

Published: 11/22/66

Identification

GE 645 Core Memory X-Ray Program  
D. J. Edwards

Objective

This memo describes a package of routines to be written for the DEC 338 Display Computer located on the 5th floor at Project MAC. This package will be used as a machine language debugging tool for examining the GE 645 core memory after crashes of the initial versions of the Multics Monitor system. The package provides routines to both simulate the address calculation algorithm of the 645 and display the contents of 645 active registers and memory cells.

Hardware

The hardware to be used will be the DEC type 338 Buffered Display Computer which will be tied to the GE 645 GIOC by a 2400 bit per second full duplex dataphone line. This will permit Multics memory words to be transferred to the DEC 338 at the rate of 67 words per second. The DEC 338 includes a PDP-8 General Purpose Computer and a CRT Display Generator both working from a 12 bit per word, 8192 word core memory. The 338 also has a DEC tape storage system which can store up to 40,000 words of Multics memory on a small reel of tape.

Software

While debugging the Multics Monitor after a crash, the GE 645 plays entirely a passive role. The only program running in the 645 is a small GIOC driver program which accepts address requests from the 338 and returns the contents of the specified address to the 338.

The X-Ray programs in the 338 maintain pseudo-registers corresponding to the base, index and arithmetic registers in the 645. The contents of these pseudo-registers may be displayed and modified on command from the 338 teletype keyboard. The contents of pseudo-machine registers may be saved and restored, en masse, within the 338 in special sets of locations known as "shelves". Five shelves, numbered 1 through 5 are provided. The X-Ray programs use the contents of these pseudo-registers when performing the 645 effective address calculation algorithm. This enables the Multics system programmers using the X-Ray programs to quickly display both 645 machine instructions and the contents of the effective addresses without going through the segment, page and indirect calculations by hand.

The X-Ray display is in the form of a window on the 645 core memory. Visible in the window are the contents of the active registers and the contents of up to 30 core memory cells selected via the 338 teletype. Also visible in the window is a small amount of log information giving time, date, frame number and a short title useful for identifying photographs and dumps taken of the display.

The general form of the core memory display lines is segment, location and contents. The segment and location may be indicated by number or name, the names having been associated with numbers by the programmer using X-Ray.

Due to the limited core storage on the 338, only 100 different names may be remembered in the 338 at any one time.

Associated with each segment is a mode specifying the form in which the contents of that segment are to be displayed. The display modes available are symbolic (common instruction mnemonics and symbolic address if available), linkage (attempts to differentiate between ASCII and ITS pairs, displaying each appropriately) and octal. The modes associated with the segments are default values assigned by the programmer using X-Ray. These display modes may be changed or overridden on command.

The display window maintains a pseudo-ILC (instruction location counter) which corresponds to the descriptor base register, procedure base register and instruction location counter in the 645. Normally the pseudo-ILC contains the descriptor base location, segment and location of the last item added to the display window. The contents are indicated by a small arrow pointing to the location and segment in the window and may be changed either on teletype command or by using the light pen.

#### X-Ray Commands

X-Ray Command Lines are given to the 338 using the on-line teletype. The general form is a command mnemonic followed by arguments (if any) and terminated by a CAR RET, LINE FEED or ALI MODE. Command arguments are delimited by spaces. Mis-typed characters or commands can be deleted using RUB OUT. Wherever a command description specifies LOC (a location) as an argument, several options may be used. They are:

- . -current contents of pseudo-ILC
- N# -where N is the octal address of an absolute machine location
- M -address or name of a memory location in the current segment.

M,N -M as described above and N an integer indicating  
N succeeding memory locations

S.M -M and N as described above and S a segment name or  
number

S.M,N

Whenever a command requires REG (register designator) as an argument, the following mnemonics may be used:

A -Accumulator  
Q -Quotient Register

X0 }  
X1 } -Index registers  
. }  
. }  
x7 }

DB -Descriptor Base Register (part of pseudo ILC)  
PB -Procedure Base Register (part of pseudo ILC)  
IL -Location register (part of pseudo-ILC)

SB }  
SP } -Base registers  
LB }  
LP }  
AB }  
AP }  
BB }  
BP }

Whenever a command mnemonic has a m as the second letter, this indicates that the programmer using X-Ray can specify the display mode. If m is absent, the default value of the display format associated with the current segment is used. Other values for the mode m are:

S -Symbolic  
L -Linkage  
O -Octal

#### Display commands

Dm LOC -Display contents of location LOC according to mode m.

CAR RET -Display contents of the next register (current DB, PB and location IL + 1)

↑ -Display contents of previous register

Im LOC -(Indirect) display contents of the effective address of the word at location LOC. Any indirect chains are followed to the end.

Em LOC     -(Effective Address) Display contents of the effective address of the word at location LOC. Indirect chains are not followed.

Erase Command

K           -Clear entire contents of the window

K LOC       -Erase the display of the indicated location.

Print Command

P           -Print entire contents of the window on the teletype.

Pm LOC      -Print contents of indicated location and mode on the on-line teletype.

Dectape Commands

U SYM       -Unload the contents of the window onto DEC tape file with the name SYM

T SYM       -Transfer the contents of the DECTape file SYM to the window (opposite of the U command)

Save Command

S n         -Save the contents of all pseudo machine registers on shelf n where n is an integer from 1 to 5.

Restore Command

R ITEM LOC - Restore pseudo-machine registers specified in ITEM from given location.

This command allows the programmer to quickly set up the pseudo machine registers by simulating certain 645 operations or macros. ITEM may be:

CU     -Control Unit

B     -Base registers

R     -Machine registers

M     -Registers set up by the standard SAVE macro

Sn    -Shelf n (n from 1 to 5)

Load Command

L REG CON - Load indicated pseudo-machine register with the number CON

Name Commands

N SYM LOC - Name indicated location with symbol SYM (up to 6 alphanumeric characters)

NS SYM SEG M- Name indicated segment, SYM as above and give the contents of the segment the display mode M. Values for M are:

S - Symbolic  
L - Linkage  
O - Octal

Examples

To display location 277 in segment 13 in symbolic form, type:

DS 13.277 (A)

Note: (A) denotes ALI MODE

To give segment 13 the name ALPHA and mode symbolic, type:

NS ALPHA 13 S (A)

To display location 300 in segment ALPHA, type (in this case):

CAR RET

or in general:

D ALPHA. 300