DESIGN OF WEB-BASED INTERFACE TO RIKEN 28 GHZ SUPER-CONDUCTING ECR ION SOURCE AND THE FUTURE PLAN

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Abstract

A new RIKEN 28GHz superconducting ECR ion source (28GHz-ECRIS) was constructed in 2009 in order to increase the intensity of Uranium ion beam for RIKEN RI beam factory project (RIBF) [1]. For effective and stable operation of the 28GHz-ECRIS, its operational software should have a user-friendly man-machine interface. The ECRIS control system was constructed with the Experimental Physics and Industrial Control System (EPICS) as well as RIBF control system. As a result, it was successful to provide the useful software, such as the operation GUI panels, the XY chart application, and the data acquisition system in EPICS-based system. On the other hand, to keep beam quality from 28GHz-ECRIS for a long beam service term, it should be possible to operate the 28GHz-ECRIS by members of the ion source team at any time. In order to relieve concern in the overseas business trip of members, we designed a real-time web-based client operational software using WebSocket, which is a new protocol presented by Internet Engineering Task Force (IETF) [2].

INTRODUCTION

The control system for RIKEN 28GHz-ECRIS was built with using EPICS which is the same as that for RIKEN RIBF [3]. The TCP/IP network was used for the communication with between local controller and client system. For manipulation of the main parameters of the ion source (gas pressure, current of the super-conducting solenoid coils, etc), F3RP61-2L was adopted, which was manufactured by Yokogawa Electric Corporation and was a CPU module of FA-M3 Programmable Logic Controller (PLC) without a ladder program. As the Linux runs on the F3RP61-2L, it can work as an EPICS Input/Output Controller (IOC). Similarly, the vacuum control system and beam diagnostic system were constructed by using EPICS, and Linux-based IOCs connected with N-DIMs, which were developed originally in RIKEN, over the Ethernet. On the other hand, for the 28GHz-ECRIS operational software, two Microsoft Windows XP PCs were used both in RIKEN linear accelerator (RILAC) and RIBF cyclotron control rooms. The PCs, in which X Window System is installed, have six displays using a multiple-display environment. And the web-based system is used for reading and writing of electric-log book and data archive viewer system for 28GHz-ECRIS.

MAIN CONTROL PANEL

The main panel to manipulate the gas pressure, extraction voltage, power supplies of the magnets and the X-Y plot of the spectrum of charge state distribution were developed with using the EDM [4]. EDM is one of the motif-based display managers provided by EPICS collaboration in order to develop the client operational software with GUI. The main panel GUI and plotter GUI are shown in Fig. 1 and 2, respectively. We adopted the Cygwin-X as an X-server, because the EDM is displayed on the X-window system.

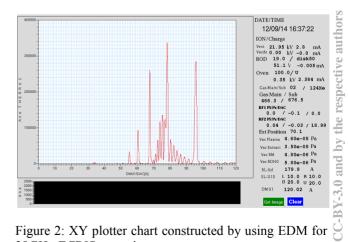Figure 1: Main control panel constructed with EDM for 28GHz-ECRIS.

Figure 2: XY plotter chart constructed by using EDM for 28GHz-ECRIS operation.

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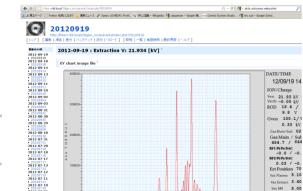
PRESENT WEB-BASED SYSTEM
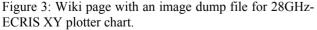
The Advantage of Web-based System

In today's society, Web and Internet access means one of the infrastructures. It is available to get various kind of information from Internet by using not only PC, but also mobile phone, TV and tablet. Therefore, the client system is not confined to the platform as long as corresponding to the Web. Besides, it is possible to reduce the cost of replacement of the client system significantly, so that it is not necessary to setup the dedicated client PCs.

Electric Log System

We obtained the log by hand-writing the numerical value indicated on the panel conventionally. However, it is not effective to obtain it, when we have many parameters. To make up for the disadvantages, we implemented the web-based Wiki instead. The Wiki is the system that one can edit the Hypertext Markup Language (HTML) on the web server by using Web browser.

To save the 28GHz-ECRIS parameter effectively, we planned to construct a paperless log system using Wiki (See Fig. 3). Recently, various kinds of Wiki are being used with a growing rate of Internet accesses around the world. In our system, open-source PukiWiki [5] was installed in the server. Simultaneously, we developed a program for the client, it dumps image files from these GUIs, and then it pastes the image file into PukiWiki page automatically. As a result, it was useful to adopt the electric log system using the Pukiwiki instead of writing the numerical value on the notebook. In the actual operation, the ion source operators obtained the log by using the method described above without any problems. Furthermore, it was useful to take over the condition of the ion source to the operators who work in the next shift.

Figure 3: Wiki page with an image dump file for 28GHz-ECRIS XY plotter chart.

Archive Viewer

Using MyDAQ2 [6] developed at JASRI/Spring-8 as the data archive system in 28GHz-ECRIS, EPICS record value such as vacuum, extraction current and RF power were recorded into MySQL database. In our system, an EPICS Channel Access (CA) client for data collection was developed. The data is inserted into MySQL database with socket connection to the server running MyDAQ2 every ten seconds. Since the plot and the text are displayed on the Web browsers with ease, the web applications have user-friendly interface as well as Wiki-based system. The data archive system using MyDAQ2 is an effective method in order to shorten turnaround time in the system construction process.

NEW SYSTEM AND FUTURE PLAN

WebSocket Protocol

As described above, we used Web-based system in the electric–log and archive viewer which is the sub part of the ion source control system. Generally, we used a method for GUI development, such as the display applications coded in C/C++, Python and Java or used with EDM/MEDM [7]/CSS [8] for EPICS-based main control panel, because it is required to ensure ergonomic interactivity for beam operation. Actually, traditional Web application was not suitable to operate the main parameters of 28GHz-ECRIS, such as gas pressure control, in the lack of interactivity.

On the other hand, the engineers in the SPring-8 proposed the development methods of GUI using the WebSocket and made a prototype implementation [9]. The prototype system was constructed using MADOCA-based system that has been developed in the SPring-8 and was different from the EPICS-based system. For these important advantages of the system and Web application using WebSocket, we developed WebSocket server and implemented Web applications using WebSocket for control system of 28GHz-ECRIS with EPICS.

WebSocket is a new protocol to achieve the bidirectional communication between Web server and Web browser. Initially, the WebSocket was the part of the HTML5. It was formulated as a RFC6455 by the ITEF in Dec. 2011. The overview of the protocol is as follows.

1. A Web browser sends the handshake request to the server for connecting to the WebSocket.
2. Server returns a response of handshake after approval.
3. After the establishment of the handshake, the protocol switches to the WebSocket, and then the bi-directional communication is done between the Web server and Web browser.

Conventionally, the Web-based client system has ever been implemented, however, only for the monitoring system where a fast control response is not required. It is difficult to ensure the interactive response like the native application because of the difficulty of bi-directional communication between the server and client using the

conventional HTML/HTTP technology. Since it is possible to make a bi-directional communication while keeping the connection between server and client, the problems described above can be solved by using WebSocket. Actually, it was found that the behaviour is comparable to the EDM when we used the WebSocket to obtain the data which change the numerical values in the period of ~100 ms. The problem is that it is not compatible with the all Web browsers (ex. Internet explorer (IE) 9). However, it is scheduled that the next version IE10 will support the WebSocket [10].

Developments Method

We used the Node.js [11] and its library (Socket-IO [12]) for development of the WebSocket server. Node.js is one of the server-side JavaScript language developed based on the Google V8 JavaScript Engine [13]. It must be available to use the EPICS CA protocol in the node.js for implementation of WebSocket server in the Node.js. Therefore, we developed add-on of Node.js (NodeCA) which interfaces to EPICS CA using EPICS base library.

Client-Side Application

The text update can be done by the description of DOM (Document Object Model) written in JavaScript. For visualization of the information, we adopted the jsgauge [14] and flot [15] which is the JavaScript library based on the jQuery [16].

Overview of the System

The overview of the whole system is shown in Fig. 4. One can obtain the data from the EPICS IOC by sending the custom events (caPut, caGet, caMonitor) to the WebSocket server from client-side JavaScript.
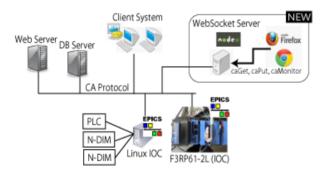

Figure 4: System overview of 28GHz-ECRIS control system and Web-based system.

System Implementation

We confirmed that it is possible to get the numerical value from the CA through WebSocket and indicate it by the iPhone 4S (See Fig. 5) and Android mobile. When implementing the application for the iPhone 4S, it is not easy to install the application developed their own without passing through the apple store. However, it is not needed in case of Web application developed by us.

At present, we are implementing it for controlling the 28GHz-ECRIS at RIKEN RIBF on a trial bases. We already checked that we had good response for monitoring the vacuum of the plasma chamber and controlling the gas-valve and so on. We continuously develop it to the actual operation.

Figure 5: WebSocket-based Web application displayed on iPhone4S.

CONCLUTION

We developed the server which makes it possible to connect with EPICS CA by WebSocket. It enabled to display the information of the accelerator's conditions and to control it using the Web browser in real time. It makes possible to call CA API from Node.js by developing the add-on to interface for CA. At present, toward the full scale operation of 28GHz ECRIS control system, we released the first version and then we implement and control it on a trial bases. We confirmed that we can control and monitor a part of the main parameters for 28GHz-ECRIS as well as traditional EPICS-based application. It lay out on the table to make an access policy for implementation of access from WAN in the future.

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