DAQ-Middleware for MLF/J-PARC

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Abstract

We present the results of commissioning of DAQ-Middleware for the data acquisition (DAQ) sub-system with a first beam at Material and Life Science Facility (MLF) in Japan Proton Accelerator Research Complex (J-PARC). We also explain a DAQ system model of MLF neutron experiments, new functions of DAQ-Middleware and results of performance measurements.

Key words:
Data acquisition system, Network based DAQ system, DAQ-Middleware

1. Introduction

We have developed DAQ-Middleware [1, 2], a software framework for a distributed data acquisition (DAQ) system based on robot technology middleware developed by the National Institute of Advanced Industrial Science and Technology [3]. The DAQ-Components in DAQ-Middleware are software units used to build an integrated DAQ system. We developed a prototype of DAQ-Middleware for MLF and used it to perform beam tests [4]. In May 2008, the instrumentation, including DAQ-Middleware, was commissioned with a first beam at IBARAKI materials design diffractometer (iMATERIA) in MLF. As of March 2009, 23 beamlines are installed in the neutron experiment hall at MLF and four instruments used DAQ-Middleware within their own DAQ sub-systems. In the future the number of DAQ-Middleware users is expected to increase at MLF.

2. DAQ model of MLF

There are two types of detectors in MLF neutron experiments, position sensitive detectors (PSDs) and 1-D/2-D photon counting detectors. The readout modules of these detectors are equipped with SiTCPs [5]. The digitized data can be retrieved from the readout modules by PCs via Ethernet (100Base-TX). In this paper, we focus on DAQ systems that use PSD detectors. Figure 1 shows the schematic of DAQ model of MLF neutron experiments. The DAQ system consists of multiple readout PCs and a user interface PC. Each DAQ unit consists of four DAQ-Components, each running on a readout PC. On the user interface PC, a DAQ-operator configures the DAQ systems using XML documents and controls DAQ-Components received from users commands via Web.

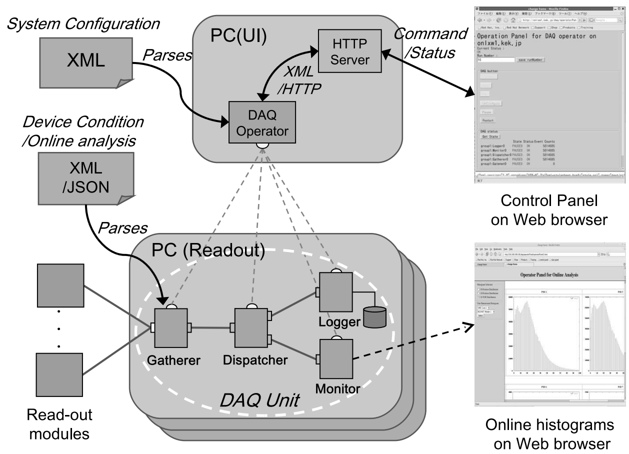

Figure 1: Schematic of the DAQ model of MLF neutron experiments.

2.1. DAQ unit

A DAQ unit consists of four DAQ-Components, such as a gatherer, a dispatcher, a logger and a monitor. The gatherer reads data from readout modules and sends the data to the dispatcher. The dispatcher relays it to the logger and the monitor. The logger stores the data to hard disks, while the monitor analyzes the data, yielding

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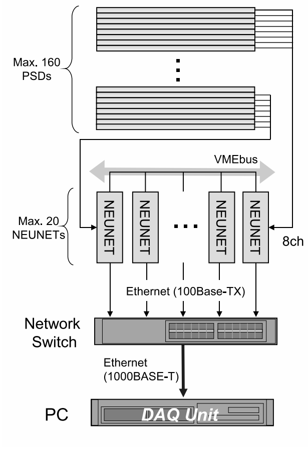

Figure 2: Basic setup of PSD DAQ system.

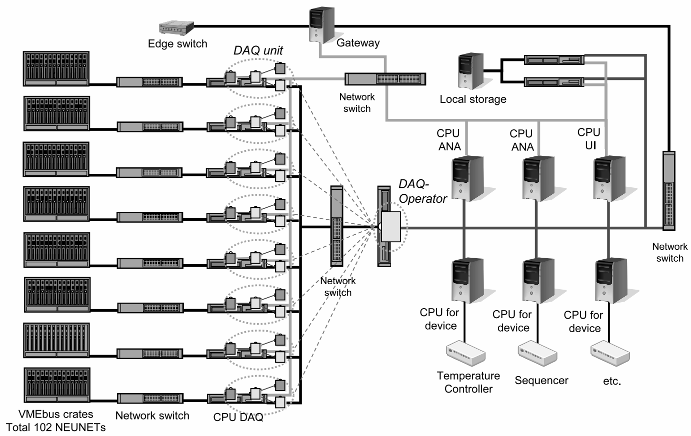

Figure 3: Setup of iMATERIA using multiple DAQ units and a DAQ-operator.

histograms in PNG format for online monitoring via the Web browser. The DAQ-operator is a controller of the DAQ-Components. Figure 2 shows the schematic of basic setup of PSD DAQ system. A PSD readout module, called NEUNET [6], receives signals from eight PSDs and digitizes them to make event data (8 bytes/event). A DAQ unit on a PC reads out event data from NEUNET modules via a network switch and stores them on hard disks. The basic setup with a DAQ unit is in charge of taking data from a maximum of 20 NEUNET modules (160 PSDs). If there are more than 160 PSDs, another DAQ unit is added in parallel. Figure 3 shows the schematic of current setup of iMATERIA. Eight DAQ units are arranged in parallel, corresponding to VMEbus crates (total 102 NEUNETs), with a DAQ-operator.

3. Requirements

Requirements from MLF to a DAQ system with DAQ-Middleware include: Each DAQ unit should have a total throughput of 25M Bytes/sec, a value derived from a maximum event rate (about $20\text{k} \cdot$ counts/sec) of 20 NEUNET modules in a VMEbus crate.

4. New functions of DAQ-Middleware

After the beam test using a prototype in 2007 [4], new functions have been added to DAQ-Middleware for MLF. The new functions are: (a) system configuration with multiple DAQ units, (b) remote booting of DAQ-Components, (c) system interface using XML/HTTP protocol and (d) configuration of devices with condition files.

4.1. System configuration with multiple DAQ units

The prototype of DAQ-Middleware for MLF [4] consisted of a DAQ unit. To adapt the experiments at MLF to a system using hundreds of PSD detectors, a new XML schema for the DAQ system configuration was implemented, along with the function of remote booting for DAQ-Components. The improved XML schema of configuration file includes "DAQ Group" elements corresponding to DAQ units. We used the extended Internet services daemon, "xinetd" of Linux. Each DAQ-Components is bootable to send commands to PCs on which "xinetd" is running.

4.2. System interface

We decided to use XML/HTTP for the communication interface protocol between DAQ-Middleware [4] and the external system, such as MLF software framework [7]. This was implemented with Python Web interface for Apache, mod_python, to communicate with the DAQ-operator.

4.3. Device configuration

A device configuration scheme with device condition files written in JSON (JavaScript Object Notation) was implemented. The DAQ system configuration is stationary for each instrument in the MLF neutron experiments, but measuring and online analysis procedures can differ according to end users. This was done to prevent configuration files from becoming too large and to separate end user configurable parameters from DAQ system parameters.

5. Commissioning at the first beam

In May 2008, the first beam was instituted at MLF, including commissioning of the following items at iMATERIA: (a) electronics, (b) DAQ-Middleware, (c) MLF software framework and (d) offline analysis. We confirmed data readout, storage, Web-enabled run control and Web-based online monitoring using DAQ-Middleware.

6. Performance measurements

Total throughput measurements were performed to confirm that the performance requirements from MLF for the DAQ unit were met. We measured total throughput while increasing to 30 NEUNET emulators, three network switches and a PC with a DAQ unit (Figure 4). The NEUNET emulators, including data generation function, were implemented on FPGA starter kits. Table 1 shows the parameters of testbed. To emulate a standard PC at MLF, the number of CPUs and the memory size were limited (4 CPUs, 2G Bytes RAM).

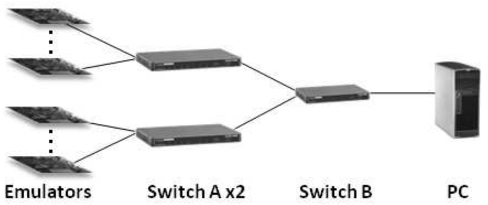

Figure 4: Schematic of the testbed setup using a DAQ unit.

Table 1: Parameters of testbed

PC HP xw8600	CPU:Xeon E5420(2.5GHz)x2, RAM:DDR2 16GB Disk:1TB/32MB Cache/7200rpm/SATA x4	
Network Switches	A:Cisco Catalyst2960G-24TC-L x2,B:2960G-8TC-L	
OS	RedHat Enterprise Linux Client 5.3	
Network parameters	net.ipv4.tcp_rmem	4096 4194304 4194304
	net.ipv4.tcp_wmem	4096 65536 4194304
File I/O parameters	File system	Ext3
	I/O scheduler	Anticipatory
	vm.dirty_background_ratio	1,10
	vm.dirty_expire_centisecs	2999
	vm.dirty_ratio	40

6.1. Results of measurements

Figure 5 shows the results of total throughput measurements with data logging. The x axis indicates the number of NEUNET emulators and the y axis indicates throughput in M Bytes/sec. The closed square data points show data logging with a single disk when the dirty_background_ratio = 10, the default value of OS. The dirty_background_ratio is the percentage of total memory at which the background writeback daemon will start writing out dirty data. The closed triangle data points show the condition of a single disk when the dirty_background_ratio = 1. The closed circle data points show the condition of stripping four disks (chunk size=512kB) when the dirty_background_ratio equal = 1. By adjusting the dirty_background_ratio = 1 and using stripping disks to store data, we could meet the performance requirements for a DAQ unit from MLF.

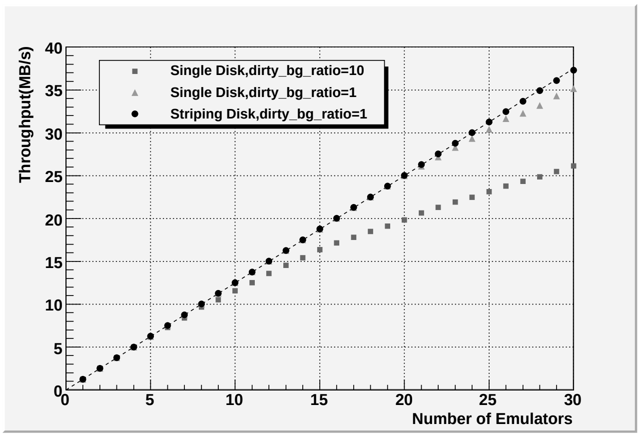

Figure 5: Results of measurement of total throughput.

7. Summary

We developed the DAQ sub-system using multiple DAQ units for MLF/J-PARC. In May 2008 the instrumentation, including DAQ-Middleware, was commissioned with the MLF first beam at iMATERIA using DAQ-Middleware. We confirmed data logging, Web based run controlling and online monitoring. The results of performance measurements showed the requirement for total throughput of a DAQ unit are met.

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