

# THE GATEWAYS OF FACILITY CONTROL FOR SPRING-8 ACCELERATORS

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## Abstract

Utilities data such as the air temperature in a machine tunnel, power line voltage, and temperature of machine-cooling water are managed by the facility management system. Previously, the accelerator control system could not obtain most of the required utilities data because the accelerator control system and facility management system were independent systems without an interconnection. In 2010, we updated the old facility management system. In order to facilitate data acquisition, we constructed gateways between the MADOCA-based accelerator control system and the new facility management system, installing the BACnet protocol. The data acquisition requirements were as follows: to monitor utilities data with the required sampling rate and resolution, to store all of the acquired data in the accelerator database, to maintain independence between the accelerator control system and the facility management system, to ensure a future expandability to control the facility equipment from the accelerator control system. We outsourced the gateway construction, including the MADOCA-based data acquisition software, to solve the problems of limited manpower and short work period. In this paper, we describe the system design and the outsourcing approach.

## INTRODUCTION

Utilities data such as the air temperature in a machine tunnel, power line voltage, and temperature of machine-cooling water assist accelerator specialists in studies on the correlation between beam stability and environmental conditions. In SPring-8, the accelerator control system, which used a Message And Database Oriented Control Architecture (MADOCA) framework [1], and the facility management system, which used the old MELBAS (Mitsubishi Electric Building Automation System), were independent systems with no interconnection. For over 15 years, the accelerator control system had no provision for obtaining most of the utilities data handled by the facility management system, except for that from legacy and offline devices such as paper records, floppy disks, and USB memories.

We started to implement an update of the old facility management system in June 2010, and we completed the project in March 2011. The new facility management system employs BACnet [2] as the underlying protocol. BACnet is an open protocol of data communication for building automation and control networks, and it has been standardized by an ASHRAE, ANSI, and ISO. The

BACnet protocol defines a number of data link/physical layers, including Ethernet and ARCNET. BACnet is widely used in the building management market. We built the gateways to facilitate communication between the MADOCA-based accelerator control system and the new facility management system.

To implement these gateways, we had to overcome the problems of limited manpower and short work period. We outsourced the construction of the gateways, including the data acquisition software of MADOCA framework. We describe the system design and outsourcing approach below.

## SYSTEM DESIGN

In this project, our objective was to make a provision for the accelerator control to acquire the utilities data handled by the new facility management system. The RF conditions are very sensitive to the facility equipment and environmental conditions such as the air temperature of machine tunnel and temperature of the machine-cooling water. We focused only these utilities data and constructed a utilities data acquisition system (utilities DAQ system). The requirements for the system were as follows:

- The utilities DAQ system can acquire the utilities data for the facility equipment with the required precision and sampling rate.
- Accelerator specialists can easily refer to the utilities data.
- The acquired utilities data can be stored in a database for the accelerator control.
- The facility management system cannot access to the accelerator control system.
- The accelerator control system and facility management system must remain independent from each other. This is because the facility management system does not have a shutdown period. Even if the utilities DAQ system or the accelerator control system is stopped during a shutdown period for the maintenance, it will not affect the facility management system and facility operations.
- The utilities DAQ system can provide a future option to control the facility equipment from the accelerator control system without a large modification. We anticipate a future need to control the facility equipment from the accelerator control system to achieve more precise beam control for SPring-8 II [3].

## Configuration

Generally, a facility management system using the BACnet protocol does not need a fast DAQ. In the facility

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management system for SPring-8, it takes 12 minutes to update all of the analog signals. There are about 16,000 points, including analog and digital signals, in the entire facility management system. At the SPring-8 storage ring, accelerator specialists found that the preservation of thermal equilibrium in the machine tunnel and precise cooling water temperature control for the magnets and vacuum chambers contributed to beam orbit stability [4]. They also reported that one of the sources of beam kick was the expansion and contraction of the floor and base girders caused by the variation in the air temperature in the machine tunnel, and that the source of this variation was the variation in the air velocity caused by the fluctuation in the power voltage of the fan coil units [5]. The machine-cooling system must acquire precise values for the temperature, resistivity, flow, and pressure of the machine-cooling water with a high sampling rate (2 s) over a long period of observation. Data acquisition via BACnet cannot satisfy a fast DAQ.

Figure 1 shows a schematic diagram of the connection between the accelerator control system and the facility management system. The red background shows the accelerator control system with the MADOCA framework. The blue background shows the facility management system with the BACnet protocol. The green areas show the FL-net [6], and purple areas show a MELSECNET [7], which is the data link protocol for the programmable logic controllers (PLCs) of Mitsubishi Electric Co., Ltd. An iCONT is an intelligent controller connecting a local device to the BACnet backbone. The

dashed line shows the gateways of the fast DAQ.

We built three types of gateways as the key devices for the utilities DAQ system. The first is a MADOCA/FL-net gateway that consists of a VME computer with an FL-net interface board for the MADOCA data acquisition software (MADOCA/FL-net GW). Second is a BACnet/FL-net gateway that consists of PLC modules with both BACnet and FL-net interfaces (BACnet/FL-net GW). The acquisition cycle from the MADOCA framework via the BACnet/FL-net GW is 60 s. Third is a MELSECNET/FL-net gateway that consists of PLC modules with both MELSECNET and FL-net interfaces for the fast DAQ (MELSECNET/FL-net GW). The acquisition cycle via the MELSECNET/FL-net GW is 2 s. An iCONT translates the data of the facility equipment data such as the electric and air conditioning utilities with a local controller to the BACnet protocol. A BACnet/FL-net GW translates the data to the FL-net protocol. A MADOCA/FL-net GW translates the data into MADOCA messages. Finally, the data are stored in the database for accelerator control. The data of the machine-cooling utilities are also stored in the database via the MELSECNET/FL-net GW and MADOCA/FL-net GW. In all, there are a BACnet/FL-net GW, four MELSECNET/FL-net GWs, and five MADOCA/FL-net GWs in the utilities DAQ system. FL-net is an Ethernet-based open standard protocol on UDP/IP for a factory floor network. We previously introduced control systems that use the FL-net such as the linac interlock system [8] in SPring-8, and the radiation monitoring system and

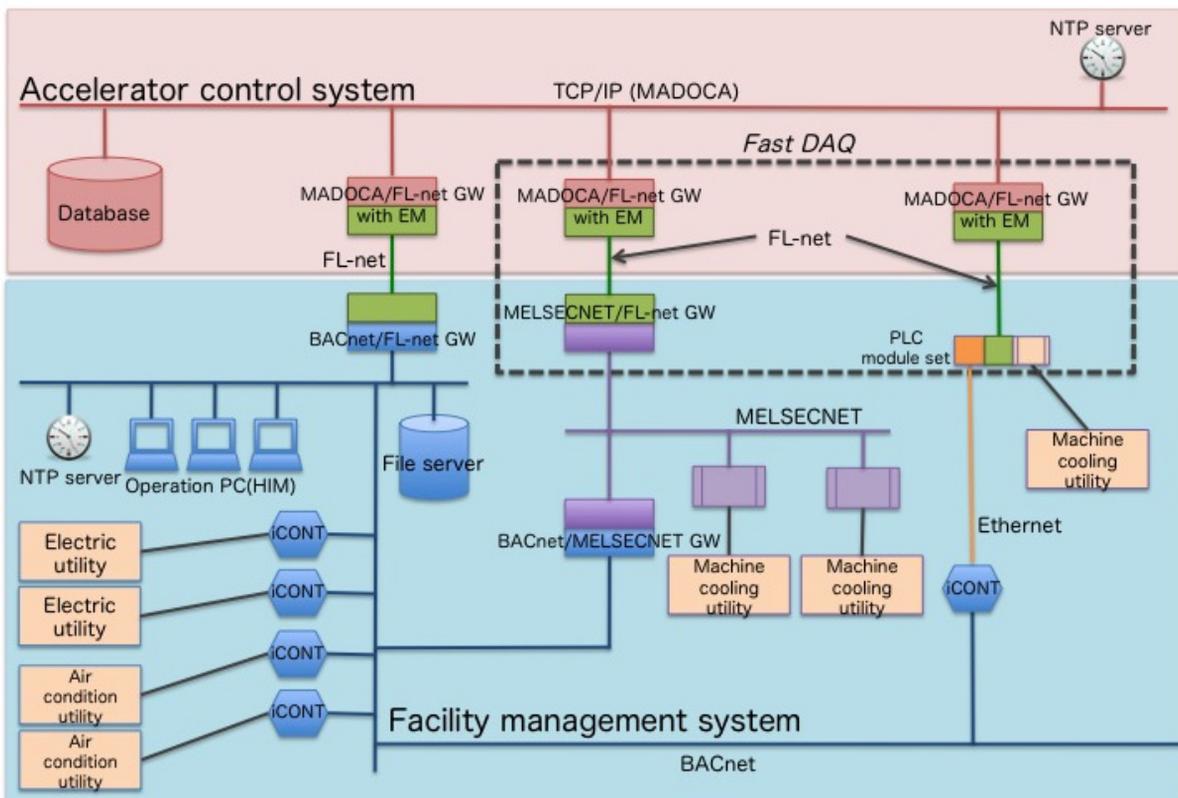


Figure 1: Schematic diagram of connection between accelerator control system and facility management system.

facility control system [9] in the XFEL facility, SACLA. These systems continue to operate stably.

A firewall is not needed for access control between the accelerator control network and facility management network when implementing the FL-net protocol. This is because a VME-based FL-net interface board implementing a MADOCA/FL-net GW can control front-end devices through the VME bus system and has a function to execute the FL-net protocol using the firmware. The FL-net board reads and writes 8 k words and 8 k bits of cyclic data transferred by the BACnet/FL-net (MELSECNET/FL-net) GW.

### Future Option

The current system has been providing only data acquisition from the facility equipment. We have the option of controlling the facility equipment such as the machine-cooling utilities directly from the accelerator control system. We can achieve only minor software modification of a MADOCA/FL-net GW and a BACnet/FL-net GW. With this option, the flow of control commands would have only one path via a BACnet/FL-net GW. At the facility management system, the commands sent from the operator PCs in the central monitoring room are executed via BACnet. In the same way, the commands from the accelerator control can be sent directly to the facility equipment through a BACnet/FL-net GW with this option.

## IMPLEMENTATION

We had to accomplish this large project over a short period of time. Additionally, we had limited manpower when constructing the utilities DAQ system. To solve these problems, we outsourced the construction of all the GWs to Mitsubishi Electric Building Techno Service Co., Ltd. [10] in June 2010 and Hitachi Zosen Corporation [11] in February 2011. In particular, it was a first trial of the development of Equip Management (EM) and poller, which were applications of a MADOCA framework and were run on Solaris 10 in a VME bus system. We provided a development tool that allowed MADOCA to set up configuration tables for the contractors. This development tool used OpenOffice.org [12]. It was very helpful at decreasing careless mistakes and saved work. The contractors did not need to develop a new C language function for EM and poller because they could use our prepared C libraries for FL-net device access.

As a test environment, we set up a test-database and a test-LAN using dark optical fiber cables. This test environment simulated the accelerator control system and was completely independent from any system at SPring-8. Even during the SPring-8 user time period, the contractors could confirm the capabilities of the utilities DAQ system in the test environment. Additionally, the contractors did not need to change the installation location and network configuration of all the GWs for the test environment. After the confirmation, we could smoothly install the GWs into the accelerator control system from the test

environment in only one day. During this work, we frequently verified the progress.

## SUMMARY

We designed and constructed a utilities DAQ system composed of three types of gateways: a VME-based MADOCA/FL-net GW, PLC-based BACnet/FL-net GW, and MELSECNET/FL-net GW between the accelerator control system and facility management system. This system can acquire the utilities data from the facility equipment with the required precision and sampling rate and can store the data in a database for the accelerator control. We also provide the future option of controlling the facility equipment from the accelerator control system. For the implementation, we outsourced the construction of the gateways, including data acquisition software of the MADOCA framework, to overcome the problems imposed by our limited manpower and short construction period. We were able to smoothly install the GWs in the accelerator control system by effectively using a test environment. The number of acquired signals is 678 signals with a slow sampling rate and 382 signals with a fast sampling rate.

Figure 2 shows the correlation between the delay of the trigger jitter at a linac M6 thyatron and the receiving voltage in July 2011. One of the sources of instability for the linac RF output is the jitter delay of a thyatron. As can be seen in figure 2, when the receiving voltage increases, the jitter delay decreases. Accelerator specialists installed an automatic voltage regulator (AVR) in the power supply of an M6 thyatron in August 2011. They are considering the installation of AVRs into other thyatrons. It is now possible to easily obtain and refer to the utilities data from the database because of the construction of the utilities DAQ system.

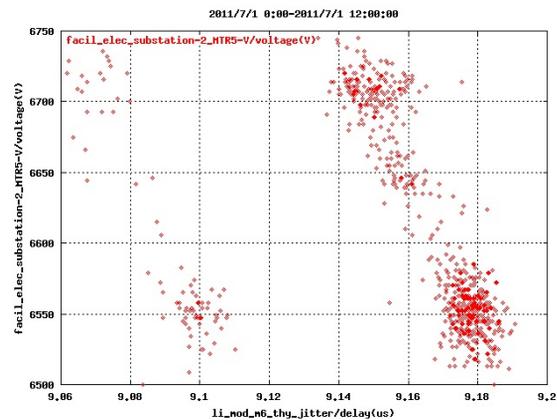


Figure 2: Correlation between delay of trigger jitter at linac M6 thyatron and receiving voltage.

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