AN OS9-UNIX DATA ACQUISITION SYSTEM WITH ECL READOUT

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Abstract

A new data acquisition system has been developed at the Hahn-Meitner-Institut to handle almost 550 parameters of nuclear physics experiments. The system combines a UNIX host running a portable data buffer router [1] and a VME front-end based on the OS9 real time operating system. Different kinds of pulse analyzers are located in several CAMAC crates which are controlled by the VME system via a VICbus connection. Data readout is performed by means of an ECL daisy chain. Besides controlling CAMAC the main purpose of the VME front-end is event data formatting and histogramming. Using TCP/IP services, the UNIX host receives formatted data packages for data storage and display. During a beam time at the antiproton accelerator LEAR/CERN, the PS208 experiment has accumulated about 100 Gbyte of event data [2].

I. INTRODUCTION

For nuclear physics experiments at the 30 AMeV heavy ion accelerator VICKSI of the Hahn-Meitner-Institut (HMI), a new software package DASP, i.e. Data Acquisition Software Package, has been developed to support data acquisition. The DASP software package consists of a client part running on a UNIX workstation and a server part running on an ethernet coupled VME processor controlled by the OS9 real time operating system.

Experiment signal conversion is performed by various CAMAC based conversion modules. A VICbus connection between VME processor and CAMAC crates facilitates the parameter setting of the converter modules. Data readout of the converted parameter values from CAMAC to VME is performed via the ECL Fera Bus which provides a data readout rate of 10 MBytes/sec. The daisy chain of the converted parameter requests on the ECL Control Bus allows zero suppression during data readout. A special 'FERA Faucet Maier' [3] module coordinates the readout of several chained FERA drivers. This module also takes care of event formatting by placing a header word in the data stream in front of each event. At present, the DASP system is able to handle various CAMAC converter modules, ADCs, QDCs, and TDCs of the SILENA 4418 series, GAN'ELEC QDC1612F, LeCroy QDC, Ortec ADC and Swistec ADC.

The DASP system has given a first proof of its abilities at the PS208 experiment which has been performed recently at LEAR/CERN to measure the multiplicities for neutrons and charged particles emitted after antiproton annihilation in a sample of target nuclei ranging from Carbon to Uranium [2]. The experimental set-up, as shown in Fig. 1, consists of two full solid angle detectors, the Berlin Neutron Ball (BNB) [4] and the Berlin Silicon Ball (BSIB) [5]. The BNB is a spherical

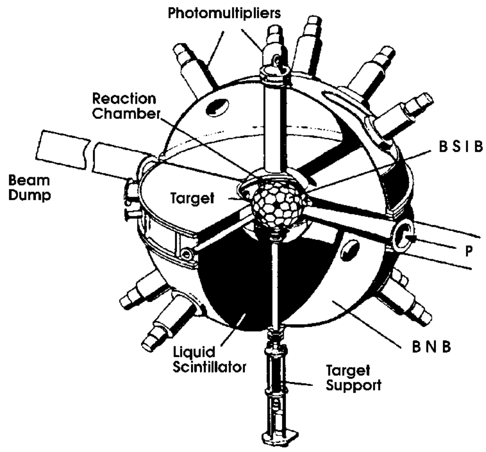

Fig. 1: Full solid angle detectors for the PS208 experiment at LEAR/CERN - neutron ball (BNB) with silicon ball (BSIB).

shell with an outer diameter of 160 cm, filled with a liquid scintillator for neutron counting. Inside the shell the BSIB is mounted.

By means of 158 silicon detectors arranged on an inside touching sphere of 20 cm in diameter, the BSIB measures energy, particle species and angular correlations of the charged nuclear particles. 20 physicists from 8 European laboratories (HMI-Berlin, GANIL-Caen, TU-Munich, Warsaw, FZ-Rossendorf, IPN-Orsay, IPN-Moscow, CERN-Geneva) participated in the first series of experiments yielding an amount of 100 GBytes of event data.

II. HARDWARE

A. CAMAC Control System

The VME resident front-end controls the experiment electronics which is distributed over several CAMAC crates. The scheme of the LEAR setup is sketched in Fig. 2. The VME crate is governed by a 68040 CPU (EUR 7 in Fig. 2), which controls the CAMAC setup by a VICbus connection (VIC in Fig. 2). Each of three CAMAC crates contains 20

BSIB signal converters of different kinds: ADCs, QDCs and TDCs of the SILENA 4418 series. For the BNB signal detection other types of signal converters (Ortec ADCs, Swistec ADCs) are placed in a fourth crate. In the course of the PS208 experiments, additional detectors have been used like a ho-

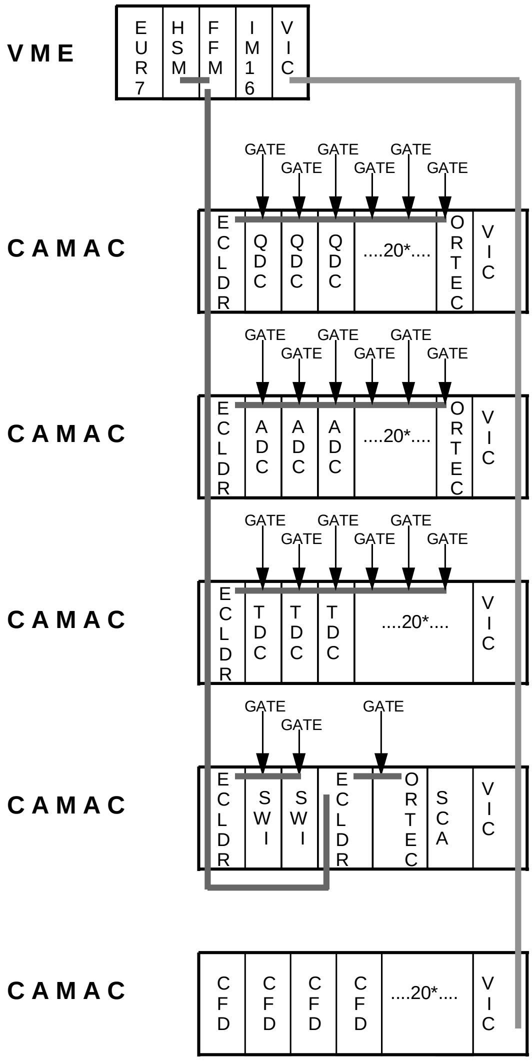

Fig. 2: Hardware configuration of the DASP front-end

doscope for detection of high energy particles and some veto scintillators for background suppression. Therefore other kinds of signal converters (GAN'ELEC QDC 1612F, LeCroy QDC) have been added to the ECL daisy chain. In the result five ECL driver modules (CES AD1570) took part in the ECL readout synchronized by the overall control of the 'Fera Faucet Maier' module (FFM, see Fig. 2). Technical details of the FFM module have been described elsewhere [3]. After readout complete events are stored in a 64 kBytes high speed memory buffer module (HSM in Fig. 2). Memory access to the HSM is feasible via three ports, an ECL port for data input, a VME port for setting the buffer overflow limit, and a VSB port for buffer readout.

To support on-line acquisition of event parameter histograms the DASP front-end is equipped with a 16 MBytes increment memory module (IM16 in Fig. 2). Memory increment is performed by VME addressing, histograms are read out via VSB access.

B. Signal Processing and Logic

Each detector of the setup delivers a fast signal which, for the Si-ball for example, is used threefold for particle characterization :

1) the energy information is obtained directly by integrating this signal with a CAMAC QDC.
2) the particle identification is done by means of pulse-shape discrimination resulting in an analogue signal of which the amplitude contains the information. These signals are recorded by CAMAC ADCs.
3) the mass of the detected ions is determined by means of the time-of-flight method. CAMAC constant fraction discriminators (CFD) are generating stop signals for CAMAC TDCs.

The start signal for the TDCs and the synchronization is obtained from a special start detector or from the RF of the accelerator if the beam used has a sufficiently pulsed structure. The whole synchronization and logic of the interface is organized by a master control unit (MCU) (ST 191, development of the electronics department of the HMI, see Fig. 3). All devices (CFD, QDC, ADC, TDC) are 8-channel units.

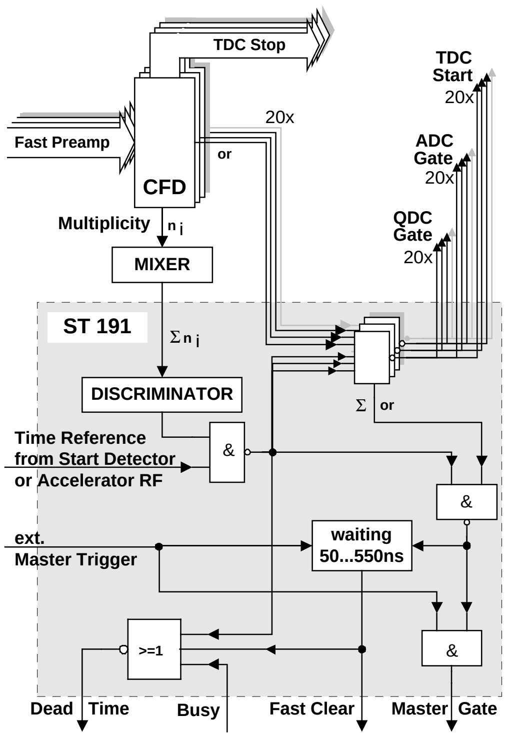

Fig. 3: Schematic logic of the ST 191 Master Control Unit

For each channel that has fired, the CFDs generate an analogue multiplicity signal n_i and a logic "or" signal. The sum of all multiplicity signals Σn_i is a measure of the number of particles involved in one event. The synchronization is started only, when this signal, $\Sigma n_{i,}$ exceeds a variable threshold which can be set within the range 0.02.-.2.02 V. In addition, an external master trigger signal (e.g. from a special detector) is required to have the possibility for coincidence measurements. If there is no master-trigger within an adjustable waiting time (50 ... 550 ns) the MCU generates a clear signal with an adjustable length corresponding to the time necessary to reset all activated converters. During the overlap of the waiting time, the length of the clear signal and the busy signal of the computer (dead time in Fig. 3), no further external start signal is accepted.

To minimize the dead time only those converters are activated for which the corresponding CFD has generated an "or" signal (i.e. at least one channel has fired). Therefore, the individual gates in the ECL chain are separately provided with valid ECL-gate signals generated by the MCU from the time reference and the corresponding "or" signal (including the multiplicity filter). The gate lengths are adjustable according to the requirements of the three different converter types and the corresponding signals in the range 50 - 1000 ns (for the QDCs), 0.5 - 2.5 µs (for the ADCs) and 0.1 - 0.5 µs (for the TDCs).

III. SOFTWARE

A. DASP Server

A data and control flow diagram of the DASP Server is sketched in Fig. 4 using the Yourdon notations [6]. The server processes can be grouped in three divisions.

The hardware initialization is performed by the CAMSTA process which interprets an UNIX-resident INI-File read in via NFS. The interpretation results in some tables which are stored in an intermediate file (HOO_par.dat in Fig. 4). The PRODUCER process uses these tables to initialize the CAMAC resident signal converters.

The data handling system is built by one PRODUCER and several CONSUMER processes sharing access to a common alternating data buffer (BUFFER in Fig. 4). These processes are created as OS9 'child' processes by the DATAIN 'parent'. After the HSM_Full flag is set by a VME interrupt handler upon crossing the preset overflow limit of the HSM module, the PRODUCER process is triggered to read in the data and to reset the electronics for the next event acquisition. The PRODUCER process converts the event data from the ECL format into the HMI event format utilizing formatting tables extracted from HOO_par.dat. Having finished event formatting the data buffer access is released by sending an OS9-signal to the DATAIN process (FULL, see Fig. 4). Now, the DATAIN process is authorized to trigger the CONSUMER processes, LINK (responsible for data transfer to the UNIX host) and MINC (responsible for incrementing event parameter histograms). After completion of data treatment each CONSUMER process sends its FREE-signal back to the DATAIN process (see Fig. 4). As the DATAIN process supervises the access to an alternating data buffer, PRODUCER and CONSUMER processes can perform data treatment simultaneously.

The CMD_SERVER process acts as 'parent' for two OS9 'child' processes (CAMSTA, DATAIN, as described above). It maintains a RPC-link to the UNIX-resident DASP client. According to the received commands (INI, STA, STO, see Fig. 4) the CMD_SERVER process creates, controls, and kills its 'child' processes.

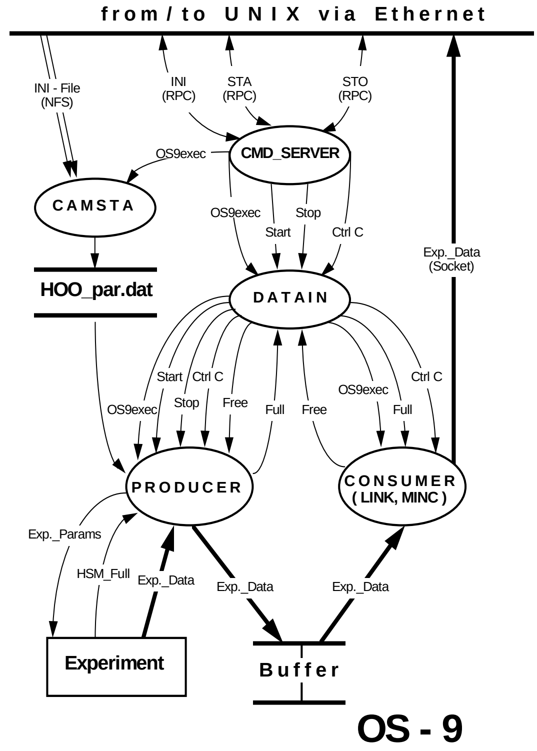

Fig. 4: Software structure of the DASP Server

B. DASP Client

The central part of the DASP client running on the UNIX host is a shared raw data pool of stored event data. A software structure diagram is sketched in Fig. 5 following the Yourdon notations for Data Flow Diagrams [6].

A dispatcher process (ROUTER [1] in Fig. 5) controls the access to the stored event data by 'producer' and 'consumer' processes. Producer (LIST_IN in Fig. 5) and consumer processes (LIST_WRIT, LIST_SHOW in Fig. 5) have indicated their access needs in advance according to user commands received via pipes from the CMD_CLIENT process (Graphical User Interface in Fig. 5). At present, one producer process (LIST_IN in Fig. 5) reads in the event data from the VME front-end via a TCP/IP socket connection and stores them into the raw data pool. The experimentalist can decide whether the graphical data display by the LIST_SHOW consumer process should be performed with equal or lower priority compared to data storage on Exabyte tape (Raw Data File, see Fig. 5) handled by the other LIST_WRIT consumer process. For data display four daemon processes [7] (TEK_DAEMON_1 to _4, see Fig. 5) are available which each controls one to four OSF/Motif-windows emulating a 'Tektronix' screen. According to user commands the display daemons also serve for spectra display requests from the SPEC_SHOW process (see Fig. 5). These spectra have been stored into the Multi Spectra File by the SPEC_WRIT process (see Fig. 5).

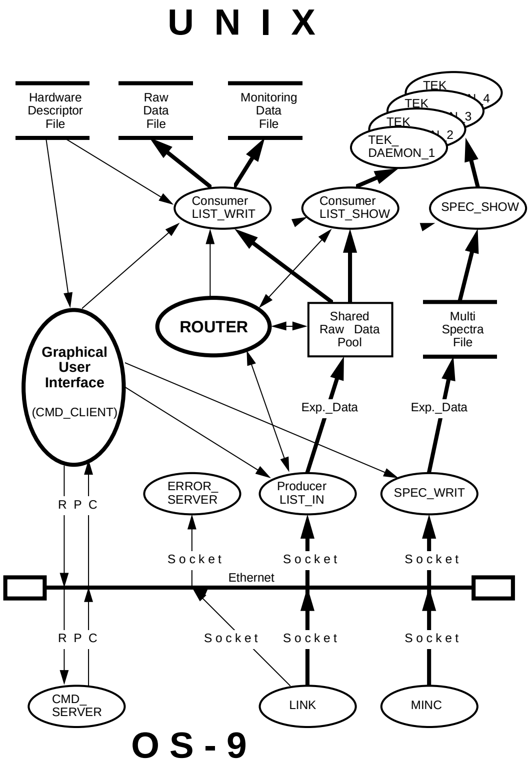

Fig. 5: Software structure of the DASP Client

Besides the continuous storage and display of the event data, actual events are stored like 'snapshots' into a Monitoring Data File (see Fig. 5). According to the rules of UNIX shared file access, appropriate data analysis programs like PAW [8] may read in these data for extended on-line data monitoring.

IV. RESULTS

During the PS208 experiment series the typical trigger rate amounted to 100 kTrigger/sec. Utilizing the facilities of the ST 191 Master Control Unit this rate has been reduced to 1000 accepted events/sec containing about 40 parameters. The data reduction has been achieved by adjusting the multiplicity signals properly. Taking advantage of the ´zero-suppression-mode´ only those channels have been read out for which a read-out request has been detected by the ECL drivers. The control of the handshake protocol on the ECL daisy chain by the FFM module guaranteed the read-out of the complete event. This makes it easier for the DASP server to keep track with the data flow during event data formatting. Due to the alternating data buffer of the DASP server the resulting data stream of about 80 kBytes/sec has been transmitted via Ethernet to the DASP client without remarkable increase of total deadtime.

The ROUTER process derandomized the incoming event data stream by means of its large circular storage buffer. No increase of deadtime has been observed caused by data monitoring. However, most of the on-line data analysis has been performed using PAW on a separate workstation.

V. SUMMARY

The success of the PS208 experiment series at LEAR/CERN demonstrates the benefits of the modular design of the DASP software system. The design of both the UNIX client and the OS9 server software is characterized by a data driven producer-consumer architecture which is open for extensions.

It is planed to use DASP also at other experiment series where the HMI take part in, i.e. the 'Euroball' collaboration and the 'European Spallation Source' project.

VI. ACKNOWLEDGEMENT

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