Use of Ethernet and TCP/IP Socket Communications Library Routines for Data Acquisition and Control in the LEP RF System

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Abstract

A general move is being made at CERN towards the direct connection of intelligent equipment and device controllers to the control room consoles by the use of local Ethernet segments bridged to the main Token Ring networks. Communications is based on standard TCP/IP protocols which allows immediate use of standard software packages. The Data Managers which control the LEP RF accelerating units and transverse feedback systems have recently been connected. The implementation of Ethernet and TCP/IP socket communications routines for RF data acquisition and control is described. The adaptation of almost all of the existing software for RF system control, data acquisition and diagnostics to make use of this means of communication has proved straightforward. Furthermore the transparent transfer of data in the form of 'C' structures from the Data Managers to the control centre workstations and other computers has considerably simplified the software required for remote surveillance and data logging with a corresponding increase in speed and reliability.

I. INTRODUCTION

The RF system of LEP is made up of individual RF units. Each consists of 16 accelerating cavities and their klystron power sources, high voltage power supply, low level electronics and controls. For the LEP phase 1 eight units using copper coupled accelerating/storage cavity assemblies have been installed near interaction points 2 and 6. For the upgrading of LEP to 90 Gev the construction of an additional 12 units using superconducting (SC) cavities is under way, eight of these for installation at points 4 and 8.

II. LEP RF SYSTEM CONTROL

A VME based 'Data Manager' (DM) running the OS9 operating system provides overall control of the RF unit [1]. The access to the equipment making up the unit is over IEEE488 (GPIB) bus to G64 based 'Equipment Controllers' (ECs) which contain the hardware interfaces [2]. There is one EC for each element of the unit i.e. one for each cavity, one for each klystron, one for HV equipment etc. The DM executes global control procedures, carries out surveillance, provides facilities for local control and the connection to the control system for remote operation and data acquisition. The DM is situated in the units control racks which are underground in a klystron gallery running parallel to the LEP machine tunnel. The connection to the general LEP control system originally installed is by a MIL-1553 standard bus which links all the DMs at an interaction point to a Process Control Assembly (PCA) in the surface building. The PCA provides the connection to the LEP token ring networks and to the Apollo workstations used for LEP operation. Another DM in the main Prevessin Control Room (PCR) with a small group of ECs providing control of RF synchronization and timing equipment is connected in a similar manner via a local PCA and MIL-1553 bus.

Communication between DM and the ECs of the RF units or PCR is based on command response transfer of simple ASCII strings. In the interests of simplicity and compatibility the same approach has been implemented for communication between the PCA and the DMs over the MIL-1553 bus. For communication between the control room workstation and the PCA command response string transfer is implemented by a remote procedure call (RPC) client on the workstation with a server running on the PCA.

Applications programs, both for the PCR workstations and for the local DMs, use make use of equipment functions built up as a set of simple macro definitions. These set up the command, call the communication routine and use the appropriate type conversion routine on the reply. The large amount of software required at both levels for LEP operations and RF specialist use has been built up entirely on this basis.

At the level of the PCR workstations a single communications routine 'lrf_eqacc()' is called whenever the RF system has to be accessed.

III. THE LEP CONTROL SYSTEM

Since the commissioning and startup and of LEP the controls groups of the CERN accelerators have agreed on a common architecture for control systems [3]. This takes advantage both of the increasing computational capacity of microprocessor systems and the availability of off-the-shelf communications packages which can be run on such systems. The PCA will be replaced by a 'Device Stub Controller' (DSC) which is the interface between the control system network and the accelerator equipment. The general network configuration agreed upon is one which will use TDM based Token Ring networks similar to those of LEP [4] with connection by dedicated bridge units to clusters of DSCs and other intelligent equipment interconnected by short Ethernet segments. TCP/IP communications protocols will be used.

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IV. ETHERNET CONNECTION OF RF DATA MANAGERS

The DMs of the RF system are functionally equivalent to the DSCs. Ethernet hardware interfaces for the 68020 CPUs used and TCP/IP software have been recently installed. Ethernet segments link the RF units at each of the two points presently installed with RF including the first superconducting unit at point 2. The LEP transverse feedback system near point 2 is also included. A local token ring network, bridged in the SR surface buildings to the main token ring, extends as far as the bottom of the pit. Here an Ethernet to Token Ring bridge provides connection to the RF segment. RF equipment in the PCR is connected via a bridge in a similar manner. Installation of TCP/IP software and setting up of the bridges and routing tables was straightforward, providing communication between all DMs and direct connection to any of the control network computers and workstations. The overall network configuration and the interconnections which concern the RF system are shown in Figure 1.

V. COMMUNICATIONS AND USE OF TCP/IP SOCKET LIBRARY Routines

Command response communication between the PCR workstation and the DM, which is the basis of RF system control, can be implemented directly using the socket library routines which are part of the TCP/IP software package. Hence the process of RPC between the Apollo workstation and the PCA and transfer via the MIL-1553 can be replaced by direct communication.

Implementation of command response involves use of the socket library routines. Both the Apollo and OS9 Internet system use the concept of sockets as the basis for network communications between tasks. A socket is defined as an end point for communication. A command response server runs permanently on the DM. It initially creates a socket using the socket() library routine, associates a port number with it using the bind() routine and then waits for a connection using the accept() routine. A calling process on the PCR apollo workstation creates a socket to which the name of the DM to be accessed and the port number are bound and opens it as an active socket. It then uses connect() to connect to the listening socket of the DM. When the command response server accepts the opening of the connection then the connect routine in the calling process terminates. Since the accept() routine creates a new socket which is used to transfer data the original socket is liberated for a new connection. The calling process sends command data in the form of a 1024 byte single packet using the send_output() routine then immediately calls recv() which awaits return data. The command data is read by the DM server using recv(). After command processing a reply is sent back to the calling process by the send() routine. The return of multiple packets is allowed for. The packet definition contains information on the type of packet and transmission of packets continues till an 'END' type packet is transferred. The calling process terminates and the server loops back to the accept() routine to handle the next connection request.

VI. DATA MANAGER SOFTWARE

At the level of the DM input command data arriving directly over the network is from the calling process is handled in the same way as are commands from the MIL-1553 multidrop. Use of the same command message format simplifies the changeover of software and keeps compatibility.
The communications, message handling and command interpreter processes are shown in Figure 2.

![Diagram of Data Manager Processes]

Figure 2. Data Manager Processes.

The system allows access both from the MIL-1553 and from Ethernet. Three processes can be called up: one permits direct equipment access via the GPIB, a second allows the execution of global RF unit control procedures and a third called DM interpreter accepts system calls and provides access to stored RF unit data. These processes are normally asleep and are woken by a signal from either the command response server or the MIL-1553 access process. Command parameters and reply data are passed via the 'MIL DATA' structure. This also stores process identities and handshake flags which are used by the various processes to ensure that signals are not sent to active processes.

VII. RF APPLICATIONS SOFTWARE

At the level of the calling workstation one cycle of command response using the above procedure is invoked by a new lrf_eqacc() function residing in a new communications library. Re-linking applications programs with the new library therefore results in incorporation of the new communications system. No major modifications were required to convert all control, data acquisition and diagnostics software.

VIII. SURVEILLANCE

Another application of communication based on TCP/IP socket routines is the transfer of data for RF system surveillance. A DM background local surveillance program gathers the most important states settings and readings from the equipment of the RF unit and stores the data in the form of a structure containing approximately 200 integers, strings and floating point values. Remote acquisition based on ASCII command response requires the conversion of all data to a string equivalent and concatenation to form a long reply string. Use of this information remotely for logging or status display requires decomposition of the message and the correct type conversions.

The socket library communication system can be used for the direct transfer of structures. A new 'survey server' process, using a different port number, runs in the DMs to return the survey data. Instead of defining the data to be transferred as an array of characters as is done for command response, it is defined as the appropriate RF unit data structure type. Returned data in memory is treated as a structure of exactly the same type. Since the data format of variables in the OS9 systems and the UNIX operating system of the Apollo are compatible no further conversion is needed.

Use is made of this to provide a global display of the state of all RF units in the control room. The acquisition program runs on the control room DM which displays data on a dedicated monitor. The same data will be used for logging programs, freeing the workstation presently used. The individual RF unit data structures can be formed into an overall RF system data structure. This can be transferred in a similar manner to remote points of the site allowing DM type systems to provide the same overall display facility as in the control room.

IX. PERFORMANCE AND RELIABILITY

Command response communication between the workstations and the DMs has been increased in speed by up to a factor 50. The main speed limitation in accessing equipment is the GPIB access to the ECs which is typically around 20 to 50mS for read operations. Overall a factor two has been gained in speed which produces a noticeable increase in the execution time of PCR application programs.

Reliability of the network, bridges and local connections is good. No problems have been encountered since the new communications system was made operational for the LEP startup in March.

X. REFERENCES