The COSY Control System, a Distributed Realtime Operating System: First Practical Experience at the COSY-Injector

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Abstract

The COSY control system is hierarchically organized with distributed intelligence and autonomous processing units for dedicated components. Data communication is performed via LAN and over a fieldbus. The hostsystems are UNIX-based, whereas the field-controllers are running a modular realtime operating-system RT/OS which has been developed at KFA. The computer-hardware consists of RISC mini computers, VME-computers in the field and G64 equipment-control-moduls in geographical expansion of the controller by a fieldbus based on the PDV-standard.

The man-machine interface consists of X-window based work stations. On top of X-window a graphical user interface based on object oriented methods is used. A distributed realtime data base allows access to the accelerator state from every workstation. A special highlevel language debugger hosted on the UNIX based workstation and connected over LAN to the VME targets will be used. Together with the software development system for UNIX applications an uniform view of the system appears to the programmer. First practical experience at the COSY injector is presented.

I. Introduction

The Cooler-Synchrotron COSY is under construction at the Research Center Juelich (KFA Jülich, Germany). This accelerator is intended to deliver high-intensity proton-beams with very low momentum-spread at an energy of 2.5 GeV. The existing variable-energy relativistic cyclotron JULIC is renovated to serve as COSY-injector delivering H_2^+-beams of 80 MeV. It is integrated into the newly designed COSY-control to give a uniform operating-platform. Commissioning for the injector starts before commissioning of the COSY-ring, so it can be used to test the control hard- and software.

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II. COSY Control Hierarchy

The control-architecture is organized strongly hierarchically with distributed intelligence (Figure 1) and extensive use of standards.

At the top level of the computer-control-hardware workstations give the operators graphical access to the process. For these tasks Hewlett-Packard 9000/300 computers with Unix HP-UX and X Window System version 11 are currently in use. RISC-computers of the series 800 give computing power for model calculations and long-term databases.

These computers are interconnected using Ethernet (IEEE 802.3) and TCP/IP to the next layer of hardware: the workcells. Each workcell autonomously controls a subsection of the accelerator (e.g. workcell "woody" is dedicated to the COSY-injector and workcell "frieda" to the dynamic dipole-power-supplies). Workcells are HP9000/800 computers with Unix operating-system.

In each subsection a specific Ethernet-line connects all field-controllers to the corresponding workcell. Diskless VME-systems contain the field-controller and additional CPUs and I/O-cards. All CPUs are running the real-time operating-system RT/OS. For fast I/O the interface-cards are directly connected to the controlled device.

The VME-control-hierarchy for the COSY-injector has been distributed on 9 VME-systems. Each system is dedicated to a subtask in accelerator-control like control of the beamline-power-supplies or cyclotron-diagnostics. Typically these are multi-processor systems with all CPUs running RT/OS and communicating with each other over the VME-bus. In slot 1 of each system the field-controller handles the network-communication to the workcell and runs specific applications. Typically this is a CPU-board "E5" (Eltec company, Mainz, Germany) equipped with a 68020-CPU (16 MHz, 1 MByte triple-ported RAM) and a piggy-pack thin-wire Ethernet-interface. Additional CPUs are interfacing to the fieldbusses. CPU-boards "IBAM" (Eltec, Mainz, Germany) with 68010-CPUs (10 MHz, 512 kByte triple-ported RAM) carry up to two piggy-pack fieldbus-controllers.

For slow I/O a level of G64-systems [1] is introduced below the VME-level and accessed by PDV-bus [2] as fieldbus. This gives higher modularity and flexibility in inter-

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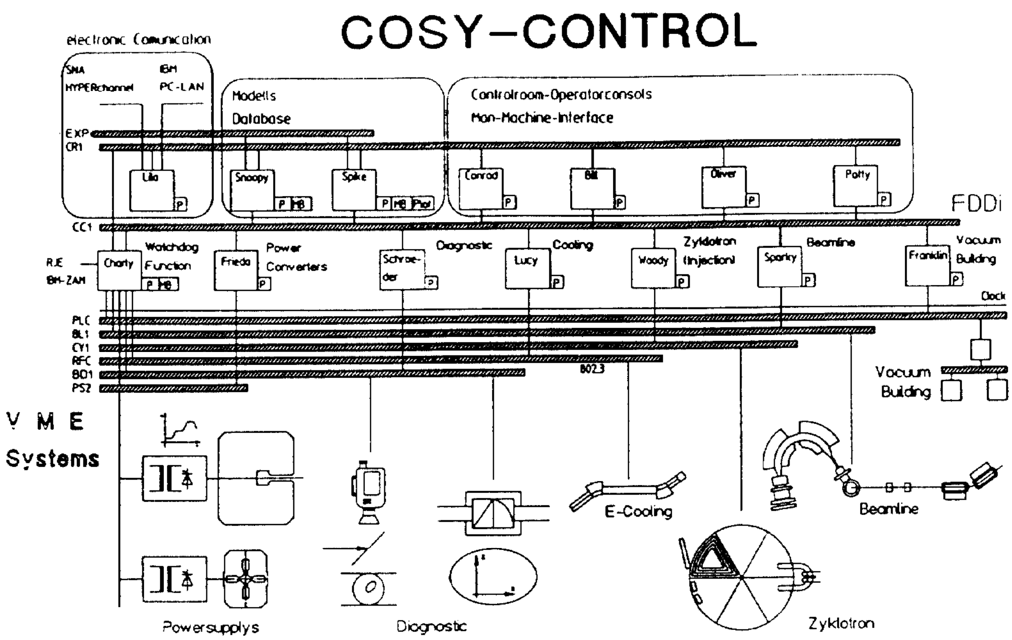


Figure 1: Cosy Control Hierarchy

facing to geographically distributed devices. Up to 4000 transactions per second have been reached on the PDV-bus. The PDV-controllers for VME and for G64 have been developed at the KFA. In G64/G96 typically 16 bit DACs are in use for magnet-power-supply control which are fully isolated against the bus. Additionally digital I/O is performed with optoisolated 16 bit parallel cards. The pulse-signals for stepper-motor power-stages are delivered by autonomous motor-controllers.

III. Injector Control Software

A uniform computer access is given to accelerator operators and software developers by use of Unix and X Window System with fully integrated program development for the VME-targets. For the Software Development System (SDS, Figure 2) the GNU-software [3] has been extended to communicate with VME-targets via the network. The GNU-compiler gcc is taken as cross-compiler for the CPU-68000.

gdb gives dbx-like debugging-tools for programs running on VME handling also the communication with the rtdb on the target. Aside the standard language C also C++ is available on Unix-machines for object-oriented developments.

Operator access to process control is given by command-driven, menu-driven or graphic interaction. For rapid prototyping of visualisation three products have been used: DataViews, InterViews and ObjectWorks. The actual process picture is always contained in a "pmf" database and is modified by these operator interactions. The process picture can be accessed from different computers and also envents can be signaled. The "pmf" database has been developed at the KFA.

All VME-systems are equipped with a DataCom-CPU containing the remote-debugger rtdb in EPROM. Programs developed using SDS can be downloaded from the workcells to all CPUs in the VME-system. In particular the realtime operating-system RT/OS [4] has been developed at the KFA Jülich in this environment (Figure 3).

It is an implementation of the D-MOSI standard [5] and was designed with high modularity in all layers: Applications, kernel, device-drivers. A priority-controlled timeslice with preemption is provided for process control.

IV. Practical Considerations after Injector Commisioning

For the instrumentation of the injector 9 VME-systems with 10 PDV-busses are installed serving 24 G64-crates. With the flexibility of the G64-systems existing local-control equipment has been made remote-controlled.

For substitution of missing hardware functions the special method of pseudo-device-drivers has been introduced. The tests of the process I/O is done integrated in the SDS of RT/OS. Rapid Prototyping of graphic user interfaces is performed by use of ObjectWorks for setup of operator control interaction.

Modularity of hard- and software gives sufficient opportunity in adaptation to existing hardware. The extense use of existing tools accelerates development times. Tools for

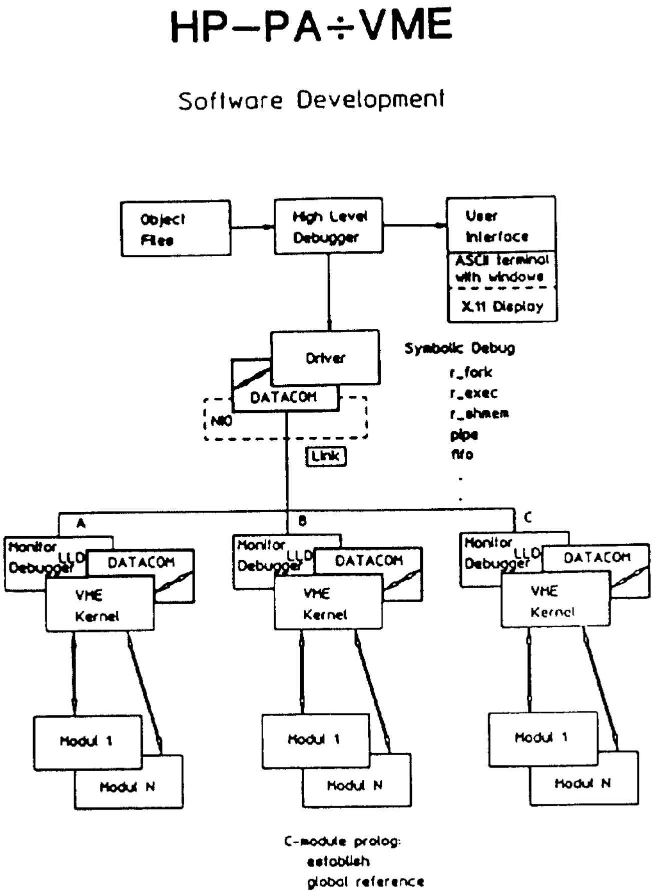
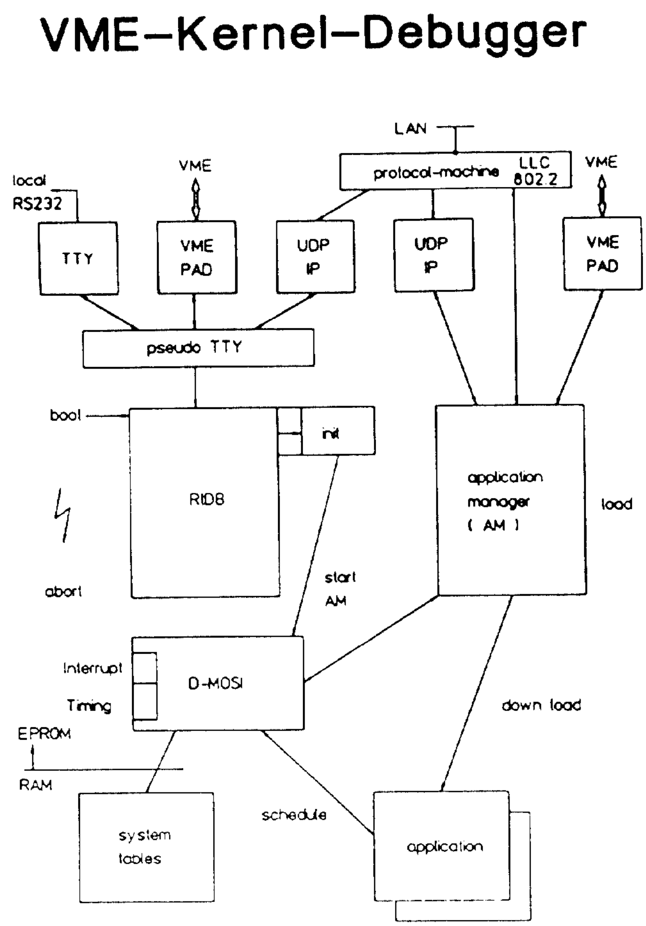


Figure 2: Software Development System



rapid integration of protocol-handlers are yet missing.

As a result a special language for process-description and control PBS has been developed. A cross-compiler has been implemented that produces C-source-code for applications running under RT/OS.

Figure 3: RT/OS

References

[1] Gespac G-64 Bus Specifications Manual, Version 3.1, January 1990

[2] DIN 19241, Bitserielles Prozeßbus-Schnittstellen-system, Juli 1985 (german standard)

[3] GNU-software, Free Software Foundation, Cambridge, MA 02139, USA

[4] anonymous ftp: cecs.cc.kfa-juelich.de

[5] IEEE std 855, IEEE Trial-Use Standard Specification for Microprocessor Operating Systems Interfaces, 1985