DEVELOPMENT OF A LINUX-BASED SMALL-SIZE CONTROLLER USING POE TECHNOLOGY

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ABSTRACT

We developed a new controller using Power-over-Ethernet (PoE) technology based on a small-sized CPU card with low power-consumption in order to handle scattered signals. The new controller consists of a CPU card of 240MHz SH-4 and an I/O card, which are connected to each other using a small-size dedicated connector with PCIbus protocol. A GP-IB controller card and a temperature measurement card are currently available. The controller provides enough software development flexibility due to a Linux operating system for the SH-4 CPU. The controller is promising to remarkably enhance the degree of freedom of installation due to the PoE technology and its compact size. And it is significant that the development of the temperature measurement instrument shows that the PoE technology can be applied to analog signals as well as digital signals.

INTRODUCTION

We frequently have opportunities to handle signals scattered around a large facility site. Environmental data such as temperature and humidity are good examples. In SPring-8, temperature measurements are requested at many points in the accelerator buildings including machine tunnels in order to investigate correlation with long-term orbit variation or energy variation of electron beams. In theses cases, it is not cost-effective to prepare a VME computer or a PC at each point to handle the signals because there are few signals at each place. We also have to prepare a 19" rack and a power line in order to set up the VME or PC control system. Moreover, these signals are not real-time, or fast processing signals neither in general.

Recently, small-sized, cost-effective, dedicated instruments/controllers with Ethernet connectivity have appeared in a market. In the SPring-8 accelerator control system, GPIB-ENET100 [1] and THT-NET [2] have been employed as such network connectable dedicated devices for continuous data acquisition. The GPIB-ENET100 is an Ethernet connectable GP-IB controller and provides Linux API binaries for the remote control. The THT-NET is a temperature and humidity measurement instrument with Ethernet connectivity and works as a socket server. We usually have to treat these devices and provided software for remote control as black boxes. Since these devices can be distributed near the controlling/measuring points by using a prepared network as a field bus, they bring us higher degree of freedom of installations than VME computers and PCs. We, however, occasionally had experiences of the data acquisition stops due to unknown problems of both devices. In such cases, it is difficult to solve the problems by ourselves because we cannot investigate the inside of the devices and the API libraries.

In order to accomplish more stable and flexible controls/measurements, we developed new network connectable small-size controllers for handling the distributed signals. A GP-IB controller and a temperature measurement instrument using a resistance temperature detector (RTD) were developed as the first step.

DESIGN CONCEPT

The newly developed controller has to provide higher degree of freedom of the installation because measured signals do not always exist in the suitable environment for the installations. The introduction of the new controller has to be satisfactorily cost-effective than that of the VME computer or the PC. Moreover, the software running on the new controller should be flexible to modify for further improvement or update. In order to meet these requirements, we designed the new distributed controllers as follows:

- The controller must have Ethernet connectivity.
- Sizes of the controllers should be as small as possible.

- One controller consists of a CPU card and an I/O card such as a GP-IB control card or an RTD measurement card as applications.
- CPU power is not necessary. If anything, the CPU heat generation should be lowered as much as possible.
- Power can be received via an Ethernet cable using the Power over Ethernet (PoE) technology, in addition to a direct DC power supply
- The CPU card supports Linux to run developed application programs.

The key of this development is application of the PoE technology.

POE TECHNOLOGY

PoE is a technology to supply the electric power to network-connected devices via an Ethernet cable. The IEEE defined the standard for PoE as the IEEE802.3af in June 2003 [3]. The PoE technology is recently applied to wireless LAN access points, network cameras, IP-phones and so on. The devices receiving the electric power via network cables are called powered devices (PDs), and the equipment which supplies the power to the PDs is called power sourcing equipment (PSE). The PSE one port can supply the maximum power of 15.4W at 48V DC.

The PoE technology brings us many advantages. Since we don't have to prepare the infrastructure for AC power lines, we can save costs, time and spaces for the installation of the PDs. The existing Ethernet CAT-5 cables can be used for the PoE if we replace an existing normal hub with a PSE hub or add a midspan PSE. We can easily introduce the PoE technology to the existing network system with minimum modification.

If the PSE hub provides management tools, we can monitor the status of the connected PDs such as power consumption, output voltage and so on. Moreover, we can turn on and off the power to the PD by remote operation. By using the management tools, we don't have to go over there to reset the devices when the PD hangs up.

The PoE technology, thus, brings a lot of benefit to the distributed computing system from viewpoints of installation and system management.

DEVELOPMENT OF SMALL-SIZE CONTROLLER

We developed the new small-size controllers in cooperation with the Advanet Inc. [4] A CPU card with the IEEE802.3af PoE function, a GP-IB controller card and an RTD measurement card were designed and developed. The CPU card is available both for the GP-IB card and the RTD card.

CPU Card

Figure 1 shows a block diagram of the CPU card. The CPU card employs a cost-effective 240MHz SH-4 (SH7751R) CPU, which provides satisfactory performance as a distributed controller. The SH-4 CPU is suitable for both the PD and embedded system due to low power consumption. The main memory is 64MB SDRAM, and the 32MB flash memory is used for a boot ROM for SH-Linux.

The CPU card has peripheral interfaces of a 10/100 Base-TX Ethernet port with PoE function, an RS-232C port, and a USB 2.0 port. A PCI interface is also prepared using a dedicated small connector in order to combine the I/O card.

The CPU card receives the electric power either from the Ethernet connector by the PoE or a DC+5V input connector. The PD has to accept both alternatives of power supply methods as defined in the IEEE802.3af. Alternative-A uses the signal pairs (pins 1, 2, and 3, 6) and alternative-B uses the spare pairs (pins 4, 5 and 7, 8) of a CAT-5 cable in order to apply the DC voltage. The IEEE802.3af compliant pulse transformer H2019 [5] is employed for the alternative-A in order to separate the data signals and the DC voltage. Diode bridges are requested in order to handle the opposite polarity of the DC voltage.

In order to provide the PoE signature and the power interface functions, the card employs LCT4257-1 [6]. The 25kΩ signature resistor is included in the chip. The LCT4257-1 simplifies the design of the PD and helps to save the card space.

MADOCA Migration

We migrated the MADOCA (Message And Database Oriented Control Architecture) framework [10] to the newly developed small-sized controller. The device control server process named Equipment Manager [11] is stably running on the controller. We can incorporate the controller smoothly into the VMEbus-based control system with the MADOCA control framework. We succeeded in developing application software flexibly on the distributed controllers.

APPLICATIONS

We will install the E-060 RTD instruments into the SCSS test accelerator [12] in order to measure the air temperatures and the wall temperatures in the accelerator tunnel. The E-060 instruments covered by radiation protection boxes will be installed in the tunnel. Since the E-060 generates less heat, thermal problems of the E-060s will not occur if the box has a certain volume. The compact PoE measurement box is useful to reduce the wiring works of the Pt100 sensors.

We will also replace VMEbus GP-IB boards with the E-059s because the GP-IB sometimes makes troubles on the VMEbus. The stability of the VMEbus system is expected to become higher by the GP-IB board removal.

FUTURE PLANS

We have plans to develop an analog input card of ±10V range and a digital I/O card. We will also use the CPU card as an Ethernet-to-RS232C converter without an I/O card.

Currently, we cannot use the USB port of the CPU card due to the problem of the device driver of the 2.4 kernel. In order to solve the problem, we will port the SH-Linux2.6 kernel to the CPU card to support the USB port.

SUMMARY

We have succeeded in developing the new Linux-based small-size controllers using the PoE technology. The controllers are stably working with the ported SH-Linux and the MADOCA framework. Practically, the PoE technology is convenient for the quick setting, cost effective with no power line, and considerably enhances the degree of freedom of the installations with the compact controller size. Since we can monitor the controller status and reset the controller from the remote places by using the network-based PSE management tool, we can enhance the controllability of the distributed controllers.

A measurement of the temperature by the E-060 shows the PoE technology can be applied not only to digital devices but also to analog devices.

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