CONTROL SYSTEM FOR THE NEW BEAM TRANSFER LINE AT IHEP

A.Matyushin, L.Kopylov, S.Merker, M.Mikheev, IHEP Protvino, Russian Federation

Abstract

New proton beam transfer line is study project to evaluate a possibility to use UNK injection line as an experimental facility. A wide set of accelerator equipment is involved in the test. The Control system is build on OPC and CAN technology using data driven and object oriented approach. The structure, key solution and operational experience are described in the paper.

INTRODUCTION

In IHEP on the basis of the beam transfer line (BTL) of not completed UNK ring the construction of installation for applied researches [1] is planned. Within the R&D study for finding-out of an opportunity of such decision the Prototype of such installation has been created using all spectrum of BTL equipment on the limited length of the channel: magnet optical elements, beam instrumentation, vacuum system, the radiating control. The beam, accelerated by proton synchrotron U-70 up to energy 50-70 GeV, is extracted into the channel, where it's demanded size (the maximal size allowed by the vacuum chamber) at a location of investigated object is formed.

The control system (CS) has been developed for management of the equipment, which is a subject of this report. As far as the most part of BTL equipment, and, in particular, operating electronics, has been inherited from UNK, the new CS shall be adapted for existing schemes, therefore, some of our solutions don't look very elegant. Meanwhile, as it is the prototype of essentially bigger installation, we aspired to realize CS with precise standard borders between levels. There are three such levels in our system (from bottom to top): the controller of the equipment (EqC), a front-end computers (FEC) and computer(s) in control room (CR).

As for the software solutions the object-oriented model driven by data has been chosen. It means that for all types of the equipment the corresponding data structures and methods for their handling have been designed. Corresponding objects have been developed for access to the equipment and the interface of the user.

Decisions made, experience of realization and two-year operation results are described further.

HARDWARE SOLUTIONS

The hardware of a BTL CS includes the centralized part, distributed controllers and communications (cables, repeaters, serial interfaces). The centralized part is located in CR, the embedded controllers - near to the process equipment. Communications between two parts are implemented via twisted pair cables supporting CAN protocol, timing pulses and signals of the dynamic interlocks.

Distributed part

The distributed part of a CS is based on three types of controllers: the universal controller of power supplies (PCC), the controller of the vacuum pumps (VC1) and those one for vacuum gauges (VC2). The PCC is constructed on two functional units: microcontroller CY8051F060 and programmed logic XC9536XL. Communication with upper level is carried out through microcontrollers CAN interface. There is a timing events receiver on the board as well as a driver of dynamic interlock. The controller has 16 inputs of status signals, 8 discrete outputs, two analogue inputs and one analog output.

The controller of ion pumps VC1 is embedded in a high voltage power supply. In each rack can be up to 3 high-voltage power supplies. The VC1 acquires the states of registers and transfers the status of pumps and their currents in predefined regular intervals.

Controller VC2 is used for vacuum measurement. It consists of 8-channel 24-digit sigma-delta ADC. The analogue signals proportional to pressure come from a power supply of gauges.

Means of data transmission, timing pulses and dynamic interlock of each building include repeaters boards, a twisted pairs main cable, as well as short cable taps.

The PCC develops a signal of the dynamic interlock if the current of a power supply is out of the window comparator thresholds. The inhibit signal in CAN terminology has a dominant level, and the permission signal – recessive one.

The timing controller carries out a number of service functions: calculation of number of cycles and distribution this information on CAN network, as well as management the dynamic interlock mode. The static interlock system is intended for supervision over a condition of doors of admission in a BTL tunnel, management of beam stopper and deliveries of the permission to the fast ejection system when safety requirements is fulfilled.

The BTL CS is located far away from the equipment of the proton beam fast ejection system. Communication between these two systems is done by means of timing signals generated by the fast ejection system and static interlock from BTL equipment.

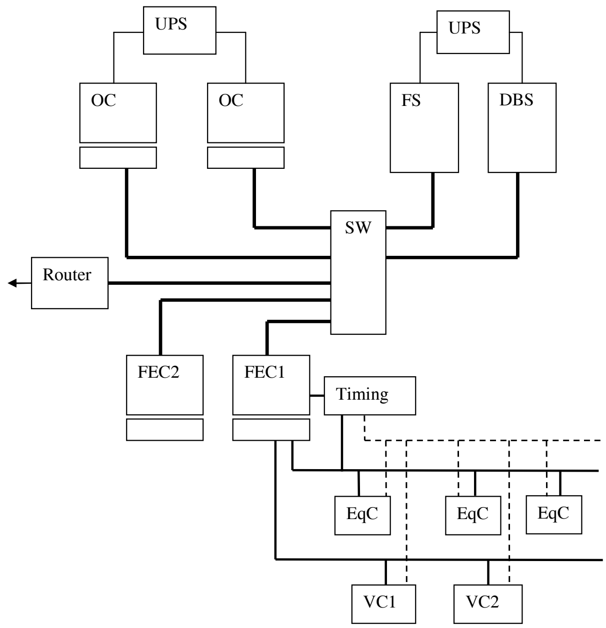

Figure 1: Hardware structure.

In addition to the static interlock the operator manually by pushbutton enables an ejection taking in account that beam intensity in the accelerator and beam quality are in proper conditions. For 300 ms till the moment of an extraction the condition of the static interlock is fixed to provide necessary time for ejection power supplies charging. At presence of the static interlock approximately for 100 μs till the moment of an extraction dynamic permission enables the experimental equipment trigger pulses.

Front-end computers

The FEC are intended for connection with the distributed level of a control system. The FEC are connected directly to a CR network through network adapters. Since few different types of EqC with different communication protocols are used, we have decided to use two types of a FEC:

- Communication FEC is intended for connecting controllers of the equipment of the bottom level. The primary goal of this type FEC – translation of the operating protocol of a CR network (Ethernet) to the operating protocol of a fieldbus (CAN). Three physical CAN buses are used in BTL, so three cards of high-speed CAN controllers are installed in such FEC.
- Specialized FEC - carries out complex equipment management directly connected to a network. In this case in FEC the necessary quantity of cards of input/output for management of the equipment is installed. The FEC should also carry out primary processing of the information. Such FECs are used for beam instrumentation and radiation control.

Control room

CR consists of control panel, servers and the network equipment. The control panel consists of three personal computers, further called Operator Consoles (OC). Any control application can be launched on any of OCs.

Servers - computers to perform the specialized function:

- The File server (FS) is intended for the centralized storage of the software and configurations. It provides access to files from any console and a handheld computer.
- The Database Server (DBS) - storage of the systematized working parameters and data of a control system. Data are used for adjustment of system and to display the parameters of the equipment in a graphical or table view.

Network

We used one level Ethernet network to interconnect CR computers and FECs based on multiport switch. CS Network is connected to IHEP network through a router which provides access to the information on a condition and parameters of accelerator U70 and interferes with penetration into a network of the parasitic traffic.

SOFTWARE SOLUTIONS

At designing the software overall objectives were:

- To provide the homogeneous interface of access to the equipment for application programs;
- To hide differences in hardware and program realization of controllers of the equipment from application programs;
- To provide the possibility for launching any (reasonable) amount of application programs on any OC within the limits of a network of a control system;
- To provide the possibility of easy enough addition of new types of the equipment and controllers in a control system.

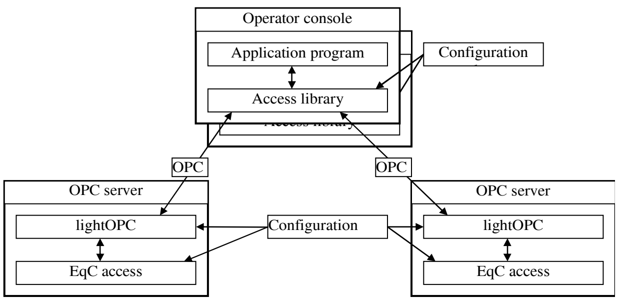

Figure 2: Software structure

For realization of these requirements on top level of a control system the client-server solution has been chosen, the communications between the client and a server is carried out by means of OPC [2]. One (or more) OPC servers are configured in CS which work with controllers of the equipment and provide to application programs a homogeneous way of access to any data coming from the equipment

The application program accesses the parameters of the equipment using device name (unique in CS) and a name of property in this device, for example: “MKG1.MCUR” - property MCUR (the measured current in Amperes) of device MKG1. For each type of device the model of data is created - which parameters are supported by this type of the device, their types of data, a way of access (read only or read/write). While writing the applications it is necessary to know in advance names of devices in system, their types and corresponding models of data.

The access library reads a configuration of a control system (from a file) and on its basis defines where exactly (on which of server computers and under what name of OPC server) the device with the given name is accessible. When device location in CS is resolved the access library carries out OPC call(s) to corresponding OPC server.

For application programs the access library provides 3 basic modes of access to the parameters of the equipment granted by OPC servers: **Reading, Wirting, Subscription** (the code in the application program is every time when parameter value is changed in OPC server).

CS contains one (or more) OPC servers running on one (or more) server computers. Every OPC server at start-up also finds a configuration (from a file) and on the basis of this information configures itself:

- Which devices are supervised by this OPC server
- Under what names devices data are made accessible through OPC
- What model of data is used for each device (i.e. which parameters are accessible through OPC and how to calculate these parameters from the values which have been read from the controller of the equipment)

OPC interface part is based on lightOPC library [3] developed in Institute for Problems of Informatics of the Russian Academy of Science.

OPERATIONAL EXPERIENCE

The Prototype of BTL has been put in operation in 2007. CS allows for operator to carry out all preoperational activity to get proper vacuum conditions in BTL, check security interlocks and door state. But the major task of course is setting parameters for beam optics and getting information from beam instrumentation.

Experimental facility requires very precise beam parameters and timing setting to be fulfilled. A serious effort has been spend to provide the logic to avoid incorrect extraction of the beam not matching the strict criteria of quality.

Gathering a historical data allowed to analyse the operation of equipment and improve stability and repeatability of beam parameter in the experimental point.

CONCLUSION

Presented CS has allowed maintaining successfully BTL operation for two years. Experience of development and implementation shown that multilevel structure with standard borders between layers allows to create easily configurable system. It also gives an opportunity of independently updating hardware and software components in process of appearance of new commercial products and improvements of a budgetary situation. Principles of Data driven system could be easily expanded and flexible. The object oriented approach has allowed facilitating support and development of program components

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