Electronic Logbook Development for the KSTAR Commissioning

Sulhee Baek*, Sangil Lee, Mikyung Park, Woong Chae Kim, Yeong-kook Oh, Hoonkyun Na and Myeun Kwon

National Fusion Research Institute 113 Kwahangno, Yuseong-gu, Daejeon, 305-333, KOREA

Abstract

During the commissioning of the KSTAR device, electronic logbook has been developed to record participant's opinions regarding experimental procedures and results. The experimental logbook, a kind of the electronic logbooks inserts principal experimental parameters by itself and gets the experimenter's comments. Since it usually takes long time to surf around raw experimental data, a summarized comment on the experimental logbook helps physicists to analyze the results. The operation logbook, the other part of electronic logbook records history about system's abnormal, including their management history. Records on the operation logbook for components provide the criteria to validate the device's stability and the basis to complement the device operation procedure. Since a large majority of readers is interested in the information on the electronic logbook, the data is manipulated to be searched and read on the web-site which is accessible by the authenticated users. The web-site also includes a formatting function to report the logbook data as a document using Java Document Object Model (DOM) and Java Simple API for XML (SAX) API. Because there were difficulties to make an action scenario on the events due to insufficient experience of takamak operation, it was developed in parallel during the commissioning. By training operators to write comments on every detail of the experimental results and operation events, it could be more valuable data source for the next experiments.

Keywords: KSTAR, electronic logbook (e-logbook), RDB, EPICS, MDSPlus, Web

1. Introduction

The Korea superconducting tokamak advanced research (KSTAR) device was operated successfully accomplishing the commissioning of the device and the experiment for the 1st plasma creation [1]. In order to assist experimenters, we asked operators to fill in a document, describing the experimental plans with blank section to put operator's opinion, and we made much effort to gather this daily report from operators. However, these written reports turned out to be not so useful in spite of spending much time because it was not easy to browse all papers manually and the data couldn't be shared simultaneously to the multiple users. Besides, in order to search a right experimental result they had to explore the experimental data over again.

For these reasons, a popular electronic logbook (e-logbook) was developed for Alcator C-Mod [2] to be connected with MDSPlus [3] which is the most widely used system for data management in the magnetic fusion energy program. Even though it seems easy to adopt an existing well-developed e-logbook, most of the fields might be remained empty because database structure developed based on the abundant experiences may be complicated for us to understand. In the end, we decided to develop a simple e-logbook which would be proper to our commissioning procedure and the 1st plasma experiments.

This paper describes the derived requirements from operators, technologies used to develop the e-logbook with system description, the future works, and conclusions.

2. Analysis of requirements

2.1. Operation procedure

During the commissioning, we performed about 20 shots in a day during day time, and the night shift operators controlled cryogenic systems in order to sustain superconductivity of the magnets and monitored system status against unexpected events. Operation procedure during the KSTAR commissioning was shown in Table 1. The night shift operators monitored and checked the status of each local device. Especially, the operators of cryogenic systems had to write down the checked status on the closely packed sheets not to make a mistake and transmit it to the next operators. The operators of the glow discharge system performed glow discharge to make the wall condition better overnight for saving time. Operators transmitted the checklist filled out during their duty hours to the next operators and explained what happened. If there were some unexpected events during their shift, they had to record the situation and handling history in the daily report designed for each local device. The Chief Machine Operator (CMO) and the operators call a short meeting to share daily experimental plan and the operators made a report about status of the local devices to the CMO. The Session Leader (SL) follows to call a meeting with key machine operators, physics operators and physicists to discuss daily experimental plan and procedure in detail. During the meetings, people in charge of personal safety conducted an activity searching around tokamak device room and then changed the 'Access' mode to the 'No Access'. After the MPS operator turned on the Toroidal Field (TF) Magnet Power Supply (MPS), the planned experiments started to be executed following the pre-defined experimental sequence.

The first shot was a dummy shot to check the machine and the integrated control status between devices. Every experimental sequence started with the preparation procedure. If the SL presented the experimental parameters for the shot, the operators configured their device as the presented direction. Meanwhile, current shot number, shot sequence, and machine status were displayed on the monitor, and a large display panel at the front side of the control room. If the operator of the supervisory control

Table 1
Operation procedure of the KSTAR machine during the 1st operation phase

Time	Procedure	Description
8:45	Status check of the local devices	The night shift operators transmit checklist filled out during night time to the day shift. The day shift checks status of each local device.
8:50	Preparation of operation	CMO explains today's experimental plan to the operators briefly.
9:00		SL and experimenters talk about today's experimental procedure in detail.
9:30	Operation of the TF superconducting magnet	Operator turns on TF magnet power supply (MPS). Experimenters repeat shot sequence based on the experimental plan decided in the morning meeting.
Experimental sequence	Preparation of the experiment	SL presents the experimental plan including goals of experiments and required parameters. By this presentation, operators configure their devices for the shot.
	Plasma experiment by shot sequence	Plasma experiment is executed by the shot sequence. During the shot sequence current charging status is trended on the MPS monitoring chart and video signal from the diagnostic TV shows a flash of plasma image.
	Post processing of the shot sequence (Inter-shot process)	Shot number is added after the post processing sequence. Operators report to CMO on the system status after the shot. Physicists extract the experimental data from the storage and discuss shot result.
17:30	End of the daily operation	Operator turns off TF MPS and some operators check status of each local device.
20:45	Shift of operators	The day shift operators transmit checklist filled out during day time to the night shift. The night shift checks status of each local device. And CMO explains monitoring points to give attention during night time.

Table 2
Derived requirements of e-logbook

Role	Contents to log or refer
CMO	• Operation shift table • Experimental plan and schedule • Gathered reports from all operators • Operator's meeting minutes and experimenter's meeting minutes
Operators	• Operation check sheet and comment notes designed for each local device for day and night • Operation manual for each local device • Summarized graph of the operation data of each local device • **Fault lists from each local control system and the supervisory interlock system including event history and management for it** • Contact information • Well-formatted document to make a report to CMO • Operator's meeting minutes
SL	• Experimental plan describing parameters and directions for each shot • Experimenter's meeting minutes
Physicists	• Summarized graph of the experimental data from diagnostics system • Opinions about shot results • Analysis data based on shot results
All (Common interests)	• Current shot information such as shot number and shot sequence • Overall machine status • Declaration of the shot procedures • Current feeding status on PF MPS • Video data taken from diagnostics TV • Commentary speech for the last shot • Notice for meetings • **Summarized shot lists**

system (SCS) pushed the start button of shot-sequence with a declaration of the start of shot, the shot-sequence was executed automatically. During the shot sequence, participants could monitor current feeding status on Poloidal Field (PF) superconducting magnets through the PF MPS monitoring chart and recognize a flash from the diagnostics TV if they were lucky.

After a series of shot sequence was finished, post-shot processing was executed automatically and the SCS operator declared the end of the shot. The operators waited for the replay of the TV data or commentary speech by physics operator. This intermission around 20 minutes was used for the physicists to conclude a quick analysis for the shot result and correct the next shot scheme. Also, the operators checked the after-effect on the machine by the shot and the recovery of the machine to steady-state during that time. All experiments were finished after turning off TF MPS around 6 pm. After a daily operation, the SL called a meeting to review today's experimental results or prepare the next day's plan till late.

2.2. Deduced requirements

Introduction of an e-logbook system have not to add burdens to the operators but to help them save time and effort. From a minute observation of the operator's daily life, requirements described in Table 2 were derived to develop an e-logbook.

Among the items, a summarized shot list was selected as a development item during the commissioning, and lists of faults coming from each local control system and supervisory interlock system were gathered to be integrated into the operation logbook around the end of the commissioning phase.

3. Development of the e-logbook system

3.1. Overall description on the KSTAR control system

The KSTAR uses Experimental Physics and Industrial Control System (EPICS) [4] to integrate the heterogeneous local control systems which are distributed over the KSTAR building. The operational data of the local devices are archived in the storage using Channel Archiver, a representative archival software among the EPICS extensions to store data as the unique data format, through the Storage Area Network (SAN) [5]. Channel Archiver supplies retrieval tools such as ArchiveExport and ArchiveViewer including XML-RPC. Experimental data is managed using MDSPlus and jScope was used as a GUI chart tool to browse experimental data as a GUI chart tool. Tree structures of MDSPlus database were designed through the meetings with the users of the experimental data.

3.2. Generating a summarized shot entry

An experiment is accomplished by shot sequence running in the central controller and a supervisor controls the experiment sequence using operator panels of the SCS. Flow diagram of the shot list implementation is shown in Fig. 1. If the end of data acquisition (DAQ) event is triggered, which means the completion of diagnostic data acquisition and storing, the shot summary application starts generating contents of the shot summary. First, it gets current shot number through EPICS CA interface from the SCS. Second, it extracts the experimental data from the storage through the interface between MDSPlus and C. Third, it generates the representative graph of the experimental data using Matlab functions.

The summarized data is inserted into MySql relational database (RDB) in order to make it be useful with searching, browsing, and editing functions. For the 1st plasma operation, the results of blip action of PF power supplies, plasma current, electron density, electron temperature, impurities and heating power were displayed through the shot summary. Then, data is inserted into the RDB with the validation information in order to reduce loss of time for the experimenters to explore invalid experimental data sets. For some experimental data node which is a matter of concern to all participants, the shot summary application extracts meaningful values such as maximum plasma current and shot length while the plasma current is over than the reference value. Even if there was a requirement to show the operational data and the experimental data in a display at one time, it's difficult to integrate them because there was a mismatch of acquisition time between them. The operational data were archived repetitively or randomly by event, on the other hands, the experimental data were archived at configured sampling frequency during a specific time period. In addition, we didn't find a solution to truncate the operational data archived continuously to fit in a shot period. It would be better to summarize both of them and insert the summarized contents into the RDB. The application for the shot list management was developed using Qt library having basic database functions as searching, editing, and viewing function.

3.3. Commentary notes for the shot result

As an experimental logbook the summarized data should be packed with experimenters' commentary notes. At least, one-line comment by the SL has to be inserted into the RDB in order to identify the shot with the representative remark. And other experimenter's comments can be added as occasional demands. The qualification of the commentator was not specified but shot summary application was executed in the KSTAR network restrictively.

3.4. Development of the fault list application

The control history of each local device was written in the check sheets by hand and format of them was designed by the operators. But in order to analyze the availability of operation, it was indispensable to integrate fault lists happened in all plant systems during the operation. Every fault information such as generated time, category of the failure, interlock level, etc. was stored in the logging file of the SIS. And management history of the fault was written in daily reports. Some information was gathered from the logging file in the local control system. The gathered

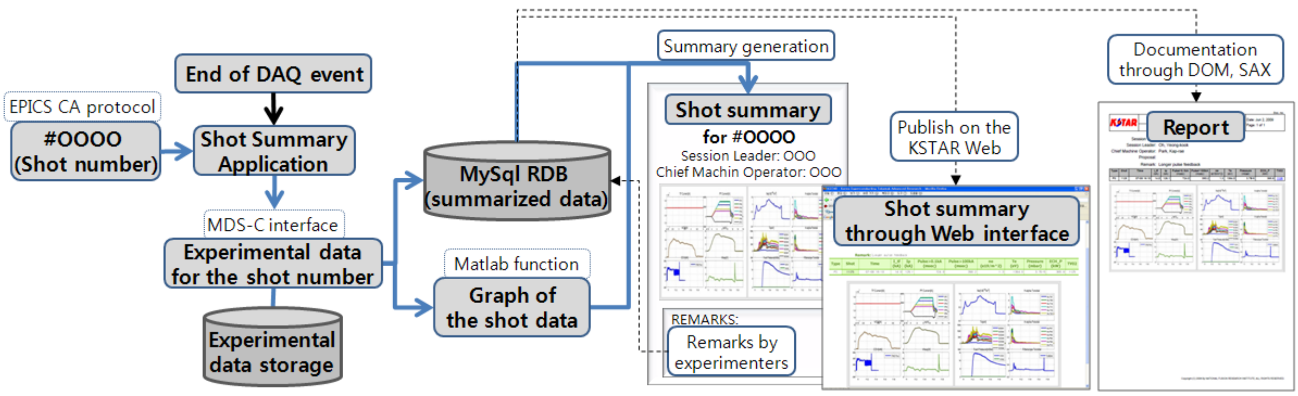

Fig. 1. Flow diagram of the shot list implementation

information was rearranged based on SIS information with the categories of system, failure, recovery, interlock, mean time between failure (MTBT), etc. and inserted into the RDB. Operators can add causes and effects for the failure, action and description for the recovery, description for the interlock, and comment into the record set. The application for the fault list management was developed using Qt library having basic database functions as searching, editing, and viewing function.

3.5. Formatting e-logbook contents

The web interface was developed to share the shot summary data and fault lists with researchers or engineers who were not involved in the experiment. It completes a query sentence based on user's configuration and transfers it to the RDB to get the result set as a list. Each record is returned as Extensible Markup Language (XML) format and the XML data is changed into Hypertext Markup Language (HTML) contents and PDF file. In order to transfer the XML contents to HTML contents and PDF file at the same time, we used XSL Formatting Objects (XMLFO) technology which is implemented using Apache Formatting Objects Processor (FOP) and it could translate contents into various types of objects such as PS, PCL, AFP, XML, Print, AWT, PNG, TXT, and so on. Java Simple API for XML (SAX) API was used to parse XML contents and Java Document Object Model (DOM) was used to translate XML contents to other objects. All contents were separated from style configuration using XSL sheet. And apache tomcat served as an engine to implement java server pages. Operators could get daily shot report as a HTML page and a PDF file just by configuring search options and clicking the execute icon. For the shot summary list page, multimedia data such as video data from diagnostics TV was linked due to the flexibility of web technology.

4. Future work

The requirements from the participants to improve e-logbook should be applied to the logbook including the derived requirements. Common requirements from them converge into the followings.

- Convenient communication tool between operators such as messenger
- Summary information arranged by session and commentary notes based on the session
- Well-organized hyperlinks between proposal, experimental plan, shot or session summary, and analysis result
- Broadcasting experimental news
- Notification of the new contents on logbook using mobile technology or e-mailing
- Notification of the changes in operation database and experimental database
- Sharing multi-media contents such as video and audio signal in the control room
- Advanced tools for the RDB
- On-line forum environment

5. Conclusions

As described in the paper, just a few contents were inserted in the e-logbook among the derived requirements and most of the logging was done manually during the commissioning. 4,000 pages of operation reports were written by hand, 650 shot summary entries and 550 fault list entries were inserted into the RDB. The remained requirements should be dissolved in phases and as the method of solving the problem, we are considering introduction of the e-logbook from the other fusion project. Even though it's introduced from outside, adjustment of the database structure to ours would take some time.

The derived requirements were focused on the experiment executed in the KSTAR control room. In order to implement the remote experiment, the policies about security, member management, proposal submission, and discussion forum have to be modified over all. And it has to be possible to transfer experimental sequence and current profile from remote site to the KSTAR control system.

Some values in the shot summary lists were acquired through the arithmetic functions from the experimental data but the decision algorithm was controversial. If the decision algorithm is reinforced through the discussion with physicists, it could be more valuable.

Automated operation logging is convenient and systematic, but a blind point of automated logging should not be overlooked by running it with check sheets to remind operators. E-logbook could be more valuable for the next experiments by training operators to write comments on every detail of comments about the experimental results and operation events.

6. References

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