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Concurrent Control System for the JAERI Tandem Accelerator

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Abstract:

Concurrent processing with a multi-processor system is introduced to the particle accelerator control system region. The control system is a good application in both logical and physical aspects. A renewal plan of the control system for the JAERI tandem accelerator is discussed.

Introduction

Progress in the micro electronics region makes real concurrent(parallel) processing reasonable for various applications today. In the logical aspect, a control system of a particle accelerator is a combination of many processes concurrently working for control and monitoring. This implies that the control system may be a good application of the concurrent processing. In the JAERI tandem, we are working to renew the computer control system. A multi-processor system and concurrent programming language will be used in the new system.

Concurrent processing in the control system

We can treat a control system of a particle accelerator as a set of processes to monitor and to control many devices. They have different tasks(roles) weakly coupled with each other. We can depict the system with a model of processes communicating with each other by message transmission, called communicating process architecture(abbreviated as CP architecture)/1/. A concurrent programming language based on the model simplifies programming of the control system, because of easy description of the intrinsic concurrency and communication in the system.

On an usually available multi-tasking operating system, it is possible to describe the above concurrency. But it is not practical because of the overhead to manage too many processes and communications. Thus we must divide the processes only at a moderate level and convert many concurrent processes to several sequential programs in the actual implementation. The resultant programs are difficult to understand. The multi tasking operating system is not ideal for the above modelling.

The merit of concurrent programming is enhanced by use of multi-processor. The concurrent program distributed on multiple processors can give us dramatical merit of performance, because computing power of the multi-processor is proportional to the number of processing elements. It depends on the concurrency of the application(explicit or implicit) and current state of the computer technology. Digital Integrated circuit technology is advanced to increase density of circuits and the performance. Today, high-performance micro processors are available with a low cost. Well organized multi-processor system has good cost performance ratio.

Communications are important in the system. They are ones between processors and ones between processor and external elements. Not only high transfer rate of the data, but also short leading time are necessary to get good response.

We are interested in Transputer/2/, OCCAM/3/,/4/ and CP architecture as a base. OCCAM and transputer were developed together by INMOS limited as parallel programming language and micro-processor to execute the concurrent program respectively. Both are commercially available with a program development system.

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OCCAM allows description of parallel processes as easy as sequential process descriptions in a usual programing language. Communications between parallel processes are made through message transfer mechanism called channels.

The transputer supports concurrent processing very efficiently. Its latency to switch context is less than 1 micro seconds. And it supports message passing mechanism by hardware. For external communication, it has 4 serial communication links called INMOS links. It is optimized to execute OCCAM program. Transputer and OCCAM are based on CP architecture theory. Transputer executes OCCAM program very efficiently.

In addition to OCCAM language, today other concurrent languages are available for transputer. One of them is Par.C language which is a parallel extension to the C language and has advantage against OCCAM on defining complexed data structures.

Needs for Computing Power

Today, a new particle accelerator is usually controlled by a computer control system. With an appropriate network, it offers low cost remote control from the operator console to the accelerator devices. It also helps the operation with its programmable computational power and mass data storage. High level languages and high level symbolic access methods to the accelerator's data points have been introduced to emphasize the advantages of computer control as mentioned above. It has simplified programming of accelerator for accelerator engineers and physicists, and makes the role of the control system more important than before.

But these benefits have been obtained at the expence of slow response to the operator's action, even in a very primitive manipulation of the devices. In larger accelerator systems, there are more data points and data classes and the network hierarchy is deeper. So the resultant response has become slower. To improve the situation, more computing power and better data throughput with good real time response are needed. With larger computing power, we can add many functions such as flexible feed back control with digital signal processing(DSP), linked control of many data points with a few macroscopic parameters and so on.

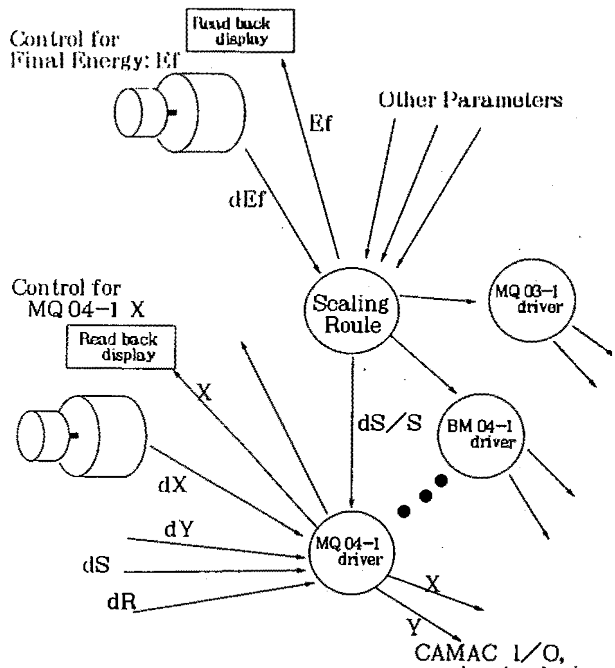

Fig. 1 : Control with macro parameter, Ef(final energy of particle)

One of the good examples is the linked control of data points with a few macroscopic parameters. In the JAERI tandem, we must tune about 50 beam optical parameters, to transport the particle beam to the target. Readjustment is needed for 30 data points of them, when we change final energy of the accelerated particle. Figure 1 shows process diagram of the linked control with macroscopic parameter, the final energy of particle(Ef). A scaling rule process accepts macroscopic parameters, the final energy(Ef), mass of the particle etc.. It calculates particle energy at each optical device position and adapts appropriate scaling rule/5/ and sends the increment(or decrement) signal to each device driver process. The drivers output low level control signals to the actual accelerator devices. When operator turns the valuator of the final energy, all beam optical parameters follow it and the beam current on target is maintained.

For comfortable real time response, the valuator value must be sampled and processed 10 to 20 times per second(or

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faster). Concurrent processing with multi-processor achieves it, distributing processes to several processors.

Design of the Concurrent Control System for the JAERI Tandem

Figure 2. shows the image sketch of the new system. The control center of the system consists of engineering work stations(EWS's) and a central processor colony. The colony is a multi-micro-processor system. Each processing unit(PU) in the colony is a transputer(T800 INMOS Limited) based processor. It consists of 32bits transputer with 64bit floating point hard-ware and local memory. They are linked with each other through serial communication links. The colony executes most time critical processings. It is programmed with concurrent programming language.

The EWS's perform several functions. One of them is CRT display for man-machine interface. A window system on the EWS is used for the purpose. The second is data base. A relational data-base management system is used. The third is a host processor for the central colony.

The front end interfaces to the accelerator devices are CAMAC modules. They will be ones working in the current control system(16 crates are working on 5 serial highways). In the new system, the serial highways will be driven by the central colony through serial high way drivers, which also have transputers as control processors.

Conclusion

The multi-processor concurrent processing is introduced in the particle accelerator control system. With appropriate modelling methodology, the control system is programmed naturally in the multi processor and very high speed processing is obtained. As an example, renewal plan of the control system for the JAERI tandem is discussed.

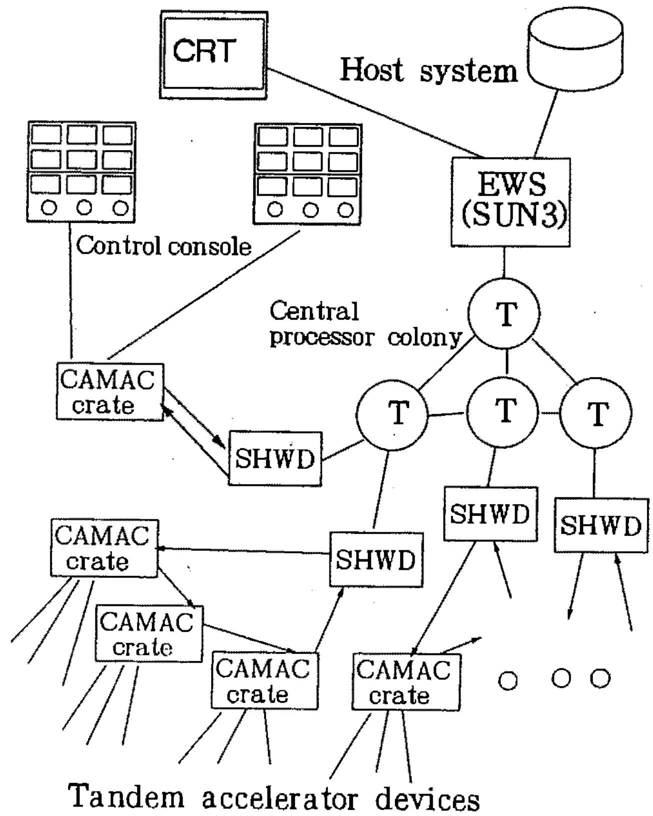

FIg.2 Image sketch of the concurrent control system for the JAERI tandem accelerator

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