MODIFICATION OF DATA ACQUISITION SYSTEM IN HLI-II EXPERIMENTAL STATION*

Zhen Zhang[†], Gongfa Liu
University of Science and Technology of
China National Synchrotron Radiation Labor-atory, Hefei, China

Abstract

With the proposal of the concept of super-facility in recent years, users of experimental stations only need to pay attention to data with scientific significance, and the management of massive experimental data are assisted by the super-facility technical support platform to effectively improve user efficiency [1]. Based on this theory, we modified the data acquisition system of the XMCD experimental station in HLS-II. We continue to use LabVIEW software to reduce development workload. Meanwhile, we have added the interaction program with the high-level application in the original data acquisition process under the principle of keeping the user habits of XMCD experimental station. We have modularized the XMCD experimental software and redesigned the experimental architecture into 4 modules: Swiping Card Module, Experimental Equipment Control Module, Storage System Interaction Module and Data Management System Interaction Module. In this way, we have completed the collection of rawdata and metadata, the docking of the data persistent storage system, and the docking of data centralized management.

INTRODUCTION

As a synchrotron radiation light source, Hefei Light Source (HLS-II) provides a basic research platform for collection system will obtain the management metadata related to the user (management metadata) on the HLS-II user platform. The experimental equipment control module is the process control module of the XMCD experiment. This module will record the original experimental data (scientific rawdata) of XMCD and the metadata related to the experiment generated during the experiment (scientific metadata), and transmit them to the data processing module in the form of a data stream. The scientific rawdata and scientific metadata are encapsulated into the standardized format of HDF5 and uploaded to the file storage system through storage system interaction module. The management metadata and scientific metadata are encapsulated into the standardized format of JSON and uploaded to the data management system through data management system interaction module.

multi-disciplinary research on cutting-edge topics [2]. Under the important trend of informatization construction [3-5] of large scientific equipment at home and abroad, we have upgraded the data acquisition system of the HLS-II XMCD experimental station.

ARCHITECTURE

Based on LabVIEW experimental system, the data acquisition system (DAQ) of HLS-II XMCD experimental station can accomplish the mission of scientific data acquisition. However, under the information construction trend of centralized data management, experimental data needs to be uploaded to the experimental data management system together with experimental metadata. At the same time, in order to facilitate the management of data, relevant information of the experimenters also needs to be collected. Therefore, based on the development of the existing XMCD experimental station data acquisition system, we upgraded it to meet the above requirements. The acquisition system architecture is shown in the Fig. 1 below.

The data acquisition system is divided into four modules: swiping card module, experimental equipment control module, storage system interaction module and data management system interaction module. After the user swipes the ID card, the data
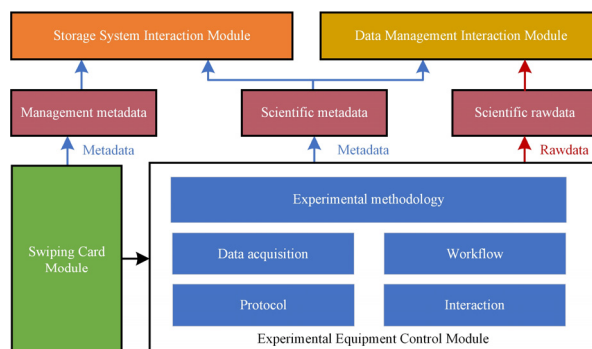

Figure 1: The architecture of DAQ system.

DATA ACQUISITION

User Management Metadata Acquisition

The User management metadata is collected from the HLS-II user platform. The process is shown in Fig. 2: (1)User needs to swipe the ID card at the card reader; (2)The user authentication module sends the collected ID number to the HLS-II user platform via RESTful API, and waits for the HLS-II user platform to return the verification result; (3)If the verification is successful, it means that

when the user has applied for the current experimental machine of the experimental station, scientific experiments can be carried out, otherwise the card needs to be swiped again; (4)After the user checks the information, the management metadata will be output.
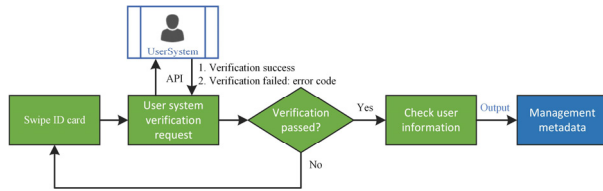

Figure 2: User authentication process.

Scientific Rawdata Acquisition

The original experimental data of the XMCD experimental station comes from the KEITHLEY 6517B electrometer. It contains two parts of data: the electrometer data at the gold mesh in front of the sample and the electrometer data at the sample. Combined with the energy point data, the three together form the the scientific rawdata. These data will be packaged into HDF5 format files together with the scientific metadata. The HDF5 file is shown in Fig. 3.
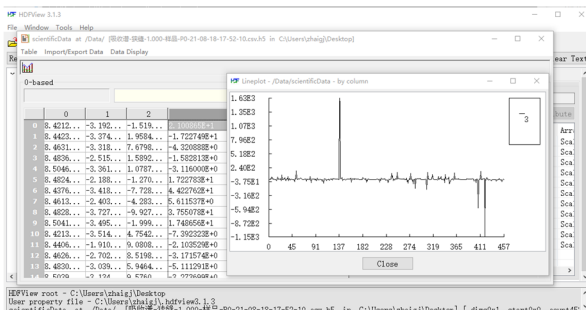

Figure 3: Scientific rawdata.

Scientific Metadata Acquisition

Combined with the management requirements of the experiment management platform and XMCD experiment station, we have compiled the relevant metadata of the XMCD experiment which is shown in Table 1.

Table 1: Scientific Metadata

metadata	sources
beamCurrent	beamline
beamPosition	beamline
gasComposition	beamline
gasPressure	beamline
waterFlow	beamline
waterPressure	beamline
waterTemperature	beamline
lowTemperature	beamline
groundResistance	beamline
vibration	beamline
magneticFieldStrength	beamline station
vacuum	beamline station

DATA MANAGEMENT

Storage System Interaction

HDF5 [6] is a common cross-platform data storage file, which can store different types of images and digital data, and can be transmitted on different types of machines. At the same time, there is also a function library for unified processing of this file format. HDF5 files generally contain two parts: groups and datasets. Groups are similar to folders and serve as the root directory of datasets. Datasets contain rawdata and metadata. Rawdata is the core data of HDF5 files, and metadata is used to store attribute values related to the rawdata. In Hefei light source, the original data of HDF5 files are mainly used for the preservation of experimental data, such as photoelectron spectroscopy.

After storage system interaction module gets the scientific rawdata and the scientific metadata transferred from the experimental equipment control module, it encapsulates them in HDF5 format. The scientific rawdata is the rawdata of HDF5 file and the scientific metadata is the metadata of HDF5file. Then the module generates the md5 checksum file of the hdf5 file. Through the API provided by the storage system, these files will be uploaded to the specified directory of the storage system

Data Management System Interaction

JSON [7] is a lightweight data exchange format. It is based on a subset of ECMAScript [8] (the js specification formulated by the European Computer Association), and uses a text format completely independent of the programming language to store and represent data. The concise and clear hierarchical structure makes JSON easy to read and write, easy to parse and generate by machine, and effectively improve network transmission efficiency.

According to the requirements of the scientific data management system, the management metadata and experimental metadata collected during the experiment need to be filtered and flattened by the data management system interaction module, and packaged into a single-layer JSON file which is shown in Fig. 4.
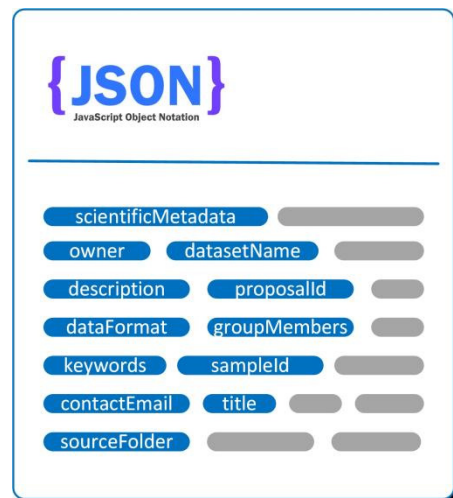

Figure 4: JSON file of metadata.

CONCLUSION

In response to the need for centralized data management, we upgraded the data acquisition system of the XMCD experimental station in Hefei light source. The upgraded data acquisition system can better realize the collection of scientific rawdata, scientific metadata and management metadata. At the same time, the data acquisition uploads the collected experimental data to the storage system and the experimental data management system to provide a basis for future experimental reproduction and high-level software data processing.

ACKNOWLEDGEMENTS

REFERENCES

[1] Wang Chunpeng, Yu Feng, Liu Yiyang, Li Xiaoyun, Chen Jige, Thiyagalingam Jeyan, Sepe Alessandro, "Deploying the Big Data Science Center at the Shanghai Synchrotron Radiation Facility: the first superfacility platform in China", Machine Learning: Science and Technology, 2021,2(3). doi:10.1088/2632-2153/abe193

[2] Lin W. *et al*., "The Upgrade Project of Hefei Light Source (HLS)[C]", in *Proc. International Conference on Intelligent Information Processing*, Oct. 2010.

[3] Blaiszik B. *et al*., "The Materials Data Facility: Data Services to Advance Materials Science Research", JOM, 2016, 68(8):2045-2052.

[4] B. V. Luvizotto, K.A., E. Stavitski, H. Bassan, "XLive: Data Acquisition and Visualization at the NSLS-II ISS Beamline", in Proc. 16th Int. Conf. on Accelerator and Large Experimental Physics Control Systems (ICALEPCS'17), Barcelona, Spain, Oct. 2017, pp. 962-965. doi:10.18429/JACoW-ICALEPCS2017-TUPHA211

[5] Blaiszik B. *et al*., "Data automation at light sources", in Proceedings of the 13th International Conference of Synchrotron Radiation Instrumentation (SRI2018), https://doi.org/10.1063/1.5084563

[6] Dheeraj Joshi, Krima Shah, Harshan Andrews, Lakshmi Kurup, "Fast Analysis & Storage of Big Data Using HDF5".

[7] John Resig, "Pro JavaScript™ Techniques", Apress:2007-01-01.

[8] Nicholas C. Zakas, "Understanding ECMAScript 6", Network Security, 2016, 2016(12).