A Study on the VME-Based Application for Integrated Control of PEFP Linac Machine Components

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Abstract

The PEFP (Proton Engineering Frontier Project) is constructing a 100MeV proton Linac (Linear Accelerator). The 20 MeV 20 mA proton beam has been serviced for an application in the fields of material, biological, information technology and medical sciences. For a stable and efficient acceleration of a proton beam, the control requirements must be optimized by studying various control methods. We propose that the integrated control system for the Linac machine components must be based on a distribution control method to improve a centralized control system. Based on EPICS (Experimental Physics and Industrial Control System) real-time software, the VME (Versa Module European package format) IOC (Input Output Controller) was developed under cross development environment with a RISC (Reduced Instruction Set Computer) PowerPC system. In this paper, we describe the design and implementation of distributed control system using the VME-based EPICS middleware for various components of the large proton accelerator.

1. Introduction

A 100MeV proton Linac (Linear Accelerator) is being developed at the PEFP (Proton Engineering Frontier Project) [1, 2]. A 20MeV proton linac has been already developed by assembling 50keV proton injector, 3MeV RFQ (Radio Frequency Quadrupole), and 20MeV DTL (Drift Tube Linac). The PEFP linac has been providing the 20MeV 20mA proton beam for users of an application in the fields of material, biological, information technology and medical sciences. The linac control system integrates all of subsystem controllers for each component. We design a distributed control system of machine devices by studying required control methods. For a control method for focusing operator's attention on the control points, the architecture of distributed control system using Experimental Physics and Industrial Control System (EPICS) was adopted [3]. The EPICS real-time software is client/server model based on EPICS CA (Channel Access). All subsystems of proton linac can be efficiently integrated into the machine network and the control network.

2. Requirements of control system

The proton linac consists of sub-components needed for beam acceleration operation, such as vacuum units, magnet power supply, beam diagnostic equipment, low-level radio frequency system, and resonant control cooling system, etc [4, 5]. For a stable and efficient acceleration, the control requirement includes integrated remote control, distributed control, and efficient maintenance, etc. We adapted a set of EPICS open source software tool to create distributed soft real-time control system for stable beam acceleration. The distribution control method chosen to control the PEFP linac is based on multi-layer architecture with IOC (Input Output Controller) systems. Logically the control system will be structured into three layers as shown in Figure 1. Each layer is distinguished by the OPI (Operator Interface) layer, IOC layer, and the machine controller layer. All the IOC servers are implemented by EPICS application framework which provides a network-based EPICS CA for efficient access control of the distributed control systems. The OPI layer comprises operator console, alarm handler, the CA client programming, sequential control module, archive, network management, general computing resources, and web monitoring system. The IOC layer consists of several local control stations including host-based Soft-IOC and micro-processor target IOC. The machine device layer is comprised with radio frequency component, water cooling system, vacuum units, magnet power supply, beam diagnostic system, ion source, timing system, and interlock system.

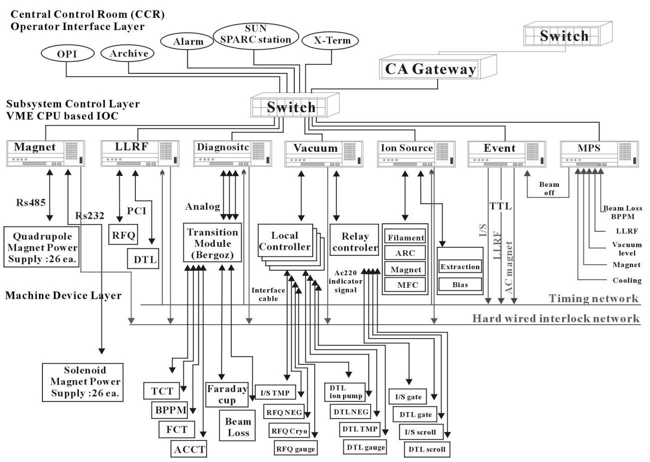

Figure 1 Schematic of Machine and Control Network for Distributed Control of Linac Components

3. Design of Hardware/Software

As a basic network communication, the IOC consisting of record/device/driver support reads voltage and current, and communicates with various protocols from physical layer. After TCP connection with an IOC through UDP broadcast to IOC servers, the OPI requires a PV (Process Variable) name to the IOC server that owns the PV.

We studied the IOC server architecture and hardware including record, device, driver support, and EPICS extension tools installed in OPI PC [6].

3.1 Implementation of IOC and OPI

For a client OPI environment, we installed the station of Soft-IOC that runs in the same environment as which it was compiled consists of IBM x3650 server, HP xw6600 workstation, and Industrial Pentium 4 PC. These OPIs are assigned for human machine interface, data archiving, and CA Gateway in linac operation. For machine control, we developed the station of the target IOC that runs in a different environment where compiled. The IOC station is Motorola MVME5100 PowerPC 7410 [7]. Figure 2 shows VME board chose as a controller main board. We use a cross-compile environment with Tornado for target architecture on SunOS 5.9 [8].

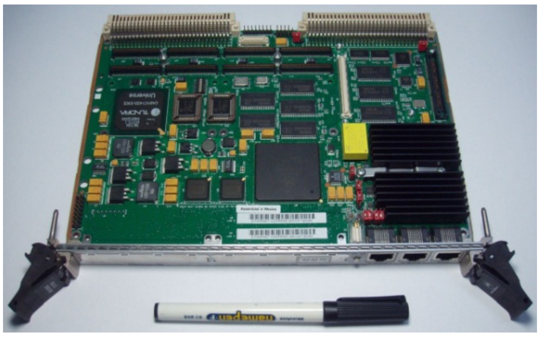

Figure 2 RISC-based VME CPU (PPC7410) Board for Input Output Control Server

3.2 Distribution Software Design of EPICS middleware

We have studied how the EPICS system can be used to the specific requirements for the machine control of the proton linac as a large particle accelerator.

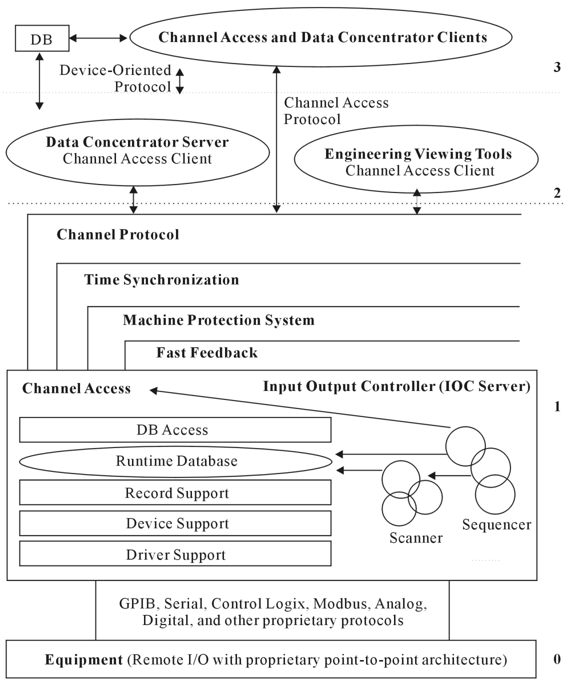

Figure 3 Architecture of EPICS Middleware for Software Real-Time Distributed Control Network

This distributed client and server architectures are depicted in Figure 2. Different levels of access and control reside at distinct layers.

At the highest layer 3, access is provided for activities that do not involve moment-by-moment control or monitoring of the accelerator. Layer 3 includes high level physics modeling, making use of live data and data stored in the site relational database. Layer 2 contains accelerator operation and monitoring activities. Layer 1 contains dedicated equipment controllers, which in turn interface to specific equipment through point-to-point protocols in layer 0.

4. Conclusion and Future Works

The VME-IOC and Soft-IOC for vacuum components, magnet power supplies, and cooling have been developed. These controllers have been arranged for monitoring and machine control around the linac. The EPICS CA has integrated the distributed IOCs with the OPIs for a central control and monitoring. We chose a CA Gateway that provides a means for many clients to access a PV while making only one connection to the server that owns the process variable. The Gateway was able to revise network traffic control.

We are designing EPICS software structures for beam current and profile monitoring, radio frequency monitoring, low-level radio frequency feedback control that are operated by other programs. In the future, a machine protection system (MPS) must be designed under the operation scenario of the PEFP 100MeV. As a basic study, a preliminary interlock control method by integrating a Programmable Logic Controller (PLC) and EPICS IOC will be studied.

5. Acknowledgements

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Reference

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