



Data Acquisition Software for quality control of CBM-TOF super module detector

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1. Introduction

Time-of-Flight (TOF) system in Compressed Baryonic Matter (CBM) experiment is composed of super modules based on multi-gap resistive plate chamber for high resolution time measurement. Each super module comprises 320 readout channels, and the peak data transfer rate will reach up to 6.4Gbps. A distributed data readout system shown in Fig.1 is developed to evaluate the quality of each detector, in which each data readout module (DRM) is based on the system on chip (SOC) and the Ethernet techniques, so that data can be parallel transmitted to the back-end computer. In this paper, the data acquisition software is focused on the performance for data transmission, status monitoring and controlling of electronics and data analysis.

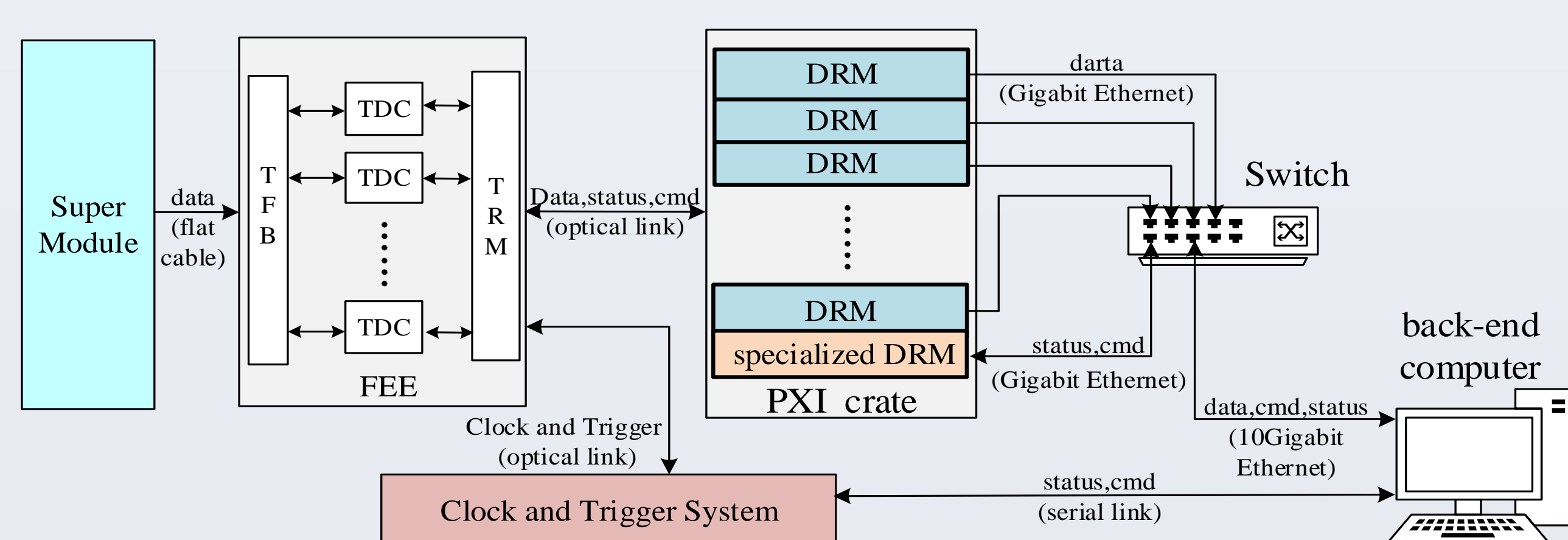


Fig.1. Structure of the distributed data readout system

2. DAQ Software System Architecture

The Data Acquisition Software is implemented under Linux operating system, and has a distributed and hierarchical architecture. It consists of three parts connected with Ethernet shown in Fig 2: Data Forwarding Node (DFN), Data Aggregation Node (DAN) and Graphical User Interface (GUI). DFN runs on the DRM board, aims at forwarding data to DAN or transmitting status and commands with GUI. DAN and GUI both run on the back-end computer. DAN is mainly responsible for data receiving and event building.

GUI provides friendly and interactive interface for users to control and monitor the electronics system. It also contains offline data analysis which can call MATLAB engines to evaluate the quality of detector. Such layered design is easy to upgrade, as the number of DFN can be configured according to the requirement of experiment, which is suitable for the distributed readout system, and GUI can be customized without any code modification.

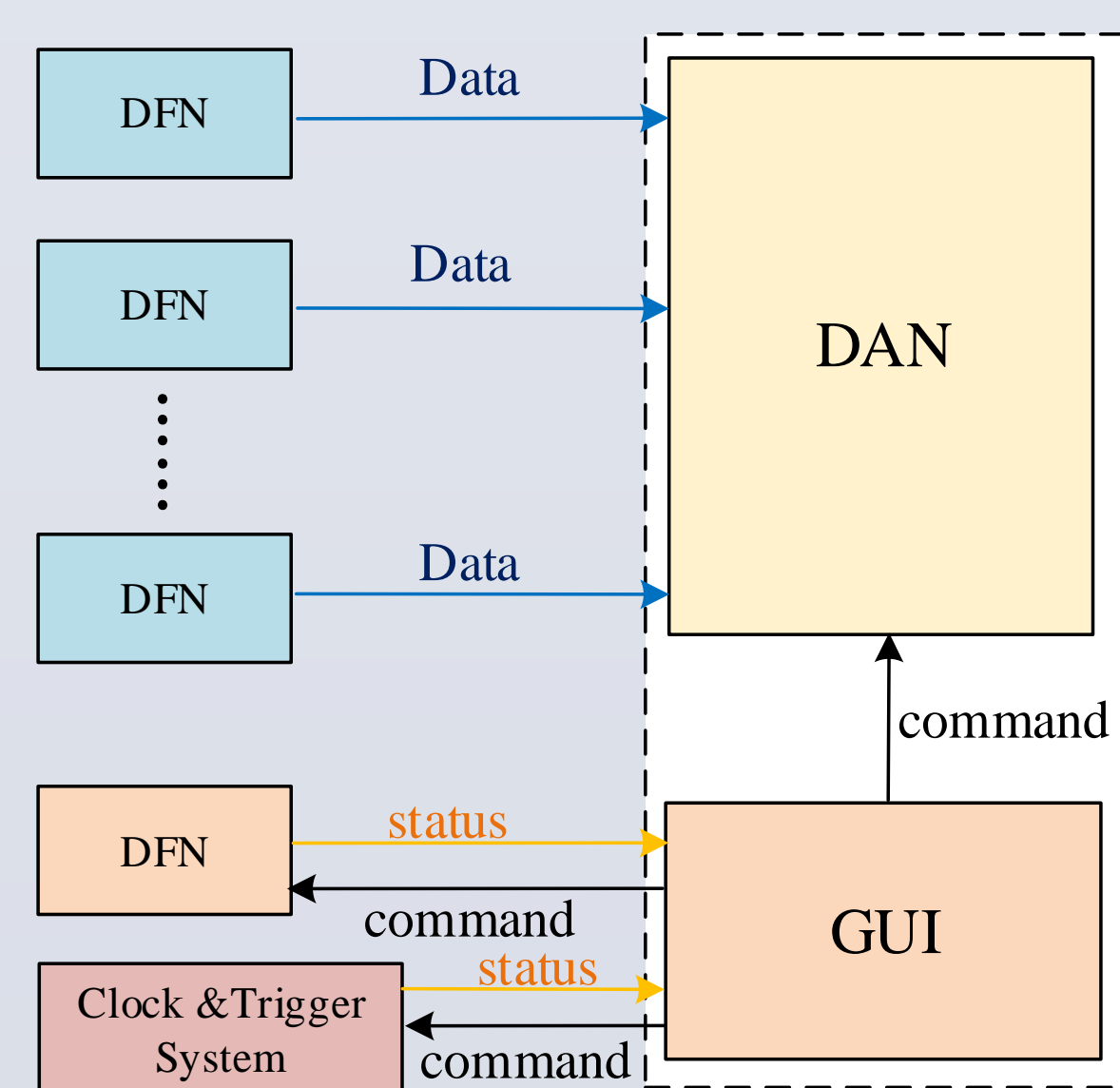


Fig.2. Structure of DAQ software system

3. Data Forwarding Node

Each Data Forwarding Node runs on DRM that Linux operating system is embedded in. DRM based on Cyclone V SoC is composed of two distinct portions: a hard processor system (HPS) and an FPGA. The structure of DFN is shown in Fig 3. DFN only forwards data, status and command it receives instead of processing them. There are three threads in DFN: main thread, data transeiving thread, command transfer thread. Main thread connects client socket to server and creates other threads with detached attributes. Command transfer thread send the command used for configuring and controlling the hardware to FPGA via the write method related to the HPS-to-FPGA interface. The task of the data transeiving thread is to receive data from the FPGA and then transmit them to the PC via the Ethernet. What's more, test shows the FPGA-to-HPS interface is the bottleneck of transmission rate, so the DMA transfer efficiency is critical. Thus the data transeiving thread uses the mmap method to reduce time of copying data from kernel space to user space and improve transmission efficiency. In the readout system, most DRM is to transmit status and command with GUI. Thus, command transfer thused for forwarding data to DAN, only one specialized DRM in the PXI crate is configured read only exists in one DFN. At the same time, data transeiving thread exists in most DNF except the one has command transfer thread.

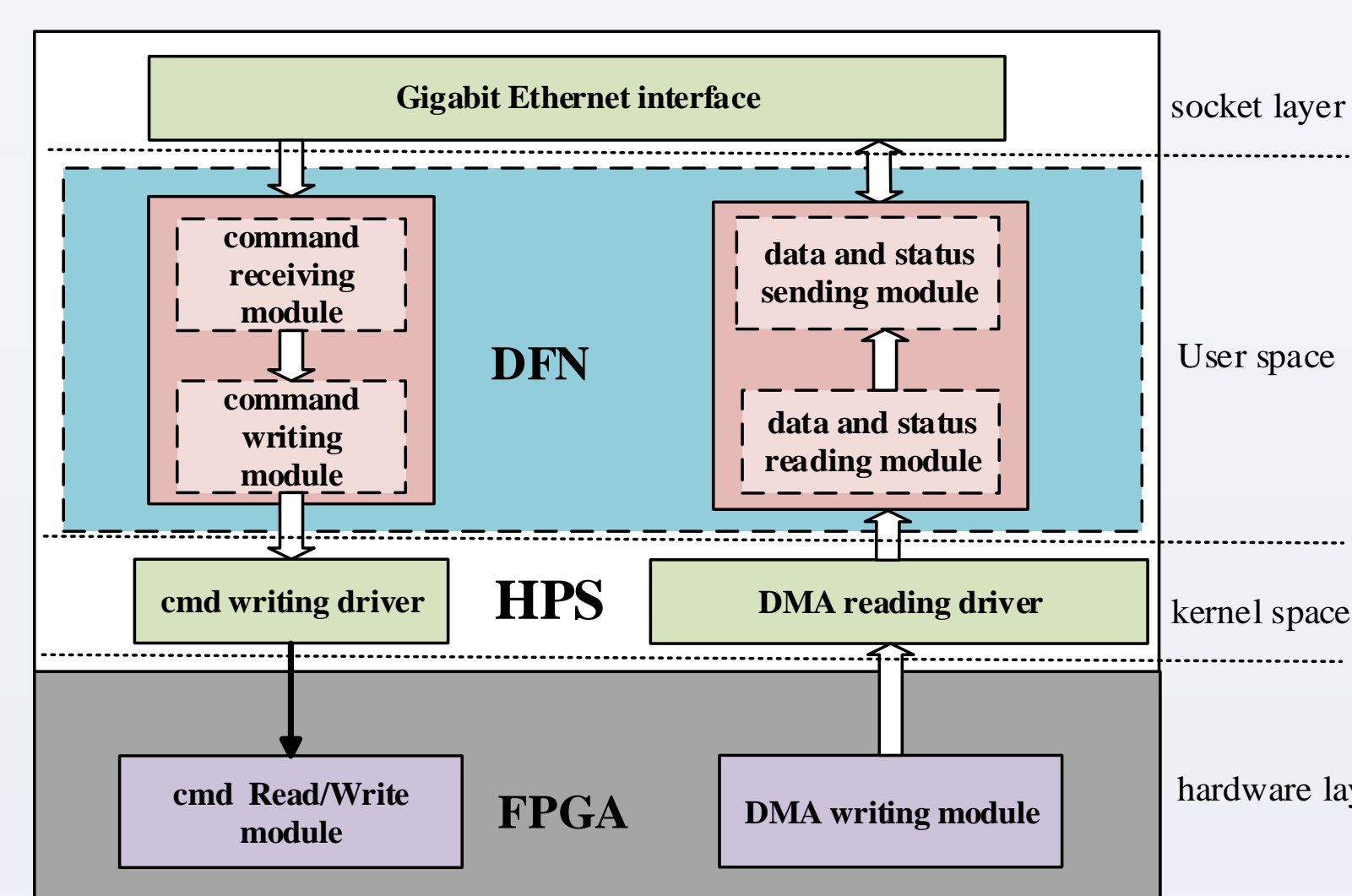


Fig. 3. Structure diagram of the DFN

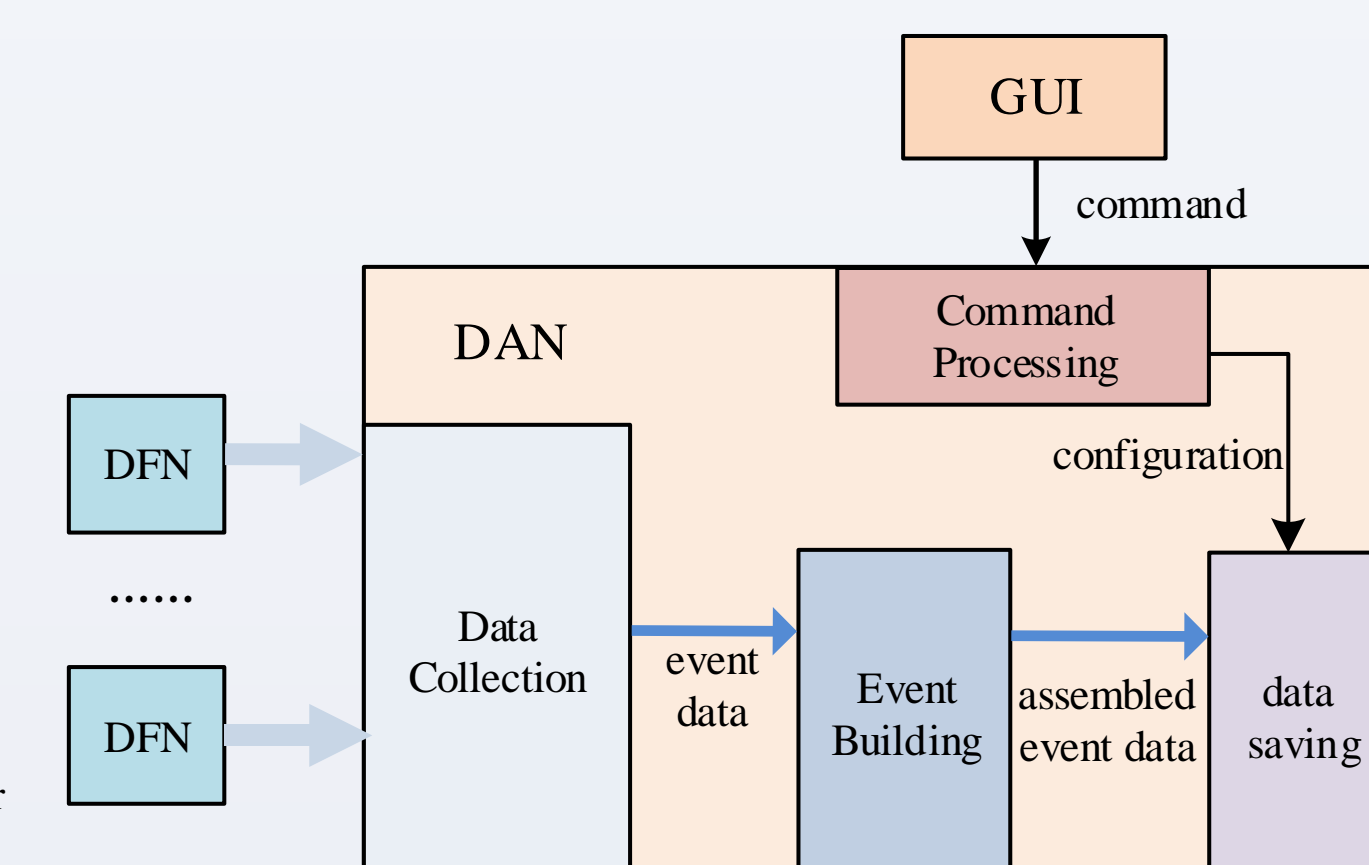


Fig. 4. Structure diagram of the DAN

4. Data Aggregation Node

Data Aggregation Node utilizes multithreading technology, comprising three parts: main thread, data collection thread, data save thread, command processing thread. Main thread initializes the mutex, the list of threads and the list of event building buffer, creates TCP sockets and accepts client connection requests from DFN and GUI, then create data collection threads and data save thread. Data collection threads, the number of which depends on the number of DFN, receives data from DFN, and writes data to the list of event building buffer according to the trigger id number. List data structure shown in Fig. 5 is utilized for event building. One event node structure represents for one trigger id number. There's only one data save thread which will be waked up by the condition variable, then save assembled data to file. The Structure diagram of the DAN is shown in Fig. 4.

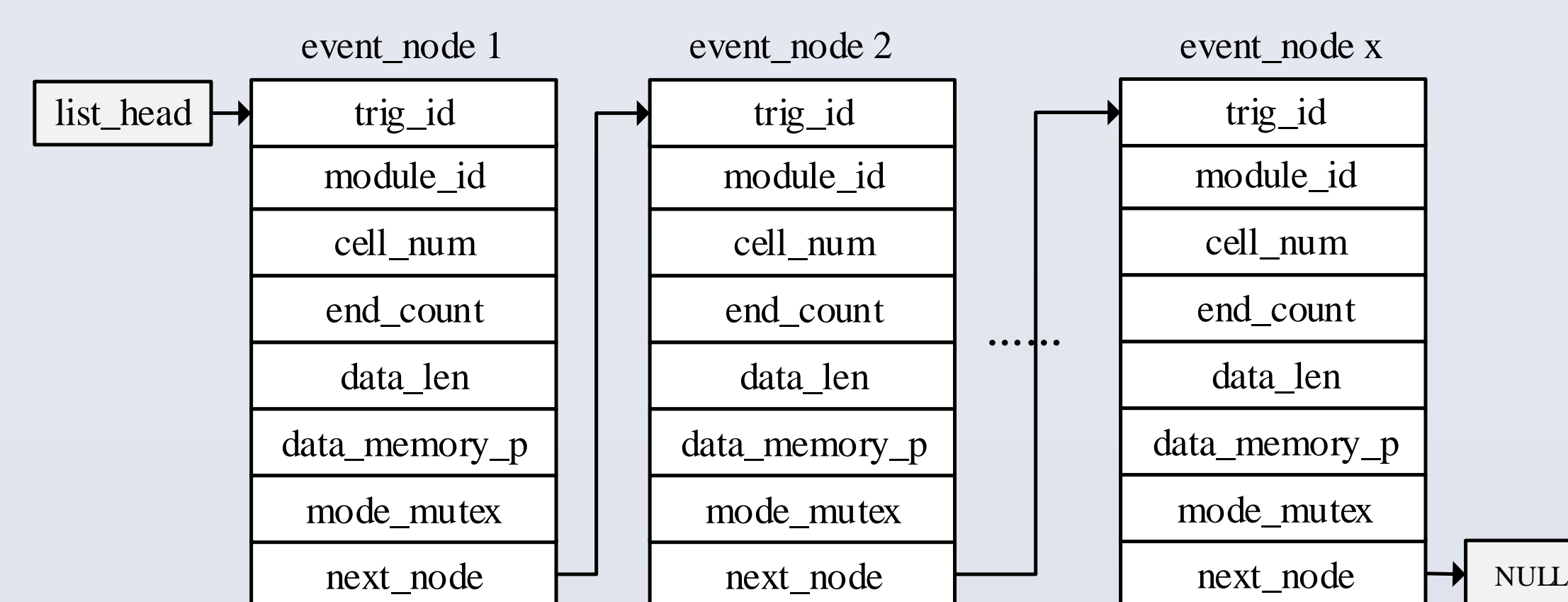


Fig. 5. Like list of event building buffer

5. GUI for Control, Monitor and Analyze

GUI shown in Fig. 6 is programmed with Qt language, also uses multithreading technology to improve the response rate of the interface application. It consists of GUI main thread, transfer thread and offline analyze thread. GUI main thread displays status and interacts with users. When user pushes command button, GUI main thread creates corresponding string and send to transfer thread. Transfer thread receives status data and convert it to text message, then send to GUI main thread. In addition, it responds to GUI main thread command signal, sending command string to DFN, DAN and CTS. Offline analyze thread call on MATLAB engine to get Bin Size, Root Mean Square, Integral Nonlinearity and Differential Nonlinearity of TDC. Fig. 7 shows the structure diagram of GUI.

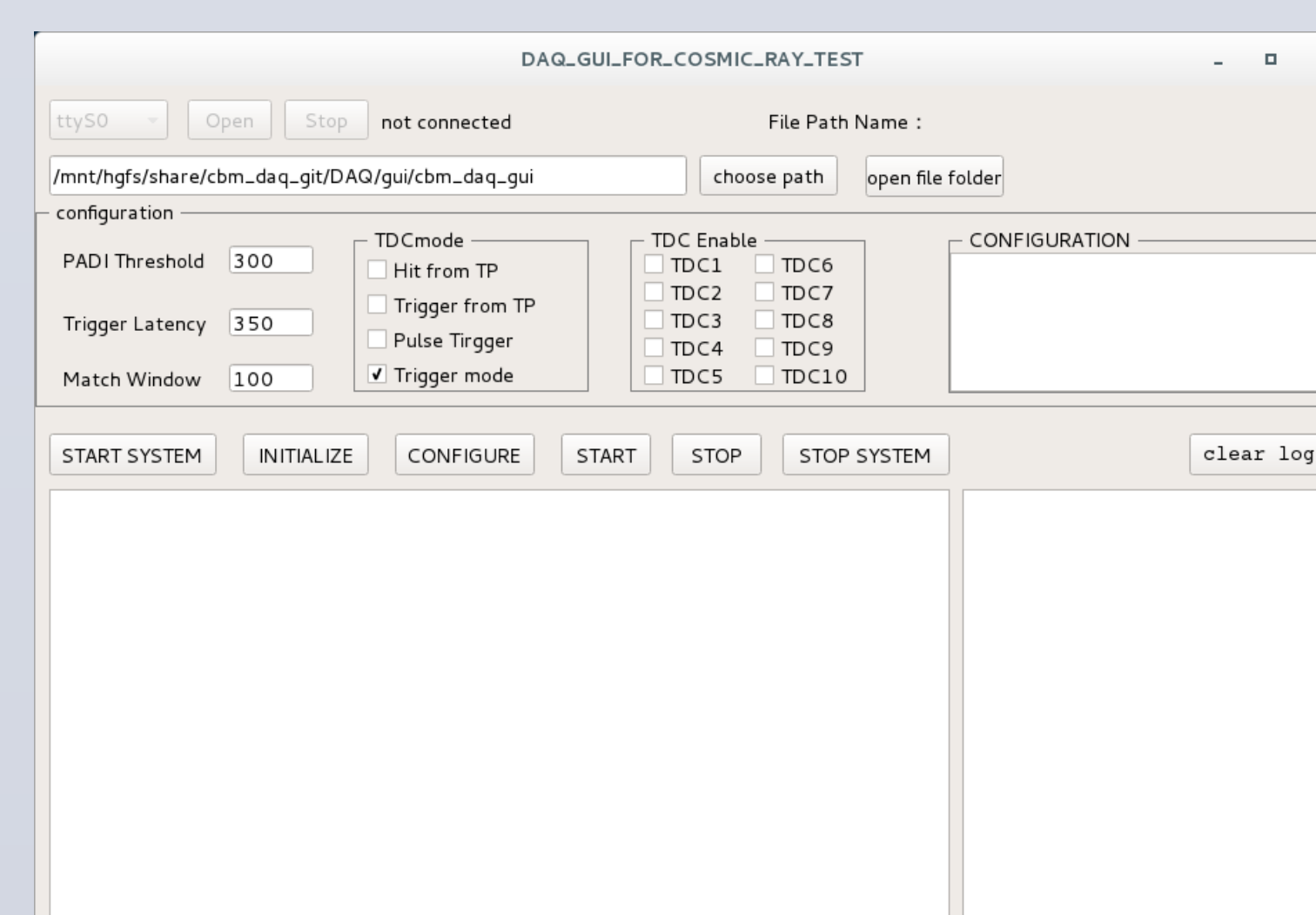


Fig. 6. GUI for control and monitor

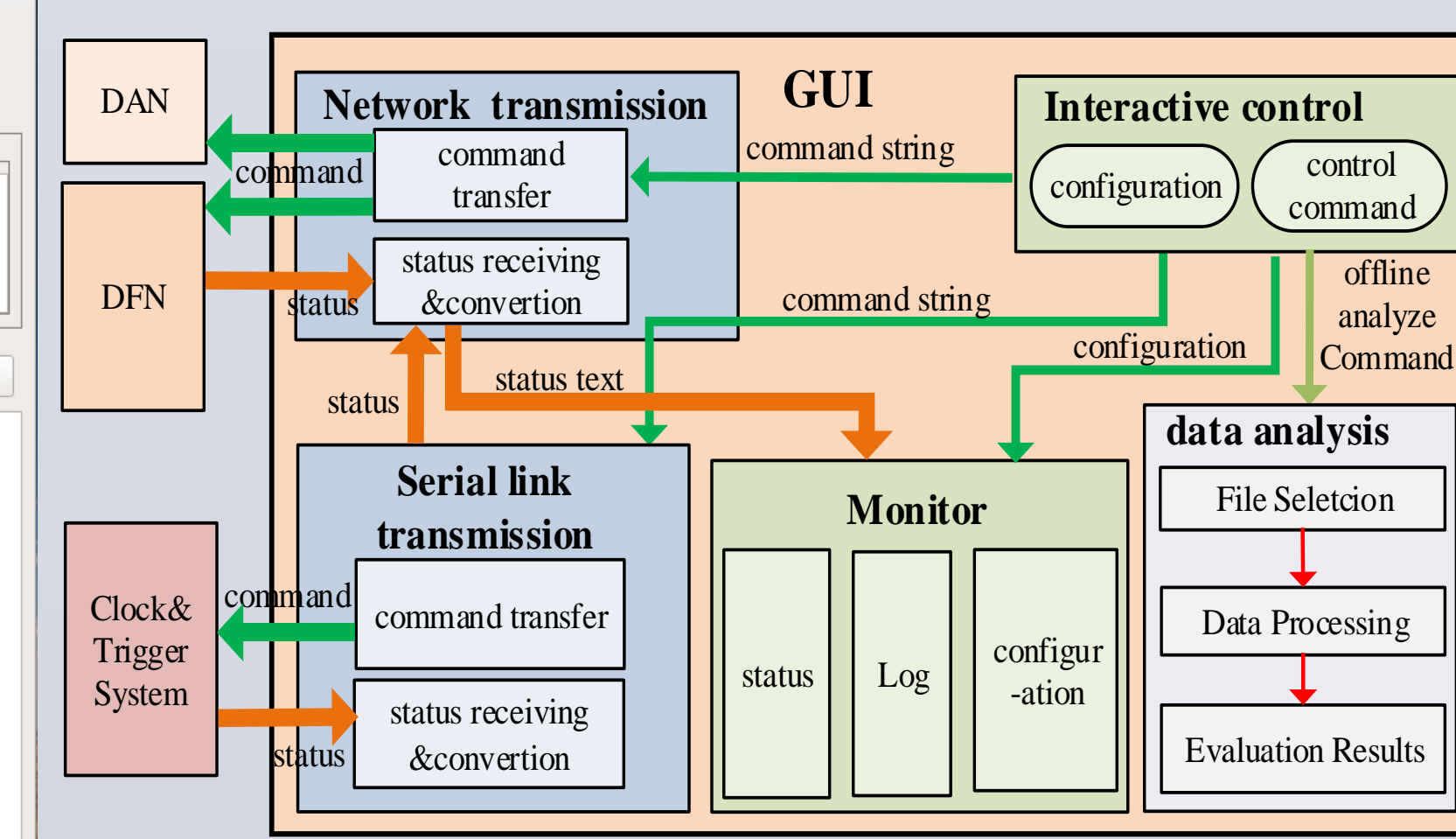


Fig. 7. Structure diagram of the GUI

6. Conclusion

The Data Acquisition Software for quality control of CBM-TOF super module detector can be customized easily according to system requirements. Meanwhile, it meets the readout demand well as laboratory test shows that a single data transmission path achieved approximate 550Mbps data transfer rate in the case of full link from FEE to backend computer storage.