FORTH-NODAL: CONCEPT AND PRELIMINARY

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Abstract

The concept and preliminary works about the development of the multi-computer real-time control system like NODAL using the unusual language, FORTH, are described. Its specific feature is the high-speed response and the transparency in the interactive and networking environment.

Introduction

It is highly desirable to obtain a high-speed, real-time control system for the accelerators and other applications. The bunch of ready-made monitors exist in the world, however our demands are always specific to the own systems and we must tune them before in use. And the recent development of the computer hardware technology is so fast that the present newest models become obsolete soon. One possibility to overcome such a situation is to employing a well-documented standard(or portable) monitor which may be implemented for all new coming models(e.g. TRON[1] or Thoth[2]). These standard monitors are usually designed to hide the internal structure as a black box. This does not fit to our purpose, and we need a fully transparent system for precise tuning and free modification. So, another choice to adopt the original monitor as the kernel of the control system seems to be attractive. However, is it realistic to develop such a monitor from the scratch in a relatively low cost? We have some experiences on the personal computer based control system, and there exists the most suitable language, FORTH[3]. Although it has an exotic syntax compared with the other languages in a look[4], it is the fastest interpretive language using a technique of the threaded interpreter with some optimizations. It is interactive and self-expandable. The program code, called WORD, is compact and it can be constructed by using both the high-level and the low-level programming styles. All these favorable characteristics conduct us to develop an interactive, distributed multi-computer control system like NODAL[5] on the personal computer environment. The similar approach in the different context is investigated in other laboratories(e.g. CERN[6]), too.

In the following, the preliminary work to implement the FORTH-NODAL system on micro computer system is introduced. And as a typical application, the control system for JAERI Free Electron Laser is described.

Preliminary work

As the starting point of the development, we first implemented the original FORTH system on the NEC PC-9801 personal computer series and evaluate its speed[7].

There are three targets to extend the previous version:

(1) writing the FORTH words to access the numerical co-processor directly,
(2) developing the multi-segmented program, and
(3) enhancing the graphics words to handle the graphics images. And these works were carried out by using NEC PC-9801 VM2(cpu V30) with 640kB memory and a numerical data processor(i8087). The demonstration program to compare the speed with BASIC interpreter shows the results as follows.

First, the boot-up is done using N88-disk BASIC(86) and FORTH system is resident on top of the disk operating system codes. At this stage, you can enter the usual BASIC mode and come back to FORTH freely. The FORTH words for applications are created in a different segment with the main body of the FORTH system, including the FORTH compiler and other tools. After the demonstrating application words are installed, you can choose one of the following tests.

(A) It draws the seven sine curves with the different colors, which uses the different codes for the floating point functions but graphics procedures are same ones (in BASIC-ROM).
(B) It draws the bifurcation plot, which shows one of the simplest chaotic system.
(C) It draws the same plot as (B) but with the tuned up version of the corresponding FORTH word, which means one can develop a FORTH word by prototyping and modify it as the maximum speed is obtained finally.

The actual speed is dependent of the cpu's clock rate, version of hardware and software you use(and the nature of the tests), but the 2-10 times improvement of the execution time is expected, generally. And the maximum speed can be able to reach to the assembler's one. As an interesting case to obtain a compact and fast code, the direct generation of the floating-number uniform random number is offered. The generator itself is coded by using only seven instructions of i8087, based on the usual linear congruential method.

Real World Control

As a typical example to apply the concept of the FORTH-NODAL described above, we are considering the control system for the JAERI Free Electron Laser[8] system. It is now in the development stage and requires a small but flexible system for controlling and monitoring of various kinds of parameters. It consists of three major components, injector section, accelerator part and optical instrumentations. And they are constructed and used in a different time scale, so we need to employ the local control modules to each major components and connect them step by step[9].

The components are linked by computer network and the realtimeness of the response is the most important issue in this system. Usually, main console is only monitoring the status of each local station, and the programmed controls are performed at the local control modules. However, this system is used for R&D study and the modifications of the local hardware and its control software would be frequent. So the flexibility of the system is also necessary. From these aspects, we must develop a control software with high-speed (execution and transfer) and flexible configuration (such as modularity, portability, expansibility). The FORTH is an attractive candidate of the system language to fulfill such requirements. It has compact code and the high-speed operation is possible in the interactive environment, so we can exchange a program(exactly, FORTH word) in a short period and upgrade dynamically. Some drawbacks may come from its unpopular syntax and programming style. We need to pay attention for users who would like to use the system without knowing the detailed structure of the whole system. At the steady state operation, it is useful to access through such an easy or user friendly console software. As one of the user interfaces for these users, the graphical interface based on the window graphics much like as Apple Macintosh computer. In this interface, we look a system visually and monitor the malfunctions. Of course, the direct use of FORTH to control is the fastest and precise, but multiple user interfaces of the control system enrich the operation styles. So we are considering the other possible control styles, such as database oriented and spreadsheet style. The former would be used in the operations according to the historical lists of the parameters to gain the guidance to the present operation, which may be coupled to the expert system or theoretical calculations. The latter would be used to control many parameters associated with some numerical calculations and automated controls.

Conclusion

The concept of FORTH-NODAL is the best solution to the problem of the conflicts between the development people and machine users. It has the maximum speed obtainable from the interpretive language(i.e. interactive and easy to use one). The most significant contribution to the control system is its compactness. The whole system can be easily re-installed into a new hardware and its maintainability becomes so high. The optional user interfaces based on the window graphics may look like as those employed by the Apple Macintosh, and, of course, they can be developed by using FORTH itself. A user can select his favorite one from both methods for controls: using FORTH words directly or using the graphical user interface.

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