transforms the CODESYS control code into native machine code to be downloaded to the hardware. The most popular CPU families are supported.

The product release V3 is based on modern languages (e.g. XML, C++, java) and offers a good flexibility in its integration to external software plug-in modules.

Another major advantage of this product is its capacity to be executed as an independent runtime system into Windows or Linux operating systems.

Nowadays many manufacturers on the market offer a large choice of hardware IPCs with CODESYS. In opposition to a standard PLC, the internal memory of an IPC is far less constrained in terms of size and IPCs running CODESYS can therefore integrate complex algorithms developed in high level programming languages (e.g. C++).

Many manufacturers desiring to follow the IEC 61131-3 have selected CODESYS to extend their device specific software. This gives the following advantages:

- Select the most suited platform for the real needs regardless of supplier.
- Avoid supplier specific language-extensions that prevent the inter-changeability.
- Reduce cost and time for migrating from devices manufactured by different vendors.
- Reduce the task of porting a program from one vendor's programming software to another.

The IEC standard does not define a standard file exchange format between the different manufacturers. The *PLCopen* organization [6] has provided a standard XML scheme for all IEC languages, which is supported by CODESYS V3 for importing and exporting PLC code.

## CODESYS INTEGRATION IN UNICOS

The integration of CODESYS implied the development of a new module in the UNICOS-CPC package including:

- a dedicated Java™ module plugged in the UNICOS automatic code generation tool (UAB)
- the associated UNICOS baseline CODESYS v3 compliant library for industrial PLCs and IPCs
- the *Jython*-based templates to deploy device instances and the specific process control logic.

### *Automatic Generation Tool*

The UAB is composed of several technology-oriented components: PLCs, local touch panels and SCADA. Two new plug-ins have been created for the generation of the CODESYS-based application (object instances and the process control logic). A third plug-in shared by Schneider and CODESYS is used for the generation of the supervision configuration database, which will be later imported in the SCADA.

The input information of the UAB CODESYS component are similar to the one used by Siemens and Schneider:

- The specification file based on the real instrumentation, on the functional analysis of the plant and containing all the instances of the CPC objects.
- The Logic User Templates that define the specific process control logic of the particular application. A default template is provided to the user as a base, but the process control engineer can develop his own.
- The configuration parameters, which should be filled in a wizard to define the PLC-SCADA communication parameters and the mapping of the PLC memory according to the needs of the project.

The plug-ins are developed in Java™, while the Templates use a scripting language: *Jython*. The format of the specification file is based on *xls/xml*.

The UAB generated output files are:



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- The controller instances: all the UNICOS-CPC objects described in the specification file are represented by a POU (Programmable Organization Unit). In each POU all the instances of this object are executed.
- The controller communication: it contains all the necessary parameters (e.g. IP address…) required from the PLC/IPC to establish the communication with the SCADA.
- The process control logic: it contains the specific logic required by the specifications of the plant control.
- The topology: this file defines the cycle scan and the execution order of all the application POUs.
- The supervision database: a file containing all CPC objects instances of the application. It has also the communication parameters for the IPC access and also the mapping of all signal addresses to be exchanged with the IPC. This is imported in the SCADA project that is created to supervise the PLC application.

The format of the first four output files is PLCopen XML. These files are afterwards imported in the CODESYS integrated software. The latter file format is text-based and will be imported in the WinCC OA SCADA system.

Figure **1** shows the integration of the UNICOS-CPC plug-ins used for the generation of a CODESYS based application in the UAB generation tool.

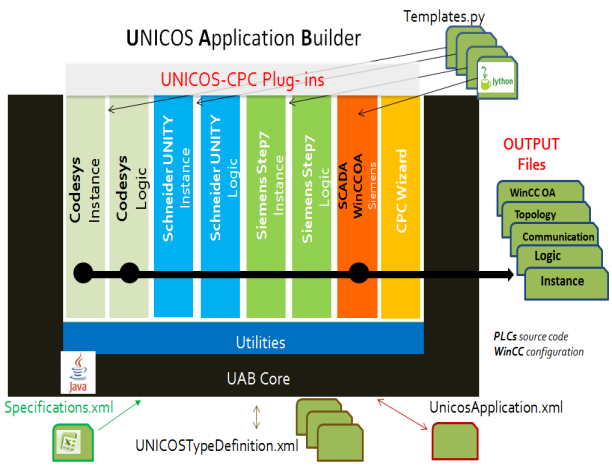


Figure 1 - UAB architecture.

## *UNICOS-CPC CODESYS Baseline*

To develop a UNICOS-CPC application with CODESYS the following pieces are required:

- Baseline
- Hardware configuration
- Output files generated by UAB

The *Baseline* is a library containing the basic UNICOS-CPC Object Types, parameters, communication functions and recipe functions. The use of common libraries was privileged to support the inter-changeability between different vendors, and in the cases that this could not be done dedicated functions were created (e.g. PLC time management, start-up conditions, Modbus communications…).

The communication functions consist of function blocks, which define the communication mechanism between the PLC and the SCADA. They are based on Modbus/TCP extended by the TSPP protocol.

The summary of the procedure is shown in Figure 2.

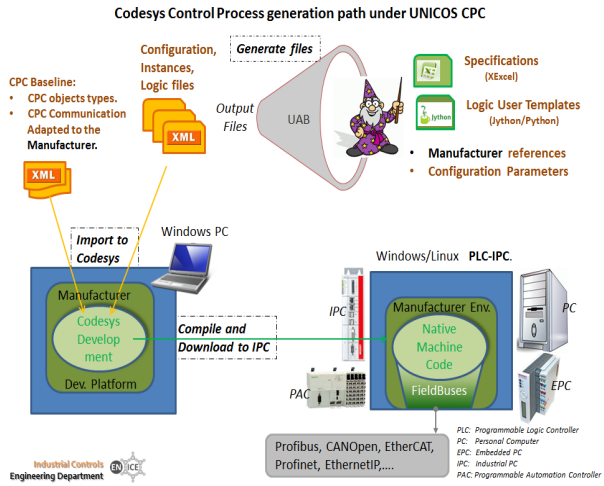


Figure 2: UNICOS-CPC CODESYS procedure.

The supported IEC-6113-3 languages for this integration are the *ST* (Structured Text) and *SFC* (Sequential Function Chart) from the CODESYS V3.5 SP1 Patch 4 release

## *Compatible Software Suites and Use Case*

A large number of manufacturers integrate CODESYS into their own software. As a proof of concept we are focusing our developments in two different software suites: (1) Schneider *Somachine* and (2) Beckhoff *TwinCAT*.

*Both, TwinCAT* V3 and *Somachine* V3 support PLCopen XML format, the latter only in the case of the ST language.

To validate the approach, a simple but yet real process is used. Two water tanks ensure the water feeding into a third one at a desired temperature. It includes tanks, pumps, valves and classical industrial instrumentation. A dedicated HMI representation can be seen in Figure 3. The application is built with a Schneider M258 PLC with *Somachine*.

This is the first CODESYS implementation with UNICOS-CPC. The whole system is monitored and controlled by our SCADA.



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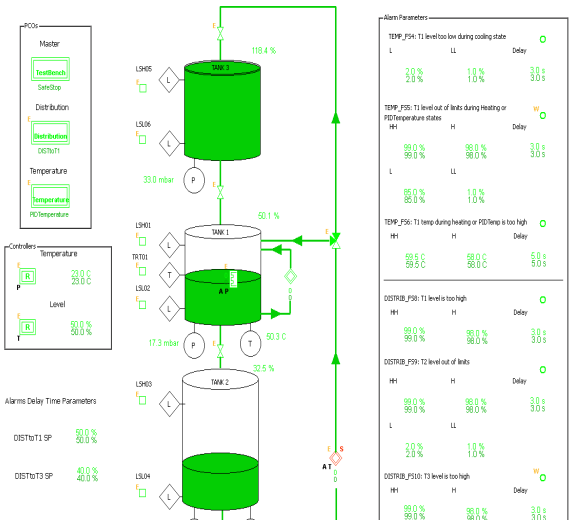

Figure 3: Water tanks process HMI.

## CONCLUSION

The industrial automation world is continuously making steps towards the establishment of standards. PLC programming is a field that deserved special attention. Despite the fact that IEC standards for the programming languages already existed, the PLC manufacturers have until now adopted and customized them inside their environments, which usually incorporate proprietary components making it difficult to port the code to another platform.

Also, the arrival of more powerful controllers, IPCs, has pushed the vendors to offer IPC based products which better suit the automation needs of their clients.

UNICOS-CPC allowed the development of the process control applications independently of the CERN standard hardware controller platforms: Siemens and Schneider.

The CODESYS environment was introduced in the UNICOS framework to attain code portability to compliant platforms.

This combination allows the automation engineer to focus on the specific process control logic of the plant rather than adapting to the specificities of the hardware platforms. It opens the door to new hardware platforms (e.g. IPCs and PACs) but also to other PLC suppliers (e.g. Beckhoff, WAGO…) keeping the UNICOS standardization and maintaining a single but still common supervision layer.

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