THE CONCEPT OF MODERNIZING THE BESSY CONTROL SYSTEM

G. v. Egan-Krieger, R. Müller

Berliner Elektronenspeicherring-Gesellschaft
für Synchrotronstrahlung m.b.H. (BESSY)
Lentzeallee 100, 1000 Berlin 33, FRG

Abstract: *Maintenance and development of the old soft- and hardware of the control system at BESSY has become increasingly difficult and costly. Modernisation has now to take place during the normal operation of the fully equipped and continously running light source. Our development of a new system will allow for a smooth turnover from the central minicomputer network in use now to a distributed network system. The* message passing *structure of the old software maps in a natural way onto the communication protocol of a serial field bus network. A PROWAY-C network of interfacing microcomputers has already been developed and attached to the old system. This hybrid system has been shown to operate reliably. Work is now in progress for an intermediate configuration, where the storage ring can be operated by the old HP 1000 F and new UNIX host computers in parallel. When the new control system on the UNIX computers has been shown to work properly, only a small part of the HP 1000 F system will stay in use. Then it has to interface the components not yet accessible by the new system, until this functionality is no longer necessary.*

Introduction

The Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung m.b.H. (BESSY) operates an 800 MeV storage ring dedicated to the generation of synchrotron light in the VUV and soft X-ray region [1]. Storage ring, separated function synchrotron and microtron are remote controlled by three linked HP 1000 F minicomputers and a commercially available electronic interface system [2].

The basic control system was completed in 1983 and has been proven to work reliably. Only minor changes have been installed since then. Application programs have been added and improved. The database has been modified and extended. New graphic presentations showing the machine status have been created.

A thorough modernisation has to take place due to various reasons:

- Maintenance of the old hardware has become costly. Repair or replacement of faulty equipment can no longer be guaranteed.
- The operating system (RTE 4B) of the minicomputers and the hardware specific software of the basic control system is obsolescent. Therefore support is hard to obtain.
- Development of application programs with all the limitations of a ten years old system is not justifiable.

Conditions

For the given configuration the only way to keep most of the software already developed is to replace the old hardware with similar equipment that could be maintained for the next ten years. Today all routine operations depend on experimentally tuned application programs. 280 pieces of equipment grouped into 12 different classes have to be addressed and up to 35 commands may be executed within a class. Due to the complexity of the system in use a complete exchange of computers and transfer of software is risky. As soon as the old system is no longer accessible all features have to be present and work reliably on the new system. The light source has to be operated continously, the performance must not be perturbed by faulty new control software.

Modernization that replaces only the hardware would require development and experiences, that could not be exploited at the 3rd generation light source BESSY II which is planned to be controlled by a modern computer network [3].

At the superconducting compact storage ring COSY [4] a distributed system of microprocessors has been introduced for device control. A minor version of the BESSY control system running on one HP 1000 F mini computer host has been combined with a network of micro computers based on a Z 80 microprocessor running a CP/M like single task kernel with vector interrupt. The token field bus 'eLAN' (DIGALOG Industrie-Mikroelektronik, Berlin, FRG) used there is a realisation of the PROWAY C (IEEE 802.4, IEC 955) standard. There the intelligent local controller has been essential to solve problems arising from the ramping procedure and from magnet imperfections.

Conceptual Considerations

The advantages of distributed systems with respect to simplicity, reliability, easy tunable performance etc., have become obvious today. Existing or emerging standards in networking enables the customer to build open systems where the choice between different promising candidates is mainly a matter of cost and special performance requirements. Standardized protocols and software interfaces reduce the need to write one's own low level software to a minimum. The life of software is drastically increased.

At a high degree of network complexity the network itself will play an important role. This topic is often lengthily discussed. According to the *manufacturing automation protocol* (MAP) our primary decision was to use the real time facility, low noise sensitivity and low costs of the token field bus on the process level. The problem to find a link between the existing control system based on HP 1000 F minicomputers and the 'eLAN' field bus has been solved at COSY. We will profit from experiences with this 'COSY' system and are able to introduce the microcomputer network wherever substitution of the electronic interfaces is necessary or advantageous.

On the presentation level we want to use UNIX workstations with their standard interconnectivity (NFS, TCP/IP). The man-machine interface will be based on X-windows [3,5]. This completely new system will be attached to the serial field bus. It will have access to the newly installed micro processor nodes *and* the old system.

The new operators interface to the machine has to show full functionality while the routine operation is still controlled by the old system.

The Old System Becomes a Field Bus Node

In the old system all hardware access is done by specialized programs, the peripheral interface modules (PIM). Any application program can communicate with these programs by standardized messages, which are transmitted through message handlers by means of system specific *program-to-program* calls.

In the network system each PIM runs on a microcomputer that controls several interface cards on a parallel bus. The microcomputers communicate with each other and with the host via data packages that are built according to the protocol of the LAN in use.

At BESSY both worlds are brought together by the scheme developed at COSY: Any message on the HP 1000 F that should perform an action on a microcomputer on the field bus is forwarded to a special LAN service program (fig. 1).

After rearrangement of the specific HP 1000 F 16 bit format to a standard IEEE format this program hands it to the IEEE 488 driver. One node of the high performance, real time field bus eLAN [6], called HP–eLAN gateway, is equipped with IEEE 488 interface cards. This node is connected to the appropriate interface card of the old HP 1000 F central minicomputer. The microcomputer of the gateway node forwards data packages from the HP 1000 F to the field bus and vice versa. A server program handles the LAN specific information.

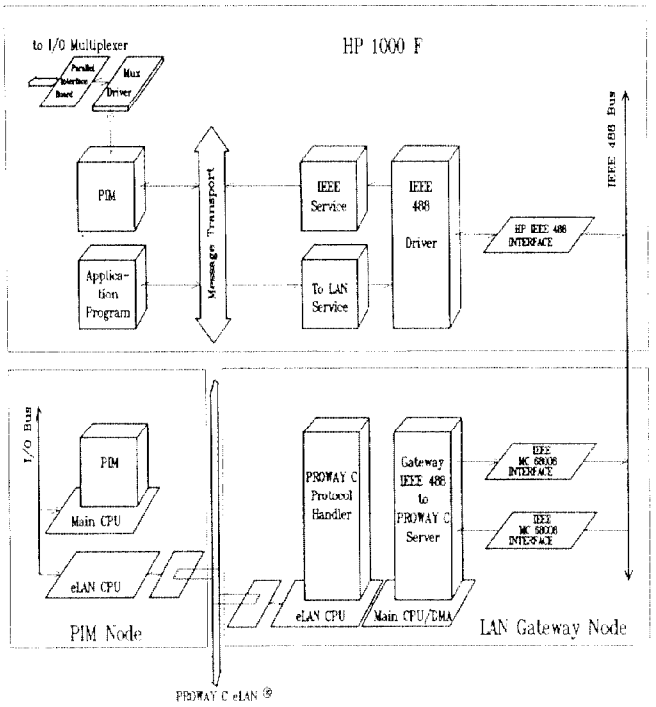

Fig. 1: *The HP 1000 F-eLAN gateway in detail*

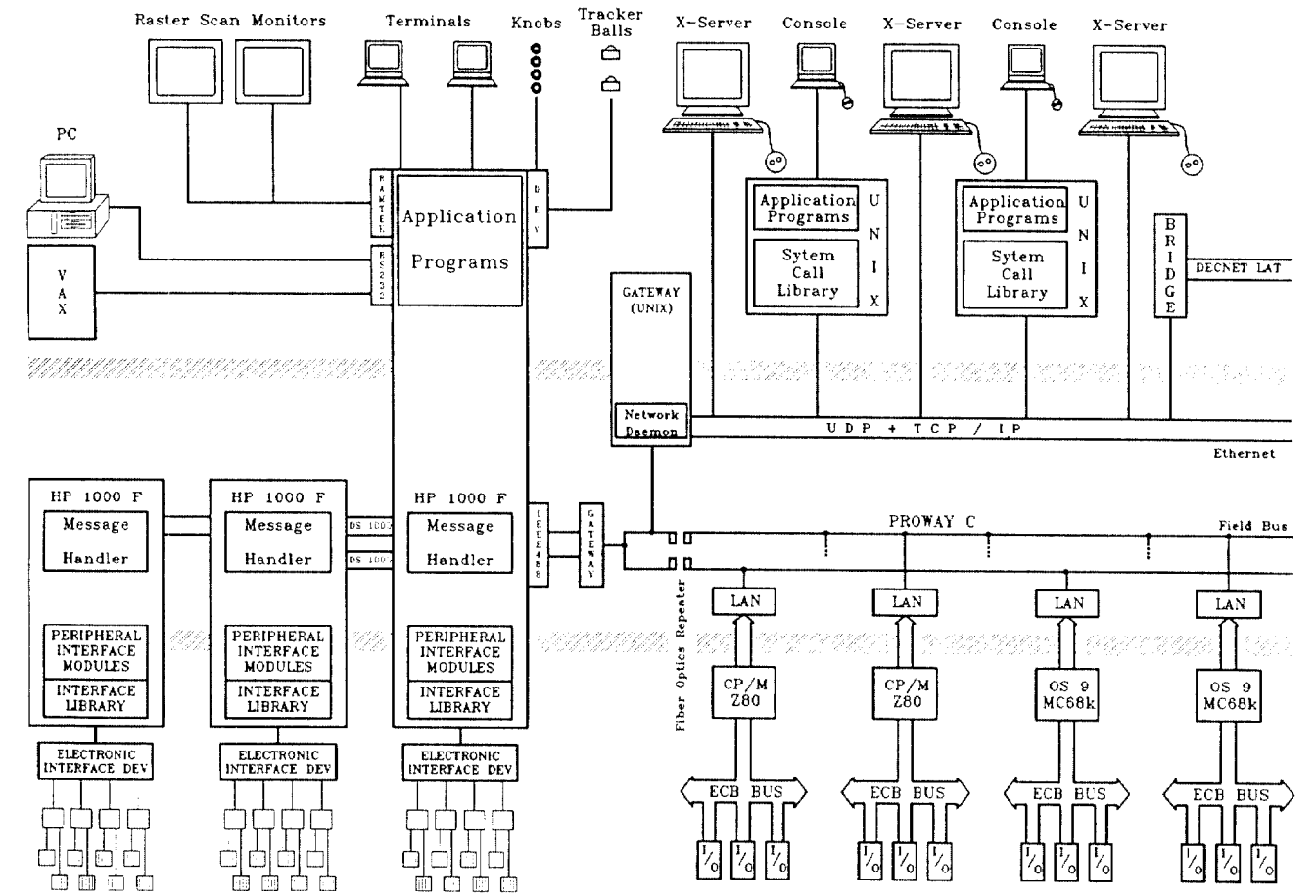

Fig. 2: *The control system building blocks and communication links. Vertical ordering is done according to the levels 'presentation' (top), 'command transport' and 'process' (bottom). The old system is on the left, the new one on the right.*

On responses or requests from any field bus station to the old HP system the gateway performs the IEEE 488 service request interrupt on the bus, on the HP system a program is started that reads the offered message, reduces it to the local 16 bit format and delivers it to the program addressed.

Collisions between incoming and outgoing messages are avoided by giving the messages from the field bus the higher priority. After completion of that transfer the pending message to the field bus is transmitted before the next request from the network is satisfied.

The database of equipment handled by a special PIM running on one microcomputer resides on that node. The equipment specific information held by the central database on the HP system is only the node number on the field bus.

Complete Schedule of the Modernisation

On the way to a new control system, where the old hard- and software is not necessary any more, three major steps have to be performed.

Introductory Phase

In may 1990 power supplies of the synchrotron–storage ring transfer line had to be replaced. This equipment is only needed during injection and mounted outside the radiation protective wall. That gave us an ideal opportunity for the introduction of the 'COSY' type hybrid system at BESSY. Differences between the systems, like complexity, presence of programs driven by high priority interrupts etc., were expected to produce unforeseen problems. Nevertheless installation and tests have been completed successfully within a few days.

In the meantime a UNIX workstation has been installed to be in use as a development system. Software has been written to be able to use this workstation as an internet–eLAN gateway. System library calls on any other workstation on the internet are picked up by an eLAN network *daemon* running on that development system and converted to the standard messages [6], that can be interpreted by the addressed eLAN node. This allows one to write application programs on UNIX workstations running the microcomputers and —making use of the HP-eLAN gateway node— the old system.

Turnover Phase

When the HP-eLAN system has been shown to run reliably and stably, a shutdown or maintenance week of the light source will be used to replace as much of the old electronic interface by distributed microcomputers as possible.

At the same time all application programs commonly used on the old system have to be ported to the UNIX system or have to be rewritten or redesigned on top of the system calls library.

During periods of time, where the operation of the machine could stand small irregularities or disturbances, such as dedicated machine time, the newly developed operators interface to the machine can be tested and improved. In the standard operational mode, where users have to be served, the machine is controlled by the old HP 1000 computers.

Finishing Phase

After a certain time of experience and stabilisation the new operators interface on the UNIX workstations will take over the control of the machine. Then only a small subset of the old HP 1000 minicomputer network will remain and need further maintenance. This subset will be operated exclusively by the UNIX host computers and will give access to all equipment that is still attached to the old electronic interface system.

Components still controlled by the old interfaces, like the particular timing unit built at BESSY, the control of the beam monitoring random access camera, etc., need both a hardware adaption to the new interface system and the PIM software dedicated to this type of equipment.

When the operator's control functions are executed exclusively on UNIX workstations, at least a second internet-eLAN gateway will go into routine operation. In case of a hardware failure of the primary eLAN server the second one will have to cover that function. New freedom in extending and modifying the field bus system will be obtained. The eLAN field bus protocol based on a message format specific to BESSY can be replaced by a more common protocol, the SUN remote procedure calls (RPC). The driver to the eLAN network and the RPCs have already been installed on microcomputers based on the MC 680x0 processor family running the OS 9 (Microware Systems Corp., Iowa) real time operating system.

From the very beginning the internet-eLAN gateway was designed for multi-protocol purpose. Today the local database supplies the network *daemon* with the information, when to forward a BESSY specific message to a node running a CP/M like kernel and when to route a RPC to a node running OS 9 [6].

For most of the equipment, where the old electronic interface still has to be replaced by microcomputer control, the programming tools of a UNIX- OS 9 cross development system will be utilized. The conversion of the old system to the field bus network will be rapidly finished and the expensive maintenance of the old system can be stopped.

In a phase of consolidation we plan to install watchdog programs that provide information about system inconsistencies on an improper working host. *Daemons* will alarm the operator, whenever faults on a field bus node can not be repaired.

Conclusion

Our modernization scheme allows for a cautious introduction of modern computer technology to the BESSY control system. The old system supplies us with a fallback solution as long as we feel that it is necessary for reliable and known operation modes of the light source or until costs of hardware maintenance prohibit any further dependence on that system.

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