3.9.1

Data acquisition and device control software framework in MLF, J-PARC

Takeshi Nakatani[1], Yasuhiro Inamura[1], Takayoshi Ito[2] and Toshiya Otomo[3]

[1] Materials and Life Science Division, J-PARC Center, Japan Atomic Energy Agency, Tokai, Ibaraki 319-1195, Japan
[2] Research Center for Neutron Science and Technology, Comprehensive Research Organization for Science and Society (CROSS), Tokai, Ibaraki, 319-1106, Japan
[3] Institute of Materials Structure Science (IMSS), KEK, Oho, Tsukuba, Ibaraki 305-0801 Japan

E-mail: takeshi.nakatani@j-parc.jp

Abstract. We have developed the standard software framework unified data acquisition and device control at the beginning of the Materials and Life Science Experimental Facility (MLF) in the Japan Proton Accelerator Research Complex (J-PARC). The software framework called "IROHA" is introduced and used in several instruments at MLF from 2008. In use of the software framework for five years, several improvement points as follows were suggested to IROHA. They are 1) separation of device control and instrument management (i.e., the roles of device control are operation, monitor and logging of devices, the roles of instrument management are logging of measurement, authorization and certification), 2) interface of experimental database for measurement information and 3) platform-independent user interface. In this article, we describe the details of the new software framework "IROHA2".

1. Introduction

Many kinds of the experimental instruments are operated in Materials and Life science experimental Facility (MLF), Japan Proton Accelerator Research Complex (J-PARC) to get scientific research results in the neutron and muon science. The instruments are composed of many devices, which are the data acquisition system (DAQ), the devices of the beam transportation and the sample environment, etc. A lot of users have done various kinds of experiments by using the instrument control system. We have developed the flexible and scalable software framework unified DAQ and device control while construction of the day-one instruments in MLF [1]. The software framework, named "IROHA", has been introduced and used in the several instruments in MLF.

After the operation of IROHA for several years, some improvements are suggested as follow. Because the software components of IROHA were tightly coupled, all components, not only software but also hardware, in the instrument had to operate correctly. If one component was broken, we had to stop the system, remove the trouble component and restart the system. In addition, because the software components were not provided the individual user interface, it was necessary that all components operate even if we wanted to control only one device.

The various information of measurement is produced by the experiments in MLF. We have developed MLF experimental database (MLF EXP-DB) to manage such measurement information [2]. To

manage this information efficiently, it is necessary to formalize the information. The role expected of IROHA is to connect between the measurement information and MLF EXP-DB.
Recently, people properly use some kinds of information apparatus according to a situation. In this case, even if the apparatus is different, a user interface is suitable to be similar i.e., platform-independent. Thus, it is preferable to be platform-independent in the user interface of the instrument control system in MLF.
In 2013, we started to plan the upgrade of IROHA to achieve higher user-friendliness, availability, flexibility and scalability. We have discussed and designed the improvement points in IROHA. The points of upgrade are as follows.

1) Software functions which are proper role-sharing between device control and instrument management
2) Interface between measurement information and MLF EXP-DB
3) Platform-independent user interface

In this article, we describe the detail of the new standard control software framework for the instrument in MLF, named "IROHA2".

2. Architecture

The software of the instrument control system in MLF is composed of three layers which are the user interface layer, the management server layer and the control server layer including DAQ Middleware [3] (shown in Figure 1). The layer of the user interface is the front end of the instrument control system. The layer of the management server is the management of measurements with the configuration of the instrument. The layer of the control servers is each device control. We have adopted the client-server model between the layers. The communication protocol between the layers is the exchange of messages formatted XML over HTTP. Because the layers communicate with HTTP, each layer is easily able to be distributed in the network. We have been able to control DAQ and devices with the single user interface while load balancing. Thus, we can construct the instrument control system with flexibility and scalability. The scope of the control software framework IROHA2" in the instrument control system is the management server and the control servers without DAQ Middleware.

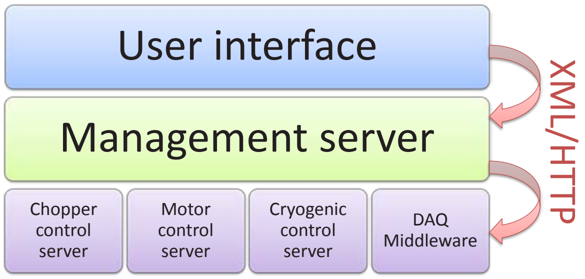

Figure 1. The software architecture of the instrument control system in MLF.

3. Upgrade points of IROHA2

3.1. Role sharing of device control and instrument management

When we designed IROHA2, we redefined the roles of each software component. The roles in the management server layer are the measurement management, which are measurement run control and logging of measurements with the configuration of the instrument, authorization and certification of users. The roles in the control server layer are each device control, such as operation, monitoring and logging of the device. In IROHA2, we defined the software of the

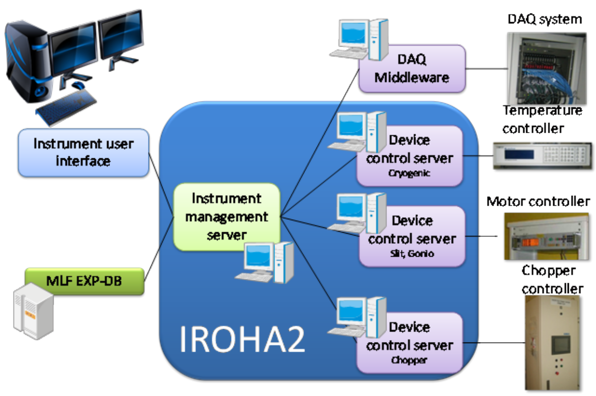

Figure 2. The deployment diagram of IROHA2.

management server layer the instrument management server and the control server layer the device control server (shown in Figure 2). The instrument management server is the single process in the instrument control system and the device control servers exist device by device. Each software component is able to run independently and connect each other on demand. We can change the configuration of the instrument control system as needed; the devices are able to attached or detached without stopping the system.

3.2. Interface between measurement information and MLF EXP-DB

We have defined one of the roles of the instrument management server the interface between the users' experimental data and MLF EXP-DB. The instrument management server performs the communication between MLF EXP-DB and IROHA2. In the measurement, the instrument management server collects and records the experimental meta-data, which includes the DAQ and devices' conditions and the information of the user, the proposal and the samples. We have named the experimental meta-data "Run Information". Run Information is generated by the instrument management server in every measurement. MLF EXP-DB automatically searches, registers and catalogues the Run Information linking the experimental raw data. By using this information, MLF EXP-DB can recognize which sample is measured, who obtains the experimental data in which proposal.

3.3. Platform-independent user interface

A web interface is one of the most popular user interfaces in the world. Nowadays, the equipment accessing to web is not only the computer but also the mobile device, such as the tablet terminal and the smart phone. Previously, the web contents were necessary to be designed according to each equipment respectively, but recently, the single web content designed with so-called "Responsive Web" is available for use from any equipment. Therefore, we have adopted the web user interface designed with Responsive Web as the platform-independent user interface of IROHA2 to realize user-friendly interface. The user interfaces of the device control servers and the instrument management server are shown in Figure 3. We can maintain the devices, configure the instrument control system and run control of measurements on a web browser.

(a) (b)

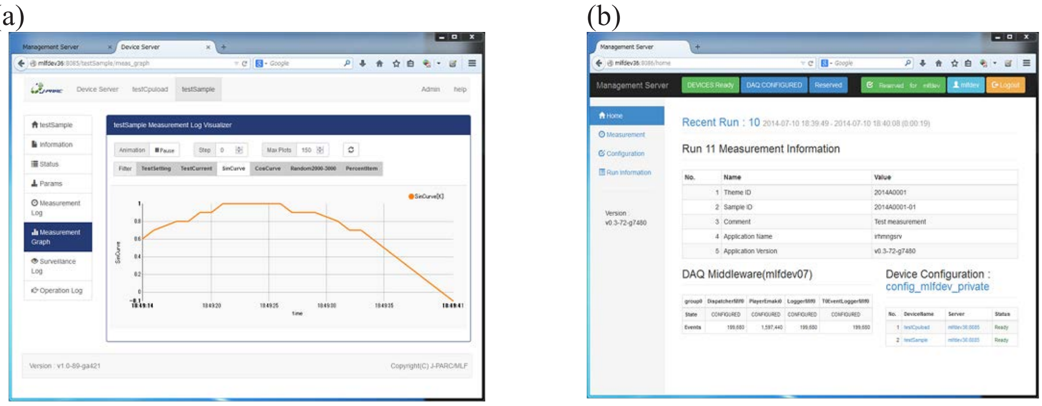

Figure 3. The Screenshots of the device control server (a) and the instrument management server (b).

4. Implementation

The implementation of IROHA2 is shown in Figure 4. As mentioned before, IROHA2 has been adopted the client-server model with XML/HTTP. To implement this model, we introduce Bottle [4] with Python. Python is one of the most popular script languages in the programming languages. In the neutron science community, Python is the most familiar script language. Python has the default module processing XML file. The web framework, Bottle, is one of the simple web frameworks for Python. Because Bottle can be used as a single file module, we have been able to easily implement the client-server model with XML/HTTP written in Python with Bottle.

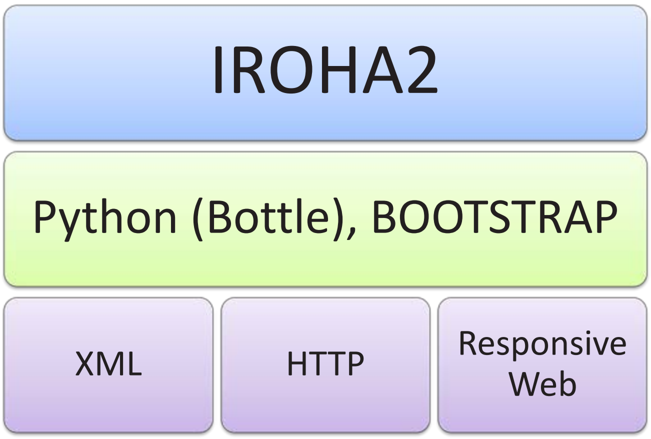

Figure 4. The implementation of IROHA2.

A web interface is primitively written in HTML. However, it is difficult to make the platform-independent web interface with HTML from scratch. We have adopted BOOTSTRAP [5] to realize the platform-independent web interface designed "Responsive Web". BOOTSTRAP is one of the most popular frameworks for Responsive Web. We have made the user interface of the device control servers and the instrument management server by BOOTSTRAP.

5. Conclusion and Future plan

We have upgraded our control software framework (IROHA2) which is user-friend, available, flexible and scalable. By using IROHA2, we will be easily able to do experiments, configure the instrument control system and maintain the devices in the instruments on a web browser. We will develop automatic measurement software called the sequence management server and introduce it into IROHA2. When the software will have developed, we will introduce IROHA2 into the instrument control system in MLF.

Acknowledgments

We wish to acknowledge valuable discussion and suggestion with the MLF computing environment team.

References

[1] T. Nakatani, Y. Inamura, T. Ito, S. Harjo, R. Kajimoto, M. Arai, T. Ohhara, H. Nakagawa, T. Aoyagi, T. Otomo, J. Suzuki, T. Morishima, S. Muto, R. Kadono, S. Torii, Y. Yasu, T. Hosoya and M. Yonemura: Proceedings of ICALEPCS2009 673-675.

[2] T. Nakatani, Y. Inamura, T. Ito, K. Moriyama and T. Otomo: JPS Conf. Proc. 1, 014010 (2014)

[3] K. Nakayoshi, Y. Yasu, E. Inoue, H. Sendai, M. Tanaka, S. Satoh, S. Muto, J. Suzuki, T. Otomo, T. Nakatani, T. Ito, Y. Inamura, M. Yonemura, T. Hosoya and T. Uchida: Nuclear. Inst. Meth. Phys. Res., A 623, 537 (2010).

[4] http://bottlepy.org/.

[5] http://getbootstrap.com/.