DISTRIBUTED CONTROL SOFTWARE FOR HIGH PERFORMANCE CONTROL LOOP ALGORITHM

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Abstract

The majority of Cooling & Ventilation (CV) industrial plants require the control of complex processes. All these processes are highly important for the operation of the machines. The stability and reliability of these processes are leading factors identifying the quality of the service provided. The control system architecture and software structure are required to have high dynamic performance and robust behaviour. The intelligent systems, based on digital controllers with proportional, integral and derivative functions (PID) or digital controllers with three polynomial (RST) equations, are used for their high level of stability and accuracy. During the design and tuning of these complex controllers one needs to know the dynamic model of the plant (generally obtained by identification) and to specify the desired performance of the various control loop for achieving required performances. The concept of having a distributed control algorithm software provides full automation facilities with well adapted functionality and required performances giving method, means and tools to master the dynamic optimisation process and achieving the required real time performance.

1 INTRODUCTION

One important consideration in control engineering is that whether the application relates to magnet cooling, accelerator tunnel ventilation, chilled water production or cooling for physics experiments, the CV plants always use complex processes. A good knowledge of the initial goals is essential before one starts to detail the engineering control tasks. We must keep that in mind when studying a new and often complex control system, because if the process control architecture is not properly designed the real performance will be poor and good plant operation can no longer be maintained. Therefore, setting up process control objectives require at first a clear understanding of how the plant operations are determined and a deep study of plant objectives.

2 PROCESS CONTROL ARCHITECTURE

2.1 Process control design

Process control is expected to cope with complex processes and to provide full automation facilities. It requires complex control algorithms and the application of additional mathematical methods for data processing plant optimisation. Also an implementation of intelligent controllers is necessary. Typically, the starting point for a control system's design and analysis is a complete preliminary process design of all components and intelligent controllers and the specification of the desired process performances. This data enables us to design and to build the control architecture according to the essential requirements prescribed during the design phase.

2.2 Architecture Overview

CV plants for both the Large Hadron Collider (LHC) and the Super Proton Synchrotron (SPS) sites are usually spread over long distances. Therefore, to overcome the geographical challenge, it is of great interest to the CV group operation to provide a client server architecture to satisfy their requirements. Moreover, the steadily increasing need for local supervisory system, in the modern plant control (enhanced by recent advance software solutions), has lead us after careful analysis of the objectives to integrate a so called multi-node architecture at the plant level. This is based on a full industrial control architecture connecting at the low level Programmable Logic Controllers (PLC) to input/output Decentralized Periphery through Industrial Fieldbuses[1]. At the high level the industrial PC acting as a supervisory and engineering station is connected to the routed TCP-IP (Transport Control Protocol-Internet Protocol) Ethernet network. The multi-node architecture is well adapted to gradually integrate new equipment from any other processes as the projects unfold and it is in addition bound to gather control equipment from the former G64-Mil-1553 structure. This multi-node architecture is potentially suitable to move in the next few years toward an OLE (Objet Linking and Embedded) for Process Control (OPC) connectivity.

2.3 Software Solution

The core component of the system is the Wizcon SCADA (Supervisory Control and Data Acquisition) software[2] that takes full advantage of Windows NT's 32-bit pre-emptive multitasking. It provides comprehensive graphical and configuration tools to develop rather sophisticated applications. Moreover it enables local computation to view, handle, and control large amount of data. Through Wizcon operators can monitor all the local process parameters (Flow, pressure, status of cooling circuit, trends, real-time data analysis,..). They can also efficiently handle all types of alarms and warnings, and link additional mathematical software (eg. Matlab "add-ons"…) .

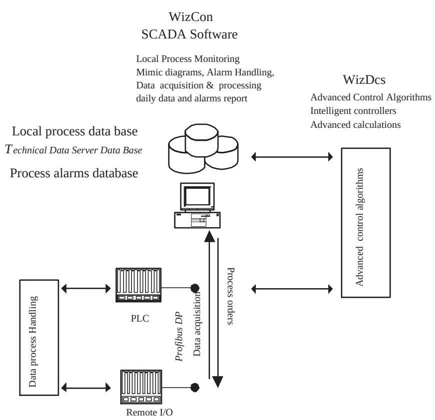

Fig.1 Multi-node control architecture combinations.

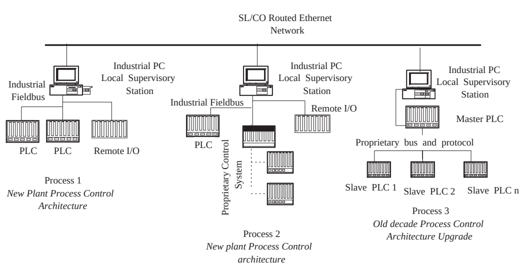

Fig.2 Wizcon software architecture for the local supervisory processes.

2.4 Client Server Configuration

The Client Server architecture is, on the one hand, used for the monitoring of processes located on different sites. Process data-bases might be exchanged under the Wizcon-DDE (Dynamic Data Exchange) functionality between the supervisory stations over an Ethernet TCP-IP connection which is opened according to the TCP-IP hostlist file. On the other hand the local supervisory stations are interconnected through Ethernet TCP-IP to a Wizcon server station not necessary used as a supervisory station. In this way all the local data, like real-time events, various predefined status and trends, as well as daily reports, can easily be stored for historic data processing. Moreover, the server station which is fitted with the Web SCADA software also allows users to monitor and control plant activities through a standard Web browser. Thereby, the Wizcon server station is turned into a Web Server with state-of-the-art tools for application handling at any location.

3 SPS PROCESS CONTROL PROGRESS

3.1 Introduction

The new concept of cooling the SPS[3] assesses a complete study for the requirements of Process Optimization Systems through an improvement of the temperature controllers for the magnet cooling. The study started at the end of '97, was reported in the '98 ST Workshop[4] and has now reached a final step with the experimental RST "Intelligent Controller" prototype which is currently tested for performance assessment and dynamic evaluation.

3.2 Plant identification

In this case identification means the determination of the model of a dynamic system, the knowledge of which is necessary for the design and the implementation of a high performance controller.
The objective was to identify a dynamic model of the main magnet cooling system. The most efficient way for the identification of the model was to acquire data in a closed loop acquisition using a PRBS (Pseudo Random Binary Sequence) signal added to the reference signal. Then, after applying the appropriate methodology we obtain the required discrete time equation for the plant identification model .

The discrete time model of the plant enables us to design the high performance digital controller. The design of this controller was done in accordance with the Robustness Analysis Methodology.
It is obvious that the high performance digital controller designed from a discrete time model of the plant requires specific and well adapted software to be successfully operated. Indeed when such digital controllers are implemented the control and computing of many different parameters are essential for a successful operation and to improve the desired time response performances. Moreover the idea is to provide an adaptive process controller algorithm in the near future specially designed to create the process model from real-time data acquisition through statistical modeling methods.

3.3 Advanced Control Algorithm software

despite the recent improvement of the PLC's functionality, it is still rather difficult to implement high performance controllers based on mathematical functions as well as knowledge-based decision system to configure the dynamic optimization and control algorithms. All these technical considerations have led us to use a PC-based control software. WizDcs is a software-based control system that combines control, networking, and data management functions built on a state of the art modular framework.

4 CONCLUSION

Due to time constraints in our general schedule, the Cooling and Ventilation group had to cope with new control systems for the new industrial plants for the LHC project as well as for the SPS. Even though the advanced technology is applied to the control for the new cooling and ventilation plants, severe problems remain for existing control systems which are based on technology a decade old. It was not fully clear how to upgrade and integrate these rather obsolete control architecture mostly on a limited budget and man-power. To use a multi-node control architecture, allowing special hardware combinations in a rather obsolete Proprietary Network Architecture (or with new Standard Fieldbuses) is the simplest way to satisfy our requirements for the purpose of mixing old and new hardware architectures.

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