Archiver System Management for Belle II Detector Operation

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Abstract

The Belle II experiment is a high-energy physics experiment using the SuperKEKB electron-positron collider. With Belle II data, high precision measurement of rare decays and CP-violation in heavy quarks and leptons will be made to probe New Physics. In this presentation, we present the archiver system save and use the monitoring data of the Belle II detector, and discuss in particular how we maintain the system that archives the monitoring process variables of the subdetectors. We currently save about 26 thousand variables including the temperature of various subdetectors components, status of water leak sensors, high voltage power supply status, data acquisition status, and luminosity information of the colliding beams. For stable data taking, it is essential to collect and archive these variables. We ensure variables are sent from the subdetector and other systems, We ensure all the variables from the subdetector and other systems, and the status of the archiver itself are consistent and regularly updated. To cope with a possible hardware failure, we prepared a backup archiver that is synchronized with the main archiver.

Introduction

The Belle II experiment[1] at the SuperKEKB collider at KEK, Tsukuba, Japan, is the latest collider experiment in high energy physics. SuperKEKB is a storage ring that collides the 7.0 GeV electron beam on the 4.0 GeV positron beam. The goal of Belle II is to collect 50 ab^{-1} of integrated luminosity, to measure rare decays and CP-violation in heavy quarks and leptons with high precision, which will provide unique probes for new physics beyond the Standard Model. The Belle II detector consists of pixel detector (PXD), silicon-strip vertex detector (SVD), central drift chamber (CDC), time of propagation detector (TOP), aerogel ring-imaging cherenkov detector (ARICH), electromagnetic calorimeter (ECL) and K-long and muon detector (KLM). One of the essential task to ensure stable data-taking at Belle II is to collect and archive various status of Belle II subdetectors. In this presentation, we present the archiver management system of Belle II, including the EPICS archiver appliance, how we secure its operation, what are stored in the archiver, how we monitor the incoming flux of information, and how we use the archived information.

Hardwares and Backend Software

Network configuration

For each subdetector system, we have dedicated readout system which resides in the Electronic hut (E-hut) around and next to the detector. Each subdetector has up to ten readout PCs, Each readout PC collects data from common pipelined platform for electronics readout (COPPER) and front-end electronics(FEE). Those information is collected by COPPERs through optical link (Belle2link). Belle II DAQ network can be accessible only inside the Belle II experimental hall. Our EPICS and NSM networks is reside inside Belle II DAQ networks. KEK computing cluster (KEKCC) can be accessed using dedicated tunnel.

Backend Software

To distribute our monitoring information, we use network shared memory 2 (NSM2)[4] variables and EPICS process variables (PV).

- Network Shared Memory 2 : Major information distribution. Can be transferred using dedicated NSM network.
- EPICS PV : For control and archive. For EPICS archiver appliance. Can be transferred using EPICS network.

Archiver

Our archiver is based on EPICS archiver appliance. EPICS archiver appliance is an implementation of an archiver for EPICS control systems that aims to archive millions of PVs. We use MySQL that makes database engine store computed variables and updated regularly in table. We prepared two identical archiver.One is the main archiver that stores data, and the other archiver for backup purpose.

Archiver Services

Archived information

In the archiver system, we save a large number of variables including the temperature of various subdetector components, status of water leak sensors, high voltage power supply status, data acquisition status, and luminosity information of colliding beams. Currently, approximately 26k PVs are archived as shown in Table. 1.

	Number of PVs	
PXD	20	have own archiver
SVD	354	have own archiver
CDC	465	
TOP	3065	
ARICH	15948	
ECL	244	
KLM	1023	
Trigger	72	
ECL Trigger	851	
DAQ	210	
SuperKEKB	795	
etc	9	

Table 1: Number of archived PVs

Based on our stress test, The system can stably archived 80k PVs and can archive 100K PVs at maximum.

Most of the subdetector groups store variables for safe detector operation such as subdetector temperature water leak status, and humidities. We utilize EPICS PV to monitor in Fig. 1. The data are stored in the PB (protocol buffers) format. We make use of the archiver to display information through the CS-studio interface and web browsers.

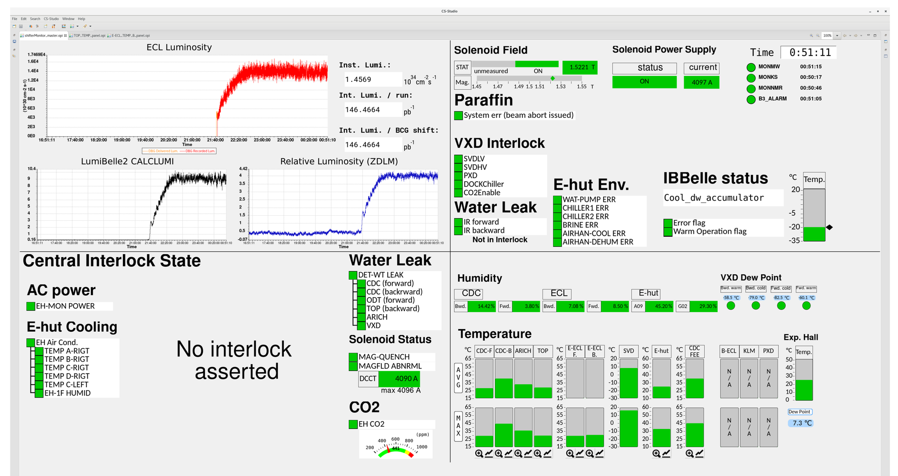

Figure 1: Safety monitoring system using EPICS PVs

Archiver Migration and Backup

We use short-term storage (STS), mid-term storage (MTS), and long-term storage (LTS) to store data.

STS uses SSD for storage. MTS and LTS use HDD.

- T1 : STS → MTS. 3 days.
- T2 : MTS → LTS. 1 week.
- T3 : Main archiver → Backup archiver. Every 20 mins.

In case of emergency, backup archiver does same procedure as main archiver as shown Fig. 2.

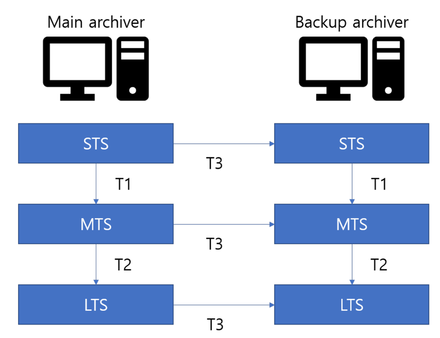

Figure 2: Data transfer and synchronization inside archiver system

Offline use of archived data

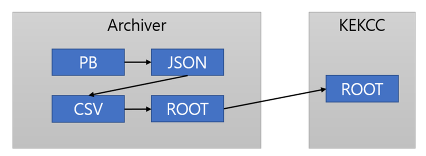

Figure 3: Daily PB to ROOT conversion procedure

EPICS archiver appliance supports retrieval webapp and offline download.

- Retrieval webapp
- Offline download
- PB to ROOT

Through retrieval webapp, we can easily check status of the PVs. Offline download is one of the easiest way to access the archiver data in a batch process. However, the function supports archiver specific format called PB, and only can be accesible in Belle II DAQ network. we developed a chain of conversion programs to convert the PB data into the ROOT[3] format by combining existing tools. We converts our monthly PB file in LTS and transfer it to KEKCC.

Managing archived variables list

As our detector have many variables, we need to check the status of the variables, such that connectivity, consistency and list of variables for each subdetectors. To check connectivity we made short shell and python scripts that makes a list of that listing disconnected variables. Every morning, archiver experts receive a list of disconnected PVs in an e-mail from the archiver. Archiver experts then notify the subdetector experts about the disconnected PVs. For PV list management, We provide wiki page of a list of archived PVs using Atlassian Confluence. A confluence wiki page is usually designed for human readers, but we keep a certain format to be able to parse using python script. The script compares list of archived PV in archiver and wiki page on web. Based on this information, archiver expert notifies subdetector experts.

Monitoring Archiver

During the operation, we use online chat system called Rocket.Chat to communicate between practically everybody who participate the detector operation, including the local and remote shifter, subdetector and DAQ experts, and beam commissioning groups. We uses this Rocket.Chat and e-mail for notification.

Archiver saving status

	First alarm	Additional alarm
STS	10 minutes	2 hours
MTS	90 minutes	2 hours
LTS	24 hours	4 hours

Table 2: Alarm frequency

To monitor archiving status, we made a dedicated PV. So we can monitor file saving status by checking file information. Our crontab job checks every minute for STS, MTS, LTS.

Retrieval status

Our retrieval webapp is one of the parts of archiver data distribution system. We found in some cases, when a flood of data requests exceeds the capaility of the archiver, the retrieval webapp, in Fig. 4, stops responding. In order to detect such a situation, we check every ten minutes whether the retrieval webapp works or not by requesting data.If retrieval webapp does not responds, our alarm system send an alarm to Rocket.Chat every ten minute.

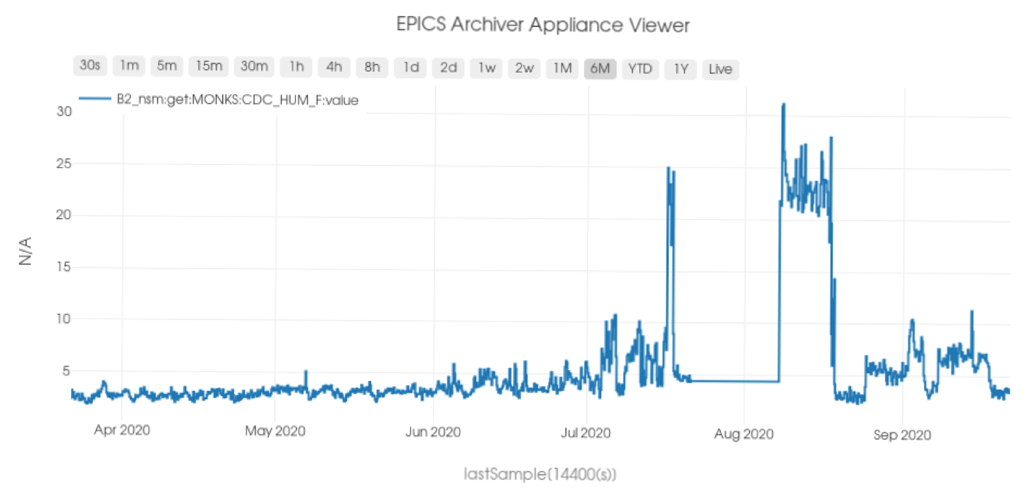

Figure 4: Archived CDC humidity variable distributed using retrieval webapp

Summary

To secure stable data taking of archiver system for Belle II detector operation, we monitor archived variable status, manage archived variables list, and monitor archiver itself. We can secure running archiver by these efforts, and we would not lose more than 20 minutes of data at maximum. We operated our archiver from March, 2019 successfully.

References

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