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CONTROL SYSTEM FOR THE JAERI TANDEM ACCELERATOR

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Abstract

A new control system for the JAERI tandem accelerator has been developed using concurrent programming and multi processor technology. There are eight transputers in the system including front end processors of CAMAC serial highways. This paper reports an experience of the development and the operation of the system.

1. Introduction

The JAERI tandem accelerator[1] had been controlled by a traditional minicomputer since 1979. However, we

had some difficulties to stay on the old base. They are the difficulty in maintenance of the old-fashioned computer and shortage of the computing power for a further expansion of the system. So, we have developed a new control system to replace old one.

In the new system we use concurrent processing technology using multiple microprocessors. In a logical aspect, a control of a particle accelerator is a set of various processes controlling and/or monitoring many control objects, that is to say, accelerator devices. Those processes are not strongly coupling each other and have logical concurrency. This implies that the

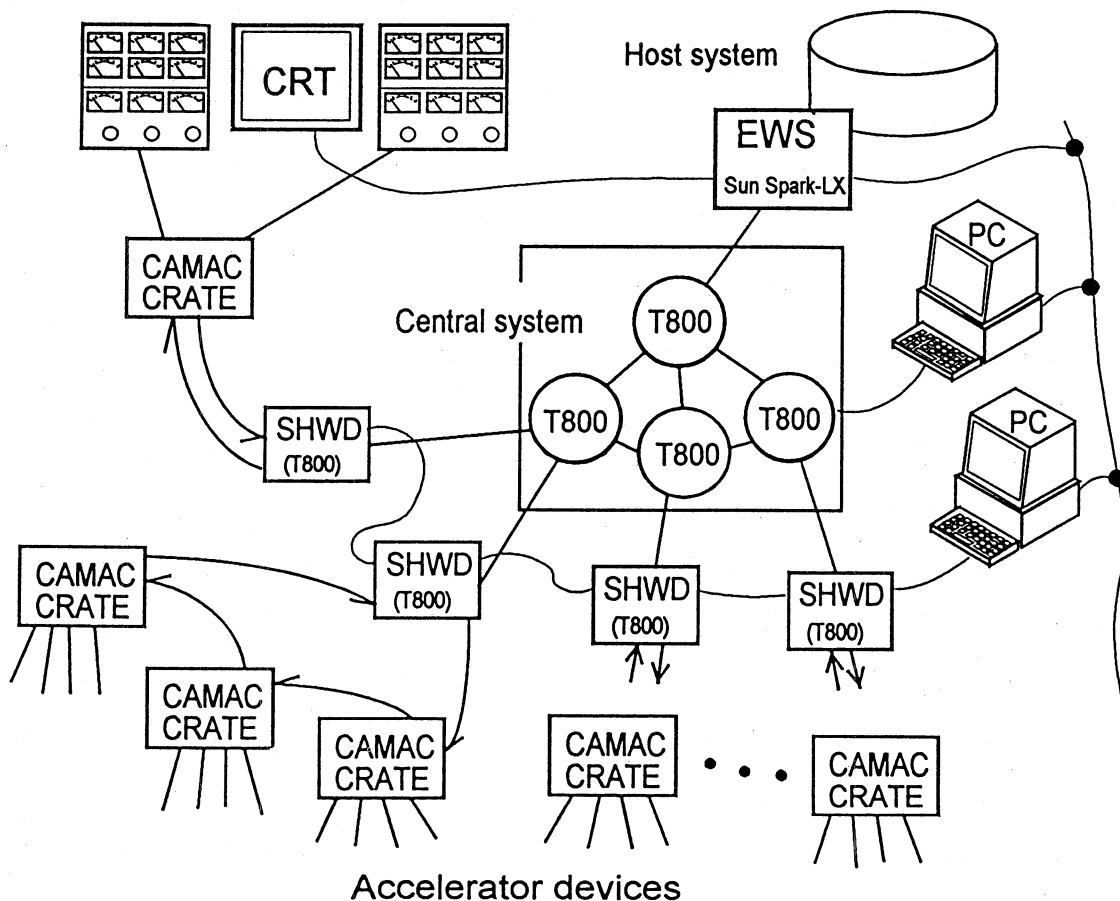


Fig.1 Block diagram of the new control system for the JAERI tandem accelerator

control system is a good field of application of concurrent processing technology. Using multiple processors, a merit of concurrent processing is enhanced in the system performance.

2. Overview of the System

The control system is using transputer[2] and concurrent processing technology. We call the system ACCELL[3]. Figure 1 shows a block diagram of the new system. The new system consists of 1)a host system using a work station, 2)a central system, 3)serial highway drivers, 4)a CAMAC serial highway system[4,5] and 5)two personal computers. The main roles of the host system are to support execution of the central system and to work as a part of a man-machine interface. Data of the central system needed to control the accelerator are loaded from the host. A bit map display of the host is embedded in the operator console of the accelerator. Programs based on X-window system[6] are used on the display. Connection to the central system is an INMOS link[2] and a S-bus link adapter. The host system is also used as a file server. The central system is a multi processor of four T800 transputers[2] with local memory of one mega bytes to 16 mega bytes. It works as a main element of data processing. We can change number of transputers to optimize loads of transputers. The serial highway drivers are front end processors of the central system to CAMAC system. Transputers are also used in the drivers. They have charge of low level control of the CAMAC serial highways. CAMAC serial highway system is almost the same as the old system. Nineteen CAMAC crates are distributed on the four serial highways. Two of the crates are dedicated to the control console. The control console has assignable valuator, which are called shaft encoders, assignable and dedicated meters etc. to control and monitor data points. Programming languages for the transputers are parallel C(INMOS ANSI-C)[7] and OCCAM2[8,9]. Programs of the transputers are developed on the personal computers. They are also used for monitoring a system operation.

3. Early Experience of Operation and Improvement of the System

The first version of the new system had started daily operation for the accelerator control in October of 1992. The reliability of the system has been good enough. But, performance of message transfer between concurrent processes in the system was not so good as expected. In the system, messages between application processes are transferred through processes named monitors.

In October of 1993, the performance of the message transfer was greatly improved from about 2 milliseconds to about 0.3 milliseconds per one message transfer. In the work, We analyzed program execution times of several instructions of the transputer and used new programming technic for better performance. So we could make the improvement without any change of external specifications of the monitors.

A new function of linked control using a virtual data points[3] was tested in March of 1994. The virtual data point named final energy(E_f) and its control process, scaling process, were installed in the test. It was intended to work as that a change of E_f reflects to several data points by the scaling rule[10] process, in the manner that beam transport of the accelerated particle is maintained and the final energy is set equal to setting value of E_f . The mechanism follows not only to a step of the change but also to the continuous change of the virtual data point. Some mismatch between valuator of the control console and the new function was found by the test. On the other hand, it was shown that system performance of message passing and calculation was enough for smooth operation. Introduction of the function into daily machine operation should be suspended till improvement of the valuator.

4. Development of the Concurrent Program

We have used OCCAM and Parallel ANSI-C as programming language. Concurrent programming enables us programming through natural modeling of the target

system that has intrinsic concurrency. It is a most important advantage of the concurrent programming. On the other hand, programming of the concurrent system has only a limited length of history in a practical world. Methodology of the programming is not well known yet. Especially, there is a problem about a deadlock in the world of concurrent programming. It is a situation in which two(or more) processes mutually wait for the other process to become ready to receive messages and the processes cannot execute farther operations. A small mistake in the programming introduces probability of the deadlock. Programmers sometimes cannot follow action of the system where several processes running concurrently. We needed training different from usual sequential programming. We met several additional difficulties about development tools etc. In spite of the difficulties, the concept of concurrent programming has been attractive one.

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