The Data Acquisition system (DAQ) of the FLASH facility

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MCS Machine Control System

Abstract

Nowadays the photon science experiments and the machines providing these photon beams, produce enormous amounts of data. To capture the data from the photon science experiments and from the machine itself we developed a novel **D**ata **AcQ**usition (DAQ) system for the FLASH (**F**ree electron **LAS**er in **H**amburg) facility [1].
Meanwhile the system is not only fully integrated into the DOOCS[2] control system, but is also the core for a number of essential machine related feedback loops and monitoring tasks.
A central DAQ server records and stores the data of more than 900 channels with 1MHz up to 2GHz sampling and several images from the photon science experiments with a typical frame rate of 5Hz.
On this server all data is synchronized on a bunch basis which makes this the perfect location to attach e.g. high level feedbacks and calculations.

Introduction

The FLASH is not only a permanent user facility providing laser like X-ray beams in a before unmatched wavelength regime, but also serves as a R&D study for exploring the superconducting cavity technologies to be used at future linear accelerators.
The requirements for both of these efforts demand a very high level of diagnostic and electronic instrumentation.
To get a deep and clear understanding of the machine, we developed a data acquisition system capable to record all relevant data from about 900 ADC channels distributed over tenths of VME crates with the full machine repetition rate (5 Hz with up to 800 bunches per cycle).

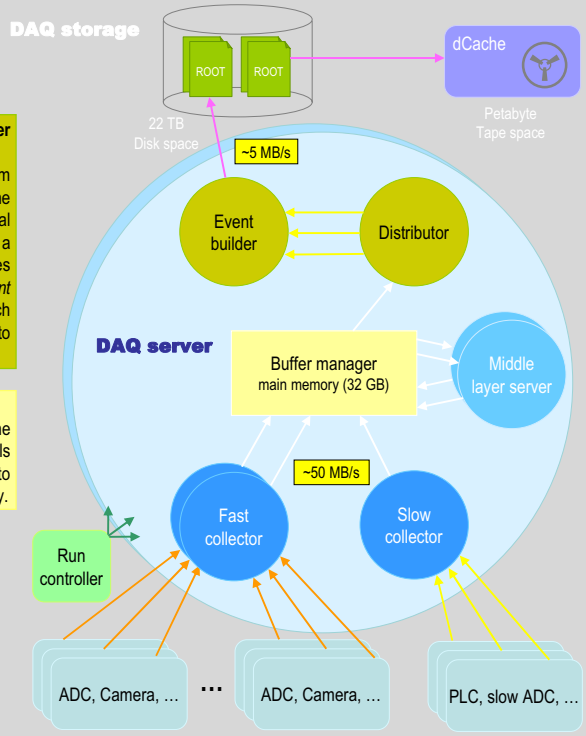
The data acquisition system

The core of the DAQ system is formed of a multiprocessor SUN Fire E2900 hosting 32 GB of memory (the DAQ server) and a SUN Fire X4500 providing 22 TB RAID file space (ZFS).
For the necessary network connections the existing infrastructure of the FLASH accelerator (1 Gigabit Ethernet) is used.

DAQ architecture

DAQ storage
The event builder writes the data to be stored to the DAQ storage machine. Here the beam relevant data of the last ~ 30 days is kept, for having good performance on data retrieval. By default the data is written in ROOT[4] file format.

dCache
Finally data older than 30 days or in case of unusual high data output stream sizes, all data from the DAQ storage is moved to a central tape, hosting a sophisticated long-term archive architecture called *dCache* [3].



Distributor, Event builder processes
To have a maximum flexibility in control of the data passed to the final storage destinations, a *distributor process* passes a set of streams to an *event builder* process which actually writes the data to discs.

Buffer Manager
The core of the DAQ is the buffer manager. It controls all read write operations to and from the main memory.

Middle Layer processes
Since all beam relevant data is passing through the buffer managers main memory, this is a perfect place for attaching slow feedback and monitoring processes. A number of high level control and monitoring programs have been implemented this way already.

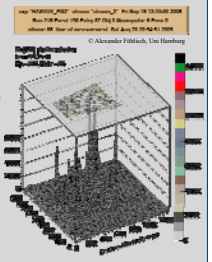
Run controller
All clients participating in a *DAQ run* get the configuration (repetition rates, number of bunches, ...) transmitted by XML strings. A finite state machine implemented in all clients, for synchronization, is supervised by the Run controller.

Data collectors
There are two sorts of collector processes: A *slow collector* for pulling slowly varying data from systems like PLC, etc., and a multiple instances of *fast collector* processes listening to the multicast streams send by the fast front-ends.

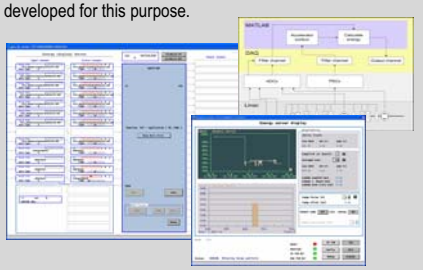
The front-ends
At the FLASH most of the fast monitoring hardware is readout and digitized by VME crates controlled by SPARC CPUs running Solaris OS. To ship the data efficiently to the main DAQ server machine the multicast UDP protocol is used.

Usage examples

Different from the original expectations, it showed that not the machine physicists but instead the photon experiments done at FLASH are heavily making use of this possibility for mass data storage. Here the huge data volume produced by various camera systems needs to be stored and methods for comfortable data retrieval must be provided.



The middle layer servers unique position within the data flow triggered a number of developments for implementing monitoring and slow feedback applications. Some of them are already part of the standard machine operation. A API to easily attach C++ and MATLAB based applications has been developed for this purpose.



Conclusions

The DAQ system developed and now already running more than a year reliable at the FLASH facility, has extended the possibilities for understanding and controlling a complex linear accelerator like this.
The novel combination of High Energy Physics (HEP) techniques and an accelerator control system successfully shows that such an integrated framework can solve the requirements demanded by the high data rates and number of components.
The FLASH DAQ system was developed in a collaboration of three institutes: DESY Zeuthen, DESY Hamburg and LEPP Cornell University, Ithaca, NY, USA

References

[1] http://flash.desy.de
[2] http://doocs.desy.de
[3] http://dCache.desy.de
[4] For ROOT see: http://root.cern.ch

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