THE HERA-B SLOW AND RUN CONTROL SYSTEM

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1 HERA-B EXPERIMENT

The HERA-B experiment is dedicated to measure CP violation in the B meson system. It is built up on the HERA proton beam and uses an internal wire target.

About 300 collaborators from 33 institutes participate at the experiment.

The detector consists of 10 sub-detectors providing the raw data, 16 subsystems are integrated in the DAQ system for building and processing events.

The final number of readout channels is more then 550K. The main detector components are the Vertex Detector, Inner and Outer Trackers, RICH, Electro-magnetic Calorimeter and Muon Chambers.

The concept of the Slow and Run control systems plays an important role for the experiment.

The aim of the paper is to present the both systems, their basic parts, implementation, the status and plans.

2 BASIC PARTS OF SLOW AND RUN CONTROL SYSTEMS

The Hera-B Slow and Run Control is a highly distributed system. Estimates for the final system give about 2300 processes running on 1600 different computing nodes employing different operating systems such as IRIX, Solaris, Linux, LynxOS. About 1200 processors are SHARC DSPs (Digital Signal Processors) that have no operating system at all.

The basic parts to build up transparent, easy maintained and scalable systems are:

- message passing system;
- state machine control;
- central services;

The software design approach was also considered as an essential part for the implementation of the systems .

2.1 Message Passing System

Interprocess communication is a primary question in the modern systems. Our decision in this area was to have a single integrated message passing interface for all the messaging needs of the HERA-B online systems. It's implemented on all variety of UNIX platforms as well as on platforms with no operating systems, namely the SHARC DSPs. The main features of the HERA-B message passing system are:

- UDP socket based interface;
- a simple naming scheme for associating each process offering a service with a name to look up address of the service by using the name;
- two interface level options (high and low) to satisfy quite diverse requirements with 4 orders of magnitude range in latency requirements and 5 orders of magnitude range in message length;
- a translation service which rearranges byte ordering, changes byte alignment and translates floating point formats, that is hidden from the user;

2.2 State Machine

The integration and synchronization of the subsystems within the common Run Control (RC) and Slow Control (SC) systems is the next basic point. These tasks are solved by applying so called state machine and arranging the all processes in a process tree, where the state transition commands propagate from the top to the bottom, and the states stream has the opposite direction. The main features of the HERA-B State Machine Control (SMC) package are:

- dynamic process configuration during its start-up
  - dynamic state transition table (STT);
  - dynamic state dependence table (SDT);
  - dynamic number of daughter processes;
- the possibility to have processes with diverse STT in one process tree;
- user defined actions for state transition.

2.3 Central services

The major central services used by any process of the HERA-B Run and Slow Control systems are:

- name service (process registration, process information provision)

- process service (remote start and process termination)
- error logging (error message distribution, error recording)

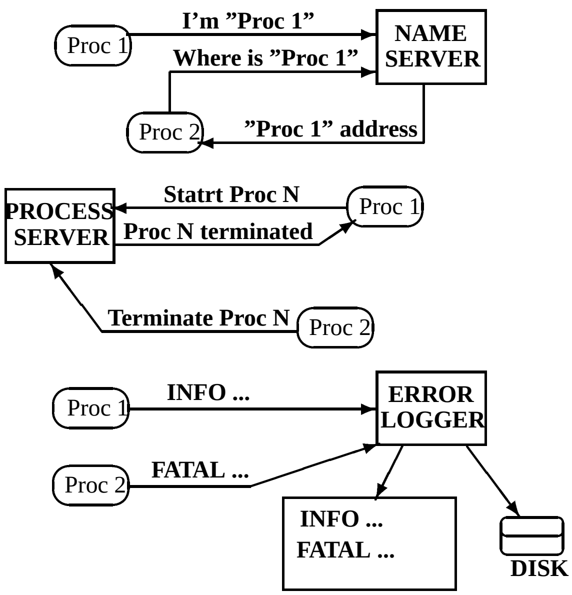

Figure 1: HERA-B Central Services

2.4 Software Design Approach

The main considerations in the design of the common online software both for the SC and RC systems are minimizing the software development by the detector groups, facilitating maintenance of the code, providing a common upgrade path and supporting the variety of the computer types and operating systems running on them. To achieve these objective the template approach has been considered as the important one. There are the following templates of common use:

- data monitors;
- slow process control;
- slow control graphical user interfaces;

3 SLOW AND RUN CONTROL SYSTEMS CONCEPT

3.1 Process Tree Applying the State Machine

All the processes are arranged in a control tree. The top process controls and monitors the state of the whole tree. It sends state transition commands to get all the processes in the state that corresponds to a particular phase of the data taking. The processes in turn send their states according to their internal status and at its change.

All the processes belonging to a certain subsystem are usually registered in a separate sub-domain provided by the name service. The processes of general use are given so called 'system' domains. This approach allows to simplify the identification of the processes in the tree.

3.2 Slow Control as a Part of the Control Tree

The slow control system has its own process tree. We assume that the system runs all the time. When a data taking run starts a special processes called 'Branches' connect to the corresponding branches of the slow control system to get them participating in the run. Therefore the slow control processes also have some internal states that change depending on the data taking run stage.

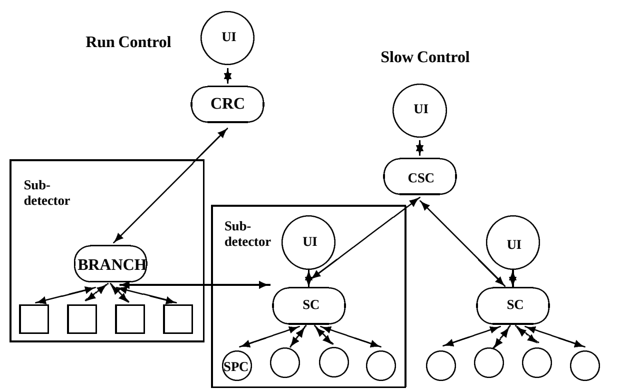

Figure 2: Slow Control as a Part of the Control Tree

3.3 Dynamic Configuration of the Run

One of the important features of the run control system is the ability to configure the run configuration dynamically. The objects of the configuration are:

- subsystems (sub-detectors providing data);
- data logging type (disk, tape, none);
- trigger type (FLT, SLT, TLT, 4LT);
- resources in use (number of farm nodes);

3.4 Parallel Runs and Controls

To have the parallel runs for different sub-detectors is an important feature of the Run Control system. It allows to test some sub-detectors in stand-alone mode along with the data taking for the other part of the sub-detectors. The parallel runs are also possible for the Slow Control of the sub-detectors.

Every run has its own 'RUN' domain provided by the name service. This excludes the interference among the runs.

4 IMPLEMENTATION OF SLOW AND RUN CONTROL SYSTEMS

Every run has its own domain not to interfere with the others. Global DB servers provide all client applications with the interested information. The information about all the processes that supposed to be started for data taking run is also stored in the DB and the process manager starts the required processes according to this information by means of the process service.

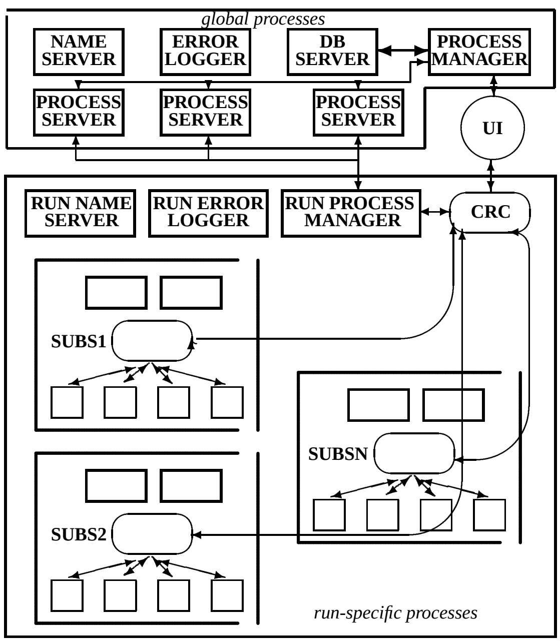

Figure 3: Slow and Run Control Start-Up

Every run starts by launching a run control graphical user interface (GUI), that will control and monitor the top process in the control tree (CRC, CSC, see fig. 2).

The operator chooses the type of the run configuration and the subsystems that are going to participate in the run.

The start-up of the process tree begins with the request from the GUI to the global process manager to launch the first portion of the run processes. They are the name server, the process manager, the local error logger, the Central Run Control (CRC) process.

All the remaining processes for the run are started by the local process manager on requests sent by the CRC and the branch processes.

After all processes have been launched, the state machine control links are established and control is granted to the operator to start data taking.

The status of processes participating in the run are being monitored and controlled. There is the possibility to restart processes on their termination. In case of the termination of a process that can not be restarted and considered as ”critical” the run will be terminated.

This scheme is applied to both the Run and Slow Control systems.

5 STATUS AND PLANS

The HERA-B detector completion is scheduled by the end of 1999. The Hera-B Run Control and Slow Control systems has been operated as two parallel systems since the beginning of this year.

Currently 500 - 600 processes are run by the Run Control and Slow Control systems. The transition to the systems with 2300 process does not mean a great effort. The most part of the processes is just a duplication of those already running. Those processes will run on the SHARC DSP nodes (switch processes) and farm nodes (fourth level trigger processes).They will also be commissioned by the end of the year.

Completion of the systems,their integration and reliability improvement are the main points of our concern. As the experiment gets complete, the both systems become more and more complex. We anticipate that the issue of start-up time and the process control reliability become more and more important. At this respect we are trying to configure the system in such a way that some processes will be turned to a kind of central services reused by many runs without their termination.

6 REFERENCES

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