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SUPERVISORY-CONTROL SYSTEM FOR 10MeV ELECTRON LINAC

Deepak kumar Sharma, Akhilesh Jain and P.R. Hannaurkar
Raja Ramanna Centre for Advanced Technology, Indore
E-mail: dksharma@cat.ernet.in

A Supervisory control system is developed for electron linear accelerator machine using computer based data acquisition cards and LabVIEW, as a programming tool, System architecture includes distributed acquisition, analysis, data storage and presentation. The main challenges in the design of the control system are sophisticated subsystems, variety of devices, gauges and there scaling. Advanced features of LabVIEW like VI server, data socket and VISA server have been fully harnessed in this design. The system is also equipped with a safety interlocks and a search-scram system.

1. INTRODUCTION

In medical & industrial accelerator series, a 10 MeV, 10 kW linear accelerator facility (LINAC) is being commissioned at RRCAT Indore [1]. The machine is designed to be used for food irradiation applications, so the control system is required to be user friendly. Also the accelerator system has high voltages, microwave source X-rays and other harmful radiations, which make it necessary for the control system to be very robust and insensitive of these factors. The requirements are meet using PC based DAQ cards for data acquisition and LabVIEW.

2. THE DESIGN

The design was carried out with few basic guidelines-economic, ease of upgrade, modularity and adherence to well known & compatible technology. To achieve these goals, PC based configuration has been for supervisory system. Due to Graphical and realistic programming approach, LabVIEW has been chosen as workhorse for software development. Compared to other data acquisition systems, PC based system is economic, easy to upgrade and maintain. Further, it allows latest technology to be used with upward compatibility.

The supervisory system monitors and controls various parameters of the Linac system. Data received from various subsystems are routed to data acquisition cards housed in industrial PCs via signal conditioning unit. Acquired data is processed by the software and the relevant and consolidated information is passed from all such computers over network to a master computer, *the supervisor*. This machine acts as data server for operator consol, as well HTTP server for remote monitoring from other nodes over internet. Along with the signal monitoring, interlocks for some critical signals are also incorporated in the system.

The safety interlock system is made modular and reconfigurable- to meet the variable system demand. The system includes a search and scram system to insure the human safety against the harmful radiations produced during system operation. The main components of the supervisory system are the data acquisition computer (the CXI), signal conditioning and isolation modules, master computer (the supervisor), search-and-scram and auxiliary subsystems.

2.1 System architecture

This distributed supervisory system is based on personel computers. These units named as *Computer extension for Instrumentation* (CXI), are the basic local controller with its own intelligence. Every parameter/channel is given a tag name, identifying that parameter in a unique way. With each tag, information is associated about its channel number, device server, machine name, data type-direction, alarm priority etc. This information is stored in a configuration file. There are various of devices, each different in communication mode, response time and priority. Thus, devices servers were developed to handle individual device.

The CXI units communicate with the supervisor over 100BaseT thin Ethernet network. The supervisor acts effectively as data server for operator consol, as a data client for data acquisition units (CXI) and as a system controller; simultaneously it can act as a web server for other lab nodes over intranet too.

3. HARDWARE DETAILS

The essential hardware of the supervisory system includes: the data acquisition units, the supervisor, GPIB-ENET interface, the search-and-scram system and the LAN. The 100BaseT LAN is the backbone of the communication among CXI unit, the supervisor and the GPIB interface. The LINAC system has a movable target platform mounted in front of the beam window. The platform can be positioned at three target points, namely electron target, Photon target and Beam target. To move the target position, a DC motor is used and it is interfaced with the supervisory system.

3.1 The CXI Unit

The CXI unit mainly consists of an intelligent controller, some data acquisition cards and the signal conditioning and isolation modules. The signals coming from various subsystems are brought to the signal distribution panel. The signals are then routed to the respective signal conditioning units. The main signal conditioning modules are: relay cards, buffer cards and analog input filtering and multiplexing units. After conditioning, the signals are given to the data acquisition cards housed in CXI machine. The CXI machine performs all acquisition, data logging and data communication tasks. The Supervisor is another CXI machine which acts as a system administrator. The supervisor is also connected with the search-and-scram system on serial link. The supervisor directly communicates with all instruments connected on the LAN.

3.2 Interlock Unit

Some of the signals in the system are very critical for the operation of the LINAC and the microwave system. Due to this, an interlock unit is developed. The output of this unit enables/disables the HT supply of the modulator. Unless and until all interlocks are OK, the interlock unit disables the HT supply, to prevent any equipment damage or human injury.

3.3 Search-and-Scram System

The search-and-scram system is an electronic mean to ensure the administrative control in the accelerator radiation and other hazardous areas. The procedure followed to get the "interlock OK" signal is to search sequentially by the operator in the plant area (around the machine) and press all search switches one-by-one [2]. This "Search operation" makes it ensures that one visual inspection is made around the machine before starting it. This is put as an interlock before the machine such that the machine can only be operated after the search has been done. To get additional safety and to provide redundancy, a feature to immediately shut off the machine, in case of any emergency like someone stuck/locked inside the hall, is provided. This is achieved by using scram switches.

4. SOFTWARE DETAILS

Supervisory system software has to perform many functions like data processing, alarm generation, preventive control, data logging, data transfer to remote machine over network etc. The distributed architecture allows each of the CXI unit to process the data in paralleled fashion. Application running under master PC performs user task as well managerial task. Complete software includes various tasks of varied nature. Hence, software development has been divided into four layers described in the section 4.2.

4.1 Data flow

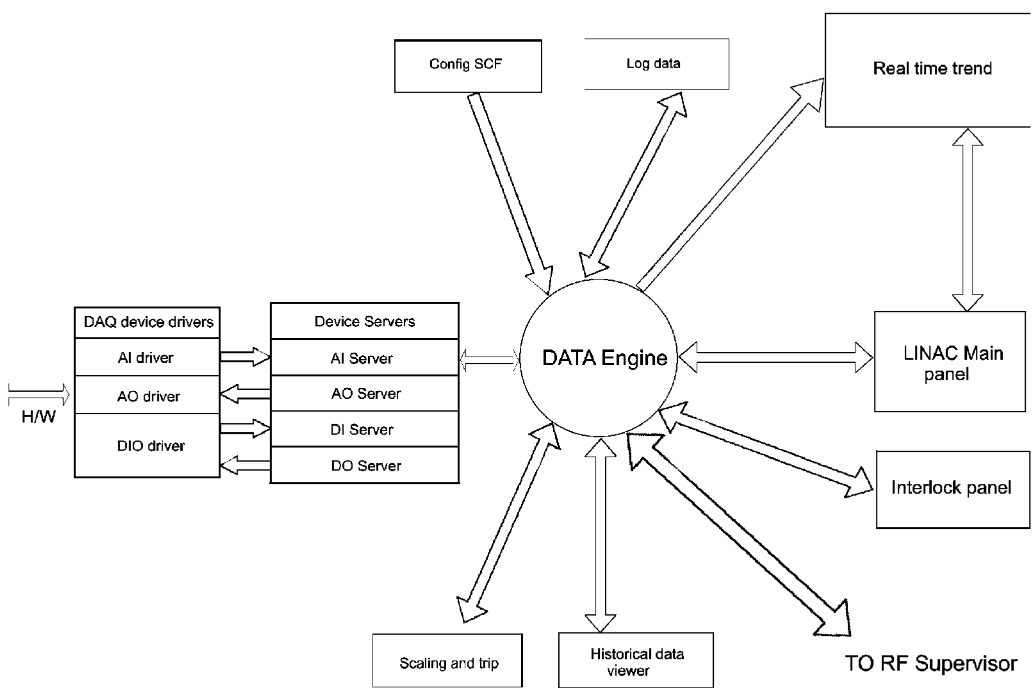

Fig.1 : Data flow diagram for the data server

Figure 1 shows the data flow diagram of data acquisition unit. The data acquisition device driver receives the data from the actual hardware and provides some control on the hardware like channel configuration data transfer modes, etc. The device server is software, which communicated with the device drivers and transfers, the data to the supervisory engine. Various device servers are developed for different devices. The supervisory engine manages the real time database and provides data to all components requesting it.

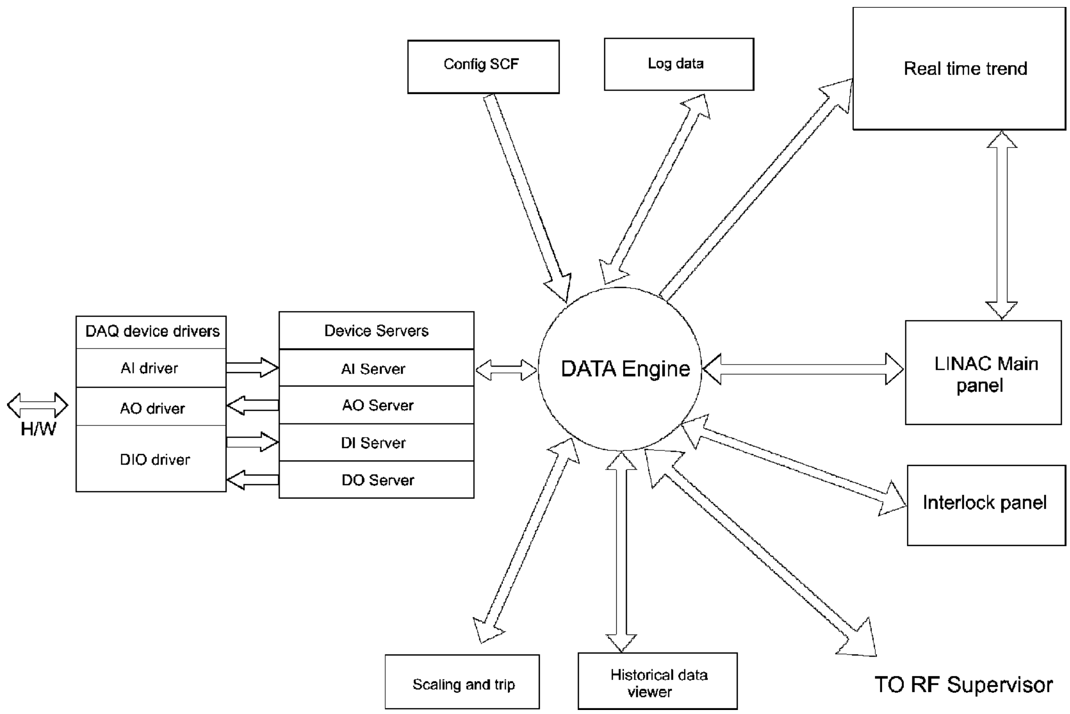

Fig. 2 : Data flow diagram for the supervisor

Figure 2 represents the data flow in the supervisor. The data coming from data acquisition units is accumulated at the data engine of the supervisor. The supervisor also collects the data from oscilloscope, signal synthesizer and the search-and-scram system. For these devices the device servers have been developed which manages communication with the external devices and provides data to the data engine. To display various events, to manage messages coming from various panels and to display them to the user, a message service named as *messenger* have been developed. The messenger is developed using graphical object oriented programming concept [3]. It displays the messages to the operator in a *message box.*

4.2 Software Layers

In order to keep modularity in design and parallel development, complete software had been functionally structured into four layers. The bottom layer is *physical layer*. This layer is responsible for DAQ card configuration and all physical connections like signal conditioning unit, multiplexing and network connection to each CXI. Above this layer is *device interface* *layer*, which acquire data from DAQ card and stores it in global memory of CXI unit. If any DAQ card is changed, only this device driver needs to be changed leaving rest of the program intact. After acquisition, data is fed to *supervisory layer*. This layer performs various subtasks like data supervision, data logging, alarm generation, machine-to-machine interface etc. Last layer viz. *Presentation layer* accomplishes human machine interface and presentation of the data in user-friendly manner and in a direct meaningful way. This presentation layer is responsible for displaying data for each panel in GUI format.

5. CONCLUSION

The supervisory system for the electron LINAC has been developed and it is satisfying our design principles and the system requirements. The system is under use since last many months and it is working satisfactorily. Both hardware and software designs are proven to be good enough and are being reused in our next systems.

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