UPGRADE OF J-PARC/MLF GENERAL CONTROL SYSTEM WITH EPICS/CSS

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Abstract

The general control system of the Materials and Life Science Experimental Facility (MLF), called the MLF-GCS, comprises programmable logic controllers (PLCs), iFix operator interfaces (OPIs), and data servers. It controls various systems and equipment, including the mercury circulation system and the safety system. The present system has worked well; however, scalability and upgradability issues exist because of the poor flexibility of its operating system (OS) and version incompatibility. To overcome the weaknesses inherent in this system, we decided to replace it with a more advanced system that has high scalability and usability. Consequently, we selected Experimental Physics and Industrial Control System (EPICS) and Control System Studio (CSS) as our framework, along with new OPI software, on which basis we built a prototype and investigated its performance. Using an OPC server and the EPICS OPC device, we confirmed that EPICS was able to communicate with the PLCs. Further, using a PostgreSQL-based data server, a data storage test on data comprising approximately 7000 points connecting to the current MLF-GCS devices was successfully conducted. In addition, we verified the OPI functions of CSS. These successful results motivated us to introduce the EPICS/CSS system as a suitably advanced MLF-GCS.

INTRODUCTION

The Materials and Life Science Experimental Facility (MLF) is a Japan Proton Accelerator Research Comparex (J-PARC) muon and neutron experimental facility [1]. The MLF's beam operation started in May 2008 with a beam power of 4 kW. The beam power subsequently increased, with the present beam power being 300 kW (May 2013). The MLF is designed for a maximum beam power of 1 MW. In the MLF, a 3 GeV proton beam is injected into a muon target (graphite) and a neutron target (mercury). The generated muon beam is then supplied to the muon beam lines. The generated neutrons are slowed in hydrogen moderators and then supplied to the neutron beam lines.

The general control system of the MLF (called the MLF-GCS) comprises several components for integrated control and interlocking, a network, server, timing systems, and a personnel protection system (PPS), and is employed to safely and efficiently supply a secondary beam in the MLF. Figure 1 gives an overview of the present monitor and operating (MO) system of the MLF-GCS [2]. The MLF comprises a number of components and systems, such as a target trolley, a mercury circulation system, water cooling systems, a gas cooling system, a gas disposal system, a moderator cooling system (20 Kelvin hydrogen), and a muon target system. These MLF instruments have local control panels (LCPs) with programmable logic controllers (PLCs). The LCPs are connected via an optical network (MELSEC NET/H) and operation data are administrated at the MLF-GCS. The MLF-GCS is independent of the accelerator control system of J-PARC, but they share information on the status of beam operation with each other via the EPICS IOC.

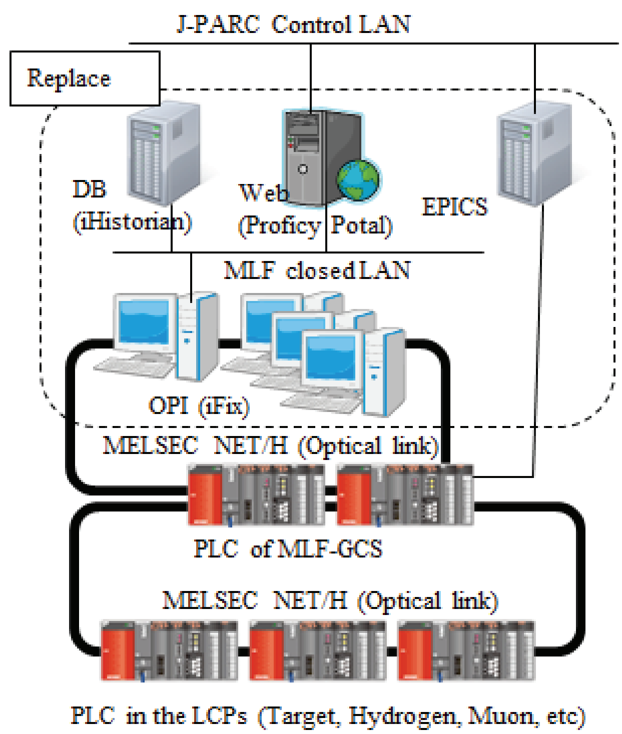

Figure 1: Outline of the present MO system in the MLF-GCS.

The operator interface (OPI) and database (DB) server used in the MLF-GCS are iFix and iHistorian, respectively. During the operation of the MLF, approximately 1000 analog data points and 6000 digital data points are processed. All of this data are saved to the DB every 5 s. The OPI has approximately 130 operation screens. This MO system performed its function as designed, since the first beam operation to the present

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time. However, because support for its operating system (OS) has expired and the PCs used for both the OPI and DB are of advanced age, both the PCs and the OS need to be replaced.

REQUIREMENTS FOR THE NEXT MO SYSTEM

The present MO system used in the MLF-GCS has upgrade and maintenance issues. One such issue is version compatibility among iFix, iHistorian, and Windows OS. The software vendor does not support mixtures of different versions of the software in a system. Therefore, we have to replace both the DB and the OPIs at the same time. Another issue is the software license fee, which costs over 15 million yen in total. Consequently, we considered the following items for our new system:

- Influence of the update cycle of the operating system
- Version compatibility of the software
- Ease of system modification
- Compatibility with EPICS
- Maintainability
- Cost.

INVESTIGATION OF THE CANDIDATES FOR THE NEW SYSTEM

We compared three kinds of systems based on iFix, LabView, and Control System Studio (CSS) as candidate framework software for the new system. The comparison results are shown in Table 1.

iFix and iHistorian are used in the present MO system. They have the advantage of reducing development effort because they enable us to reuse the screen definition data of the present system. However, they require software license fees. Specifically, iHistorian's license fee is 10 million yen for 10000 data points. Additional costs such as client access licenses are also involved. Further, if we select that system, we would have to replace the PCs of the MO system and DB every five to seven years in line with the lifecycle of the Windows OS.

LabView is a general-purpose control software. An EPICS-LabView device driver has been developed and is available on the EPCIS website [3]. With the NI-OPC server software [4], LabView can communicate with the numerous PLCs. It is therefore possible to reproduce the functionality of the present system using LabView. However, because there are over 130 operation screens on the present MO system, layer management is very complex and difficult. In addition, because the LabView development environment is graphical, it means many graphical objects are connecting with many lines in LabView programing, it is not suitable for dealing with data comprising 7000 points.

CSS was developed as a user interface for EPICS. It comprises many screen components and utility tools, including archive systems and alarm server systems. It is also possible to reproduce our present screens using functions available in CSS. In addition, CSS is open source software and has no licensing fee (i.e., it is free). Thus, in addition to the functions it provides off-the-shelf, we can develop new components for CSS. It can also operate on a variety of platforms, such as Windows, Linux, and Mac OS. Furthermore, because CSS is based on the JAVA language, it is not affected by versioning of the operating system.

Table 1: Comparison of the Potential System Candidates

	iFix and iHistorian	LabView and SQL	CSS and PostgreSQL
OPI	iFix	LabView	CSS
OS (OPI)	Windows	Win/MAC Linux	Win/MAC Linux
OPC server	iFix	NI OPC	Tk OPC
DB	iHistorian	SQL	PostgreSQL
Function	OK	OK	OK
Software fee	Expensive:	Reasonable:	Free
Build effort	Low	Very High	High
Version compatibility	Not enough	Unconfirmed	Good
Modification of OPI	Easy	Difficult for beginner	Easy
EPICS IOC	EPICS OPC	EPICS LabView	EPICS OPC

With an OPC server and the EPICS OPC device driver, it is able to share all the data between the PLC and EPICS. We selected the Takebishi OPC server (Tk-OPC) [5] as our OPC server software. It supports many PLC models. As candidate for the OPI, we considered CSS to be the best in terms of cost, performance, ease of maintenance, and scalability. As a result, we decided to introduce a system based on EPICS and CSS for the MO system in the MLF-GCS.

An overview of the new system is given in Fig. 2. It consists of a number of servers: One is Windows-based and is used as the Tk-OPC server and the EPICS IOC. The other is Linux-based and is used as a data and alarm server. A Web server is also set up on the Linux server for WEB-OPI remote monitoring. Four Linux PCs are used as the OPI of the CSS. The operation data is sent to the J-PARC control Ethernet LAN (C-LAN) through the EPICS Gateway. The Web server on the C-LAN is used by the WEB-OPI server for remote monitoring and data sharing.

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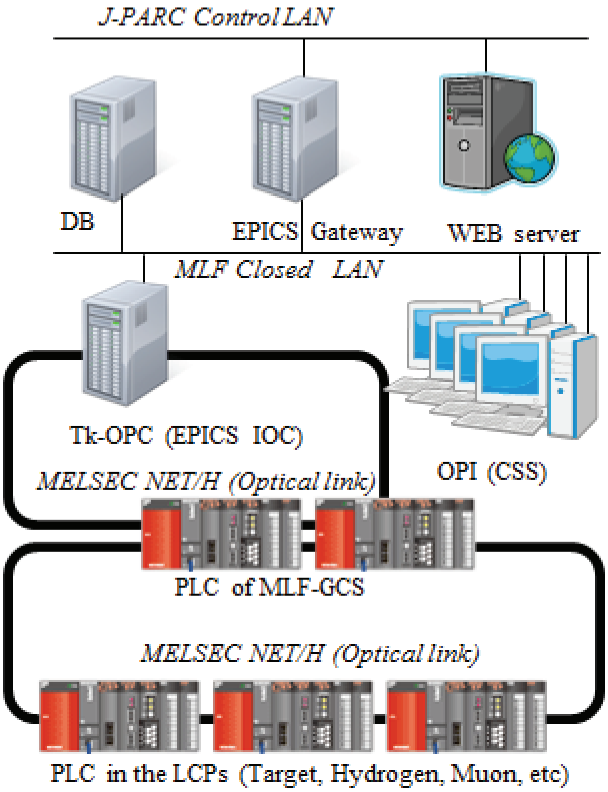

Figure 2: Overview of the upgraded MO system.

VERIFICATION OF THE PROTOTYPE SYSTEM

In order to verify the basic functions and overall performance of a system based on EPICS and CSS, we constructed a prototype system. Figure 3 shows the functional structure of the prototype system constructed. The prototype system consists of two PCs: One has the Windows OS installed for the Tk-OPC server and EPICS IOC server. The other is a Linux server that is used as a PostgreSQL server (DB and Alarm server) and a CSS client. The Windows PC is connected to the PLCs via the optical network (MELSEC/NET) in Fig. 2. The Windows PC (EPICS IOC) and the Linux PC (DB server) are connected via the Ethernet LAN. The specifications of the prototype system and the results of the tests conducted are shown in Table 2. Although only five operation screens were produced for this prototype, all the data (comprising approximately 7000 points) were registered to the OPC and data servers for the actual load test.

All of the functions, such as data read/write, alarm function, data archive, and OPI worked well. We found that all the data was read within 1 s. As shown in the table, the CPU load was 5% on average, network load less than 1%, and disk usage rate of the data server 35 MB per hour. The system demonstrated performance suitable for an MLF-GCS.

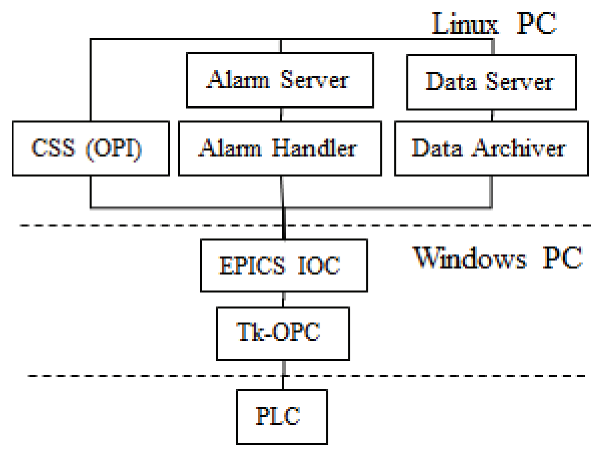

Figure 3: Functional structure of the prototype system.

Table 2: Specification of the Prototype System and Performance Test Results

	OPC server	DB server
OS	Windows 7 32-bit	RH Linux 6.2 Ent. 64-bit
CPU	Intel i3 2120 3.3 GHz	
Memory	3 GB	8 GB
CPU load	5%	5%
Network load	0.3%	30 kb/s
Memory usage	800 MB	5 GB
Main programs	TK-OPC server EPICS IOC	PostgreSQL CSS Data server Alarm server
Disk usage rate		35 MB/hour

SCHEDULE

We started testing potential candidates for the new system in October 2011. Subsequently, in April 2012, we decided on the specifications for the prototype. This was followed by testing of the prototype in November 2012, and determination of the specifications for the new system in March 2013. We intend to introduce the new system into operation, in parallel with the current system, in December 2013, and into full operation starting April 2014.

SUMMARY

In this paper, we compared three pieces of software as candidates for a new MO system of the MLF-GCS. We considered the EPICS and CSS system the best candidate in terms of practicality and design concept. CSS has enough functions to develop our MO system and can also be extended by developing any specific function required

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for it. With the Tk-OPC server and the EPICS OPC device driver on a prototype system, we confirmed that EPICS could communicate with the PLCs within an interval of 1 s. We plan to introduce the system in December 2013 and, after a test period, full-scale operation will start in April 2014.

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