Present SLAC Accelerator Computer Control System Features*

V. Davidson and R. Johnson
Stanford Linear Accelerator Center
Stanford University, Stanford, California 94305

Abstract

The current functional organization and state of software development of the computer control system of the Stanford Linear Accelerator is described. Included is a discussion of the distribution of functions throughout the system, the local controller features, and currently implemented features of the touch panel portion of the system. The functional use of our "triplex" of PDP11-34 computers sharing common memory is described. Also included is a description of the use of "pseudopanel" tables as data tables for closed loop control functions.

System Configuration

The present accelerator control system has evolved slowly for more than ten years. Over the past two years we have come to a system which is basically a star network. At the center are three PDP11-34's sharing common memory. Fifteen arms radiate outward connecting to various mini/micro computers. A few local processors are connected using parallel links, but most links are 9600 baud asynchronous. Eight arms consist of a PDP8 heading a secondary partyline of twelve microprocessors. The PDP8's and microprocessors are all local controllers containing monitoring and control loops as described below. All together the system includes three PDP11-34's, ten PDP8's, 31 Intel 8080 systems, 66 Motorola 6800 systems, and one PDP9. This summer we plan to install Intel 8066 multiprocessors to replace the PDP9 and one of the 6800 systems.

PDP11 Triplex

The PDP11 triplex, under the RSX-11M† operating system (V3.2), provides touch panel software as the operator interface, specialized functions such as net conditioning, link interfacing, etc. Common memory contains status arrays, digitized analog arrays, buffering for displays and inter-cpu communications, and touch panel tables.

In general, one PDP11 provides the network interfacing, task initialization, push button controls, and global data selection, and effects controls which originate as touch panel pushes. Another PDP11 provides the display system interfacing; manages all normal touch panel displays or analogs, status, and messages; and provides a few special displays. The third PDP11 currently provides "higher order" functions such as magnet conditioning, logging of data, special analysis, etc. It also serves as the program development computer and as a spare for the other PDP11's. Each PDP11 has 80K of local memory and 48 k of common memory. Each has an RK05 removable disk drive. The program development computer additionally has a read and RK05 drive, an SEL drive, a tape drive, and a Versatec line printer.

The operating system is single user and the executive is unmodified. However, we have modified the SAVE task to prevent memory clearing and the INSTALL task to provide a NOLOAD feature which inhibits actually loading a common partition image into memory. Both features were required for booting the systems in a common memory environment. Also, we use a driver subroutine to send unsolicited data to a task and/or request or resume a task. Until recently, we have not had hardware interrupt capabilities between cpu's, so each has a system task to monitor various common memory buffers for activity. Task communication between cpu's and display data are handled by drivers which interface to common memory arrays rather than hardware interfaces. File transfers are done via a deposit and retrieve one-block-at-a-time scheme. Handshaking is generally done via common memory flags.

Touch Panel Software

Touch panel software consists of a collection of programs which run on two of the PDP11's to provide the operator interface. It provides the basic functions of panel selection, global selection; task initiation; push button controls; and displays of analog, status and messages. It uses panel and global tables (one for each of 16 terminals) and analog and status arrays in common memory such panel tables actually consist of two separate binary tables. One contains the static text, graphics, and button coordinates and is used only by the panel select program to initialize the display of a newly selected panel on a terminal. The other is the table which is kept in common memory (one for each terminal) for reference by all online functions.

In addition to these two tables, the panel compiler permits one to design a pseudopanel to describe a set of elements to be used by the closed loop set programs. This mechanism uses the compiler to generate control blocks for elements so that control subroutines used for touch panels can also be used by other programs to retrieve data from common arrays and to effect control. These control blocks form part of an online control data base which is separate from the touch panel tables.

The source data bases containing parameters for all elements in the system, all touch panel sources, and the panel compiler (a P11 program) are located on the SLAC computer center system. We compile panel tables and other secondary data bases and download binary tables to the PDP11's for on-line use.

Global (Terminal) Data

In addition to each of the 16 separate panel tables in common memory, there is also a separate table of global data for each terminal. This is data that does not change as different panels are selected on a given terminal. Presently we have the following global selects available: elements for control and analog display; accelerator sector and beamline for indexing control, analog, and status displays by sector and beamline; rate selects for dynamically modifying slew rates, DAC increments; setpoint and slew rates for DAC controls; and field offsets and time increments for btr controls. Planned, but not implemented, is the ability to select whether the digital value displayed for an element is its current value or another of its parameters such as its upper/lower DAC limits, tolerance maximum/minimum, slew rate, etc.

Local Controllers

As presently implemented all local functions are driven by local tables whose parameters are set by the PDP11's. For program diagnostic or special table changes outside normal control functions, local controller memory can remotely be read or written from the PDP11's by a read/write function. Also, there are

* Work supported by the Department of Energy, contract DE-AC03-76SF00515.
† Digital Equipment Corporation trademark
typically four other basic functions: DAC control with
slewling, bit control with variable field width and on
time, status or binary state monitoring, and analog
digitizing and monitoring. There is no operating sys-
tem; all basic functions are table driven foreground
or background loops.

Some table parameters are predefined at program
assembly or load time, while others are dynamic, orig-
inating from touch panel data or special online pro-
grams. Generally, local control is effected by a loop
response to table entries rather than to the direct
recognition of network control packet. The tables pro-
vide the interface between the loop and the local control.
Likewise, monitor loops flag changes in tables which
in turn are monitored by a network monitor loop which sends
off changes as rapidly as possible.

DAC Control

The DAC control mechanism can be used for control-
ling any digital value whether DAC or memory location.
The local controller has a slew loop which has a re-
peat rate of ten times per second. For each DAC, or
digital value, to be controlled there is a table entry
for each of the following items: the current state or the current
from the upper and lower DAC limits, the integer and fractional portions of the slew rate,
and a counter for fractional slew rates. Should the
limits be invariant and the same for all elements in a
given controller, single constants rather than tables
are used to save memory.
The local slew loop monitors the slew rate (integer
plus fraction) and if nonzero compares the requested
value with the current value. If different, the slew
value is added to (subtracted from) the current value
at each loop execution until the current value reaches
the requested value. The slew rate table entries for
that element are then set to zero and no further change
takes place. Asynchronously, control packets may arrive. These
carry data which the receiving routine sets in the
the local control network monitoring
routine scans the changed table and sends to the

Analog Monitoring

The local monitor loop period is about 1/10
second. Current states are compared to the state of
the last scan on a per byte basis and are subject to
a filter mask. Changes are saved in a fourth table.
Although we have not as yet implemented it, the filter
mask could be dynamically changed via a control packet
from the central computer. A network monitoring loop
continually cycles through the changed lists, trans-
mitting the current state and changed bits of any bytes
flagged as changed. In the central computers, status
bytes are updated in common memory and individual bit
changes processed and logged. Individual status bits (elements) can be displayed on
touch panels as 1/0, boxes, or bars. A few are routed
to special display routines.
The message display program manages a scrolling
text display of status messages together with their time
of occurrence and geographical location. Data base parameters determine how the display is
react to a state change of a given element. There is
a parent-child masking scheme whereby secondary fault
messages occurring with a primary fault are not dis-
played. Elements can be entirely masked, state
changes can be appended to the bottom of the display,
and if desired, any previously shown fault messages
erased. Message displays can be put on any panel with
the number and length of the text lines and characters
sizes specified.

Analog Monitoring

In general, digitized analog data is acquired and
placed into a current value table in memory by a rou-
tine which manages an A-D converter. A local loop
(period 1/5 second) monitors three states of an ana-
ing's value: hardware errors (e.g., overrange),
tolerance limits, and changes of value for the purposes
of sending unsolicited current data to keep the
central computer data up-to-date. There are six tables
with an entry for each element monitored. These are:
the current value, the previous scan value (for com-
parison to the current), a delta for determining if the
value has changed enough to send to the central com-
puters, maximum and minimum values for determining out-
of-tolerance conditions, and a status word for flagging
changes and saving current error states. A changed
flag bit can be set via a control packet from the
central computers, providing a solicited analog read
capability. The local controller network monitoring
routine scans the changed table and sends to the
central computers the current digitized value and the
status of any analog flagged as changed.

Upon receipt of the AM (analog monitoring) packet,
the PDPll interrupt routine saves the new value in
common memory. Asynchronously, an analog display
program regularly monitors all currently selected touch
panel tables and updates the panel displays from data
in common memory. Values associated with an increase/
decrease type of button are updated about five times
per second while the button is being pushed.

Presently, analog values can be displayed digitally
as an n.m. format (n=total digits, m=number of
decimal digits) using a y = a+bx algorithm for units
conversion, an eight digit decimal equivalent of the
raw binary, a vertical or horizontal bar, or a verti-
cally moving asterisk. Polynomial expansions and
displays are done by special programs outside the touch
panel routines. For the digital displays character
size can be specified. For the bar displays, bar
scaling can be specified.

Summary

With our present distribution of functions, the
local controllers can have high duty cycle control and
monitor loops to provide rapid responses for large
numbers of elements. Tables used to drive the local
loops not only provide a simple interface to the net-
work aspects of control but are an effective clutch
preventing overloading, pile up delays, and overrun
effects. Display routines, in a separate cpu from the
control routines, do not affect control response, even
if the display overhead becomes quite large at times.
Also, high bursts of control activity are readily
absorbed. The deposition of analog values directly
into common memory by the link drivers and the un-
solicited sending of other packets received by drivers
directly to tasks reduces context switching permitting
the system to run smoothly.

Reference

K. Crook and R. Johnson, "A Touch Panel System for
Control Applications," Digital Computer Applications
to Process Control, 5th IFAC/IPIP Conference, The Hague,
June 14-17, 1977.