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FLEXIBLE CONTROL SYSTEM FOR EXPERIMENT AUTOMATION WITH HIERARCHICAL STRUCTURED SOFTWARE

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1. Introduction

The experiment and Laboratory automation deals not only with data acquisition, but also with man machine communication or communication between machines themselves and control and monitoring of experiment parameters and status. Larger and more complex experiments require larger subsystems dealing with the experiment control, which must be very flexible. On the one hand flexibility is required to write various measuring programs. This problem is normally solved by implementing special control languages. On the other hand, the system often has to deal with a very heterogeneous process control interface and experiment environment. Raising or changing requirements, system extensions and improvements can cause significant changes in hardware. To reduce the influence on the software a flexible modular software system is necessary. In this paper a proposal for a software architecture is presented.

2. Hardware structure

The flexibility of the hardware can be achieved by applying modular structured interfaces such as CAMAC. The typical structure of an automomous experiment control system with CAMAC or CAMAC like process interfaces could be divided into 3 major spheres (fig. 1):

- process I/O modules including the local bus,
- measurement and control equipment (with transducer and actuators),
- (sub)processes that have to be controlled.

3. Software structure

One way of minimizing the amount for software development caused by changes of I/O modules or process control equipment and system extensions is to design a software system with a hierarchical layered structure /1/.

Layered architectures, which have proved themselves good in the field of computer communication, have many advantages /2,3/ :

- independence of different layers,
- simplier design and maintenance,
- support migration of control functions from the control language level into the lower program level or into the hardware (intelligent I/O modules, co-processors, special process controllers) to gain speed of information processing.

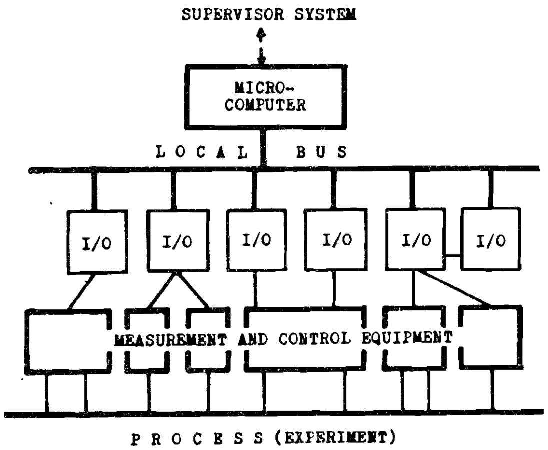

Fig. 1. Hardware structure of a control and monitoring system.

Here each "hardware sphere" is represented by a sowftware layer (fig. 2). The function of a layer is composed by software modules, which are linked together during system generation. A software module consists of a parameter list containing the address of the program, module status and specific control parameters (time constants, parameter limits, etc.) and the program itself (fig. 3).

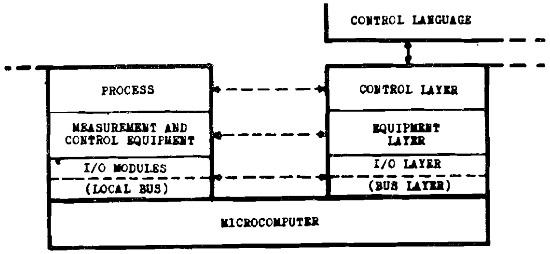

Fig. 2. Program layer structure.

4. Layer functions

4.1. I/O layer

In this layer the influence of microcomputer peripheral modules is handled, e.g., code conversion, timing. I/O device arbitration proceeds here to reduce the lock time. The bus protocol is also carried out here. In some cases it might be reasonable to put this protocol into a separate layer.

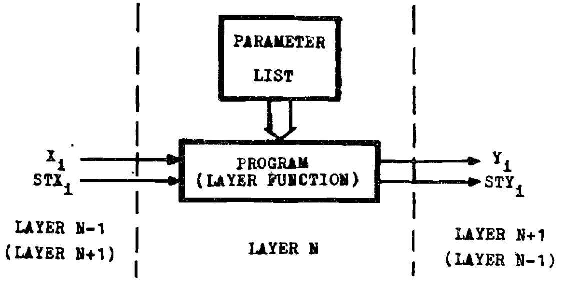

Fig. 3. Software module structure : X_i, Y_i - process control information, STX_i - program control information, STY_i - module status, i - number of the process.

4.2. Equipment layer

Information processing in this layer has to ensure that data are valid and effects of the measurement and control equipment, transducers and actuators are "invisible" for the control layer (device timing, code conversion, normalization of data, linearisation, static and dynamic limit tests, etc.).

4.3. Control layer

Here simple read or write functions, more time consuming control functions, as DDC algorithms, digital filtering, or special control functions (2 of 3 selections, signal channel reconfiguration, etc.) are carried out.

4.4. Control language interface

In this layer the input parameters from control language have to be scaled and tested.

5. Example

For a neutron scattering experiment at JINR a data acquisition system was designed, which consists of several loosely coupled subsystems /4,5/. On a monitoring and control subsystem (realized in CAMAC standard) a program system of the proposed structure is implemented. Its main functions are to control magnetic fields, temperature, vacuum, to measure necessary parameters, to monitor status of the experiment and device. The system is controlled by an intelligent CAMAC crate controller based on Z80 CPU /6/. All programs are written in assembler. The software is embedded into the control language MCL (Multi-Control-Language) developed for this experiment /7/. It has an open instruction set and provides great flexibility.

References

/1/ W.P.Gertenbach: A hierarchical organization of real-time process control systems. Proc. of REAL-TIME DATA 79, West Berlin, Oct.1979, North-Holand Publ., 1980, pp. 443-446.

/2/ A.S.Tanenbaum: Computer networks. Prentice-Hall, 1981.

/3/ J.Martin: Design and strategy for distributed data processing. Prentice-Hall, 1981.

/4/ S.Guenther et al. : Experiment Automatisierung unter Einsatz von Mikrorechnern. Wiss. Berichte der TH Leipzig, 1983, No.1, pp. 135-138.

/5/ W.Banse et al. : Ein Beitrag zur Automatisierung des Spectrometers polarisierter Neutronen SPN-1 am Impulsreaktor IBR-2 des VIK Dunna. Wiss. Zeitschrift der TH Magdeburg 28 (1984), H. 1, pp. 42-46.

/6/ S.Guenther et al. : Microprocessor CAMAC crate controller with 32 kbyte internal memory. Preprint JINR 11-84-482, Dubna, 1984 (in Russian).

/7/ S.Guenther et al. : Application of the dialogue language MCL for automation of an autonomous multi channel analyser. Poster at the XII International Symposium on Nuclear Electronics, Dubna, July 1985 (in Russian).

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Гюнтер З. E10-86-267

Гибкая система управления для автоматизации эксперимента с программным обеспечением иерархической структуры

Представлена архитектура программного обеспечения для микропроцессорной системы управления параметрами и контроля состояния установки. Электронное оборудование систем управления экспериментальными установками может достаточно часто меняться. Гибкая модульная программная система с иерархической структурой уменьшает влияние смены электронного оборудования на программное обеспечение. Функции управления, влияние модулей ввода-вывода /КАМАК/ и влияние измерительных и управляемых устройств на измеряемые и управляющие сигналы установки обрабатываются на различных программных уровнях. Программная система включена в язык управления экспериментом. Коротко описан пример реализации системы управления в стандарте КАМАК с микропроцессорным контроллером крейта.

Работа выполнена в Лаборатории нейтронной физики ОИЯИ.

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Guenther S. E10-86-267

Flexible Control System for Experiment Automation with Hierarchical Structured Software

The software architecture of a microprocessor based experiment control and monitoring system is presented. The hardware and instrumentation of experiment control systems often changes with time. A flexible modular software package with a hierarchical structure reduces the influence on software caused by hardware changes. Process control functions, the effects of the I/O modules (CAMAC) and of the measurement and control equipment on the measurement and control signals are handled in different program layers. The software system is embedded in an experiment control language. An example of a realized control system with an intelligent crate controller (CAMAC standard) is briefly described.

The investigation has been performed at the Laboratory of Neutron Physics, JINR.

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