Inter-Office Memorandum

To	David Liddle	Date	October 18, 1978
From	John Wick	Location	Palo Alto
Subject	D0 Timing Simulation	Organization	SDD/SS/DE

XEROX

Filed on: [Iris] < Thistle > Doc > ThistleReport.bravo

DRAFT

This report describes a series of experiments conducted to evaluate the performance of a number of proposed display configurations running on a D0, the OIS processor. The primary objective of this study was to verify the expected performance of the processor with a single large format display, and to discover the effects of adding a second display.

Because the eventual hardware, firmware, and software configurations are not presently available, a simulation approach was adopted. A program called Thistle was written to simulate the timing characteristics of the D0 processor at the micro instruction level. Instruction traces of a number of real programs (such as Apex and DeskTop) running on Alto/Mesa 4.1 were used to drive the simulation. A dozen experiments were run simulating the current hardware/firmware configuration to verify correct operation. Six program samples were then run with five different display configurations to predict their expected performance.

Simulator Input

Thistle requires two inputs to perform a simulation. The first is a trace of Mesa byte codes to be executed. The second is a description of the microcode which implements those instructions; provision for describing the display and memory refresh microcode is also included.

Instruction Traces

To obtain the instruction traces, a modified version of the Alto/Mesa 4.1 microcode was written which traps to the RAM at the beginning of each Mesa instruction. The RAM microcode records the opcode and its parameters in a trace buffer, which is written to the disk periodically; normal execution is then resumed. In a number of cases, additional information about the machine state is also captured. For example, all control transfers (XFERs and jumps) record the destination PC, so that buffer refill can be properly simulated. The alignment of operands was also recorded for some opcodes. The details of the trace format are described in [JohnssonITF].

There was little attempt to compensate for the differences between the current Alto/Mesa instruction set and the set proposed in the PrincOps [ThackerOIS]. The data contained here is therefore mildly pessimistic.

Instruction Profiles

Thistle also requires a description of the emulator and display microcode to be simulated. Because only timing charateristics of the processor are simulated, a rather terse description of the microcode is sufficient. It need only include processor and I/O memory references (and their alignment), memory interlocks and aborts, instruction buffer refill, and task switching. Microinstructions that are not otherwise interesting are grouped together into a count of execution cycles.

To arrive at this microcode description, we expanded on the idea of *instruction profiles* described in [Garner]. Instructions are divided into classes which exhibit the same memory and timing behavior. An instruction profile is then assigned to each class, as well as to the display and memory refresh tasks. Details of the instruction profile description can be found in [JohnssonTIP].

(Although we considered the possiblity of a program which compiled actual microcode source files into their profiles, it became clear that this would be much too big a project given the time constraints. Therefore all instruction profiles were produced by hand, and are subject to transcription errors.)

The important data dependicies were handled by including extra data in the instruction trace (for example, buffer refill depends heavily on alignment constraints; hence, the trace includes the PC value after each XFER and jump). Most other data dependencies result in very small differences in execution time (e.g., shifting right requires one more cycle than shifting left); these differences were ignored by the simulator. However, instructions like BLT and BITBLT required special casing. Their profiles were based on knowledge of the types of BITBLTs used in the test cases (as well as on an analysis of the microcode). For the display experiments, the profile for BLT assumed a four word block, and the profile for BITBLT assumed that a character was being painted.

Simulator Operation

The principle design objective of Thistle was to accurately simulate the interaction of the microprocessor and the memory. The instruction profiles for the Mesa emulator show the pattern of memory use that occurs while executing a given Mesa opcode. The main power of Thistle is that the interactions between adjacent opcodes and interactions between the emulator and other tasks (such as the display) can also be simulated, not for some abstract instruction mix, but for actual typical code sequences.

Automata

In addition to the microprocessor, the D0 contains two additional automata: the memory controllers MC1 and MC2. Thistle simulated the operation of MC1 and MC2 as described in [ThackerMT]; it also simulates the various kinds of aborts described in [ThackerD0]. Thus, if the profile calls for a PFETCH1 while MC1 is still active, the processor will undergo an MC1 abort for as many cycles as MC1 remains active. Likewise, referencing the data from a recent fetch will abort until MC2 finishes. Thistle keeps track of which task most recently used the memory, so the right thing happens if a task switch occurs between a fetch and use of the data.

Tasks

Most returns occurring within microinstructions will cause a task switch if another microtask of higher priority is ready to run. The display task is special in that it will also allow a lower priority task to run when it tasks. Thistle simulates this situation using coroutines.

Each task has a profile to execute. Every task except the emulator task has a "next wakeup" time associated with it. After every tasking return in a profile, control is passed to the coroutine executing the profile of the highest priority task willing to run (the emulator is always willing to run). When a task is finished for a while, it updates its wakeup time.

For the display experiments, the only tasks simulated were the emulator, the display, and memory refresh. Other tasks can be added to Thistle without much difficulty.

Simulator Output

While the primary use of Thistle in this study is for large batch runs, it also has an interactive mode for debugging purposes. (We expect Thistle to continue to be of use in fine tunning the microcode with very little overhead.) The current state of the processor and memory controller, as well as accumulated statistics on all of the tasks (emulator, display, and memory refresh) are displayed continuously if desired, and Thistle has various forms of "single-stepping" at the micro and macro instruction level. Complete information on the operation of Thistle and its output format can be found in the *Thistle User's Guide* [JohnssonTUG].

For the purposes of this report, Thistle accumulates the number of cycles spent in each of the three tasks (emulator, display, and memory refresh). Cycles are assigned to tasks based on the value of the processor's current task register. The time in each task is broken down into running and waiting; the waiting time is further broken down into MC1, MC2, suspend, and (for the emulator task) NEWINST aborts. Details of these states can be found in the *D0 Functional Specification* [ThackerD0].

Thistle also records the number of Mesa instructions executed as well as the total cycles expended (the sum of the run and wait times discussed above). These together with the processor clock speed (85*ns*) are used to calculate a Kip rate (kilo instructions per second).

Benchmarks

Our first step was to verify correct operation of the simulator. These were run under current conditions, and should be carefully distinguished from the experiments described in the next section. We chose eight benchmark tests to match against actual D0 elapsed time. We also made several probes of a running D0 with a digital voltmeter to verify the various wait times reported by Thistle.

Integer and String Sorting

Our primary benchmarks were the sort programs which have been in use for measuring Mesa performance since 1976; they were extended slightly to operate optionally with a full page display of random data (they perform no display related operations themselves). A total of eight tests were run: small and large integer and string sorts with the display on and off. A set of instruction profiles was derived from (the then current) microcode Version 1.5' (with the clock bug fixed -- PCR#20.53). All tests were run on EM016 after verifying its board revision levels. Note that these tests and their corresponding simulations were run with an IUTFP driving the 850 display and with old microcode which is known to have unacceptable diplay performance.

The results of these benchmarks are described in [Wick]. They show accuracy of execution time well within 10%, with the simulator running slightly faster than a real D0. Some possible explanations for this discrepancy can be found in the reference.

Wait Times

To verify proper modeling of the memory controller and its interaction with the processor, a set of four signals (MC1 active, MC2 active, suspend, and abort) were measured and compared with corresponding figures produced by Thistle. Four cases were compared using the benchmark programs: integer and string sort with the display on and off.

The results of this benchmark are presented and discussed in [JohnssonTBV]. While comparisons with the actual voltages are not very meaningful (because the signals cannot be measured accurately), both the real D0 and Thistle exhibited the same behavior with respect to these four signals as the display was turned on and off, and this behavior was consistent across all of the test cases.

Experiments

Several changes to the input were made before running the experimental data (the simulator itself was not changed after running the benchmark tests). New microcode was written for each display configuration; several hardware fixes were enabled, and key parts of the emulator microcode were rewritten. These modifications are described in more detail below.

Display Configurations

The hardware (UTVFC) is described in [Cameron]; [JarvisPDC] contains a functional specification for the device driver, including cursor, mouse, and keyboard support.

Three display devices were involved in the experiments, in a total of five different configurations. They are identified as follows:

LF One and two 17" Large Format displays
FP One and two 850 Full Page displays
QP Four Quarter Page displays

Detailed characteristics of these devices are described in [JarvisDC], which also contains a description of the microcode used to support each device and the assumptions made about it (particularly regarding scanline alignment).

Hardware

We assumed the presence of a number of fixes to the hardware which have not yet been installed (although most have been tested on Thacker's D0).

NEWINST aborts will be reduced from the end of MC1 (six to seventeen cycles) to completion of the mapping operation (four to six cycles) [Memory control board revision K].

A change to NEXTINST/NEXTDATA will result in tasking between Mesa instructions and eliminate the need for the "time to task" counter [Control board revision I].

A change in the Misc board will allow the test for pending interrupts to be moved from the buffer refill code to NOOP [Misc board revision G]

LONGJUMP will be added to allow changing the current page and performing a jump in the same instruction [Control board revision I].

These changes are described in the documentation on D0 board revision levels maintained by ED.

Firmware

The current D0 microcode (version 1.5) was rewritten (on paper) to take advantage of the hardware changes and to include a number of known but as yet unimplemented improvements suggested by Chuck Thacker. The rewrite concentrated on three areas: XFER, jumps, and buffer refill. Quadword code alignment and proper code byte ordering were assumed, as was a hardware stack error check, and numerous TASKs were added throughout the microcode. We incorporated as many changes as we could track from the 2.0 microcode, which is still under development.

Due to time constraints, we were not able to implement the PrincOps microcode. The simulations were run with the Alto/Mesa instruction set as it currently exists (version 4.1), with process bytecodes implemented in Nova code, and an Alto compatible BITBLT.

Experimental Data

Six sample instruction traces were taken from three Alto/Mesa application programs; all samples involved display manipulation. One sample of each program focused on the inner loop containing the code to paint characters on the display.

> DTest: a test program for the Alto/Mesa system display package. It writes characters on the display as if it were a Teletype, while also maintaining a typescript file.
>
> DeskTop: Advanced Design/User Prototype's experimental Star like environment. Two traces involving opening a document and painting the screen were taken.
>
> Apex: Product Software's applications executive. The three samples obtained involved moving a document into a folder, opening a document, and painting characters in a window.

The samples ranged from 0.48 to 2.86 seconds of simulated execution time; they varied from 121k to 468k Mesa instructions. More details on the samples can be found in [Sandman].

Results

The thirty test cases -- six instruction traces and five display configurations -- were run in about 56 hours of elapsed Alto time (about 36 seconds of simulated time). The raw data is summarized in Table 1; it shows the percentage of time running and waiting in the display and emulator tasks, followed by the sum of running and waiting for each task. (The memory refresh task accounts for a constand 2% of the cycles in all test cases.) The table also shows the instruction rate in Kips.

One display configuration was eliminated from the rest of the analysis. While running two Full Page displays, the simulator reported a large number (about 45%) of "misses", in which the display had missed a wakeup for a new scan line because it had not finished processing the previous one (this would show up as screen tearing). This explains why the Kip rates for the two FP case are only slightly smaller than with a single Full Page display.

Figures 1-4 summarize the run and run plus wait time (as a percentage of total cycles) for the display and emulator tasks. Figure 5 summarizes the Kip rates for all display configurations.

As we expected, one LF display consumes about 20% of the cycles, and two LF displays need just under 40%. One FP falls inbetween, at just under 30%, and four QP displays require a bit more

(just over 30%). The simulation indicates that two Full Page displays cannot be supported.

References

[Cameron] Cameron, J., Thacker, C., Tseng, C. *User Terminal Variable Format Controller (UTVFC) Specification.* Revision 5.0. September 28, 1978.

[Garner] Garner, B. *Mesa Opcode Timing.* June 21, 1978.

[JarvisPDC] Jarvis, J. P. *Functional Specification for the Prototype Display Controller.* October 13, 1978.

[JarvisDC] Jarvis, J. P. *Display Characteristics.* October 12, 1978.

[JohnssonITF] Johnsson, R., Sandman, J., Wick, J. *Instruction Trace Format.* October 11, 1978.

[JohnssonTUG] Johnsson, R., Sweet, R., Wick, J. *Thistle User's Guide.* October 11, 1978.

[JohnssonTIP] Johnsson, R., Sweet, R., Wick, J. *Thistle Instruction Profiles.* October 11, 1978.

[JohnssonTBV] Johnsson, R., Wick, J. *Thistle Benchmark: Voltages.* October 12, 1978.

[Sandman] Sandman, J. *Thistle Trace Data.* October 13, 1978.

[ThackerOIS] Thacker, C. *OIS Processor Principles of Operation.* Version 2.0. April 9, 1977.

[ThackerD0] Thacker, C. *D0 Processor Functional Specification.* January 16, 1978.

[ThackerMT] Thacker, C. *MemTiming.sil.* July 14, 1978.

[Wick] Wick, J. *Thistle Benchmark: Elapsed Time.* October 12, 1978.

Distribution:
Jarvis
Lampson
Lynch
Metcalfe
Thacker
Weaver
Mesa Group

	1LF		2LF		1FP		2FP		4QP	
ApexA	56.4	14.4	43.8	27.4	51.5	18.7	50.5	19.3	50.9	21.2
	22.5	4.5	16.5	10.1	18.8	8.8	18.2	9.8	16.8	8.9
	78.9	18.9	60.3	37.5	70.3	27.5	68.7	29.1	67.7	30.1
	271.2		210.5		247.7		243.0		244.9	
ApexB	54.7	14.4	42.4	27.4	49.9	18.7	48.9	19.4	49.3	21.2
	23.9	4.8	17.3	10.6	19.9	9.3	19.2	10.4	17.8	9.5
	78.6	19.2	59.7	38.0	69.8	28.0	68.1	29.8	67.1	30.7
	275.4		213.6		251.6		246.3		248.5	
ApexC	50.7	14.4	39.0	27.4	46.2	18.7	44.3	20.6	45.7	21.2
	27.3	5.3	19.3	11.9	22.4	10.5	20.9	11.9	20.1	10.8
	78.0	19.7	58.3	39.3	68.6	29.2	65.2	32.5	65.8	32.0
	324.6		249.7		295.4		283.7		292.4	
DeskTopA	58.7	14.4	45.7	27.4	53.5	18.7	52.3	19.5	52.8	21.2
	20.0	4.6	14.2	10.4	16.7	9.0	15.8	10.1	14.8	9.0
	78.7	19.0	59.9	37.8	70.2	27.7	68.1	29.6	67.6	30.2
	265.3		206.5		241.5		236.4		238.6	
DeskTopB	60.5	14.4	47.3	27.4	55.1	18.7	53.9	19.5	54.4	21.3
	18.4	4.4	13.0	9.9	15.4	8.6	14.6	9.7	13.7	8.5
	78.9	18.8	60.3	37.3	70.5	27.3	68.5	29.2	68.1	29.8
	253.3		198.1		231.0		225.9		227.9	
DTestA	52.2	14.4	40.7	27.4	47.8	18.7	46.9	19.4	47.3	21.2
	25.9	5.2	18.4	11.1	21.5	9.8	20.5	10.9	19.1	10.2
	78.1	19.6	59.1	38.5	69.3	28.5	67.4	30.3	66.4	31.4
	210.5		164.0		192.6		189.3		190.6	

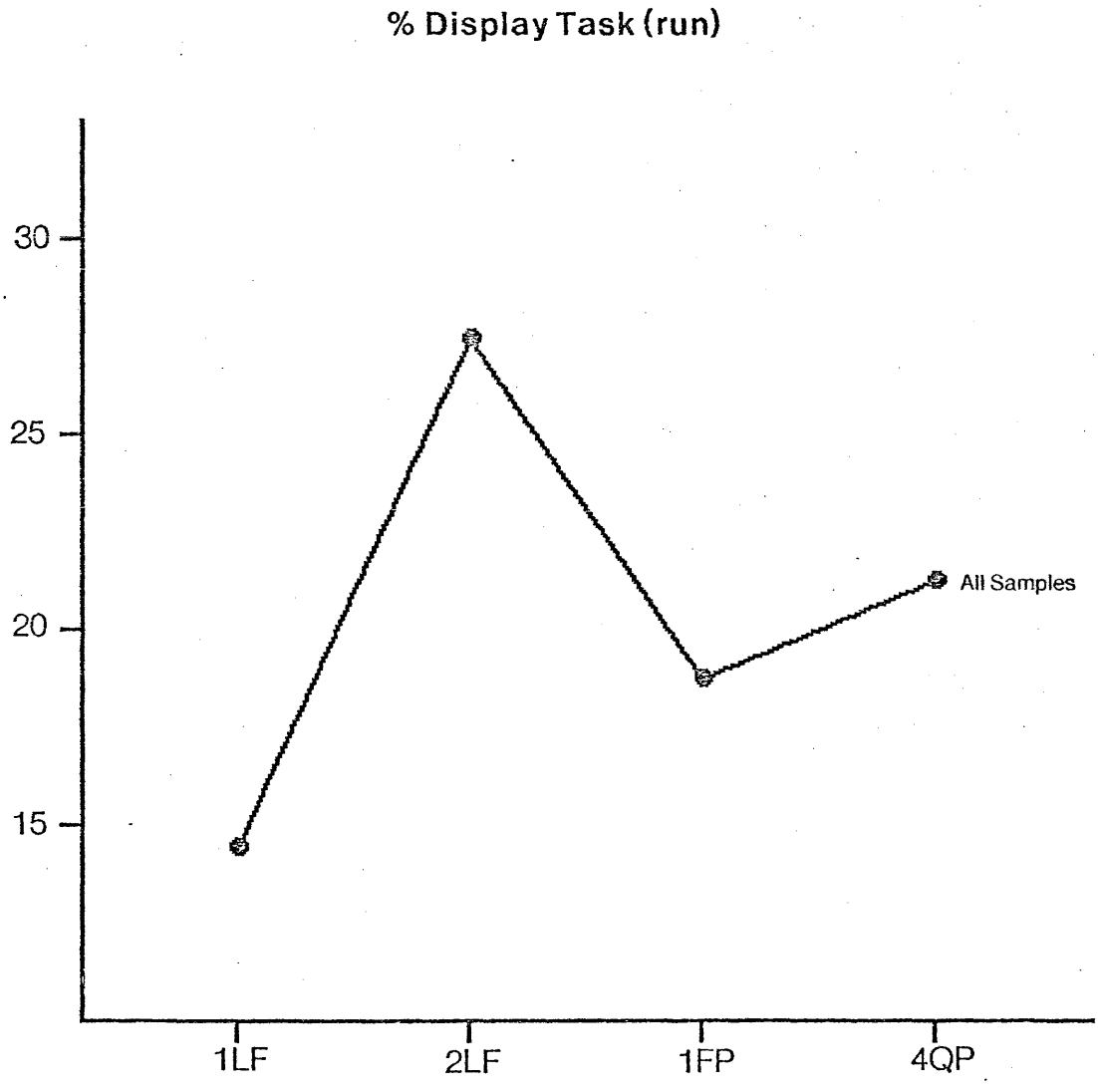
Display Configuration

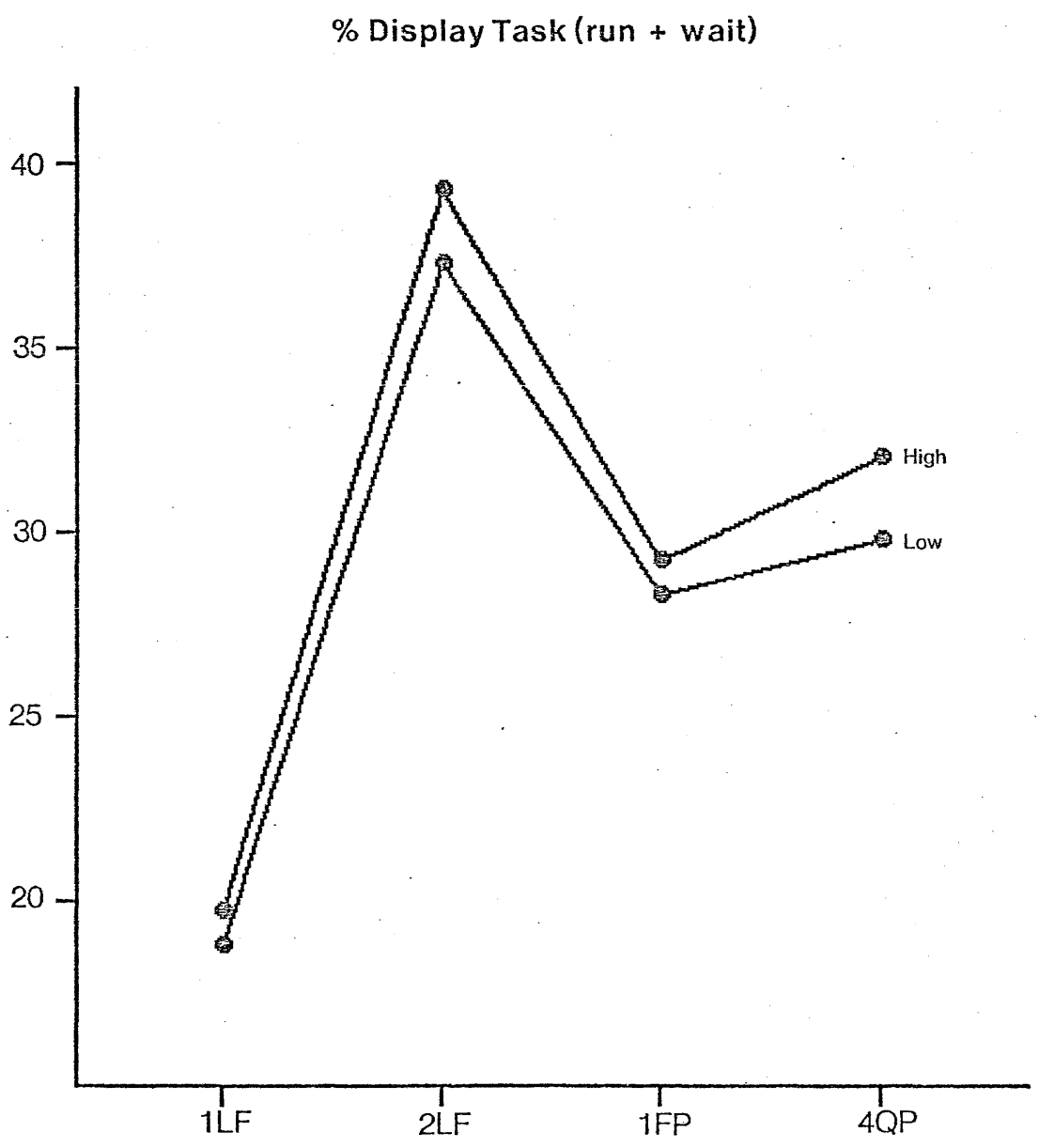
Emulator	Display
running	running
waiting	waiting
total	total

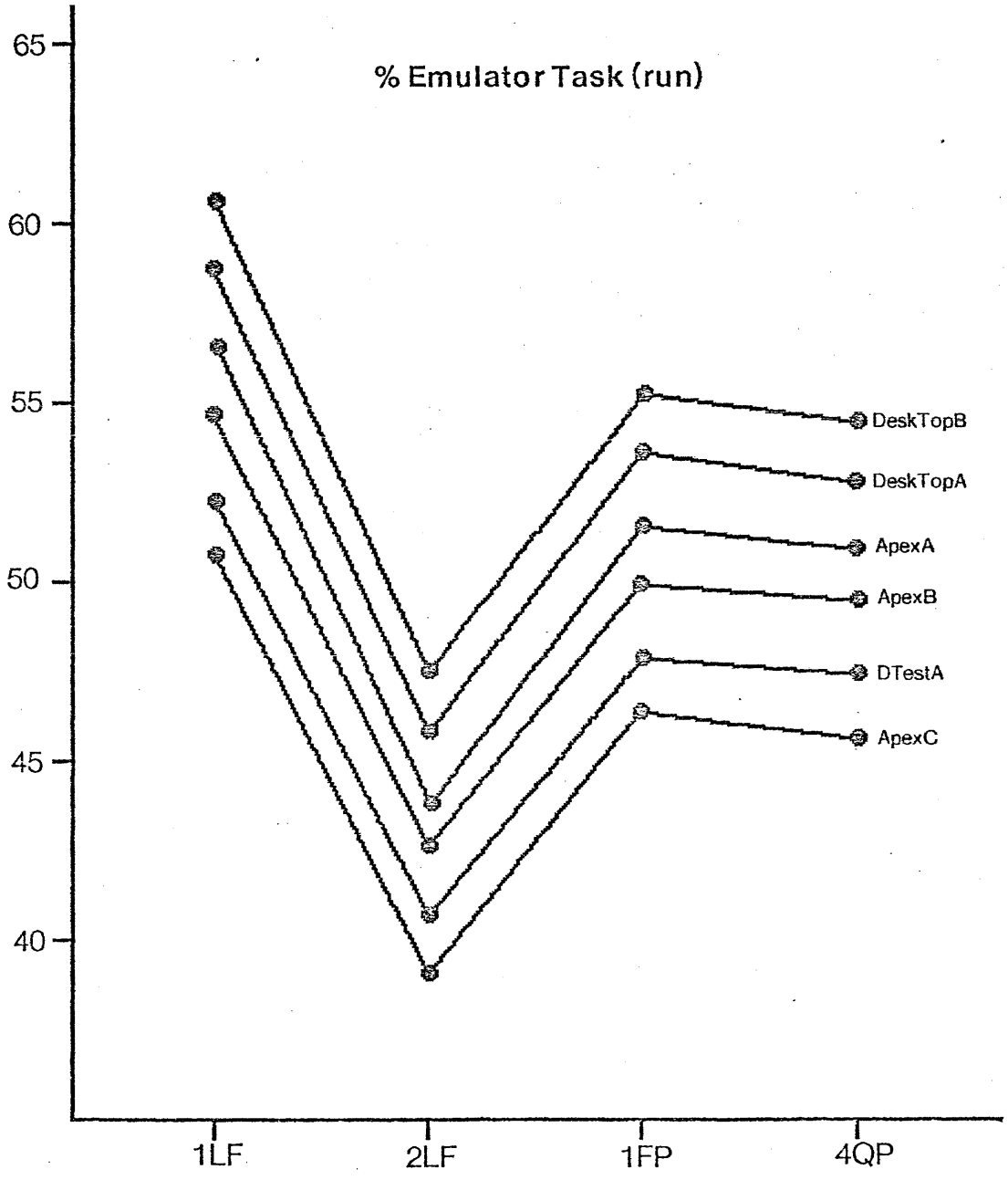
Kips

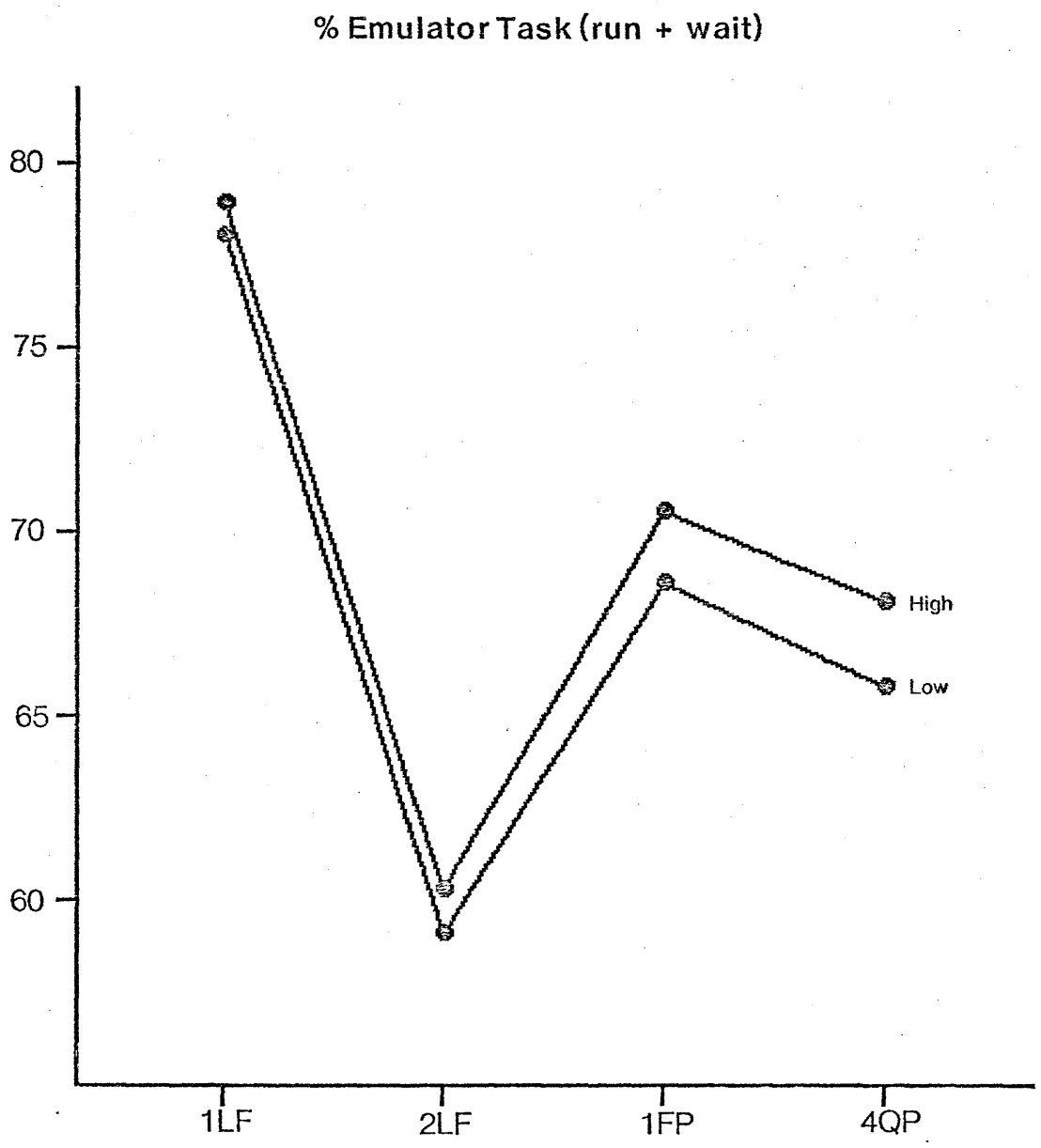
Displays

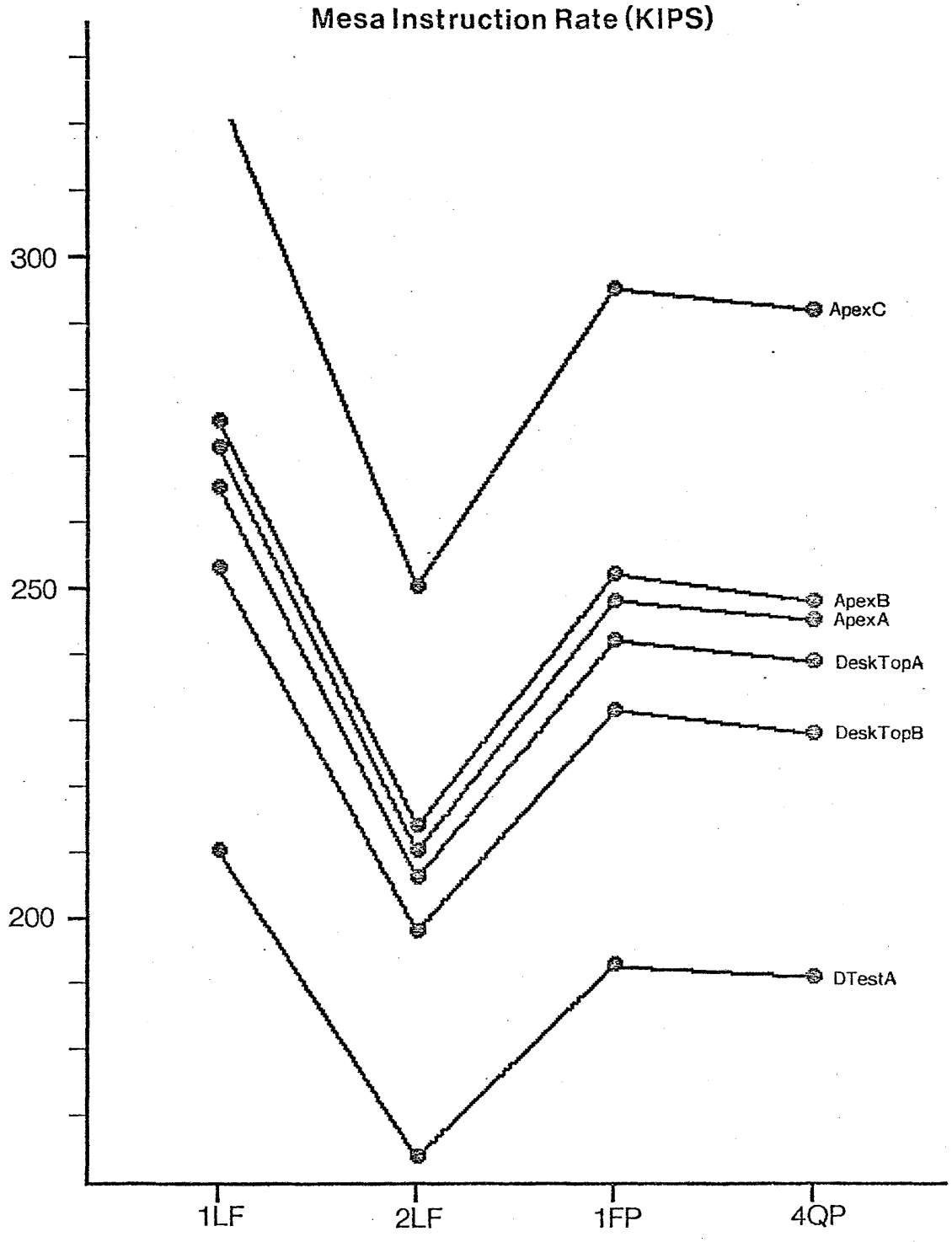
1LF: one large format (17") display
2LF: two large format (17") displays
1FP: one full page (850) display
2FP: two full page (850) displays
1QP: four quarter page displays


% Display Task (run)
30
25
20
15
All Samples
1LF
2LF
1FP
4QP


% Display Task (run + wait)
40
35
30
25
20
High
Low
1LF
2LF
1FP
4QP


% Emulator Task (run)
65
60
55
50
45
40
1LF
2LF
1FP
4QP
DeskTopB
DeskTopA
ApexA
ApexB
DTestA
ApexC


% Emulator Task (run + wait)
80
75
70
65
60
High
Low
1LF
2LF
1FP
4QP


Mesa Instruction Rate (KIPS)
300
250
200
ApexC
ApexB
ApexA
DeskTopA
DeskTopB
DTestA
1LF
2LF
1FP
4QP

Inter-Office Memorandum

To	File	Date	October 11, 1978
From	R. Johnsson, J. Sandman, J. Wick	Location	Palo Alto
Subject	**Instruction Trace Format**	Organization	SDD/SD

XEROX

Filed on: [Iris] < Thistle > Doc > TraceFormat.bravo

DRAFT

This memo describes the format of the instruction traces which are input to Thistle, a D0 timing simulator.

Thistle is driven by data obtained from a byte code trace of a running Alto/Mesa program. A special version of the Alto/Mesa 4.1 microcode was produced and installed in the second ROM which traps to the RAM on each instruction. Two versions of RAM microcode were then produced: the first records a trace of all instructions in a buffer; the second accumulates the dynamic frequency of each opcode.

Instruction Trace

Instruction tracing is turned on and off by special forms of the CATCH instruction (with alpha bytes greater than or equal to 200B). These instructions can be compiled into any program at the desired point using machine code inline procedures. Alternately, a specialized breakpoint handler can be loaded with the subject program which reinterprets the meaning of conditional breakpoints as follows:

CATCH	Condition	Meaning
200B	0	Start tracing
201B	1	Stop tracing

This allows tracing to be turned on and off conviently by setting breakpoints, without modification to the traced program.

The contents of the trace file is as follows:

For each bytecode:

1. the bytecode.
2. alpha and beta if any (order is beta, alpha if both).

For conditional jumps:

3. a condition code for the relation of the operands:

40B - less (signed)
20B - equal
10B - greater (signed)
04B - less (unsigned)
02B - greater (unsigned)

For zRD0, zRDB, zWD0, zWDB, zSFC:

4. the low order eight bits of top-of-stack.

For zWSDB:

5. the low order eight bits of top-of-stack minus two.

For XFERs, zCATCH, zBRK, zJIB, zJIW, monitor operations:

6. the low order eight bits of the new byte pc.

Each page of the data file begins with a zDWDC and a zLST from the trap handler (a total of 4 bytes of data). These are not a part of the bytecode trace. If the bytes for a bytecode overflow a page boundry, the bytecode is reexecuted after the trap, i.e. the same bytecode will appear again starting in the fifth byte of the new page. The pc from an XFER is not considered to be a part of the xfering bytecode for purposes of this restart, i.e. it may be the first significant byte of a page, with its matching XFER in the previous page.

In addition, there are a few bytes of overhead associated with turning the trace on and off which are included in the trace data but are not part of the traced program. By opcode, they are as follows:

Instruction	Count	Instruction	Count
NOOP	1	SL0	1
SL6	1	LI0	1
LIB	2	R0	1
R2	1	W2	1
J8	1	IWDC	1
DWDC	1	CATCH	1
DST	1	LST	1
BRK	1		

Because these discrepancies are small, they are ignored by the simulator.

Instruction Frequencies

As a cross check on the instruction trace data, dynamic frequencies were also obtained for each of the data samples with another version of RAM microcode. This microcode is also controlled by special CATCH instructions or conditional breakpoints with the following meanings:

CATCH	Condition	Meaning
200B	0	Zero counters, start counting
201B	1	Start counting
202B	2	Stop counting
203B	3	Stop counting, store results

As in the instruction trace, there are a few bytes of overhead associated with turning the trace on and off which are included in the accumulated frequencies but are not part of the traced program. By opcode, they are as follows:

Instruction	Count	Instruction	Count
NOOP	1	SL0	1
SL6	1	LI0	1
LIB	2	R0	1
R1	1	W1	1
JB	1	IWDC	1
DWDC	1	DST	1
LST	1	BRK	1

A program was also written to scan the trace data file and accumulate the same frequencies, which were then compared with the microcode output. The microcode frquency output was also compared with a set of frequencies constructed by hand (by counting "legs" with the performance monitor); one error in the manually constructed data was found.

Known Problems

There is one known bug in the tracing and frequency microcode: there are a number of extra NOOP intructions counted and recorded in the trace. Specifically, aligned three-byte pair instructions whose alpha byte is zero cause a spurious NOOP to be recorded (and counted). Any program which processes an instruction trace should take this case into account, as there appears to be no simple fix to the trace microcode.

Inter-Office Memorandum

To	File	Date	October 11, 1978
From	R. Johnsson, R. Sweet, J. Wick	Location	Palo Alto
Subject	**Thistle Instruction Profiles**	Organization	SDD

XEROX

Filed on: [Iris] < Thistle > Doc > Profiles.bravo

DRAFT

This memo describes the instruction classes and profiles used by Thistle, a D0 timing simulator. Thistle simulates the D0 (including interaction with main memory and among tasks) by "executing" the instruction profile for each opcode in the input instruction trace. The interpretation simulates only timing and memory contention; no other semantics are included. Hence, each profile must include complete information about memory operations as well as the number of micro cycles used, but it need not reflect any other properties of the actual D0 emulator microcode (from which the instruction profiles are derived).

Instruction Profiles

Thistle deals with Mesa bytecodes (and the display and memory refresh tasks; see below). The bytecodes are grouped into equivalence classes. Two bytecodes are equivalent if the microcode which implements them has identical timing and memory characteristics. Names of bytecodes begin with the letter z, names of classes begin with the letter x. For example the bytecodes zLG0 and zLG1 are equivalent and belong to class xLGn; zLLB and zLGB are equivalent and belong to class xLGB. In general a class is named after the first bytecode in the class. Note that zLLB and zLGB are equivalent because their implementations have identical timing and memory characteristics; they clearly do not have the same semantics.

The profile for the classes and the class assignments are read from a parameter file when Thistle is started; they can also be edited interactively. The following slice from the parameter file illustrates the syntax for specifying class assignments:

```
zLG0: [xLGn]
zLG1: [xLGn]
zLG2: [xLGn]
zLL0: [xLGn]
zLL1: [xLGn]
zLL2: [xLGn]
zLGDB: [xLGDB,xLGDBQ]
zLLDB: [xLGDB,xLGDBQ]
```

This slice shows classes being assigned for bytecodes zLG0-2, zLL0-2, zLGDB, and zLLDB. The load double bytecodes have two classes corresponding to the two cases in the implementation, i.e. the execution characteristics of the bytecode depends on some additional data. (In this case the additional data is whether or not the doubleword being addressed crosses a quadword boundry.)

Since Thistle does not understand the semantics of bytecodes, the bytecode trace must provide enough information for Thistle to select the correct class. Thistle also deals with alternatives for success/failure of conditional jumps, alignment, and XFER destination link type. See [Johnsson] for a complete description of the contents of the instruction trace data.

For each instruction class, Thistle requires an instruction profile characterizing the microcode that implements the class.

```
xLGn: "nb2fk1"
xLGDB: "nb2fk24b4"
xLGDBQ: "nb9fk12rfk1b4"
```

This slice shows the profiles of the above classes. These strings are similar to those in [Garner]. The meaning of the characters in the string is:

n The next instruction contains NEWINST, i.e. abort until the previous emulator memory operation has mapped.

b The next instruction contains NEXTINST or NEXTDATA, i.e. fetch a byte from the instruction buffer and invoke the buffer refill trap if necessary.

0-9 The number of cycles required by a sequence of instructions executed. Unless otherwise specified the other characters in the string do not include the execution time of the instruction referenced.

( ) Enclose multidigit numbers.

r The previous instruction contained a RETURN, i.e. switch tasks if appropriate.

f Initiate a PFETCH of the size indicated in the following digit. If the following character is a k, the destination of the fetch is the STACK and the size digit follows the k. This operation takes two cycles (and leaves the memory busy).

s Initiate a PSTORE of the size indicated in the following digit. This operation takes two cycles (and leaves the memory busy).

o Initiate an IO operation as indicated by the next digit, which is one of the following:

0 OUTPUT
1 INPUT
4 IOFETCH4
6 IOFETCH16
9 REFRESH

This operation takes two cycles (and leaves the memory busy).

m The next instruction will abort until the last memory operation is complete, i.e. it uses fetched data or changes data being stored. There is no provision for interlocking of the earlier of two currently active memory operations. These aborts are infrequent and must be included in the string.

k Like m except that the interlock is on the stack. The stack operation is indicated by the next character, which is one of the following:

i Stack pointer incremented (aborts if store pending)
d Stack pointer decremented (aborts if fetch pending)

In general, memory interlocks within a bytecode are marked by m; those between instructions are marked by k.

q Macro. Invoke the string contained in the macro named by the next character (0-9 or A-Z). This simplifies the encoding of long sequences of common code, e.g. parts of XFER.

Other Profiles

Other profiles for the display and memory refresh tasks are similar to the instruction profiles; the same command characters are used. For example, the parameters for the 850 full page display (IUTFP) and the current (Version 1.5) microcode are:

```
displayPeriod: 247  -- cycles
displayScan: 1217  -- scan lines
displayVisible: 1188  -- scan lines
displayOnString: "4o08o6(22)6o62r6o62r7(16)o08(12)"
displayOffString: "2(14)o0m2o04"
```

Currently, the profile and period for the memory refresh task are built into the simulator; they are "4o96" and 704 cycles, respectively.

References

Garner, B. Mesa Opcode Timings. June 21, 1978.

Johnsson, R., Sandman, J., Wick, J. *Instruction Trace Format.* October 8, 1978.

Inter-Office Memorandum

To	Thistle Users	Date	October 17, 1978
From	R. Johnsson, R. Sweet, J. Wick	Location	Palo Alto
Subject	**Thistle User's Guide**	Organization	SDD/SS/DE

XEROX

Filed on: [Iris] < Thistle > Doc > ThistleGuide.bravo

DRAFT

Thistle is a D0 timing simulator intended to help answer questions about the effects of changes in microcode or hardware on the performance of Mesa programs. Thistle interprets an encoding of D0 microcode and simulates interaction with main memory and among tasks. The interpretation simulates only timing and memory contention; no other semantics are included.

Instruction Profiles

Thistle deals primarily with Mesa bytecodes. The bytecodes are grouped into *equivalence classes*; two bytecodes are equivalent if the microcode which implements them has identical timing and memory characteristics. Each class is then assigned a *profile* which describes the operation of the microcode which implements it. Each profile is a short string that describes the memory and I/O operations, memory interlocks, instruction buffer refill, task switching, and the number of cycles performed by that instruction class.

The class assignments and the profiles for the classes are read from a parameter file when Thistle is started; they can also be edited interactively. There is a facility for including macros in the profiles, and characteristics of the display can also be specified. Complete details on the parameter file can be found in [Johnsson].

Running Thistle

Obtain Thistle.bcd and Thistle.params from [Iris] < Thistle > (or use the Basic Thistle Disk). You will also need Mesa.image and RunMesa.run from [Iris] < Mesa >. Insure you have a fixed pitch font in SysFont.al; Gacha10 works best. Run Thistle by saying:

```
> Mesa Thistle
```

It will read the .params file and display two windows on the screen. The top window contains the state of the machine; the bottom window accepts commands. It will first ask for a data file containing your instruction trace. (Several standard trace data files are available on [Iris] < Thistle > *.tr; see [Sandman] for details.)

You can install Thistle with a constant parameter file by holding down the backspace-word key when Thistle fires up. After it has read the parameter file, it will checkpoint itself on Thistle.image, which will start up much faster.

Thistle can be run in single step, walk, or run modes; it will simulate faster if the Alto display is turned off. The complete set of commands is as follows:

s Step: execute one Mesa instruction (if detailed tracing is enabled, execute one character of the instruction profile).

r Run: simulates as fast as possible (stops when any character is typed).

w Walk: same as run, but updates the screen at each step.

l Long instruction trap toggle: if you don't expect any long pointer instructions in the trace, it's a good idea to trap them.

t Task toggle: task between each Mesa instruction; when this toggle is off, the time-to-task counter is used instead.

u Unknown instruction trap toggle: halts when garbage is discovered in the trace data.

n NEWINST fix toggle: NEWINST after mapping only; if this toggle is off, NEWINST aborts until MC1 is complete.

d D0 display toggle: turns off the simulated display (there is a profile for both display on and display off states).

p Proceed (count): like run, but with a count of steps.

q Quit: checkpoints the machine state onto the typescript file, clears the machine and asks for a new data file.

a Alto display toggle: no display when running (this doesn't affect the D0 display being simulated, of course).

e Detail trace toggle: reduces step size to cycles instead of Mesa instructions.

i Input parameter file: overrides the current profiles.

o Output parameter file: outputs current profiles in text format.

b Binary (Load or Dump): like Input and Output, except in binary format.

↑r Reset: like Quit, except the display is not checkpointed.

h Checkpoint: writes the machine state onto the typescript file.

c Change parameter: replaces a single instruction profile and class assignment. Macros and any of the display parameters can also be changed.

? List these commands

Any other character halts the simulation.

Thistle Output

The Thistle screen is divided into six vertical regions, organized roughly by function. Below is a copy of the screen with a brief description of each region. (All numbers except the pc, the current opcode, and the trace file position are decimal.)

```
TIME                    MEMORY      PENDING      @
usec          928510    mc1     17  strtMC2  11  6    pc  306
cycles      10923654    mc2      0  newInOK   0  6    buff  1
nxtDisp     10923709    lstMem   E  transfr   1 13
nxtRef      10923968
```

The first region shows simulated elapsed time and the status of the memory system and instruction buffer.

The first column describes the simulated clock. It tells the elapsed time of the simulation in microseconds and processor cycles (at 85 ns per cycle). It also gives the next wakeup time of the periodically scheduled tasks for the display and memory refresh.

The next column tells the number of remaining cycles during which the memory controller automata MC1 and MC2 will be active. It also tells which task (Emulator, Display, or Refresh) was the last to touch the memory.

The third column contains a list of events that are scheduled to occur in the future. In this example (immediately after a PSTORE1 microinstruction) MC2 will be started for 11 cycles in 6 cycles, a NEWINST function in a microinstruction will abort for 6 cycles, and the processor will be suspended (if not already aborted) for 1 cycle in 13 cycles in order that the memory may read from the processor's R-register.

The last column tell the value of the Mesa program counter (Modulo 256) and the number of remaining bytes in the quadword instruction buffer.

```
EMULATOR TASK              %     WAIT                    %
run          5629552    51.5     mc1          727207    6.6
totWait      2059591    18.8     mc2          580977    5.3
                                 suspend      451535    4.1
                                 NewInst      299872    2.7
```

When the microprocessor is "in" a given task, it is either running, aborted (waiting on the memory for one reason or another), or suspended while the memory is accessing the processor registers. This region of the screen divides the emulator task time into five different categories. All percentages are based on total elapsed time.

The first column contains the run category, which counts running microprocessor cycles and also the total of the four categories of column two.

The second column describes the time spent "waiting" during the emulator task. The mc1 category counts time spent in MC1 aborts (waiting to start a memory operation). The mc2 category counts time spent in MC2 aborts (waiting for data to arrive or be taken for a memory operation). The NewInst category counts time spent in NEWINST aborts (waiting until the previous Mesa instruction can no longer page fault). The suspend category counts time spent with the processor suspended. Time spent with the processor both aborted and suspended is only counted as suspended in order to keep the categories disjoint.

```
DISPLAY TASK              %      WAIT                    %
run          2045907   18.7      mc1          769327   7.0
totWait       970159    8.8      mc2               0   0.0
                                  suspend      200832   1.8

REFRESH TASK              %      WAIT                    %
run           186192    1.7      mc1           21826   0.1
totWait        32253    0.2      suspend       10427   0.0
```

These two sections of the screen show the distribution of time while the microprocessor is running the display and memory refresh tasks.

```
COND JUMPS            ST LINE CODE          DISPLAY ON
count       18116     count       21324     count       42339
%TRUE        40.1     ave          16.3     missed          0
                      cur            12
```

This region contains some interesting dynamic program statistics and the status of the display task.

The first column has a count of the number of conditional jumps and the percent of them which actually jump.

The second column has statistics about straight line code sequences in the instruction trace. The ave field is the average number of bytes of code executed between jumps actually taken (or other transfers such as procedure calls).

The third column describes the number of times that the display task has run, and the number of times that its wakeup had already passed before it finished a scan line.

```
INSTRUCTION 229951                  % ACTIVE        FLAGS
[110] W2            dPage  1306     mc1  52.9       LONGT ON
wNULL               dByte   742     mc2  48.6       UNKNT ON
xWn                                 bzy   9.9       niFix YES
                    task: Emulator          Task between
```

This region contains assorted information, some of it used primarily for stepping through trace files.

In the first row is a count of Mesa instructions executed in this trace.

The first column shows the current Mesa instruction (W2), its class (wNULL) that determines how the trace file is to be read, and the name of the equivalence class of the instruction (xWn). This equivalence class is used to select the profile string from the params file.

The next column show the stream index of the trace file, and the currently running microtask.

The third column tells the percent of time that the two memory controllers MC1 and MC2 are running. The bzy field tells the percent of the total time that MC1 is busy waiting for the MC2 of the previous memory operation to complete.

The last column tells the state of various simulator flags. The long instruction trap (LONGT) and unknown instruction trap (UNKNT) are used primarily to validate the trace data. The niFix field tells whether the improvement to the NEWINST abort logic is being simulated. The last entry of this columns tells whether the hardware change to allow tasking between instructions is being simulated.

or whether the "time to task" counter is being simulated. If the count is used, its current value is also shown.

```
 q9
(11)f2mq6
      ↑
```

These lines appear only when detailed tracing is on; they show the current instruction profile. Current macro names are displayed on top, and the arrow points to the current location in the profile.

References

Johnsson, R., Sweet, R., Wick, J. *Thistle Instruction Profiles.* October 11, 1978.

Sandman, J. *Thistle Trace Data.* October 13, 1978.

Inter-Office Memorandum

To File

Date October 12, 1978

From John Wick

Location Palo Alto

Subject **Thistle Benchmark: Elapsed Time**

Organization SDD/SS/DE

XEROX

Filed on: [Iris] < Thistle > Doc > Benchmark.bravo

DRAFT

This memo describes one of the benchmark tests run on Thistle, a D0 timing simulator. The goal of this test was to reproduce, as accurately as possible, the actual elapsed time of a real D0 running a set of standard test programs. The tests chosen were the familiar sort programs, in use as Alto/Mesa benchmarks since 1976. These tests run the processor flat out, with no disk or interrupt activity. The tests have typically been run with the display off; they were modified to optionally display a full screen of arbitrary memory while running the sort.

Note that the data below is for benchmark purposes only and should not be the basis for evaluation of the D0's display support capabilities. Because this was a benchmark test, the simulation was constrained to use the current IUTFP controller and microcode (Version 1.5). This configuration is known to have unacceptable display performance. There are also a number of known hardware fixes left out of this simulation since they are not yet installed on our EMs.

Microseconds on EM016, microcode version 1.5' at 4-Oct-78 14:27; Thistle of 10-Oct-78 17:53

	D0 EM016	Thistle	
Integer 200, Display off	212695	189221	89.0%
Integer 200, Display on	309628	279878	90.4%
Ratio on/off	1.456	1.479	101.6%
off/on	0.687	0.676	98.4%
Integer 1500, Display off	2284609	2030021	88.9%
Integer 1500, Display on	3323260	2988132	89.9%
Ratio on/off	1.455	1.472	101.2%
off/on	0.688	0.679	98.7%
String 100, Display off	515260	468561	90.9%
String 100, Display on	750766	700905	93.4%
Ratio on/off	1.457	1.496	102.7%
off/on	0.686	0.669	97.5%
String 400, Display off	3031377	2752357	90.8%

String 400, Display on	4415623	4112727	93.1%
Ratio on/off	1.457	1.494	102.5%
off/on	0.687	0.669	97.4%

There are a few known problems with the simulations which we have not yet had time to correct.

Thistle does not simulate the timer microcode, which requires 8 cycles out of every 448 (1.8%).

Thistle does not simulate the disk task. Since it wakes up only every 3ms and never has anything to do (except post status to memory), the effect is negligible.

The trace data run through the simulator has a number of spurious NOOP instructions. (Due to a bug in the trace microcode, aligned pair instructions whose alpha byte is zero cause a bogus NOOP to be recorded in the trace.)

The simulated display ran less often than it should have (every 247 cycles instead of every 243). This was a result of misinformation on the number of scanlines per frame for the IUTFP (1200 virsus 1217 actual).

I conjecture that the combination of these effects adds two or three percent to the above figures, bringing the simulator well within 10% accuracy, which should be adequate for our purposes. Perhaps more important, the effects of the display on the simulation match the characteristics of the D0 quite well.

Inter-Office Memorandum

To	File	Date	October 12, 1978
From	Richard Johnsson, John Wick	Location	Palo Alto
Subject	**Thistle Benchmark: Voltages**	Organization	SDD/SS/DE

XEROX

Filed on: [Iris] < Thistle > Doc > Voltages.bravo

DRAFT

This memo describes one of the benchmark tests run on Thistle, a D0 timing simulator. We attempted to verify some of the hardware signals (as measured with a digital voltmeter) with corresponding figures generated by the simulator. The signals are all involved with processor/memory interaction; the four signals measured were:

`abort`: the number of cycles waiting for memory operations. This is the total wait time less the time during suspend (approximately).

`mc1`: the number of cycles during which MC1 was active.

`mc2`: the number of cycles during which MC2 was active.

`suspend`: the number of cycles waiting for actual data transfer between the memory controller and the processor.

Voltages measured 5-Oct-78 EM09 Microcode 1.5'

signal	high	low	range
abort'	3.75	0.30	3.45
mc1'	3.70	0.20	3.50
mc2'	3.60	0.15	3.45
suspend	3.70	0.20	3.50

The above signals were then calibrated against a known microcode loop of 19 cycles. Values in parentheses show true percentages for complemented signals. Values in brackets are calculated.

	obsrv	norm	pct	true	calculated	
abort'	1.15	0.85	24.6	(75.4)	[13/19 = 68.4]	+10%
mc1'	2.48	2.28	65.1	(34.9)	[6/19 = 31.6]	+10%
mc2'	2.64	2.49	72.2	(27.8)	[7/19 = 36.8]	-25%
suspend	0.42	0.22	6.3	6.3	[1/19 = 5.3]	+20%

`normalized = observed - low` `percent on = normalized/range`

This stage of the experiment verified that the measured voltages, while not very accurate, have roughly the expected behavior. The same signals were measured while EM09 was running the

benchmark tests (integer and string sorts). The tests were run with the display both on and off (this is the Dallas 850 Full Page display driven by the IUTFP, microcode version 1.5).

DO EM09

abort'	obsrv	norm	pct	true
Integer off	2.97	2.67	77.4	22.6
Integer on	3.31	3.01	87.2	12.8
String off	2.94	2.64	76.5	23.5
String on	3.28	2.98	86.4	13.6

mc1'	obsrv	norm	pct	true
Integer off	3.13	2.93	83.7	16.3
Integer on	2.33	2.13	60.9	39.1
String off	2.83	2.63	75.1	24.9
String on	2.14	1.94	55.4	44.6

mc2'	obsrv	norm	pct	true
Integer off	3.22	3.07	89.0	11.0
Integer on	2.46	2.31	67.0	33.0
String off	3.01	2.86	82.9	17.1
String on	2.34	2.19	63.5	36.5

suspend	obsrv	norm	pct	true
Integer off	0.41	0.21	6.0	6.0
Integer on	0.37	0.17	4.9	4.9
String off	0.43	0.23	6.6	6.6
String on	0.38	0.18	5.1	5.1

These are compared below with the corresponding figures produced by the simulator running both the small (200 integers, 100 strings) and large (1500 integers, 400 strings) benchmark instruction traces.

	DO	Thistle	
	EM09	large	small
abort			
Integer off	22.6	23.3	23.3
Integer on	12.8	17.7	17.7
String off	23.5	22.1	22.3
String on	13.6	16.2	16.1
mc1			
Integer off	16.3	26.4	26.8
Integer on	39.1	38.9	39.2
String off	24.9	31.2	31.3
String on	44.6	42.6	42.7
mc2			
Integer off	11.0	25.0	25.2
Integer on	33.0	38.3	38.6
String off	17.1	27.6	27.6
String on	36.5	40.8	40.9

suspend			
Integer off	6.0	5.5	5.5
Integer on	4.9	3.9	3.9
String off	6.6	5.6	5.6
String on	5.1	3.9	3.9

Conclusion: when the display is turned on and off, Thistle behaves the same as a real D0.

Inter-Office Memorandum

To	John Wick	Date	September 29, 1978
From	Pitts Jarvis	Location	Palo Alto
Subject	Functional Specification for the Prototype Display Controller	Organization	SDD

XEROX

Filed on: [Iris] < Jarvis > prototype-display.bravo

This note describes the prototype display controller. The prototype display controller resembles the UTVFC controller and attempts to minimize the processor overhead necessary to refresh the IUTFP and to transmit keyboard and mouse data to main storage. Two features distinguish the prototype controller from the Alto like controller. The prototype controller does not have an IOCB structure. The controller refreshes the display from a single monolithic bit map described by the controller status block, CSB, located at 400B. The prototype controller writes keyboard and mouse data into a ring buffer described by the CSB. Each ring buffer entry specifies a state change in the keyboard and mouse. A state change would include key up, key down, and incremental changes to mouse coordinates.

```
CSB: TYPE = MACHINE DEPENDENT RECORD[
   pad8: BYTE,                          -- 0  begin quadword
   bitMap: LONG POINTER,                -- 0
   lineSize: WORD,                      -- 2
   lineCount: WORD,                     -- 3
   cursorX: WORD,                       -- 4  begin quadword
   cursorY: WORD,                       -- 5
   pad8a: BYTE,                         -- 6
   cursor: LONG POINTER,                -- 6
   keySynch: WORD,                      -- 8  begin quadword
   ringBase: WORD,                      -- 9
   ringEnd: WORD,                       -- 10
   ringIn: WORD,                        -- 11
   ringOut: WORD,                       -- 12  begin quadword
   garbage: ARRAY [0..2] OF UNSPECIFIED]
```

At the beginning of each field, the controller fetches the bit map and cursor parameters located in the first two quadwords in the CSB. **LineSize** holds the number of words in a scan. **BitMap** points to the first location of the bit map. The controller explicitly clears the low four bits of the **bitMap** and **lineSize** fields, *i.e.*, each scan line must be aligned on a sixteen word boundary. **CursorX** holds the cursor's abscissa, number of pixels from the left. **CursorY** holds the cursor's ordinate, the number of scan lines from the top. **Cursor** points to an array of sixteen words, the cursor bit map. There are not any alignment restrictions for the cursor bit map.

Whenever the keyboard or mouse changes state, the controller uses **keySynch** as bit mask to initiate interrupts after writing the ring buffer entry. The ring buffer must be quadword aligned and located somewhere in the first 64K of virtual storage. **RingBase** points to the first word of the buffer and **ringEnd** points to the first word past the end of the buffer. **RingIn** points at the first free entry in the buffer. **RingOut** points to the oldest entry in the ring. If the buffer is empty, **ringIn** equals **ringOut**.

A ring buffer entry consists of a quadword.

```
RingEntry: TYPE = MACHINE DEPENDENT RECORD[
  incrementX: BIT,
  decrementX: BIT,
  incrementY: BIT,
  decrementY: BIT,
  mouseLeft: BIT,
  mouseCenter: BIT,
  mouseRight: BIT,
  keyCode: [0..177B],
  keyUp: BOOLEAN,
  vs: BIT,
  unused: BIT,
  keyboardChange: BOOLEAN,
  unused: BIT,
  pad13: [0..1777B],
  garbage: ARRAY [0..1] OF UNSPECIFIED]
```

Other features of the Alto controller omitted from the prototype controller include HTAB, a black background bit, and less restrictive alignment constraints on the bit map.

c: Belleville, Irby, Kennedy, Lauer, Liddle, Lynch, Metcalfe, Purcell, Thacker

Inter-Office Memorandum

DRAFT - DRAFT - DRAFT - DRAFT

To John Wick

Date October 12, 1978

From Pitts Jarvis

Location Palo Alto

Subject Display Characteristics

Organization SDD

XEROX

Filed on: [Iris] < Jarvis > displays.bravo

The following table summarizes the characteristics of some raster scanned displays which exist or planned for the D0. The charcterstics of the Alto display are also given to provide some basis for comparison. The D0 displays include the 850 display designated by FP for full page, the large format display (a seventeen inch video monitor) designated by LF for large fromat, and the quarter page display, QP. f denotes the frame rate measured in frames per second. l denotes the number of lines scanned in a single frame; this includes the visible lines as well as the lines blanked during vertical retrace. T denotes the time, in microseconds, to scan a single line on the raster. T is a derived quantity given by the formula

$$T = 1/(f\,l).$$

x denotes the number of pixels on a scan line. y denotes the number of visible lines in a frame. s denotes the number of words necessary to store a single scan line after accounting for storage alignment restrictions. M denotes the number of words necessary to store a full bit map. Mn is the storage necessary to represent a bit map normalized by a full LF bit map. Finally, V gives the video bit rate measured in megabits per second. V is derived from x and T:

$$V = x/T.$$

	f	l	T	x	y	s	M	Mn	V
Alto	30.0	875	38.1	606	808	38	30704	0.6	16.0
FP	37.5	1217	21.9	896	1188	56	66528	1.3	40.9
LF	40.0	875	28.6	1024	808	64	51712	1.0	35.8
QP	30.0	525	63.5	640	480	40	19200	0.4	10.1

Several simplifying assumptions were made for all displays when translating the display microcode into the strings used by the Thistle simulator. Since mouse coordinates, CSB, and cursor are processed only once each field, they were not taken into account by the simulation. The processing necessary for key strokes was also ignored because the bit rates were several orders of magnitude less than V; however, the processing necessary to check for the presence of key strokes once each scan line was taken into account.

Several storage alignment restrictions were also added for individual displays. All bit maps must begin on hexword boundaries. All bit maps for multiple displays driven by a single controller must be the same size. The size of each scan line is fixed at 40 and 56 words for quarter page and 850 displays respectively; the programmer cannot reduce the size of the bit map by specifying the number of words per line. For reasons of storage and bandwidth efficency, the loops which transfer data from main storage to the 850 and quarter page displays are open coded. Each scan line of a large format display must begin on a hexword boundary.

Inter-Office Memorandum

To	File	Date	October 13, 1978
From	Sandman	Location	Palo Alto
Subject	Thistle Trace Data	Organization	SDD/DE

XEROX

Filed on: [Iris] < Thistle > Doc > TraceData.bravo

This memo documents the steps taken to generate data for Thistle, the D0 simulator. Three systems were used as a source of the data: Apex, DeskTop, and DTest (a display test program for Alto/Mesa). The operations traced were those involved in displaying text on the screen.

The data was collected by using the module TraceKernel which supplied a trap handler and a breakpoint handler. The trap handler was invoked when the microcode fill the buffer with trace data. It flushed the buffer onto a pre-existing file. Tracing was disabled if the file had filled up. The breakpoint handler understood special conditional breakpoints which served to turn tracing on and off. The TraceKernel required one page of memory for its code and one page for the buffer.

All traces were done with interrupts disabled. Otherwise, seventy five percent of each page of data was required to trace the interrupt routine. This is because the trap handler must run with interrupts disabled, and takes sufficiently long so that an interrupt occurs each time the trap handler returns.

Before each trace, the operation was performed to make sure all modules involved had been started, and their code was in memory.

Apex

The Apex used was obtained from Jerry Morrison and found on [Iris] < Morrison > Apex5.5 > . The documents and folders involved in the data generation were loaded from [Iris] < Morrison > Apex5.5 > SFS > SFS3.dm. Three traces were taken from Apex. The first traced the inner loop of displaying characters in a window. The second traced the whole process of opening a window, including setting up the border and menu items. The last traced the moving of a document from the desktop into a folder.

ApexA

Start: Entry to FillScreen in DocSwnPack.
End: Exit from FillScreen in DocSwnPack.
Operation: Opening Document 3.

ApexB

Start: Entry to Open in DocWnPack.
End: Exit from Open in DocWnPack.
Operation: Opening Document 3.

ApexC

Start: Entry to Move in IconPack.
End: Exit from Move in IconPack.
Operation: Moving Document 2 from desktop into Folder 1 on the desktop

DeskTop

The DeskTop used was obtained from Scott McGregor and found on [Iris]<DeskTop>September13>. The DeskTop system contained the following components: Nub, Test, FormsPad, DocRef, FileCabinet and End. Two traces were taken from DeskTop. The first traced the whole process of opening a window while the second was just the inner loop of painting the text in that window.

DeskTopA

Start: Entry to PaintInWindow in WindowUtilities.
End: Exit from PaintInWindow in WindowUtilities.
Operation: Opening a form containing HelpTrainingDoc.form.

DeskTopB

Start: Entry to PaintFromFrame in DeskFrame.
End: Exit from PaintFromFrame in DeskFrame.
Operation: Opening a form containing HelpTrainingDoc.form

DTest

DTest is a program written by Richard Johnsson that tests the display package contained in the standard Alto/Mesa system. It was used to write a text file onto the display by putting bytes from a disk stream onto the standard display stream (which also writes a typescript file). Only one trace was taken with DTest. The file displayed was a portion of HelpTrainingDoc.form used in the DeskTop traces. It is stored on [Iris]<Thistle>DTest>DTest.txt.

DTestA

Start: At line ResetControlDEL of TypeFile in DTest.
End: Exit from TypeFile in DTest.
Operation: Displaying DTest.txt

Before any trace data was collected, some dynamic instruction mix studies were conducted to get a quick picture of the trace data. After the traces were taken, they were analyzed to obtain dynamic instruction mix of the trace data itself. These independent frequency studies showed that the disabling interrupts during tracing had negligible effect. A general observation on the frequency data is that both Apex and DeskTop call relatively few procedures and have larger local frames than DTest, which tended to call many procedures and have smaller local frames.

```
Alto/Mesa 4.1 of 30-Aug-78  9:48
12-Oct-78  8:44
>thistle -- 146604B
Tables loaded from Thistle.binaryThistle of 11-Oct-78 19:10:20
Data from file: ApexA.tr

!Binary ???????????????load from file: Thacker.Binary
!Input instruction data from: OneLF.params
-- One Large Format display 40 frames/sec
!Alto Display off
!Run (1:46:49)

TIME                    MEMORY      PENDING      @
usec          848039    mc1    17   strtMC2  11  6    pc  306
cycles       9976941    mc2     0   newInOK   0  6    buff  1
nxtDisp      9977095    lstMem  E   transfr   1 13
nxtRef       9977088


EMULATOR TASK             %       WAIT                    %
run          5629552    56.4       mc1           606013     6.0
totWait      2246832    22.5       mc2           760294     7.6
                                   suspend       520661     5.2
                                   NewInst       359864     3.6

DISPLAY TASK              %       WAIT                    %
run          1441141    14.4       mc1           338256     3.3
totWait       457059     4.5       mc2                0     0.0
                                   suspend       118803     1.1

REFRESH TASK              %       WAIT                    %
run           170052     1.7       mc1            21621     0.2
totWait        32305     0.3       suspend        10684     0.1

COND JUMPS            ST LINE CODE          DISPLAY ON
count         18116   count        21324    count         29693
%TRUE          40.1   ave           16.3    missed            0
                      cur             12

INSTRUCTION 229951                % ACTIVE        FLAGS
[110] W2            dPage  1306   mc1  49.6       LONGT ON
wNULL               dByte   742   mc2  43.8       UNKNT ON
xWn                               bzy  11.3       niFix YES
                    task: Emulator          Task between  34


Data from file:
```

```
Alto/Mesa 4.1 of 30-Aug-78  9:48
12-Oct-78  9:43
>Thistle -- 146604B
Tables loaded from Thistle.binary
Thistle of 11-Oct-78 19:10:20
Data from file: ApexA.tr

!Binary load from file: Thacker.binary
!Input instruction data from: TwoLF.params
-- Two Large Format displays 40 frames/sec
!Alto Display off
!Run (1:38:47)

TIME                    MEMORY      PENDING      @
usec         1092368    mc1    17   strtMC2  11  6    pc  306
cycles      12851391    mc2     5   newInOK   0  6    buff  1
nxtDisp     12851239    lstMem  E   transfr   1 13
nxtRef      12851520


EMULATOR TASK              %       WAIT                    %
run           5629552    43.8      mc1            1050533     8.1
totWait       2122443    16.5      mc2             446229     3.4
                                   suspend         380073     2.9
                                   NewInst         245608     1.9

DISPLAY TASK               %       WAIT                    %
run           3521538    27.4      mc1             994506     7.7
totWait       1300554    10.1      mc2                  0     0.0
                                   suspend         306048     2.3

REFRESH TASK               %       WAIT                    %
run            219048     1.7      mc1              47696     0.3
totWait         58256     0.4      suspend          10560     0.0

COND JUMPS            ST LINE CODE          DISPLAY ON
count         18116   count        21324    count         38112
%TRUE          40.1   ave           16.3    missed          135
                      cur             12

INSTRUCTION 229951                % ACTIVE          FLAGS
[110] W2            dPage  1306     mc1  64.6       LONGT ON
wNULL               dByte   742     mc2  62.0       UNKNT ON
xWn                                 bzy   7.1       niFix YES
                    task: Emulator            Task between  34


Data from file:
```

```
Alto/Mesa 4.1 of 30-Aug-78  9:48
11-Oct-78 19:28
>Thistle -- 146604B
Tables loaded from Thistle.binary
Thistle of 11-Oct-78 19:10:20
Data from file: ApexA.tr

!Binary load from file: Thacker.arams
Binary file format wrong
File not found
!Binary load from file: Thacker.binary
!Input instruction data from: OneFP.params
-- One Full Page display 37.5 frames/sec
!Alto Display off
!Run (1:27:50)

TIME                  MEMORY      PENDING      @
usec        928510    mc1    17   strtMC2  11  6    pc  306
cycles    10923654    mc2     0   newInOK   0  6    buff  1
nxtDisp   10923709    lstMem  E   transfr   1 13
nxtRef    10923968

EMULATOR TASK           %       WAIT                  %
run         5629552   51.5      mc1           727207    6.6
totWait     2059591   18.8      mc2           580977    5.3
                                suspend       451535    4.1
                                NewInst       299872    2.7

DISPLAY TASK            %       WAIT                  %
run         2045907   18.7      mc1           769327    7.0
totWait      970159    8.8      mc2                0    0.0
                                suspend       200832    1.8

REFRESH TASK            %       WAIT                  %
run          186192    1.7      mc1            21826    0.1
totWait       32253    0.2      suspend        10427    0.0

COND JUMPS          ST LINE CODE          DISPLAY ON
count       18116   count       21324     count        42339
%TRUE        40.1   ave          16.3     missed           0
                    cur            12

INSTRUCTION 229951              % ACTIVE        FLAGS
[110] W2          dPage  1306   mc1  52.9       LONGT ON
wNULL             dByte   742   mc2  48.6       UNKNT ON
xWn                             bzy   9.9       niFix YES
                  task: Emulator          Task between  34


Data from file:
```

```
Alto/Mesa 4.1 of 30-Aug-78  9:48
12-Oct-78  8:09
>thistle -- 146604B
Tables loaded from Thistle.binary
Thistle of 11-Oct-78 19:10:20
Data from file: ApexA.tr

!Binary load from file: Thacker.inary
!Input instruction data from: TwoFP.params
-- Two Full Page displays 37.5 frames/sec
!Alto Display off
!Run (1:29:25)

TIME                    MEMORY      PENDING       @
usec          946225    mc1    17   strtMC2  11  6     pc  306
cycles      11132064    mc2     0   newInOK   0  6     buff  1
nxtDisp     11132173    lstMem  E   transfr   1 13
nxtRef      11132352


EMULATOR TASK             %       WAIT                    %
run          5629552    50.5       mc1           771977     6.9
totWait      2031155    18.2       mc2           548623     4.9
                                   suspend       431681     3.8
                                   NewInst       278874     2.5

DISPLAY TASK              %       WAIT                    %
run          2149090    19.3       mc1           873488     7.8
totWait      1098363     9.8       mc2                0     0.0
                                   suspend       224875     2.0

REFRESH TASK              %       WAIT                    %
run           189744     1.7       mc1            23863     0.2
totWait        34160     0.3       suspend        10297     0.0

COND JUMPS            ST LINE CODE          DISPLAY ON
count        18116    count        21324    count         23199
%TRUE         40.1    ave           16.3    missed        19948
                      cur             12

INSTRUCTION 229951                  % ACTIVE          FLAGS
[110] W2            dPage  1306     mc1  54.4         LONGT ON
wNULL               dByte   742     mc2  50.5         UNKNT ON
xWn                                 bzy   9.4         niFix YES
                    task: Emulator            Task between  30


Data from file:
```

```
Alto/Mesa 4.1 of 30-Aug-78  9:48
12-Oct-78  9:48
>Thistle -- 146604B
Tables loaded from Thistle.binary
Thistle of 11-Oct-78 19:10:20
Data from file: ApexA.tr

!Binary load from file: Thacker.binary
!Input instruction data from: FourQP.params
-- Four Quarter Page display 30 frames/sec
!Alto Display off
!Run (1:30:19)

TIME                    MEMORY      PENDING       @
usec          938850    mc1    17   strtMC2  11  6     pc  306
cycles      11045296    mc2     0   newInOK   0  6     buff  1
nxtDisp     11045389    lstMem  E   transfr   1 13
nxtRef      11045760


EMULATOR TASK             %       WAIT                    %
run           5629552    50.9     mc1             571334    5.1
totWait       1860762    16.8     mc2             557782    5.0
                                  suspend         435523    3.9
                                  NewInst         296123    2.6

DISPLAY TASK              %       WAIT                    %
run           2352336    21.2     mc1             754457    6.8
totWait        988539     8.9     mc2                  0    0.0
                                  suspend         234082    2.1

REFRESH TASK              %       WAIT                    %
run            188268     1.7     mc1              15845    0.1
totWait         25839     0.2     suspend           9994    0.0

COND JUMPS              ST LINE CODE          DISPLAY ON
count         18116     count        21324    count          14786
%TRUE          40.1     ave           16.3    missed             0
                        cur             12

INSTRUCTION 229951                % ACTIVE          FLAGS
[110] W2            dPage  1306   mc1  51.7        LONGT ON
wNULL               dByte   742   mc2  48.1        UNKNT ON
xWn                               bzy  10.0        niFix YES
                    task: Emulator          Task between  34


Data from file:
```

```
Alto/Mesa 4.1 of 30-Aug-78  9:48
12-Oct-78 10:29
>thistle -- 146604B
Tables loaded from Thistle.binaryThistle of 11-Oct-78 19:10:20
Data from file: ApexB.tr

!Binary load from file: Thacker.binary
!Input instruction data from: OneLF.params
-- One Large Format display 40 frames/sec
!Alto Display off
!Run (2:30:20)

TIME                    MEMORY      PENDING       @
usec         1552497    mc1    17   strtMC2  11  6    pc  306
cycles      18264677    mc2     2   newInOK   0  6    buff  1
nxtDisp     18264871    lstMem  E   transfr   1 13
nxtRef      18265280


EMULATOR TASK             %       WAIT                    %
run           9991245    54.7     mc1           1214742    6.6
totWait       4379351    23.9     mc2           1572406    8.6
                                  suspend        980229    5.3
                                  NewInst        611974    3.3

DISPLAY TASK              %       WAIT                    %
run           2637397    14.4     mc1            649821    3.5
totWait        881520     4.8     mc2                 0    0.0
                                  suspend        231699    1.2

REFRESH TASK              %       WAIT                    %
run            311328     1.7     mc1             42571    0.2
totWait         63836     0.3     suspend         21265    0.1

COND JUMPS            ST LINE CODE          DISPLAY ON
count         38658   count        47290    count         54359
%TRUE          45.8   ave           13.7    missed            0
                      cur             12

INSTRUCTION 427624                % ACTIVE          FLAGS
[110] W2            dPage  2456   mc1  50.6         LONGT ON
wNULL               dByte   577   mc2  44.7         UNKNT ON
xWn                               bzy  11.9         niFix YES
                    task: Emulator          Task between  12


Data from file:
```

```
Thistle of 11-Oct-78 19:10:20
Data from file: Apex.tr

Data from file: ApexB.tr

!Binary load from file: Thacker.binary
!Input instruction data from: TwoLF.params
-- Two Large Format displays 40 frames/sec
!Alto Display off
!Run (4:01:00)

TIME                    MEMORY      PENDING      @
usec        2002181     mc1    17   strtMC2  11  6    pc  306
cycles     23555077     mc2     0   newInOK   0  6    buff  1
nxtDisp    23555191     lstMem  E   transfr   1 13
nxtRef     23555136


EMULATOR TASK             %       WAIT                    %
run         9991245    42.4       mc1          2057079    8.7
totWait     4093849    17.3       mc2           932815    3.9
                                  suspend       701076    2.9
                                  NewInst       402879    1.7

DISPLAY TASK              %       WAIT                    %
run         6458762    27.4       mc1          1902691    8.0
totWait     2499131    10.6       mc2                0    0.0
                                  suspend       596440    2.5

REFRESH TASK              %       WAIT                    %
run          401496     1.7       mc1            89490    0.3
totWait      110594     0.4       suspend        21104    0.0

COND JUMPS          ST LINE CODE          DISPLAY ON
count       38658   count       47290     count        69893
%TRUE        45.8   ave          13.7     missed         211
                    cur            12

INSTRUCTION 427624                % ACTIVE        FLAGS
[110] W2            dPage  2456   mc1  65.4       LONGT ON
wNULL               dByte   577   mc2  62.7       UNKNT ON
xWn                               bzy   7.4       niFix YES
                    task: Emulator          Task between  34


Data from file:
```

```
Alto/Mesa 4.1 of 30-Aug-78  9:48
12-Oct-78  8:20
>thistle -- 146604B
Tables loaded from Thistle.binaryThistle of 11-Oct-78 19:10:20
Data from file: ApexB.tr

!Binary load from file: Thacker.binary
!Input instruction data from: OneFP.params
-- One Full Page display 37.5 frames/sec
!Alto Display off
!Run (2:44:42)

TIME                    MEMORY      PENDING      @
usec         1699718    mc1    17   strtMC2  11  6    pc  306
cycles      19996693    mc2     0   newInOK   0  6    buff  1
nxtDisp     19996795    lstMem  E   transfr   1 13
nxtRef      19997120


EMULATOR TASK             %       WAIT                    %
run          9991245    49.9       mc1          1427895     7.1
totWait      3992694    19.9       mc2          1220987     6.1
                                   suspend       839479     4.1
                                   NewInst       504333     2.5

DISPLAY TASK              %       WAIT                    %
run          3744962    18.7       mc1          1468095     7.3
totWait      1864738     9.3       mc2                0     0.0
                                   suspend       396643     1.9

REFRESH TASK              %       WAIT                    %
run           340848     1.7       mc1            41988     0.2
totWait        62206     0.3       suspend        20218     0.1

COND JUMPS            ST LINE CODE          DISPLAY ON
count        38658    count       47290    count         77506
%TRUE         45.8    ave          13.7    missed            0
                      cur            12

INSTRUCTION 427624                 % ACTIVE          FLAGS
[110] W2            dPage  2456    mc1  53.8         LONGT ON
wNULL               dByte   577    mc2  49.4         UNKNT ON
xWn                                bzy  10.4         niFix YES
                    task: Emulator          Task between  22


Data from file:
```

```
Alto/Mesa 4.1 of 30-Aug-78  9:48
12-Oct-78  8:31
>thistle -- 146604B
Tables loaded from Thistle.binaryThistle of 11-Oct-78 19:10:20
Data from file: ApexB.tr

!Binary load from file: Thacker.binary
!Input instruction data from: TwoFP.params
-- Two Full Page displays 37.5 frames/sec
!Alto Display off
!Run (2:48:19)

TIME                    MEMORY      PENDING      @
usec        1736251     mc1    17   strtMC2  11  6     pc  306
cycles     20426486     mc2     0   newInOK   0  6     buff  1
nxtDisp    20426623     lstMem  E   transfr   1 13
nxtRef     20426560


EMULATOR TASK             %       WAIT                    %
run          9991245    48.9       mc1           1523055     7.4
totWait      3922254    19.2       mc2           1127045     5.5
                                   suspend        801682     3.9
                                   NewInst        470472     2.3

DISPLAY TASK              %       WAIT                    %
run          3972292    19.4       mc1           1684136     8.2
totWait      2126365    10.4       mc2                 0     0.0
                                   suspend        442229     2.1

REFRESH TASK              %       WAIT                    %
run           348168     1.7       mc1             45483     0.2
totWait        66162     0.3       suspend         20679     0.1

COND JUMPS          ST LINE CODE          DISPLAY ON
count       38658   count       47290     count         42878
%TRUE        45.8   ave          13.7     missed        36294
                    cur            12

INSTRUCTION 427624                % ACTIVE          FLAGS
[110] W2            dPage  2456     mc1  55.5        LONGT ON
wNULL               dByte   577     mc2  51.5        UNKNT ON
xWn                                 bzy   9.9        niFix YES
                    task: Emulator            Task between  22


Data from file:
```

```
Thistle of 11-Oct-78 19:10:20
Data from file: ApexB.tr

!Input instruction data from: XXX
!Binary load from file: Thacker.binary
!Input instruction data from: FourQP.params
-- Four Quarter Page display 30 frames/sec
!Alto Display off
!Run (2:52:43)

TIME                  MEMORY      PENDING      @
usec       1720528    mc1    17   strtMC2  11  6    pc  306
cycles    20241509    mc2     0   newInOK   0  6    buff  1
nxtDisp   20241706    lstMem  E   transfr   1 13
nxtRef    20242112


EMULATOR TASK           %       WAIT                    %
run        9991245    49.3      mc1          1145910    5.6
totWait    3606859    17.8      mc2          1161628    5.7
                                suspend       813006    4.0
                                NewInst       486315    2.4

DISPLAY TASK            %       WAIT                    %
run        4310040    21.2      mc1          1482841    7.3
totWait    1937412     9.5      mc2                0    0.0
                                suspend       454571    2.2

REFRESH TASK            %       WAIT                    %
run         345024     1.7      mc1            31284    0.1
totWait      50929     0.2      suspend        19645    0.0

COND JUMPS          ST LINE CODE          DISPLAY ON
count      38658    count       47290    count        27097
%TRUE       45.8    ave          13.7    missed           0
                    cur            12

INSTRUCTION 427624                % ACTIVE        FLAGS
[110] W2            dPage  2456   mc1  52.6       LONGT ON
wNULL               dByte   577   mc2  48.9       UNKNT ON
xWn                               bzy  10.5       niFix YES
                    task: Emulator          Task between  22


Data from file:
```

```
Thistle of 11-Oct-78 19:10:20
Data from file: ApexC.tr

!Binary load from file: Thacker.binary
!Input instruction data from: OneLF.params
-- One Large Format display 40 frames/sec
!Alto Display off
!Run (1:08:10)

TIME                    MEMORY      PENDING      @
usec          645063    mc1    17   strtMC2  11  6    pc  370
cycles       7588981    mc2     0   newInOK   0  6    buff  7
nxtDisp      7589143    lstMem  E   transfr   1 13
nxtRef       7589120


EMULATOR TASK             %      WAIT                      %
run          3853042    50.7      mc1           543869     7.1
totWait      2072735    27.3      mc2           830853    10.9
                                  suspend       450322     5.9
                                  NewInst       247691     3.2

DISPLAY TASK              %      WAIT                      %
run          1096398    14.4      mc1           298588     3.9
totWait       407836     5.3      mc2                0     0.0
                                  suspend       109248     1.4

REFRESH TASK              %      WAIT                      %
run           129348     1.7      mc1            19656     0.2
totWait        29622     0.3      suspend         9966     0.1

COND JUMPS           ST LINE CODE          DISPLAY ON
count        29517   count        28096    count         22586
%TRUE         38.9   ave           11.4    missed            0
                     cur             12

INSTRUCTION 209374                 % ACTIVE          FLAGS
[110] W2           dPage  1226     mc1  52.5         LONGT ON
wNULL              dByte   413     mc2  46.7         UNKNT ON
xWn                                bzy  13.7         niFix YES
                   task: Emulator            Task between   4


Data from file:
```

```
Thistle of 11-Oct-78 19:10:20
Data from file: ApexC.tr

!Binary load from file: Thacker.binary
!Input instruction data from: TwoLF.params
-- Two Large Format displays 40 frames/sec
!Alto Display off
!Run (1:20:56)

TIME                  MEMORY      PENDING      @
usec          838452  mc1    17   strtMC2  11  6    pc  370
cycles       9864147  mc2     0   newInOK   0  6    buff  7
nxtDisp      9864199  lstMem  E   transfr   1 13
nxtRef       9864448


EMULATOR TASK            %       WAIT                    %
run          3853042   39.0       mc1           935308   9.4
totWait      1905053   19.3       mc2           511880   5.1
                                  suspend       314684   3.1
                                  NewInst       143181   1.4

DISPLAY TASK             %       WAIT                    %
run          2711296   27.4       mc1           896348   9.0
totWait      1177118   11.9       mc2                0   0.0
                                  suspend       280770   2.8

REFRESH TASK             %       WAIT                    %
run           168132    1.7       mc1            39322   0.3
totWait        49506    0.5       suspend        10184   0.1

COND JUMPS           ST LINE CODE          DISPLAY ON
count        29517   count        28096    count         29344
%TRUE         38.9   ave           11.4    missed           13
                     cur             12

INSTRUCTION 209374                % ACTIVE        FLAGS
[110] W2           dPage  1226    mc1  66.8       LONGT ON
wNULL              dByte   413    mc2  64.2       UNKNT ON
xWn                               bzy   8.4       niFix YES
                   task: Emulator          Task between   4


Data from file:
```

```
Thistle of 11-Oct-78 19:10:20
Data from file: ApexC.tr

!Binary load from file: Thacker.binary
!Input instruction data from: OneFP.params
-- One Full Page display 37.5 frames/sec
!Alto Display off
!Run (1:14:12)

TIME                  MEMORY      PENDING      @
usec         708837   mc1    17   strtMC2  11  6    pc  370
cycles      8339267   mc2     0   newInOK   0  6    buff  7
nxtDisp     8339323   lstMem  E   transfr   1 13
nxtRef      8339584


EMULATOR TASK            %      WAIT                    %
run         3853042    46.2     mc1           633951    7.6
totWait     1874306    22.4     mc2           661150    7.9
                                suspend       379573    4.5
                                NewInst       199632    2.3

DISPLAY TASK             %      WAIT                    %
run         1561730    18.7     mc1           688719    8.2
totWait      878152    10.5     mc2                0    0.0
                                suspend       189433    2.2

REFRESH TASK             %      WAIT                    %
run          142140     1.7     mc1            19631    0.2
totWait       29897     0.3     suspend        10266    0.1

COND JUMPS          ST LINE CODE          DISPLAY ON
count       29517   count       28096     count        32322
%TRUE        38.9   ave          11.4     missed           0
                    cur            12

INSTRUCTION 209374                % ACTIVE        FLAGS
[110] W2            dPage  1226   mc1  55.6       LONGT ON
wNULL               dByte   413   mc2  51.1       UNKNT ON
xWn                               bzy  12.0       niFix YES
                  task: Emulator          Task between   4


Data from file:
```

```
Thistle of 11-Oct-78 19:10:20
Data from file: ApexC.tr

!Binary load from file: Thacker.binary
!Input instruction data from: TwoFP.params
-- Two Full Page displays 37.5 frames/sec
!Alto Display off
!Run (1:16:45)

TIME                MEMORY      PENDING      @
usec        737939  mc1    17   strtMC2  11  6   pc  370
cycles     8681643  mc2     0   newInOK   0  6   buff  7
nxtDisp    8681689  1stMem  E   transfr   1 13
nxtRef     8681728


EMULATOR TASK          %      WAIT                    %
run        3853042   44.3     mc1          728264    8.3
totWait    1815598   20.9     mc2          550538    6.3
                              suspend      352679    4.0
                              NewInst      184117    2.1

DISPLAY TASK           %      WAIT                    %
run        1792450   20.6     mc1          817988    9.4
totWait    1041087   11.9     mc2               0    0.0
                              suspend      223099    2.5

REFRESH TASK           %      WAIT                    %
run         147972    1.7     mc1           21636    0.2
totWait      31494    0.3     suspend        9858    0.1

COND JUMPS          ST LINE CODE          DISPLAY ON
count      29517    count       28096     count       19343
%TRUE       38.9    ave          11.4     missed      14306
                    cur            12

INSTRUCTION 209374                % ACTIVE        FLAGS
[110] W2            dPage  1226   mc1  58.4       LONGT ON
wNULL               dByte   413   mc2  54.7       UNKNT ON
xWn                               bzy  10.8       niFix YES
                    task: Emulator          Task between   4


Data from file:
```

```
Thistle of 11-Oct-78 19:10:20
Data from file: ApexC.tr

!Binary load from file: Thacker.binary
!Input instruction data from: FourQP.params
-- Four Quarter Page display 30 frames/sec
!Alto Display off
!Run (1:15:49)

TIME                    MEMORY      PENDING      @
usec         716112     mc1    17   strtMC2  11  6    pc  370
cycles      8424856     mc2     0   newInOK   0  6    buff  7
nxtDisp     8424913     lstMem  E   transfr   1 13
nxtRef      8425472


EMULATOR TASK             %        WAIT                    %
run         3853042     45.7       mc1           521485     6.1
totWait     1698736     20.1       mc2           622447     7.3
                                   suspend       369908     4.3
                                   NewInst       184896     2.1

DISPLAY TASK              %        WAIT                    %
run         1793568     21.2       mc1           699547     8.3
totWait      912221     10.8       mc2                0     0.0
                                   suspend       212674     2.5

REFRESH TASK              %        WAIT                    %
run          143604      1.7       mc1            14205     0.1
totWait       23685      0.2       suspend         9480     0.1

COND JUMPS            ST LINE CODE          DISPLAY ON
count       29517     count        28096    count         11278
%TRUE        38.9     ave           11.4    missed            0
                      cur             12

INSTRUCTION 209374                 % ACTIVE          FLAGS
[110] W2              dPage  1226    mc1  54.3         LONGT ON
wNULL                 dByte   413    mc2  50.6         UNKNT ON
xWn                                  bzy  11.9         niFix YES
                      task: Emulator            Task between   4


Data from file:
```

```
Thistle of 11-Oct-78 19:10:20
Data from file: DeskTopA.tr

!Binary load from file: Thacker.binary
!Input instruction data from: OneLF.params
-- One Large Format display 40 frames/sec
!Alto Display off
!Run (56:27)

TIME                    MEMORY      PENDING      @
usec          627988    mc1    17   strtMC2  11  6    pc  370
cycles       7388105    mc2     0   newInOK   0  6    buff  7
nxtDisp      7388215    lstMem  E   transfr   1 13
nxtRef       7388480


EMULATOR TASK             %        WAIT                    %
run          4341575    58.7       mc1           380316    5.1
totWait      1483082    20.0       mc2           463740    6.2
                                   suspend       384616    5.2
                                   NewInst       254410    3.4

DISPLAY TASK              %        WAIT                    %
run          1066988    14.4       mc1           257559    3.4
totWait       345218     4.6       mc2                0    0.0
                                   suspend        87659    1.1

REFRESH TASK              %        WAIT                    %
run           125928     1.7       mc1            17088    0.2
totWait        25314     0.3       suspend         8226    0.1

COND JUMPS          ST LINE CODE          DISPLAY ON
count       16509   count        17877    count        21988
%TRUE        77.4   ave           15.7    missed           0
                    cur             12

INSTRUCTION 166584                 % ACTIVE          FLAGS
[110] W2            dPage  1045    mc1  46.1         LONGT ON
wNULL               dByte   256    mc2  41.2         UNKNT ON
xWn                                bzy  10.5         niFix YES
                    task: Emulator          Task between   4


Data from file:
```

Thistle of 11-Oct-78 19:10:20
Data from file: DeskTopA.tr

!Binary load from file: Thacker.binary
!Input instruction data from: TwoLF.params
-- Two Large Format displays 40 frames/sec
!Alto Display off
!Run (1:08:26)

TIME		MEMORY		PENDING		@		
usec	806689	mc1	17	strtMC2	11	6	pc	370
cycles	9490461	mc2	6	newInOK	0	6	buff	7
nxtDisp	9490567	lstMem	E	transfr	1	13		
nxtRef	9490624							

EMULATOR TASK		%	WAIT		%
run	4341575	45.7	mc1	629409	6.6
totWait	1348104	14.2	mc2	279638	2.9
			suspend	282147	2.9
			NewInst	156910	1.6

DISPLAY TASK		%	WAIT		%
run	2608413	27.4	mc1	763078	8.0
totWait	987757	10.4	mc2	0	0.0
			suspend	224679	2.3

REFRESH TASK		%	WAIT		%
run	161760	1.7	mc1	34723	0.3
totWait	42852	0.4	suspend	8129	0.0

COND JUMPS		ST LINE CODE		DISPLAY ON	
count	16509	count	17877	count	28221
%TRUE	77.4	ave	15.7	missed	24
		cur	12		

INSTRUCTION 166584			% ACTIVE		FLAGS	
[110] W2	dPage	1045	mc1	62.1	LONGT	ON
wNULL	dByte	256	mc2	60.2	UNKNT	ON
xWn			bzy	6.5	niFix	YES
	task: Emulator			Task between		4

Data from file:

Thistle of 11-Oct-78 19:10:20
Data from file: DeskTopA.tr

!Binary load from file: Thacker.binary
!Input instruction data from: OneFP.params
-- One Full Page display 37.5 frames/sec
!Alto Display off
!Run (1:02:19)

TIME		MEMORY		PENDING		@		
usec	689754	mc1	17	strtMC2	11	6	pc	370
cycles	8114764	mc2	0	newInOK	0	6	buff	7
nxtDisp	8114863	lstMem	E	transfr	1	13		
nxtRef	8115008							

EMULATOR TASK		%	WAIT		%
run	4341575	53.5	mc1	458324	5.6
totWait	1356503	16.7	mc2	365828	4.5
			suspend	331054	4.0
			NewInst	201297	2.4

DISPLAY TASK		%	WAIT		%
run	1519932	18.7	mc1	583152	7.1
totWait	734040	9.0	mc2	0	0.0
			suspend	150888	1.8

REFRESH TASK		%	WAIT		%
run	138312	1.7	mc1	16379	0.2
totWait	24402	0.3	suspend	8023	0.0

COND JUMPS		ST LINE CODE		DISPLAY ON	
count	16509	count	17877	count	31452
%TRUE	77.4	ave	15.7	missed	0
		cur	12		

INSTRUCTION 166584			% ACTIVE		FLAGS	
[110] W2	dPage	1045	mc1	49.7	LONGT	ON
wNULL	dByte	256	mc2	46.2	UNKNT	ON
xWn			bzy	9.1	niFix	YES
	task: Emulator			Task between		4

Data from file:

```
Thistle of 11-Oct-78 19:10:20
Data from file: DeskTopA.tr

!Binary load from file: Thacker.binary
!Input instruction data from: TwoFP.params
-- Two Full Page displays 37.5 frames/sec
!Alto Display off
!Run (1:03:28)

TIME                    MEMORY      PENDING       @
usec          704595    mc1    17   strtMC2  11  6    pc  370
cycles       8289360    mc2     5   newInOK   0  6    buff  7
nxtDisp      8289271    lstMem  E   transfr   1 13
nxtRef       8289600


EMULATOR TASK             %        WAIT                    %
run          4341575    52.3        mc1           479809     5.7
totWait      1316634    15.8        mc2           337561     4.0
                                    suspend       315817     3.8
                                    NewInst       183447     2.2

DISPLAY TASK              %        WAIT                    %
run          1619763    19.5        mc1           673523     8.1
totWait       843478    10.1        mc2                0     0.0
                                    suspend       169955     2.0

REFRESH TASK              %        WAIT                    %
run           141288     1.7        mc1            18922     0.2
totWait        26622     0.3        suspend         7700     0.0

COND JUMPS            ST LINE CODE          DISPLAY ON
count        16509    count        17877    count         17479
%TRUE         77.4    ave           15.7    missed        14649
                      cur             12

INSTRUCTION 166584                 % ACTIVE          FLAGS
[110] W2            dPage  1045    mc1  51.5         LONGT ON
wNULL               dByte   256    mc2  48.5         UNKNT ON
xWn                                bzy   8.7         niFix YES
                    task: Emulator          Task between   4


Data from file:
```

Thistle of 11-Oct-78 19:10:20
Data from file: DeskTopA.tr

!Binary load from file: Thacker.binary
!Input instruction data from: FourQP.params
-- Four Quarter Page display 30 frames/sec
!Alto Display off
!Run (1:04:00)

TIME		MEMORY		PENDING		@		
usec	698251	mc1	17	strtMC2	11	6	pc	370
cycles	8214727	mc2	0	newInOK	0	6	buff	7
nxtDisp	8215006	lstMem	E	transfr	1	13		
nxtRef	8214976							

EMULATOR TASK		%	WAIT		%
run	4341575	52.8	mc1	354519	4.3
totWait	1218655	14.8	mc2	345332	4.2
			suspend	322285	3.9
			NewInst	196519	2.3

DISPLAY TASK		%	WAIT		%
run	1749496	21.2	mc1	571884	6.9
totWait	744239	9.0	mc2	0	0.0
			suspend	172355	2.0

REFRESH TASK		%	WAIT		%
run	140016	1.7	mc1	12885	0.1
totWait	20746	0.2	suspend	7861	0.0

COND JUMPS		ST LINE CODE		DISPLAY ON	
count	16509	count	17877	count	10997
%TRUE	77.4	ave	15.7	missed	0
		cur	12		

INSTRUCTION 166584			% ACTIVE		FLAGS	
[110] W2	dPage	1045	mc1	48.4	LONGT	ON
wNULL	dByte	256	mc2	45.7	UNKNT	ON
xWn			bzy	9.3	niFix	YES
	task: Emulator			Task between		4

Data from file:

```
Thistle of 11-Oct-78 19:10:20
Data from file: DeskTopB.tr

!Binary load from file: Thacker.binary
!Input instruction data from: OneLF.params
-- One Large Format display 40 frames/sec
!Alto Display off
!Run (41:25)

TIME                    MEMORY      PENDING       @
usec         478097     mc1    17   strtMC2  11  6    pc  370
cycles      5624680     mc2     0   newInOK   0  6    buff  7
nxtDisp     5624887     lstMem  E   transfr   1 13
nxtRef      5624960


EMULATOR TASK             %        WAIT                    %
run          3404682    60.5        mc1           247353    4.3
totWait      1040486    18.4        mc2           322716    5.7
                                    suspend       288864    5.1
                                    NewInst       181553    3.2

DISPLAY TASK              %        WAIT                    %
run           812396    14.4        mc1           187895    3.3
totWait       252699     4.4        mc2                0    0.0
                                    suspend        64804    1.1

REFRESH TASK              %        WAIT                    %
run            95868     1.7        mc1            12475    0.2
totWait        18549     0.3        suspend         6074    0.1

COND JUMPS            ST LINE CODE          DISPLAY ON
count       13795     count       14167     count        16740
%TRUE        82.2     ave          15.1     missed           0
                      cur            12

INSTRUCTION 121125                  % ACTIVE        FLAGS
[110] W2            dPage   637     mc1  44.0       LONGT ON
wNULL               dByte   242     mc2  39.7       UNKNT ON
xWn                                 bzy  10.1       niFix YES
                    task: Emulator          Task between   4


Data from file:
```

```
Thistle of 11-Oct-78 19:10:20
Data from file: DeskTopB.tr

!Binary load from file: Thacker.binary
!Input instruction data from: TwoLF.params
-- Two Large Format displays 40 frames/sec
!Quit [Confirm]XXX
!Alto Display off
!Run (50:33)

TIME                  MEMORY      PENDING      @
usec         611508   mc1    17   strtMC2  11  6    pc  370
cycles      7194214   mc2     0   newInOK   0  6    buff  7
nxtDisp     7194343   lstMem  E   transfr   1 13
nxtRef      7194880


EMULATOR TASK            %       WAIT                    %
run         3404682    47.3      mc1           417800     5.8
totWait      940683    13.0      mc2           198160     2.7
                                 suspend       214399     2.9
                                 NewInst       110324     1.5

DISPLAY TASK             %       WAIT                    %
run         1977801    27.4      mc1           551325     7.6
totWait      716803     9.9      mc2                0     0.0
                                 suspend       165478     2.3

REFRESH TASK             %       WAIT                    %
run          122628     1.7      mc1            25694     0.3
totWait       31617     0.4      suspend         5923     0.0

COND JUMPS          ST LINE CODE          DISPLAY ON
count       13795   count       14167     count        21399
%TRUE        82.2   ave          15.1     missed          12
                    cur            12

INSTRUCTION 121125                % ACTIVE        FLAGS
[110] W2            dPage   637   mc1  60.5       LONGT ON
wNULL               dByte   242   mc2  59.1       UNKNT ON
xWn                               bzy   6.3       niFix YES
                    task: Emulator          Task between   4


Data from file:
```

Thistle of 11-Oct-78 19:10:20
Data from file: DeskTopB.tr

!Binary load from file: Thacker.binary
!Input instruction data from: OneFP.params
-- One Full Page display 37.5 frames/sec
!Alto Display off
!Run (45:38)

TIME		MEMORY		PENDING		@		
usec	524298	mc1	17	strtMC2	11	6	pc	370
cycles	6168220	mc2	0	newInOK	0	6	buff	7
nxtDisp	6168253	lstMem	E	transfr	1	13		
nxtRef	6168448							

EMULATOR TASK		%	WAIT		%
run	3404682	55.1	mc1	307594	4.9
totWait	953094	15.4	mc2	253080	4.1
			suspend	249484	4.0
			NewInst	142936	2.3

DISPLAY TASK		%	WAIT		%
run	1155219	18.7	mc1	420492	6.8
totWait	532009	8.6	mc2	0	0.0
			suspend	111517	1.8

REFRESH TASK		%	WAIT		%
run	105132	1.7	mc1	12176	0.1
totWait	18084	0.2	suspend	5908	0.0

COND JUMPS		ST LINE CODE		DISPLAY ON	
count	13795	count	14167	count	23907
%TRUE	82.2	ave	15.1	missed	0
		cur	12		

INSTRUCTION 121125				% ACTIVE		FLAGS	
[110] W2		dPage	637	mc1	47.7	LONGT	ON
wNULL		dByte	242	mc2	44.8	UNKNT	ON
xWn				bzy	8.8	niFix	YES
		task: Emulator				Task between	4

Data from file:

```
Thistle of 11-Oct-78 19:10:20
Data from file: DeskTopB.tr

!Binary load from file: Thacker.binary
!Input instruction data from: TwoFP.params
-- Two Full Page displays 37.5 frames/sec
!Alto Display off
!Run (47:46)

TIME                    MEMORY      PENDING      @
usec          536090    mc1    17   strtMC2  11  6    pc  370
cycles       6306951    mc2     0   newInOK   0  6    buff  7
nxtDisp      6307057    lstMem  E   transfr   1 13
nxtRef       6307136


EMULATOR TASK             %       WAIT                    %
run          3404682    53.9       mc1           320479    5.0
totWait       922101    14.6       mc2           234957    3.7
                                   suspend       238027    3.7
                                   NewInst       128638    2.0

DISPLAY TASK              %       WAIT                    %
run          1235360    19.5       mc1           491675    7.7
totWait       617699     9.7       mc2                0    0.0
                                   suspend       126024    1.9

REFRESH TASK              %       WAIT                    %
run           107496     1.7       mc1            14006    0.2
totWait        19613     0.3       suspend         5607    0.0

COND JUMPS          ST LINE CODE          DISPLAY ON
count       13795   count       14167     count        13328
%TRUE        82.2   ave          15.1     missed       11117
                    cur            12

INSTRUCTION 121125                  % ACTIVE        FLAGS
[110] W2            dPage   637     mc1  49.7       LONGT ON
wNULL               dByte   242     mc2  47.2       UNKNT ON
xWn                                 bzy   8.3       niFix YES
                    task: Emulator          Task between   4


Data from file:
```

Thistle of 11-Oct-78 19:10:20
Data from file: DeskTopB.tr

!Binary load from file: Thacker.binary
!Input instruction data from: FourQP.params
-- Four Quarter Page display 30 frames/sec
!Alto Display off
!Run (1:03:03)

TIME		MEMORY		PENDING		@		
usec	531446	mc1	17	strtMC2	11	6	pc	370
cycles	6252309	mc2	0	newInOK	0	6	buff	7
nxtDisp	6252637	lstMem	E	transfr	1	13		
nxtRef	6252928							

EMULATOR TASK		%	WAIT		%
run	3404682	54.4	mc1	235360	3.7
totWait	860832	13.7	mc2	240915	3.8
			suspend	243901	3.9
			NewInst	140656	2.2

DISPLAY TASK		%	WAIT		%
run	1332464	21.3	mc1	406184	6.4
totWait	532844	8.5	mc2	0	0.0
			suspend	126660	2.0

REFRESH TASK		%	WAIT		%
run	106572	1.7	mc1	8994	0.1
totWait	14915	0.2	suspend	5921	0.0

COND JUMPS		ST LINE CODE		DISPLAY ON	
count	13795	count	14167	count	8370
%TRUE	82.2	ave	15.1	missed	0
		cur	12		

INSTRUCTION 121125			% ACTIVE		FLAGS	
[110] W2	dPage	637	mc1	46.5	LONGT	ON
wNULL	dByte	242	mc2	44.3	UNKNT	ON
xWn			bzy	9.0	niFix	YES
	task: Emulator			Task between		4

Data from file:

```
Thistle of 11-Oct-78 19:10:20
Data from file: DTestA.tr

!Binary load from file: Thacker.binary
!Input instruction data from: OneLF.params
-- One Large Format display 40 frames/sec
!Quit [Confirm]XXX
!Alto Display off
!Run (3:30:03)

TIME                  MEMORY      PENDING      @
usec       2225385    mc1    17   strtMC2  11  6    pc  370
cycles    26181006    mc2     0   newInOK   0  6    buff  7
nxtDisp   26181031    lstMem  E   transfr   1 13
nxtRef    26181056


EMULATOR TASK            %       WAIT                    %
run        13687458    52.2      mc1          2005059    7.6
totWait     6798525    25.9      mc2          2812289   10.7
                                 suspend      1514457    5.7
                                 NewInst       466720    1.7

DISPLAY TASK             %       WAIT                    %
run         3780205    14.4      mc1          1015814    3.8
totWait     1367606     5.2      mc2                0    0.0
                                 suspend       351792    1.3

REFRESH TASK             %       WAIT                    %
run          446256     1.7      mc1            71982    0.2
totWait      100956     0.3      suspend        28974    0.1

COND JUMPS          ST LINE CODE          DISPLAY ON
count       45197   count       73266     count        77919
%TRUE        38.1   ave          10.3     missed           0
                    cur            12

INSTRUCTION 468492                % ACTIVE        FLAGS
[110] W2            dPage  2765   mc1  51.8       LONGT ON
wNULL               dByte    57   mc2  45.1       UNKNT ON
xWn                               bzy  12.4       niFix YES
                    task: Emulator          Task between   4


Data from file:
```

```
Thistle of 11-Oct-78 19:10:20
Data from file: blThacker.binary

Data from file: DTestA.tr

!Binary load from file: Thacker.binary
!Input instruction data from: TwoLF.params
-- Two Large Format displays 40 frames/sec
!Alto Display off
!Run (4:12:53)

TIME                  MEMORY      PENDING      @
usec        2856278   mc1    17   strtMC2  11  6    pc  370
cycles     33603282   mc2     0   newInOK   0  6    buff  7
nxtDisp    33603271   lstMem  E   transfr   1 13
nxtRef     33603328


EMULATOR TASK            %       WAIT                    %
run        13687458    40.7      mc1          3147874     9.3
totWait     6188813    18.4      mc2          1652542     4.9
                                 suspend      1117838     3.3
                                 NewInst       270559     0.8

DISPLAY TASK             %       WAIT                    %
run         9240643    27.4      mc1          2882999     8.5
totWait     3751331    11.1      mc2                0     0.0
                                 suspend       868332     2.5

REFRESH TASK             %       WAIT                    %
run          572772     1.7      mc1           131125     0.3
totWait      162265     0.4      suspend        31140     0.0

COND JUMPS           ST LINE CODE          DISPLAY ON
count       45197    count       73266     count        100003
%TRUE        38.1    ave          10.3     missed            6
                     cur            12

INSTRUCTION 468492                % ACTIVE        FLAGS
[110] W2           dPage  2765    mc1  66.6       LONGT ON
wNULL              dByte    57    mc2  63.3       UNKNT ON
xWn                               bzy   7.6       niFix YES
                   task: Emulator          Task between   4


Data from file:
```

```
Alto/Mesa 4.1 of 30-Aug-78  9:48
12-Oct-78  9:22
>Thistle -- 146604B
Tables loaded from Thistle.binary
Thistle of 11-Oct-78 19:10:20
Data from file: DTestA.tr

!Binary load from file: Thacker.binary
!Input instruction data from: OneFP.params
-- One Full Page display 37.5 frames/sec
!D0 Display off
!Alto Display off
!D0 Display on
!Run (3:49:49)

TIME                  MEMORY      PENDING      @
usec        2432034   mc1    17   strtMC2  11  6    pc  370
cycles     28612171   mc2     0   newInOK   0  6    buff  7
nxtDisp    28612200   lstMem  E   transfr   1 13
nxtRef     28612672

EMULATOR TASK            %       WAIT                    %
run         13687458    47.8     mc1          2282026     7.9
totWait      6167919    21.5     mc2          2203124     7.6
                                 suspend      1311729     4.5
                                 NewInst       371040     1.2

DISPLAY TASK             %       WAIT                    %
run          5358339    18.7     mc1          2227346     7.7
totWait      2815023     9.8     mc2                0     0.0
                                 suspend       587677     2.0

REFRESH TASK             %       WAIT                    %
run           487704     1.7     mc1            66931     0.2
totWait        95728     0.3     suspend        28797     0.1

COND JUMPS          ST LINE CODE          DISPLAY ON
count       45197   count       73266     count       110899
%TRUE        38.1   ave          10.3     missed           0
                    cur            12

INSTRUCTION 468492                % ACTIVE        FLAGS
[110] W2            dPage  2765   mc1  55.1       LONGT ON
wNULL               dByte    57   mc2  49.8       UNKNT ON
xWn                               bzy  10.7       niFix YES
                    task: Emulator          Task between   4


Data from file:
```

Thistle of 11-Oct-78 19:10:20
Data from file: DTestA.tr

!Binary load from file: Thacker.binary
!Input instruction data from: TwoFP.params
-- Two Full Page displays 37.5 frames/sec
!Alto Display off
!Run (3:53:54)

TIME		MEMORY		PENDING		@		
usec	2475519	mc1	17	strtMC2	11	6	pc	370
cycles	29123766	mc2	5	newInOK	0	6	buff	7
nxtDisp	29123545	lstMem	E	transfr	1	13		
nxtRef	29123776							

EMULATOR TASK		%	WAIT		%
run	13687458	46.9	mc1	2374882	8.1
totWait	5975763	20.5	mc2	1984234	6.8
			suspend	1260351	4.3
			NewInst	356296	1.2

DISPLAY TASK		%	WAIT		%
run	5668926	19.4	mc1	2543619	8.7
totWait	3194246	10.9	mc2	0	0.0
			suspend	650627	2.2

REFRESH TASK		%	WAIT		%
run	496416	1.7	mc1	72245	0.2
totWait	100957	0.3	suspend	28712	0.0

COND JUMPS		ST LINE CODE		DISPLAY ON	
count	45197	count	73266	count	61192
%TRUE	38.1	ave	10.3	missed	51689
		cur	12		

INSTRUCTION 468492			% ACTIVE		FLAGS	
[110] W2	dPage	2765	mc1	56.8	LONGT	ON
wNULL	dByte	57	mc2	52.0	UNKNT	ON
xWn			bzy	10.2	niFix	YES
	task: Emulator			Task between		4

Data from file:

```
Alto/Mesa 4.1 of 30-Aug-78  9:48
12-Oct-78 14:04
>Thistle -- 146604B
Tables loaded from Thistle.binaryThistle of 11-Oct-78 19:10:20
Data from file: DTestA.tr

!Binary load from file: Thacker.binary
!Input instruction data from: FourQP.params
-- Four Quarter Page display 30 frames/sec
!Alto Display off
!Run (3:56:49)

TIME                    MEMORY      PENDING      @
usec        2457841     mc1    17   strtMC2  11  6    pc  370
cycles     28915791     mc2     0   newInOK   0  6    buff  7
nxtDisp    28915870     lstMem  E   transfr   1 13
nxtRef     28916096


EMULATOR TASK             %        WAIT                    %
run        13687458    47.3        mc1          1878348    6.4
totWait     5540649    19.1        mc2          2045320    7.0
                                   suspend      1275712    4.4
                                   NewInst       341269    1.1

DISPLAY TASK              %        WAIT                    %
run         6157368    21.2        mc1          2289070    7.9
totWait     2957370    10.2        mc2                0    0.0
                                   suspend       668300    2.3

REFRESH TASK              %        WAIT                    %
run          492876     1.7        mc1            51942    0.1
totWait       80070     0.2        suspend        28128    0.0

COND JUMPS          ST LINE CODE          DISPLAY ON
count       45197   count       73266     count        38709
%TRUE        38.1   ave          10.3     missed           0
                    cur            12

INSTRUCTION 468492                % ACTIVE        FLAGS
[110] W2            dPage  2765   mc1  53.8       LONGT ON
wNULL               dByte    57   mc2  49.4       UNKNT ON
xWn                               bzy  10.8       niFix YES
                    task: Emulator          Task between   4


Data from file:
```