DEVELOPMENT OF THE ELECTRONIC LOGBOOK FOR THE BM@N EXPERIMENT AT NICA

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The acquisition of experimental data is an integral part of all modern high-energy physics experiments. During experiment runs, not only data collected from detectors are important for understanding the produced collision events, but also records in a logbook, which are written by the shift crew and describe operating modes of various systems and detectors of the experiment and various types of occurred events. The article presents a new electronic logbook developed to automate the described process in the BM@N experiment, a fixed target experiment of the NICA project at the Joint Institute for Nuclear Research in Dubna. The online electronic logbook allows shift members to record information on current events, states of various systems, operation conditions of detectors and many others, which are further used in processing and physics analysis of the particle collision events. The system provides collaboration members with tools for convenient viewing, managing and searching for the required information in the logbook. The specialized Web service and application programming interface for storing and accessing the data are considered. The important task of integrating the online electronic logbook with the central experiment database is described. A set of auxiliary services has been developed and presented in the paper.

Keywords: NICA project, BM@N experiment, electronic logbook, logbook platform, online information system, database

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1. Introduction

The acquisition, storage, processing, and analysis of experimental data are an integral part of modern high-energy physics experiments. These problems are of particular importance in the experiments of the NICA (Nuclotron-based ion collider facility) megaproject [1], which is one of the flagship projects of the Joint Institute for Nuclear Research in Dubna, due to the high interaction rate and large multiplicity of events in heavy ion collisions. Therefore, the task of automating the mentioned processes of data collecting, storing, processing and analysing is very urgent topic for the NICA experiments.

One of the key elements of the first stage of the NICA project is BM@N (Baryonic Matter at Nuclotron) [2], a fixed target experiment at extracted Nuclotron beams aimed at studying collisions of ions with a fixed target at the energies up to 6 GeV per nucleon. Since 2015, a set of technical runs of the BM@N experiment has been already conducted with deuteron, carbon, argon and krypton beams collided with various targets at the beam energies from 2.3 to about 5 GeV per nucleon. The BM@N detectors have recorded a large amount of experimental data being reconstructed and subsequently analyzed.

During runs of high-energy physics experiments, not only data obtained from detectors are important for understanding the particle collision events, but also journal records made by shift collaborators, which describe operating modes of various systems of the experiment, detectors, and occurred events. Shift operators fill out a paper journal, in which they make notes about current parameters of the experiment, as well as problems encountered in runs and taken actions and solutions. Paper journals are quite traditional and have been used in experiment runs for a long time; however, they are inconvenient in finding the necessary information and using it in further data processing and physics analysis.

The first version of the online electronic logbook for the first BM@N runs employed an HTML table that was stored in a text file. The system solved the problem of finding the required information on the Logbook Web page, but it did not provide the ability to search and access to the log data for other software systems of the experiment, for example, for online histogramming, raw data digitization and for data processing in the main BM@N software environment, BmnRoot [3]. In addition, the information in the logbook was recorded in a rather arbitrary format, which made it impossible to automatically analyze stored parameters.

The following main disadvantages of the first logbook system with the file storing approach can be highlighted. Some of the logbook information was duplicated at different columns or never used. There was no interface for searching and obtaining the required logbook data by external BM@N systems for experimental data processing and analysis. The complexity of the task on automatically parsing the text file of the logbook containing the tabular data in columns of arbitrary formats in order to transfer necessary data to other information systems was comparable with the complexity of creating an artificial intelligence. To solve the above problems, a new information system with stricter rules was required.

2. Development of the Electronic Logbook for the BM@N experiment

Today the use of databases is a prerequisite for storing and managing data in high-energy physics experiments, therefore a new electronic logbook, called e-Log platform, was implemented based on the developed database. The e-Log platform provides shift members with a web interface to store and share information with offline users on various events or problems occurred in the BM@N experiment during its operation. The information on current events, states of various experiment systems, operation conditions of detectors and others, such as record type and time, current shift leader, period and run number, status of the data acquisition system, trigger type, magnetic field values, type of the beam particle and its energy, target and its width, and additional comment are recorded during experiment runs. Then the required data can be read from the electronic logbook and further used in the processing and physics analysis of the particle collision events.

Since the logbook information is employed in analysis of experimental data in the BM@N experiment, providing a correct multi-user access to the electronic logbook is important while executing data processing algorithms. The e-Log platform uses the implemented Logbook Database to store the experiment logbook data, ensure correct multi-user access, data consistency, integrity and provide automatic regular data backup for cases of software errors or hardware failures. The diagram of the database designed on the PostgreSQL database management system is shown in Figure 1.

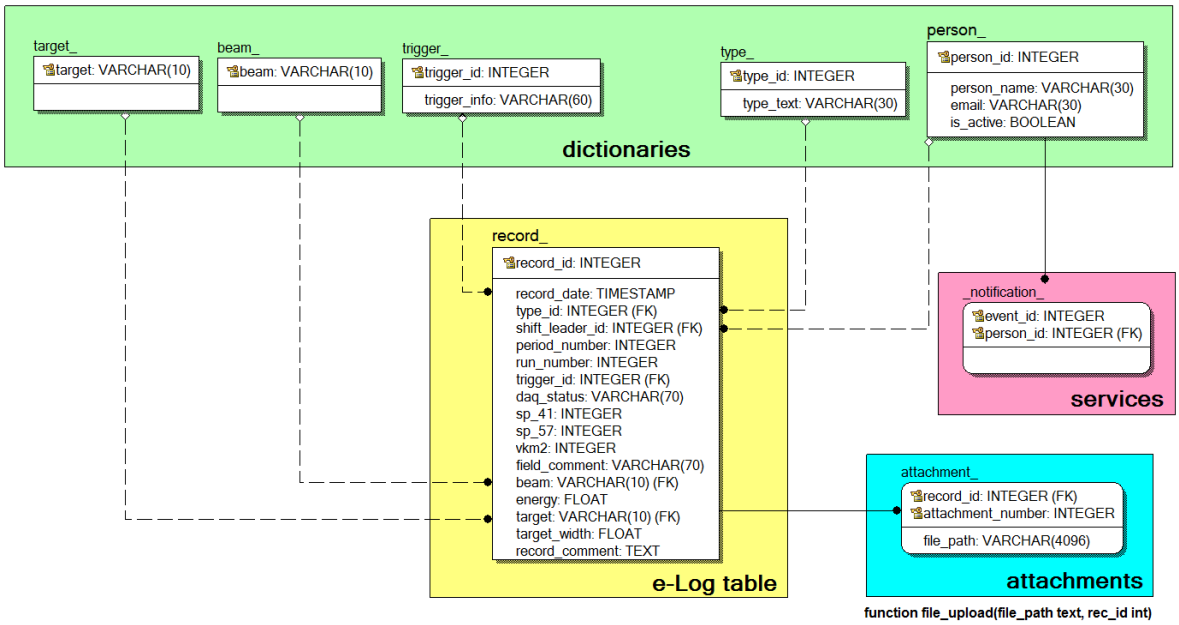

Figure 1. Diagram of the logbook database

The main table with all logbook records (*record_* table located in the center of the figure) uses the following set of dictionaries:

- a dictionary of all possible beam particles;
- a dictionary of all possible targets;
- a dictionary of all possible trigger types;
- a dictionary of record types, such as 'shift started', 'problem report', 'configuration', 'new run', etcetera;
- a list of the shift members.

In addition, the e-Log platform allows attaching files to a record with some supporting information, for example, a photo of corrected detector mapping.

3. Implementation of the Web and API interfaces for the e-Log platform

To provide users with a convenient viewing, transparent managing and searching for the required information in the electronic logbook and ensure a unified access to the logbook data for various online and offline systems of the BM@N experiment, the Web-based and application programming (API) interfaces have been developed.

Figure 2 shows the implemented user-friendly web interface of the electronic logbook for shift operators and collaboration members. Once logged into the Web site of the e-Log platform, shift operators can add or update logbook entries directly from their Web browser. The Web-based interface provides the following features: restricted access to authenticated users according to their roles, such as an administrator, shift operator or user, possibility to attach files with text descriptions and photos, multi-column sorting, "last day" view and many other features. Currently, the system contains records of different types on all BM@N conducted runs, about 3,000 entries, and the interface provides easy searching the necessary data by any parameter.

BM@N Electronic Logbook — Logged in as gertsen

Home | New | Find | Last day | Account | Reference Book — Page: 1 of 282 — Number of items per page: 10 — Logout

Date	Shift Leader	Type	№ Run	Trigger	DAQ Status	SP-41, A	SP-57, A	VKM2, A	Beam	Energy, GeV	Target	Comment	Attachment	
2018-04-05 11:47:06	Rumyantsev	Inform All	5185 per.7	Special Trigger	All	0	0	0	Kr	2.94	Cu (2 mm)	End of the RUN7		Edit
2018-04-05 11:09:20	Rumyantsev	New Run	5184 per.7	Beam Trigger + Si >3	All	1250	50	125	Kr	2.94	Cu (2 mm)	Cu target; Tr.= BC1 & BC2 & VC & Si>3 VKM2: I=125A, SP-57=50A, SP41=1250A; 100 k		Edit
2018-04-05 08:12:35	Rumyantsev	New Run	5183 per.7	Beam Trigger + Si >3	All	1250	50	125	Kr	2.94	Cu (2 mm)	Cu target; Tr.= BC1 & BC2 & VC & Si>2 VKM2: I=125A, SP-57=50A, SP41=1250A; 120 k		Edit
2018-04-05 07:46:35	Babkin	New Run	5182 per.7	Beam Trigger + Si >3	All	1250	50	125	Kr	2.94	Cu (2 mm)	Cu target; Tr.= BC1 & BC2 & VC & Si>3 VKM2: I=125A, SP-57=50A, SP41=1250A; 208 kev		Edit
2018-04-05 07:41:29	Babkin	New Run	5180 per.7	Beam Trigger + Si >3	All	1250	50	125	Kr	2.94	Cu (2 mm)	Cu target; Tr.= BC1 & BC2 & VC & Si>3; VKM2: I=125A, SP-57=50A, SP41=1250A; 201 kev		Edit
2018-04-05 07:25:08	Babkin	New Run	5179 per.7	Beam Trigger + Si >3	All	1250	50	125	Kr	2.94	Cu (2 mm)	Cu target; Tr.= BC1 & BC2 & VC & Si>3; VKM2: I=125A, SP-57=50A, SP41=1250A; 201 kev		Edit

Figure 2. Web interface of the electronic logbook system

One of the important BM@N software systems that requires electronic logbook data is the BmnRoot environment, which serves for event simulation, reconstruction of experimental and simulated data and physics analysis of particle collisions with a fixed target at the BM@N facility. To obtain logbook information for raw data digitization, event reconstruction and physics analysis tasks, a specialized C++ programming interface has been developed as a set of C++ class wrappers for all database tables with many specific functions. It allows for the access to the necessary data of the electronic logbook without SQL statements from the experiment software, such as online histogramming system, raw data digitizer and BmnRoot.

4. The e-Log platform online integration and additional services

The integration of the developed logbook platform into online data processing was accomplished in the following way. When a shift operator records information on a new experiment run into the electronic logbook, the fields, such as period and run numbers, beam particle and its energy, target and magnetic field are automatically transferred to the Unified Database [4] of the experiment for further use in the offline processing and analysis of the collision events. Moreover, the online histogramming system converts raw data obtained from the detectors and fills the remaining fields (start and end time of the run, event count, raw file path and its size) of the record in the BM@N database.

The e-Log platform is constantly improving via development of many additional services. An email notification service of the logbook platform has been implemented. It has fully configurable mechanism depending on different entry properties, such as record type (for example, "shift started", "problem report", "configuration", "inform all") and systems affected list, and some specific user actions. Users subscribed to certain types of events receive the notifications by email if a record of the corresponding type is added to the electronic logbook. The section called Private Cabinet of the web interface can be used to configure these email notifications.

Another service, Logbook FreeIPA Authentication has been also implemented. The FreeIPA system provides centralized authentication, authorization and account information by storing data about BM@N users, groups and other objects necessary to manage the security aspects of the e-Log platform. The central FreeIPA server has been deployed, and the collaboration members have been registered to have an access to the electronic logbook. Three groups for administrators, shift operators

and readers have been created in the FreeIPA system to restrict user access to the e-Log platform, depending on which the corresponding actions in the logbook interfaces are available.

In addition, it is planned to develop an Auto Recovery Service for the e-Log platform in the nearest future. The service will include Diagnostic and Recovery Agents, which will eliminate downtime in the operation of the online logbook system in the case of hardware failures.

5. Conclusion

The developed e-Log platform of the BM@N experiment is relevant and important for the successful operation of the experiment. The implemented Web-based interface provides convenient logbook viewing and managing for administrators, shift operators and users, and the developed C++ database interface ensures a unified access to the required logbook data for online and offline systems of the experiment. A part of the logbook data is automatically transferred to the central database of the experiment to use it in the offline event analysis. The developed additional services, such as email notifications and FreeIPA authorization improve the functionality of the e-Log platform and increase the convenience of its use by collaboration members of the experiment. The electronic logbook platform was successfully tested, and now it is planned to expand the system for using it in the future MPD experiment of the NICA project. The implementation of such information system is a necessary step for the successful future operation of the NICA experiments. The detailed information on the developed electronic logbook can be found on the BM@N official Web site: bmn.jinr.ru.

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