FOUR-YEAR EXPERIENCE OF THE KEK NODAL SYSTEM

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ABSTRACT

TRISTAN Main Ring and TRISTAN Accumulation Ring have successfully been operated under the KEK NODAL system. Many experiences are accumulated with the NODAL system for four years. At this stage the KEK NODAL system is not completely homogeneous system. So the subject to the control system in the next generation is how we can construct a homogeneous system.

INTRODUCTION

Since October 1986, TRISTAN Main Ring has come into operation and the physics outputs have started to come. Prior to Main Ring, TRISTAN Accumulation Ring has already been operated successfully under the TRISTAN control computer system based on a KEK version of NODAL. For these four years, since the commissioning of Accumulation Ring, we have accumulated the experience with the control system and have made the efforts to upgrade the system. In this paper we describe the experience with KEK NODAL system and discuss some future prospects.

OVERVIEW OF THE TRISTAN CONTROL COMPUTER SYSTEM

The TRISTAN accelerators are operated using a distributed computer control system[1] consisting of twenty-five minicomputers which are connected with a token ring network of optical fiber cables. From each minicomputer, the CAMAC serial highway is extended to hardware equipments along the accelerators. Figure 1 illustrates the architecture of TRISTAN control computer system.

The minicomputers are classified into two groups; the system computers and the device-control computers. Each of the system computers works as a operator's console (OP0-OP5), alarm-processing (AL0-AL1) and library (LB0). Each of the console computers has two touch panels and two graphic displays. The LB0 computer is connected to the KEK Central Computer System by a fast network, TRNET[2]. The large computation which overloads the minicomputers is carried out on the Central Computers.

The software of the TRISTAN control system is based on a KEK version of the NODAL interpreter language. The syntax of NODAL was originally developed at CERN to operate SPS[3]. NODAL has the multi-computer commands; EXEC, EXEC-P and IMEX, which enable us to transmit NODAL program lines to another computer on the network and execute it on the computer.

In the KEK NODAL system, there exist two types of external procedures; the data module and the NODAL function. The former is a handler to access hardware equipment and the lattar is a subroutine which performs some particuler services such as the communication with the central computers. These routines are coded in PCL (a FORTRAN-like compiler language).

KEK NODAL system has some extended features as follows:

1) the adoption of intermediate-language scheme
2) the dynamic linkage of external procedures
3) the multi-computer file system
4) the screen editing facility

DISCUSSIONS ON ARCHITECTURE

<u>Computers and operating system</u> Around 1981 and 1982, we selected computers for the TRISTAN control system. Considering the situation around minicomputers in those days, it is proper that we adopted HITACHI HIDIC 80E. This is a 16-bit minicomputer widely used in process control of industrial factories and has the multi-tasking operating system, PMS (Process Monitor System), which is compact and fast.

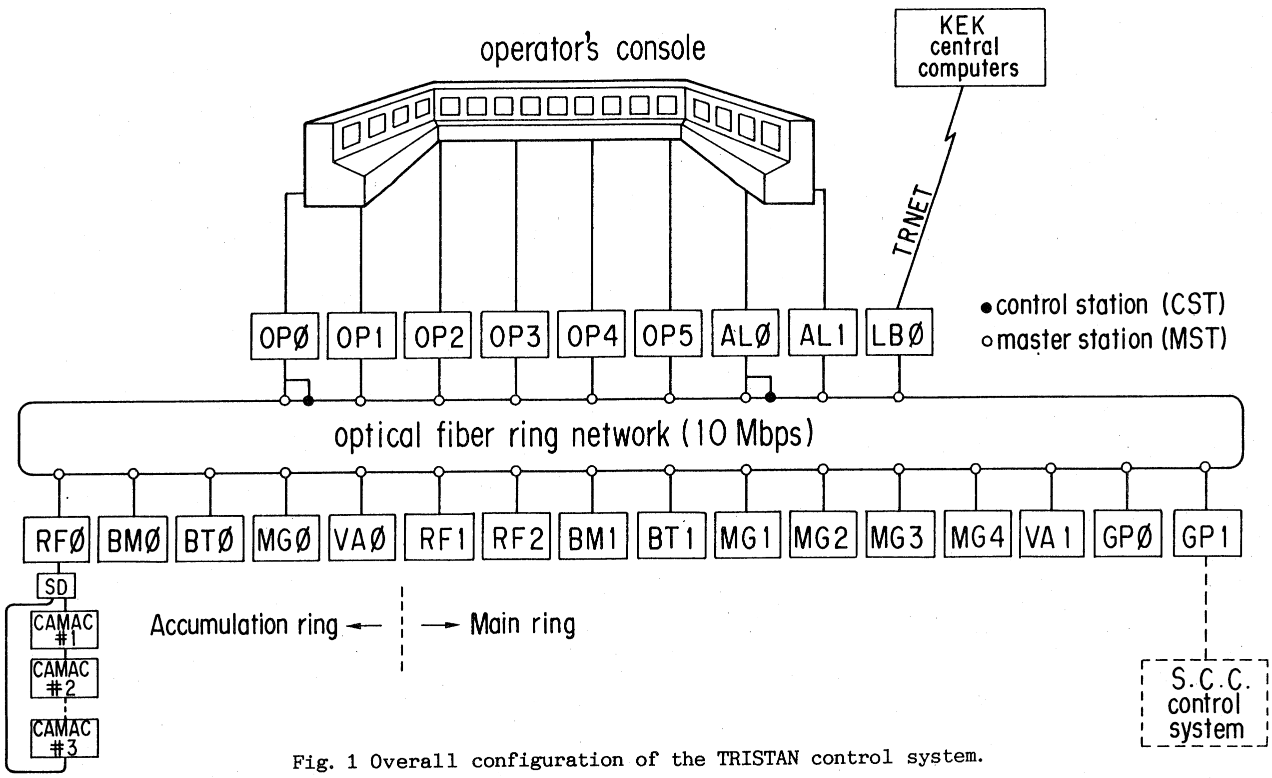

Fig. 1 Overall configuration of the TRISTAN control system.

In the TRISTAN system, each minicomputer has 256 kw memory. However, since it is a 16-bit computer, the physical memory must be divided into 13 logical spaces whose maximum size are 64 kw. Fig. 2 explains the arrangement of memory. Then the size of tasks and areas for resident subroutines are limited.

<u>Disposition of computers</u> As shown in Fig. 3, we distributed the device-control computers around the accelerators. But it would be more convenient for maintenance if all the computers were gathered in one building.

<u>The ring network</u> The token ring network works very well with satisfactory speed. The maximum throughput is nearly 1000 kbytes/sec.

At present, the memory on the other computers can be accessed only by using the multi-computer NODAL commands, such as EXEC, IMEX. However, through the operation experiences, we plan to make NODAL functions which access directly a special area of the memory on different computers through the network. With this method the standard information on the accelerator operation such as the beam current and timing status (injection or flat-top) are easily available from any minicomputers if they are stored in the special area.

<u>CAMAC system</u> The CAMAC system works very well using more than 2000 plag-ins in 185 CAMAC crates. All the hardware, *i.e.* serial drivers, U-port adapters, serial crate controllers and many plag-ins are very reliable. But one shortcoming is that the CAMAC system costs relatively much. In near future, the control architecture using many micro-processors will become the main stream. But at the stage of TRISTAN, the adoption of CAMAC is proper.

<u>Use of the central computers</u> The network between the LBO computer and the KEK Central Computer System works very well. This is useful not only for the online usage such as the correction of closed orbits but also for optics design and simulations. In the case of the closed orbit correction of TRISTAN Main Ring, data of 9.4 kbytes are sent and the CPU time of ~40 sec is necessary on the central computer.

DISCUSSION ON KEK NODAL

<u>Execution speed</u> The fast execution speed of the KEK NODAL is achieved by the following methods; 1) the adoption of intermediate codes, 2) the use of hashing for variable search, and 3) the use of cache tables for lines and functions.

<u>Interpreter and logical space</u> Four logical spaces, LS#9, LS#10, LS#11 and LS#12 are assigened to four NODAL interpreter tasks, i.e. terminal #1, the terminal #2, remote execution and fast remote execution. Considering the execution speed of the NODAL interpreter, it is not realistic choice that more than 4 logical spaces are assigened to the interpreter task. Then we prepared a part of logical space #2 (3 kw) for the task written by users in PCL. These task is convenient for monitoring the various parameters of the accelerators. If we could assign larger space for this user task, the rich information would be available.

<u>Dynamic Linkage scheme</u> The information necessary to linking external procedures (data modules or functions) is summarized in a table, the EFUN table. At the execution time, the external procedure are linked dynamically according to the EFUN table. When a user load a new external procedure, he have only to register the relevant parameters to the EFUN table. This dynamic linkage scheme works very well and can isolate the coding of data modules or functions from the kernel of NODAL system.

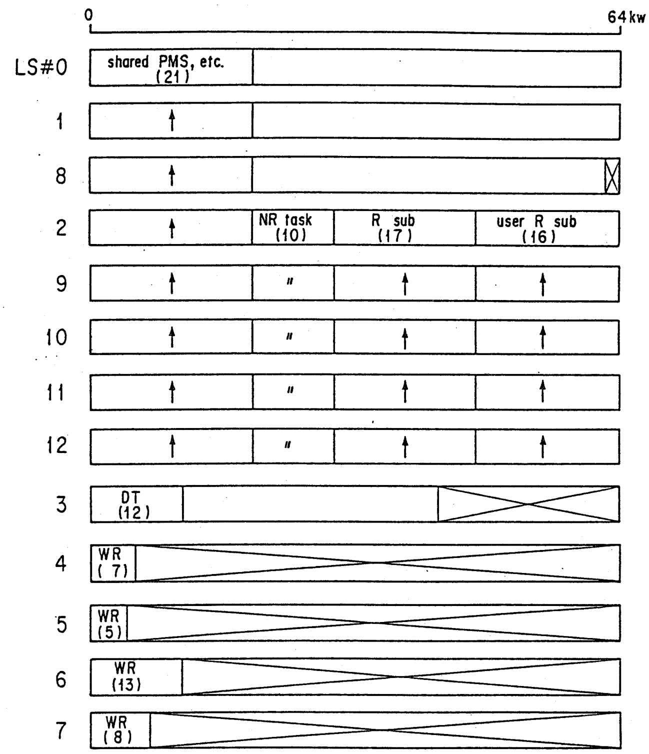

Fig. 2 Organizaion of memory into logical spaces. Arrows mean that the same physical memory is shared by several logical spaces. The letters WR, NR, and DT stand for the words, "working area", "non-resident", "resident", and "data table", respectively, Numbers between parentheses mean the memory size in kw.

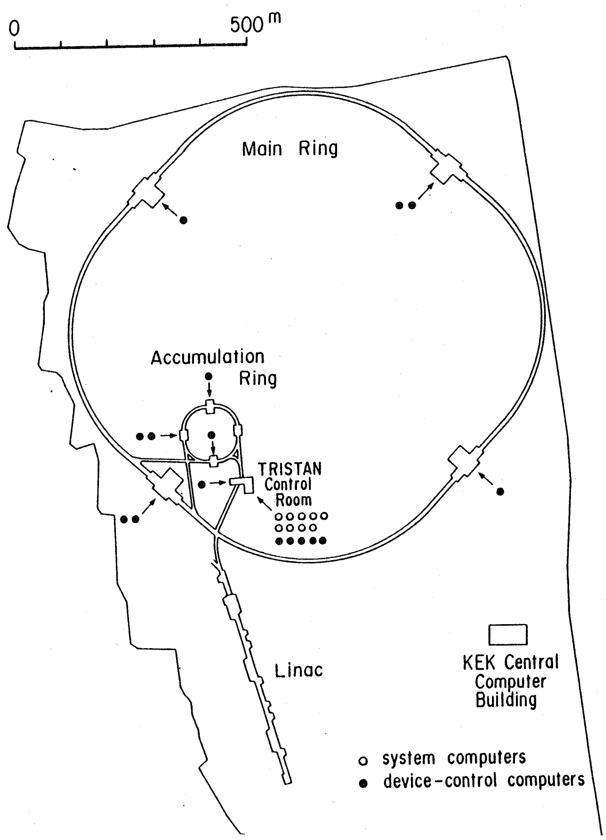

Fig. 3 Dispositions of minicomputers on the network.

File system NODAL program files and NODAL data files are manipulated by the NODAL file system which has the multi-computer facility. Under the NODAL file system, any file on any computer can be accessed uniformly through the network. Not only ordinary file on disks but also any I/O devices on any computer can be accessed.

However, PCL source files are out of the handling of the NODAL file system. They are handled by the IPS (Interactive Programming System) file system which is originally implemented in HIDIC 80's for the development and maintenance of programs. Because this file system has no multi-computer facility, the transportation of IPS file among the minicomputers on the network must be done with the buffer files on the LBO computer. It is less useful than the NODAL file system.

The IPS screen editor, which is very similar to the NODAL screen editor, was developed. But these two editors are facilitated on the different file systems. Therefore it is very difficult to construct a homogeneous system under which users can edit IPS files in the NODAL session.

Other impressions of KEK NODAL Through experience of operation various things impressed us. The main items are:

1) Graphic display handler is generally good. But considering extension in future, it would be better that the handler is based on some standard, e.g. GKS.

2) The character manipulation of NODAL which is from the SNOBOL-4 is scarcely used in KEK NODAL system.

3) The CHAIN command is added to the set of SPS NODAL commands. This command is useful to write down long programs. In RUN command all the variables as well as program lines in the working area are erased. But in CHAIN command the variables remain in the working area.

4) The terminals are interface with a half-duplex interface. Thus some troubles occurs in screen editor.

SUMMARY AND FUTURE PROSPECT

The KEK NODAL system has succeeded to make good environment for non-professional programmers. Accelerator physicists and engineers can easily and freely develop application programs and can improve them through many trial-and-error steps in actual operation. Viewed at this angle, the KEK NODAL system is working well as accelerator-physics oriented control system. In future, however, more systematic approach in constructing operation software will be required from the view points of saving man-power and up-grading the reliability.

The KEK NODAL system has some weak points one of which is that it is not a completely homogeneous system. In near future use of many micro-processors will be the mainstream of accelerator control system. It will be serious problem how to construct a homogeneous environment in which micro- and minicomputers are unified, for example, unified scheme for program development of mini- and micro computers.

The TRNET has been playing an important role in the TRISTAN accelerator operation. In the next-generation control system, it is very probable that large general purpose computers as well as vector processors are widely used in variety of methods.

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REFERENCES

1) S. Kurokawa et al., "THE TRISTAN CONTROL SYSTEM", Nucl. Instrm. Methods A247 (1986) 29.

2) E. Kikutani, et al., "Online Usage of General Purpose Computers in Accelerator Operation", Contributed paper to this conference.

3) M.C. Crowley-Milling and G.C. Shering, "The NODAL system for the SPS", CERN 78-07 (1878).