UNICOS CPC NEW DOMAINS OF APPLICATION: VACUUM AND COOLING & VENTILATION

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Abstract

The UNICOS (**UN**ified **I**ndustrial **CO**ntrol **S**ystem) framework, and concretely the CPC (Continuous Process Control) package, has been extensively used in the domain of continuous processes (e.g. cryogenics, gas flows) and also in others specific to the LHC machine as the collimators environmental measurements interlock system. The application of the UNICOS-CPC to other kind of processes: vacuum and the cooling and ventilation cases are depicted here.

One of the major challenges was to figure out whether the model and devices created so far were also adapted for other type of processes (e.g. Vacuum). To illustrate this challenge two domain use cases will be shown: ISOLDE vacuum control system and the RFQ4 and STP18 (cooling & ventilation) control systems. Both scenarios will be illustrated emphasizing the adaptability of the UNICOS CPC package to create those applications and highlighting the discovered needed features to include in a future version of the UNICOS CPC package.

This paper will also introduce the mechanisms used to optimize the commissioning time, the so-called virtual commissioning. In most of the cases, either the process is not yet accessible or the process is critical and its availability is then reduced, therefore a model of the process is used to validate offline the designed control system.

UNICOS-CPC BASICS

UNICOS (UNified Industrial COntrol System) with its CPC (Continuous Process Control) package is a control framework which was created to design, develop and finally deploy control systems applied mostly to industrial continuous processes [1].

UNICOS-CPC intervenes in the three classical layers of an industrial control system although provides deliverables only for the control and supervision layers. (1) At the field layer, actuators (e.g. valves, pumps...) and sensors (e.g. temperature or pressure measurements) are extensively described in the UNICOS-CPC control system specifications. (2) At the control layer, the framework provides both, a PLC (Programmable Logic Controller) baseline with basic objects and methodology to design the control system.

After an UNICOS unit-oriented design, the process control architecture is defined. A basic structure containing specific devices (e.g. process control units, field objects…) and the interactions between them will be automatically generated. In most of the cases the user introduces the process specific control logic in predefined placeholders keeping the consistency and homogeneity of different applications. (3) At the supervision layer, the so-called SCADA (Supervisory Control and Data Acquisition) layer, the UNICOS-CPC framework will provide also a baseline with all the devices mentioned before and the peer instances already created for the control layer.

Populating those instances, which are automatically generated for the layers of control and supervision, naturally avoids the synchronization problems between them. In addition, the communication resources for the PLCs and the SCADA are also provided and deployed in both layers. Only the control logic, which is process dependent, has to be coded by the control developer.

All plant actuators and sensors are modeled as one or combined in several UNICOS types. The idea of UNICOS-CPC has always been to keep the devices as generic as possible willing to homogenize both design and operation. As a practical example, motors, pumps and digital valves are modeled with a basic type called *OnOff*.

Other UNICOS-CPC strength is the plant operator capability to intervene any time and any place in the plant through its control components. To achieve this, all field objects (e.g. valves, pumps, heaters…) never have direct access to the I/O of the PLCs but through appropriate I/O types. A general view of the UNICOS-CPC objects can be seen in Fig. 1. There are four types of objects: (1) I/O objects (e.g. Analog Input) which link the sensors cabled on a particular channel to the control system, (2) the plant actuators are then modeled by field objects (e.g. OnOff for discrete and Analog for analog actuators). (3) The control objects (e.g. Process Control Object) drive a group of field objects. The controller object (PID) is used for feedback control, and finally the (4) the interface objects used to parameterize alarm thresholds or showing basic plant status.

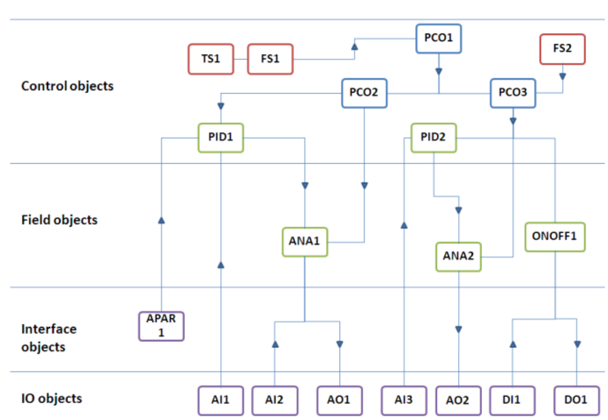

Figure 1: UNICOS-CPC objects hierarchy.

The advantage of a high granularity of types, which gives the framework a great versatility to combine objects to model new needs, could also be judged as an overload in new domain devices where an integration to create more complex devices is likely advisable.

The UNICOS framework was born in 1998 and was firstly used in the LHC cryogenic system. After some evolution and application to other processes (gas flows, interlocks…), we face another challenge: validate the approach in other different domains close to the continuous processes but still with additional requirements.

When CERN decided to replace the out-phased vacuum control system in ISOLDE, we had to check the validity of the UNICOS-CPC in a completely different domain: the vacuum. ISOLDE is a physics facility dedicated to the production of a large variety of radioactive ion beams for a large number of experiments. The vacuum was essential and a high critical component of the installation.

A new challenge started when CERN decided that the control systems of all CERN cooling and ventilation plants had to be done using the UNICOS-CPC framework. More than 150 installations, new and existing, will be deployed using the framework. A brief report of the first installations is provided in this paper.

UNICOS-CPC APPLIED TO VACUUM CONTROL

In large physic experiments, vacuum systems are vital to keep a beam of particles alive and also compulsory in employing cryogenic systems and superconducting magnets. Vacuum can, depending on the experiment, be more or less critical and then the choice of actuators and sensors employed will highly depend on these needs. Other characteristics of the vacuum process are the high repeatability of the control system together with the absence of feedback regulation and predominance of discrete systems.

Vacuum systems are mostly composed by a set of different kind of pumps (e.g. primary, turbomolecular...), and different kind of pneumatic or electrical valves. The measurements are mostly focused on pressure sensors with different ranges of validity.

Most of these devices are usually found in different domains, concretely in the continuous process industry. This is one of the reasons why we believed that the UNICOS-CPC framework was adequate to vacuum installations. The existing UNICOS-CPC types library easily fitted the vacuum requirements.

The ISOLDE vacuum control system was the first vacuum system built with the UNICOS-CPC framework [2]. The vacuum of ISOLDE contains 19 vacuum sectors, 13 pumping stations, 2 venting systems and 1 exhaust facility; see the Fig. 2 where a plant schema is represented. All these subsystems are composed of the devices depicted in Table 1.

Table1: ISOLDE Equipment

Equipment	Number
Valves	180
Turbomolecular pumps	30
Primary pumps	20
Pirani gauges	80
Penning gauges	20

All the penning and Pirani gauges are connected to TPG300 controllers. These controllers are then connected to the PLC via Profibus, an industrial fieldbus.

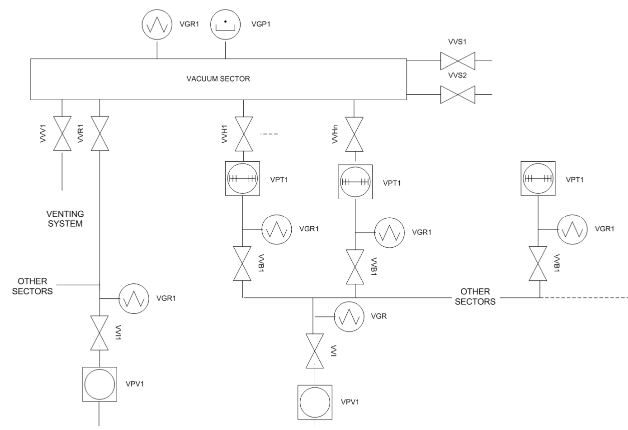

Figure 2: Plant schema of an ISOLDE vacuum sector.

This type of process is highly repeatable. All the vacuum sectors are very similar in ISOLDE and only the number of turbomolecular pumps and its attached valves varies. The goal with installations of this type is to create a set of templates to generate automatically the associated logic only depending in a parameterization. (See Fig. 3). These parameters are the only interaction with the process expert. Once that information is in the UNICOS-CPC spreadsheet specification, the control system logic is automatically generated without a single line of code typed by the developer. This approach considerably saved time for the control system development and for the subsequent upgrades.

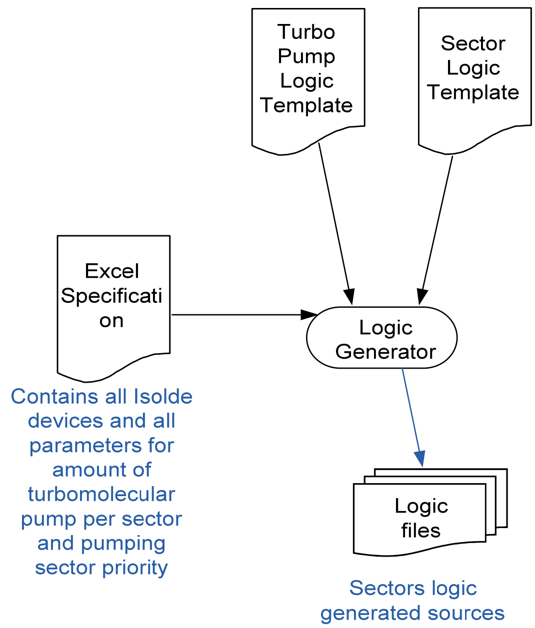

Figure 3: Principle of automatic logic generation.

Following the same philosophy, the operation synoptics were described as templates and with only a few parameters introduced, all the supervision synoptics were automatically created. Again a precious time saved for both, development and maintenance.

The ISOLDE control requirements were challenging. Pumping sector priority management, possibility to manage vacuum level sector by sector and the criticality of the exhaust facility to avoid an undesired release of the irradiated gases contained in ISOLDE, were easily managed with UNICOS-CPC by only parameterization in the control specification.

As an example of matching vacuum devices to UNICOS-CPC objects, the case of the TPG300 vacuum device measuring the pressure combining Pirani and Penning gauges could be analyzed. The final solution combined several basic UNICOS-CPC types to keep the minimum functionality required: only the analogue values and statuses were extracted from the devices and placed in appropriate based UNICOS-CPC objects.

The extraction of all of the information coming from such devices will end up in combining several I/O and interface basic objects. This was one of the motivations to make evolve the UNICOS-CPC framework: to cope with the need of being more flexible in the creation of new types when required. The new UNICOS-CPC v6 package provides the tools to create easily new types in a standard way [3]. This increases the flexibility of UNICOS-CPC to produce new control functionalities and to fulfil operators and process engineers requirements.

UNICOS APPLIED TO COOLING & VENTILATION CONTROL SYSTEMS

Cooling and Ventilation (CV) systems embed very large types of processes. Cooling systems allow the production of cold water by means of chillers or refrigeration towers. They are mainly composed by industrial devices like valves, heat exchangers, compressors, pumps and fans. This kind of processes can be classified as continuous. Then, the HVAC (Heating, Ventilation and Air Conditioning) are performed by air handling units ensuring the control of the indoor air quality (temperature, humidity, oxygen, cleanness). In the scope of accelerators and large experimental physics, the ventilation must be ensured inside tunnels, experimental caverns, experimental halls or computing centers. HVAC systems are also composed by industrial equipments (e.g. heat exchangers, heaters, fans, dampers, valves, filters…).

The control of a refrigeration cooling plant, called STP18 (See Fig. 4), and the cooling of the radiofrequency quadrupole for the future CERN LINAC (RFQ4) were deployed using the UNICOS-CPC package. Once more the framework showed its nature of adaptation to new process domains.

Concerning air handling units, the first control projects are starting up using UNICOS-CPC. Due to the nature of such processes and to handle the new requirements imposed by HVAC systems, the UNICOS-CPC basic package has been enriched with new operation widgets (equipment representation) in a first stage.

The UNICOS-CPC v6 includes the needs in terms of new types and requirements coming from its application to this new domain. These include a new library of HVAC widgets, a color library to show flows of different fluids (e.g. water, gas,…) and additional features such a more secured interlock handling system on some field equipments and automatic integration of regulation structures (e.g.: cascade control).

Moreover, due to different operation needs in Cooling and HVAC systems, where control rooms are not necessarily present and where operation is done via industrial local panels, UNICOS-CPC has been embedded in industrial touch panels in order to ensure local operation at any time.

In the next years, most of Cooling and Ventilation systems at CERN will be progressively upgraded using the UNICOS-CPC framework.

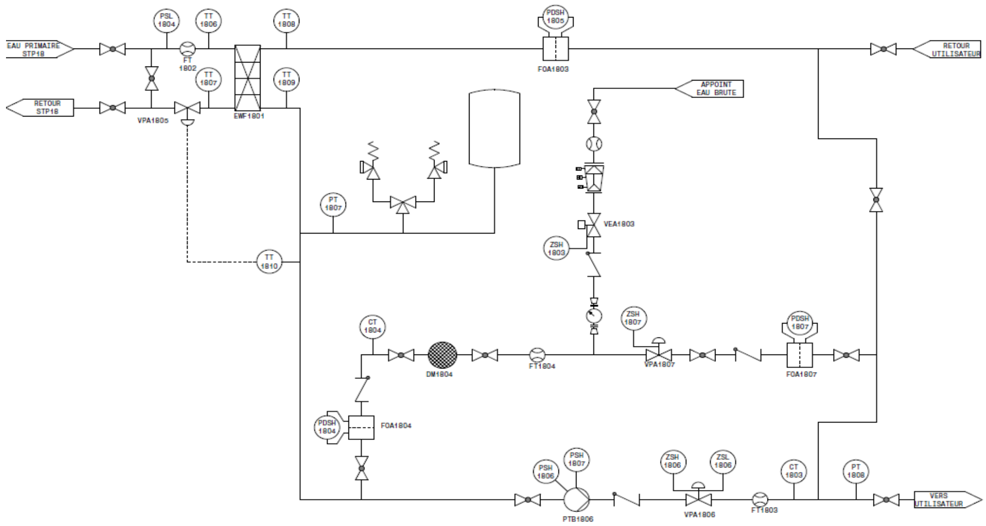

Figure 4: Plant schema of the STP18 cooling plant.

VIRTUAL COMMISSIONING

A cryogenic process simulator able to be plugged to UNICOS-CPC control system has been developed in the last years [4]. This simulator reproduces the process dynamic behaviours based on a set of DAE (Differential Algebraic Equations) describing the physics of the processes. The model of the process is connected to the real control system, reading the PLC outputs (actuators) and simulating the PLC inputs (sensors) in real-time.

The setup of such a simulator allows the development of virtual commissioning platforms in order to make a commissioning of the control system (PLC program and supervision) in advance. Virtual commissioning is a very powerful tool in case of control system upgrades when the commissioning time has to be reduced to minimize the shutdown time of a critical process. In addition to this, the virtual commissioning allows a faster and safer check of the PLC control program where all functional sequences can be tested with the simulator without any risk.

The current process simulator used at CERN for cryogenics has been extended and also supports water cooling simulations. The two systems STP18 and RFQ4 were successfully simulated ensuring an efficient commissioning. Due to the critical nature of some ventilation installations, a dedicated library for HVAC systems will be developed.

CONCLUSION

The ISOLDE control application for vacuum systems, RFQ4 and STP18 for cooling systems were successfully implemented using UNICOS-CPC framework. For all projects, the UNICOS principles applied during the operation and the SCADA features were quickly understood by the operators. The UNICOS-CPC application architecture has been assimilated by vacuum control experts, and since the first implementation, they are autonomous and able to develop and maintain their own control projects. This generic way of control system programming shows its high versatility and its easy learning in different domains of engineering.

The UNICOS-CPC v6 framework will cover missing functionalities identified during the development of both, vacuum and HVAC, control systems. Moreover, the new framework reinforces the local operation by using appropriate industrial devices. It also provides new tools able to create new types and a generic interface to perform virtual commissioning using a simulator.

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