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Bell Laboratories

subject: Performance Measurement of the File Access Subsystem - A UNIX-Based System

date: May 21, 1975

from: G. C. Vogel
MF-75-8234-54

ABSTRACT

As a result of new requirements placed on the File Access Subsystem (FAS) the FAS Development Group (Dept. 5215) was asked to define the capacity limits of the current FAS and to determine what could be done to extend the capacity to meet future needs. The FAS Development Group had made no previous performance measurements and was unaware of any spare capacity or bottlenecks. The UNIX Support Group was requested to make and interpret hardware monitor measurements.

Measurements were taken on April 10,1975 at the Toms River FAS (a New Jersey Bell installation) running at several load levels. Analysis of the data revealed that increased capacity could be achieved by reducing the load on the RK disk. It was recommended that the memory be increased by 32K words (about $9,000) to reduce the swapping load on the disk.

On May 13,1975, after increasing the FAS memory size by the recommended amount, the system was tested under increased loads. An increase in capacity of more than 60% was observed.

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MEMORANDUM FOR FILE

I. INTRODUCTION

The File Access Subsystem (FAS) of the Automatic Intercept System (AIS) is a UNIX-based system that is used to administer the intercept number data base of the AIS. The AIS is designed to automate the processing of calls to non-working numbers. When a call is made to a non-working number, it is routed to an Automatic Intercept Center (AIC) where the intercept number data base is consulted and a customized announcement is generated from prerecorded phrases.

An AIS may include from one to five AICs, each with the capacity of handling about 200,000 intercepted calls per day. Since each AIC handles such a large volume of calls, there are frequently only one or two AICs per operating company unit. For example, one AIS with two AICs now serves the state of New Jersey. FAS was originally designed to handle one or two AICs. At Toms River, New Jersey an FAS is handling the state's two AICs that require up to 18,000 updates (total) per day.

Other operating telephone companies, in particular Illinois Bell, now foresee a need for an AIS with three AICs and would like to purchase a single FAS to serve all three AICs. Another company is even considering an AIS with the maximum of five AICs.

As a result of this new requirement the FAS Development Group (Dept. 5215) was asked to define the capacity limits of the current FAS and to determine what can be done to extend the capacity to meet future needs. The FAS Development Group had made no previous performance measurements and was unaware of any spare capacity or bottlenecks. The UNIX Support Group was requested to make and interpret hardware monitor measurements in order to make a timely response to the above questions.

II. CONCLUSIONS

Measurements made on the FAS system at Toms River, New Jersey and analysis of that data resulted in the following answers to the FAS capacity concern:

(i) FAS performance in terms of number of AICs served is inappropriate. The increased load of an additional AIC is small in terms of the overall Update function. A more appropriate capacity metric is the number of transactions per unit time.

The present FAS hardware configuration has a maximum capacity of about 34,000 transactions per 8-hour shift. Higher loading of the FAS would result in increased delays experienced by clerks entering updates. Indeed, it may be true that loads greater than this maximum can not be entered. On the other hand, by spreading the work over a longer period of time, the number of transactions handled by the present configuration could be increased by a factor of two or three.

(ii) Increased capacity could be achieved by reducing the load on the RK disk, which is the limiting resource in the current FAS configuration. The most cost-effective means of reducing the RK disk load is to reduce the amount of swapping by adding additional core memory.

The benefits from increasing the amount of memory will be significant up to about 72K words total. (This assumes 20 terminals simultaneously entering updates to 2 AICs.) Further increases will be of marginal benefit, since the most active programs used for updating will fit in this amount of core memory.

(iii) Handling of many synchronous lines simultaneously could result in data overruns leading to excessive retransmissions. The retransmissions would then appear as increased synchronous line usage that further aggravates the problem.

The solution appears to be straight forward. First, determine the maximum allowable delay in handling a synchronous line interrupt. For a 2000 bps line this is 4 milliseconds. Then sum the processor time required to service all probable interrupts that could occur during this time at equal or higher priorities. (This means the clock, disk, magnetic tape drive, and other synchronous lines.) If the processing time is about the same as the allowable delay or less, the probability of losing characters due to data overrun is low.

If all of the synchronous lines can not be run simultaneously, certainly a subset can. The duty cycle (synchronous line busy) of the AIC lines is typically less than 25%. The overall throughput of the system would remain essentially the same if an M out of N (M<N) software lock were imposed. This lock would insure that only as many lines as can reasonably be serviced would be active simultaneously.

(iv) The ultimate transaction capacity of an FAS can not be predicted accurately from the measurements discussed here. What has been shown is that at full load in the particular configuration measured, the limiting resource was the RK disk.

The fraction of the load on the RK disk due to swapping as opposed to file system usage was not directly measured. Therefore, it is difficult to quantify how much increased capacity can be achieved by adding additional core memory. However, there are indications that the amount of disk usage due to swapping may be in the order of 25% or more. If this is true, the addition of 32K words of memory (about $9,000) should result in increased transaction handling capacity of 30% or more. With such an increase one FAS could handle more than the present maximum of two AICs.

III. EPILOGUE

On May 13, 1975, after adding an additional 32K words of core memory, the Toms River FAS was measured again. The results (see Table 10) confirmed the estimates made from earlier measurements. The system handled 18 active clerical work stations (the maximum number available at Toms River) with immediate response. The capacity limit for this enhanced configuration is about 7,200 transactions per hour or 57,600 transactions per 8-hour shift (20 active clerical work stations at 6 transactions per minute to 2 AICs).

An effort was made to determine the effect of transmitting to additional AICs. Measurements were taken during transmission to 1 and 2 AICs with 0 terminals active but with batches queued for transmission. The results (see Table 11) show that the addition of a second AIC requires about 10% of the processor and RK disk capacities. Therefore, in projecting FAS capacity to systems with more than 2 AICs, it is necessary to diminish the transaction capacity by about 10% for each additional AIC after the first 2. It will also be necessary to adjust the memory requirements to prevent an increase in swapping.

IV. FAS OPERATION

The major function of the FAS is to update the AIC intercept number data base. Each AIC has a duplicated disk file with a capacity of up to 2,400,000 entries. Each telephone number stored on the disk requires one or two 48 bit data words. Entries with no new number use one disk word, while entries with a referral number require two words. Each entry contains the intercepted telephone number (called number), a two-digit status code, a count of calls to the intercepted number and, if appropriate, a new number (referral number). The status code indicates why the number is on intercept, and what kind of announcement should be given. In cases where a tens, hundreds, or thousands group of telephone numbers has a common status (e.g. vacant) the group is stored as a single entry called a block entry.

Telephone service orders are used by FAS clerks to enter update messages about a change in telephone service. If a telephone is to be disconnected, then that number should be placed in the AIC data base before the actual plant work is done. If a new telephone is being installed, the number should be deleted from the intercept number data base after the plant work is completed.

The only penalty for inserting intercept numbers too early or deleting working numbers too late is lost disk space, while if numbers are inserted late or removed early, the AIC will issue not-in-file (NIF) messages and the customer will be given an incorrect announcement.

Update messages are entered at clerical work stations (RT02s or VT05s) directly from service orders. The updates, inserts and deletes, are checked for proper syntax as they are entered. If an error is detected, the clerk is given the capability to change the erroneous portion.

The update messages are buffered and grouped into numbered and time-stamped batches that are always less than or equal to 512 bytes. When the update buffer has been filled and a batch has been generated, the clerk is notified via a message on the work station. All service orders associated with this batch are then set aside as a group. A batch can also be forced before the buffer is full by issuing an end-of-batch request at the work station.

The updates, organized in batches, are recorded on magnetic tape (the journal tape) and then transmitted via synchronous line to the AIC. The actual changes to the data base are made at the AIC. If inconsistencies are found, such as attempting to insert a number that is already in the data base or attempting to delete a number that is not in the data base, an exception message is generated and returned to the

FAS via data link. The exception messages are appended to the batch of updates and listed on the line printer. These reports are then distributed to the clerks for resolution of the inconsistencies and for a record of completed work.

V. FAS SOFTWARE ORGANIZATION

The FAS Update program consists of a series of independent processes connected by queues through which each batch of updates is passed. (See figure 1). The process that reads update messages from a terminal and batches them is named INPUT. After INPUT has queued a batch, the JOURN process reads the batch from the queue and writes it on a magnetic tape called the journal tape. The journal tape can be used to reenter the transactions in case of system failure. JOURN then queues the batch for the TRANS process. TRANS transmits the batch of updates to the appropriate AIC, and waits for a response. Update messages which attempt to insert a number that is already in the file, or delete a number that is not in the file, cause the AIC to generate exception messages that are transmitted via synchronous line to the FAS. When the AIC has finished processing the batch, both the update messages and the exception messages are queued for the UPRINT process, which prints them on the line printer.

Batches may also be read from magnetic tape by the TAPIN process. The batches are read from the tape and passed directly to the TRANS queue.

When a change is made to a number that is contained in a block entry, the block must first be replaced by the equivalent individual entries and, possibly, smaller block entries. This procedure is called block expansion and is accomplished by use of the EXPAND process. EXPAND allows a clerk to specify the block entry and how it is to be broken down. EXPAND generates the required insert and delete messages, forms a batch, and queues the batch for the TRANS process.

VI. FAS HARDWARE CONFIGURATION

Figure 2 shows a typical FAS hardware configuration. The Toms River FAS is configured as follows:

1	PDP*11/40 Processor with 40K words of core memory
1	RK11 moving head cartridge disk, 1.2 million words
2	TU10 magnetic tape drives, 9-track, 800 bpi
2	DP11 synchronous line interfaces connected to Bell System 201 data sets, 2000 bps
18	RT02 Remote Data Entry Terminals, 1200 bps (clerical work stations)
1	LP11FA line printer, 350 lpm
2	VT05 CRT console terminals, 1200 bps

VII. UNIX MEASUREMENTS

The measurements discussed in this memorandum were made with the Comress Dyna-Myte Model 8016 hardware monitor. (Comress is a division of Comten, Inc.) This monitor takes 100,000 equally spaced samples over a variable length of time. The total number of "1"s of a Boolean variable is divided by 1000 and interpreted as a percentage. For example, if a 10 second interval were used, the samples would be taken every 100 microseconds. If the probe point were logically true for 15,000 of these samples, the condition associated with that probe point would be interpreted as occurring 15% of the time.

Several measurements were taken with the hardware monitor on the FAS Development Group's PDP-11/40 system running standard UNIX programs. The objectives were to:

1. Verify that the probe points were giving reasonable results.
2. Determine the background UNIX resource usage (overhead).
3. Establish resource usage levels for some common operations.
4. Simulate the swapping that occurs when FAS is running the Update function.

The results are listed in Tables 1 and 2. The numbers are averages of two or three runs taken over a reasonably short time period, approximately 1 minute total. Therefore, it should be recognized that there may be substantial errors in these numbers.

Both raw and corrected measurements appear in Table 1. Correction is necessary to separate the processor activity due to a specific load from the activity generated by clock

*PDP is a trademark of the Digital Equipment Corporation.

interrupts during the WAIT instruction and other UNIX overhead. The formula for making this correction is shown in Table 1.

The UNIX idle measurement was made with UNIX running but with no user processes active. The 8.3% processor activity is misleadingly high. When UNIX has nothing to do, it executes a WAIT instruction which releases the UNIBUS and suspends processor activity until an interrupt occurs. If a clock interrupt occurs while the processor is WAITING, the SWITCH system routine is executed before the processor returns to the WAIT instruction. Thus, when UNIX has nothing to do, the SWITCH routine is executed every clock tick (17 milliseconds). When the processor is busy with a user process, only the clock handler is executed every clock tick.

The SUM command was used on the RK disk to force high disk activity.

Several measurements were taken to give a rough idea of the processor load due to various forms of character I/O. Driving the line printer (350 lines per minute, 80 columns) with either CAT or LPR required about 40% of the processor. Terminals printing at 1200 bps use about 16% of the processor capacity each.

A compute-bound C program was written consisting of a small looping portion and a large data array. No system calls were made. When one such process was run, the processor was 100% active with 98.4% in user mode. This suggests that under this load UNIX overhead is only 1.6%. The RK disk activity was very small. When a second process was added the processor activity decreased to 86% (82% in user mode) and the RK BUSY became 18%. The increase is understandable since only one of these processes could reside in core at a time and the processes are switched approximately once per second. Measurements were made with 3 and 10 such processes active simultaneously. Three processes produced 77% processor ACTIVE, 71% USER mode, and 28% RK BUSY. The addition of processes beyond three had only a slight effect on the results.

Table 2 shows the results of running both small and large CPU bound processes. The large program was the same as used to obtain the measurements in Table 1. The small program had the same CPU loop but had a much smaller data array. The results obtained running 4 small programs and 2 large programs is of particular interest because, as will be discussed later, it may generate approximately the same swapping activity as the FAS Update processes.

VIII. FAS MEASUREMENTS

Two measurements were made on the FAS Development Group's machine running FAS programs. First, the Update function was started and measurements were taken with 3 terminals logged on but not active. The results (See Table 3) are about the same as for the UNIX idle measurement. Next, update messages were entered on the 3 terminals, at an average rate of 8.5 seconds per transaction. Batches were generated, journalled and queued for transmission to an AIC as in an operating company system except that they could not be transmitted and printed. That is, everything up to the actual transmission to an AIC was done. These 3 terminals increased the processor ACTIVE to 21% and RK BUSY to 30%.

In addition to the Update function, FAS can perform a data base backup function. This is done by the AIC transmitting disk file data to the FAS via the synchronous data link and writing the data on magnetic tape. Measuring this function is useful for identifying the processor activity associated with running the synchronous line since the Backup function involves little processing other than receiving data from the data link and writing it on magnetic tape. Using the Backup function a DP BUSY measurement of 61% had a corresponding CORRECTED ACTIVE measurement of 12.6%. This implies that a 2000 bps synchronous line 100% busy would require about 20% of the 11/40 processor capacity.

Measurements were taken on April 10, 1975 at the Toms River FAS (a New Jersey Bell installation) running Update at several load levels. (See Tables 4 through 9.) Since the measurements were being taken on an active operating telephone company system, the number of clerks logged on during a measurement, as well as the rate at which the update messages were being entered, was subject to normal operating fluctuations. It was necessary to run a status report program to determine how many clerks were logged on at any given time. The procedure used was to run the status report program, take several measurements, run the status reporting program again, and compute the average number of clerks logged on.

Measurements were taken over 1 minute and 5 second intervals. The 5 second intervals are most useful since they show the variability of measurements on the time scale of interest.

The operating conditions and measurement parameters are listed in tables 4 through 9. For loadings up to 7 active terminals, the delays occurring at the end of each update message averaged less than 2 seconds. However, delays of 5 to 10 seconds were occasionally experienced. These long delays are probably caused by the generation of a new batch from the INPUT process.

The 5 second interval measurements (Tables 7 through 9) indicate that under a load of about 7 active terminals the RK disk frequently reached high busy levels although the average activity is in the 50% to 60% range. As the number of active clerical work stations increases to 12, the average delay time increases sharply to between 3 and 4 seconds, with more frequent 10 second delays.

The following diagram gives a breakdown of the time required to complete a typical update transaction.

```
          Enter Update                Get Next             Wait
Clerk:    Message                     Service Order
          |__________________________|__________________|_______|
                                     |                          |
System:                              Process Update Message
```

The average transaction time, measured on systems that have average processing delays of about 2 seconds or less, is 10 seconds per transaction. After entering an update message, a clerk spends a short time, in the order of 2 seconds, examining the next service order. Therefore, processing delays of about 2 seconds or less have little effect on the rate at which clerks can enter update messages. Delays in excess of the time it takes to read the next service order require the clerk to wait. At a loading of about 11 clerks the RK disk becomes saturated: RK BUSY 92% with a mean deviation of 8%. Processing delays average between 3 and 4 seconds with frequent delays up to 10 seconds. Adding more active terminals would not significantly increase the number of transactions entered.

IX. OBSERVATIONS

9.1 FAS CAPACITY

FAS capacity should be measured in terms of transactions per hour rather than number of AICs supported.

The processor load imposed by a synchronous line connected to an AIC is estimated to be about 5%. (A 100% busy synchronous line uses about 20% of the processor capacity. A synchronous line to an AIC is in use about 25% of the time.) The current FAS has the capacity to handle about 12 clerks typing update messages at the rate of 6 transactions per minute (4,320 transactions per hour). Care should be exercised when extrapolating this figure to a daily rate, since no allowance is made for system down time or time when less than 12 clerks are active.

If the maximum rate were continued for one 8-hour shift, the present FAS configuration could handle 34,560 update transactions per day. By this measure the present FAS configuration might be considered capable of handling 4 AICs. (The Toms River FAS, with 2 AICs, handles about 10,000 transactions per day on the average and up to 18,000 per day during peak seasons.)

In practice, the Toms River FAS occasionally experiences "excessive" delays even though their average rate is well below the FAS maximum theoretical daily capacity. Therefore, careful attention should be given to load balancing in order to achieve daily rates closer to the theoretical maximum. Entering updates in bursts should be avoided. More uniform loading might be achieved through improved operating instructions and some software features that notify clerks when the system is lightly loaded.

9.2 ADDITIONAL CORE MEMORY

Nearly all swapping could be eliminated by increasing the FAS memory by 32K words to a total of 72K words. The question of how much this would reduce the load on the RK disk is complex, since no direct measurement of the amount of swapping was made. However, based on the characteristics of the update processes, estimates of the amount of swapping can be made.

The average batch of updates contains 28 transactions: 50% delete and 50% insert with 20% of the inserts containing a new number. Inserts with a new number require two lines of input, while all other transactions require only one line. Thus, about 31 lines are entered for each batch. We assume that the INPUT process performs a small amount of processing for each line entered so that the process completes before it is swapped out of core. For an average transaction time of 10 seconds, each INPUT process would be active about every 9 seconds (once per line). JOURN, TRANS and UPRINT make requests to the file system that result in I/O blocking. During some of these blocked periods, it is likely that the process will be swapped. It is estimated that the JOURN process is swapped about 5 times per batch. TRANS and UPRINT are probably swapped about 2 times per batch. With 11 clerks actively entering update messages, this gives estimated swapping rates of about once every 6 seconds for JOURN and once every 12 seconds for TRANS and UPRINT. The total FAS Update swapping rate is estimated to be about 1 swap per second.

Recall from Table 2 that six CPU bound processes, 2 large (>8K words) and 4 small (0.2K words), created a 23% RK BUSY load that can be attributed to swapping. For a compute-bound jobstream, processes are swapped approximately once per second. Thus, the FAS Update processes probably generate about the same amount of swapping as these six CPU bound processes. Estimation of the actual FAS swapping load on the RK disk is complicated by the fact that the swap space and the file system space are on different parts of the disk, requiring substantially more head movement for the same amount of swapping. Therefore, the simulation with CPU bound processes probably underestimates the actual FAS swapping load on the RK disk.

It would be unwise to predict more that a 30% improvement in FAS capacity (updates per hour) as a result of simply adding additional core memory. More accurate predictions for larger increases could be obtained by making measurements on a FAS with more core. One proposal now under discussion is to temporarily put an additional 32K words of core memory on the Toms River FAS and then take measurements under increased loads.

X. ACKNOWLEDGEMENTS

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2. F. S. Menzel, "Administration of the Automatic Intercept System Data Base Using the File Access Subsystem," TM-75-5215-1, March 3, 1975.

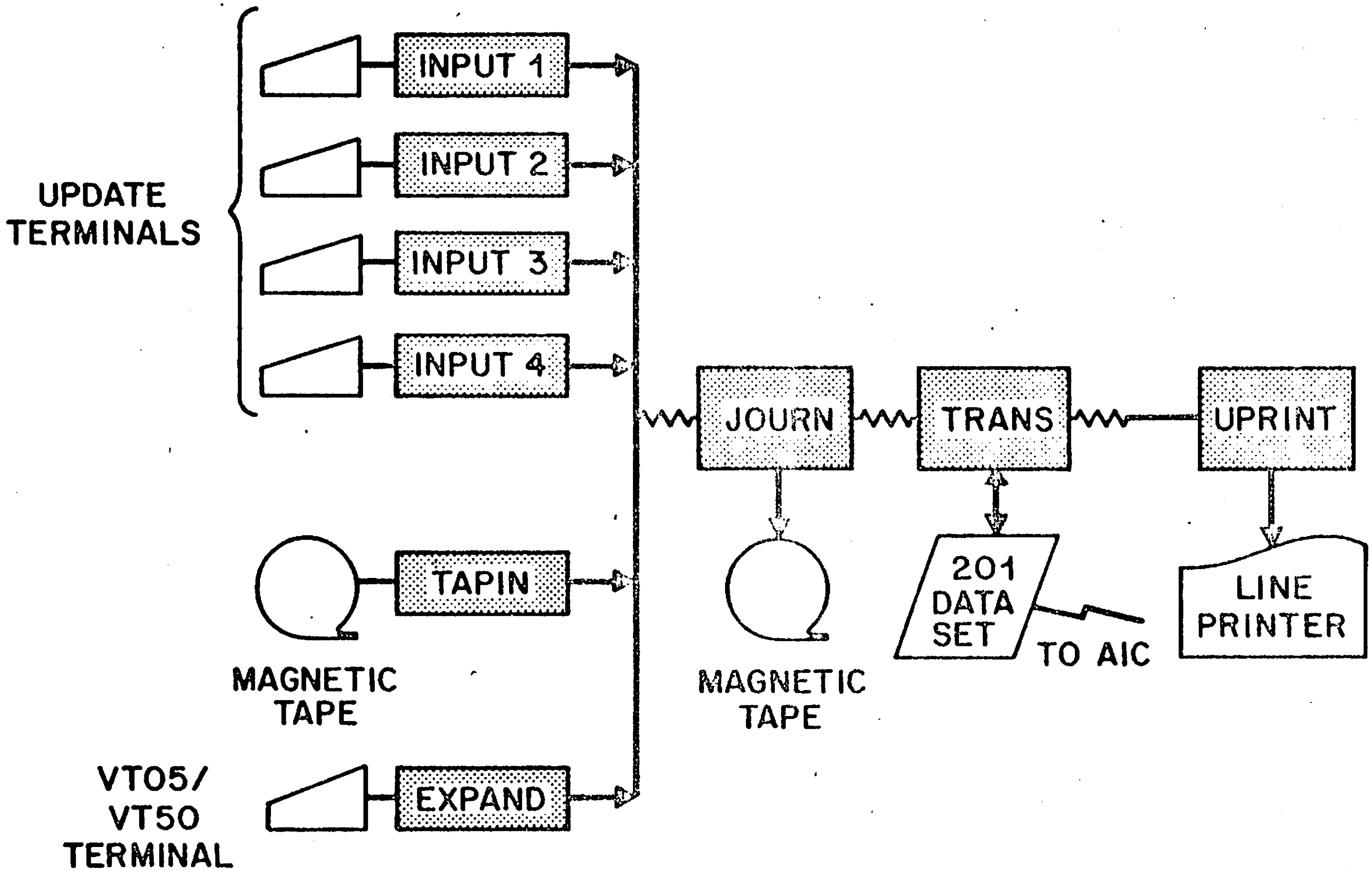

FIGURE 1. FLOW OF UPDATE BATCHES THROUGH FAS

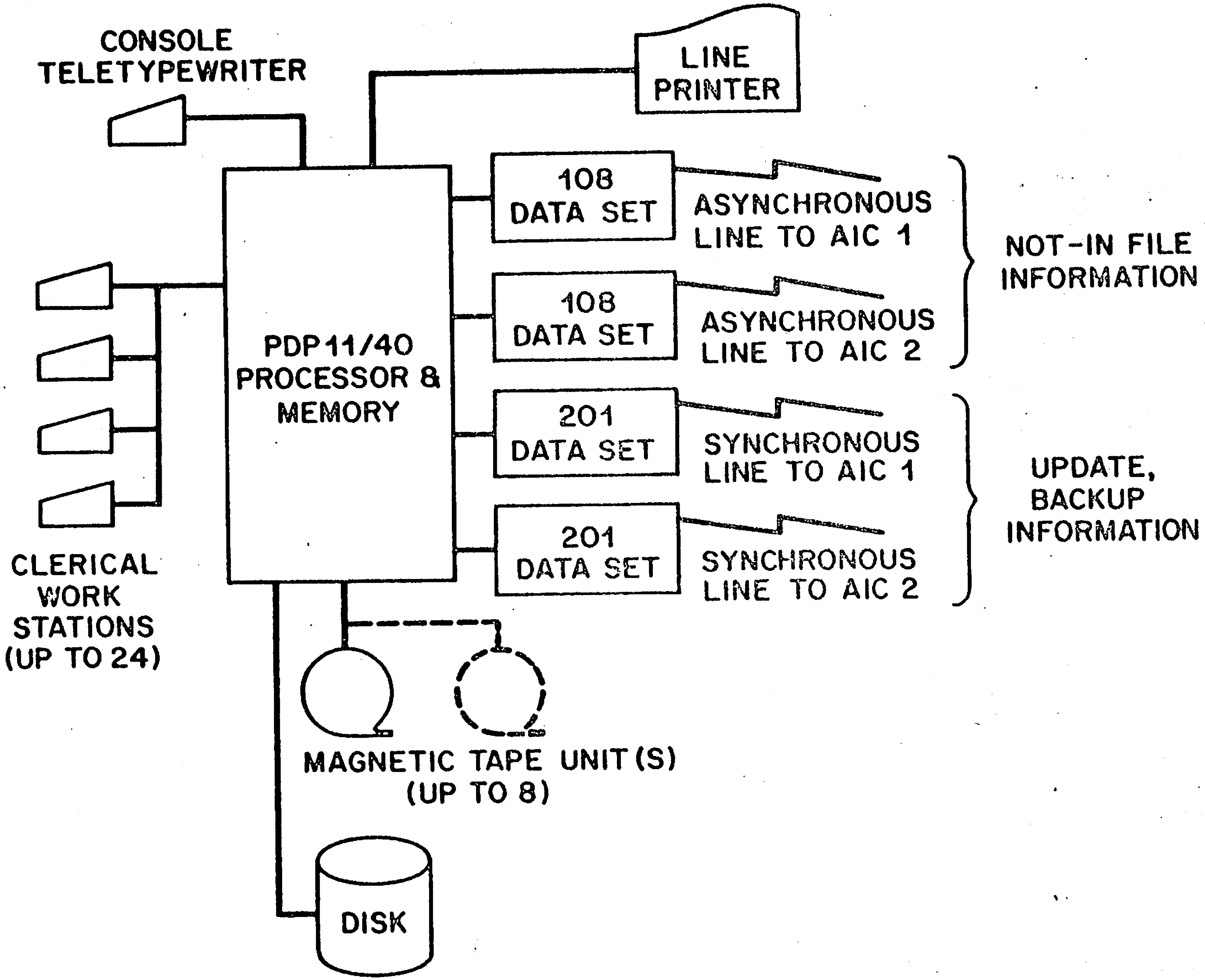

FIGURE 2. TYPICAL FAS HARDWARE CONFIGURATION

EXPLANATION OF TERMS

ACTIVE

The processor is ACTIVE when it is running and not executing a WAIT instruction. This state is derived from the IDLE filp-flop. (It is NOT derived from the console RUN light.)

USER

The processor is in USER mode.

RK BUSY

The RK controller is BUSY from the time it starts executing a command until the command is completed. This time includes seek, rotational latency, and data transfer times. Only one command is processed at a time.

DPØ ACTIVE (DP1 ACTIVE)

Synchronous line Ø (or 1) is either transmitting or receiving characters.

BOTH DP ACTIVE

Simultaneous activity on both synchronous lines.

STATISTICS

Mean - arithmetic mean

M. D. - Mean deviation = mean of the absolute vaules of the deviations from the mean

Table 1

MEASUREMENTS OF TYPICAL UNIX FUNCTIONS ON FAS CONFIGURATION

Measurements in Units of Percent

LOAD	ACTIVE	CORRECTED ACTIVE	USER	RK BUSY
Idle	8.3	0	0	0.8
sum /dev/rk0	45	39	10.6	96
cat file>/dev/lp	44	38	7.7	9
lpr file	39	33	2	8
cat file (1200 bps)	24	17	.2	2.9
two - cat file (both 1200 bps)	35	29	.38	5.1
1 large CPU-bound process	100	98.4	98.4	0.9
2 large CPU-bound processes	86		82	18
3 large CPU-bound processes	77		71	28
10 large CPU-bound processes	76		69	29

UNIX Overhead Correction

With UNIX Idle the ACTIVE measurement was 8.3%. With one CPU bound process running the processor spent 1.6% of the time in Kernel mode. Taking a linear interpolation gives:

$$U = -0.073\ A + 0.089$$

where U is the fraction of processor capacity used for UNIX overhead and A is the fraction of time the processor was ACTIVE. The results labeled CORRECTED ACTIVE have the "UNIX Overhead" subtracted.

$$\text{CORRECTED ACTIVE} = 1.073\ A - 0.089$$

Table 2

UNIX SWAPPING SIMULATIONS WITH CPU-BOUND PROCESSES

Measurements in Units of Percent

LOAD	ACTIVE	RK BUSY
1 to 12 small programs	100	1.0
4 small programs and 1 large program	100	1.3
4 small programs and 2 large programs	93.5	23.4
2 large programs	86.5	16.6

Small program - less than 0.2K words
Large program - about 8K words
All programs are processor bound loops.

The purpose of these experiments was to simulate and measure the FAS RK disk load due to swapping.

Table 3

FAS STAND-ALONE MEASUREMENTS

Measurements in Units of Percent

LOAD	ACTIVE	CORRECTED ACTIVE	USER	RK BUSY	DP BUSY
FAS Update idle 3 terminals waiting for input	9		Ø	2	
FAS Update active 3 terminals 8.5 seconds average transaction time	21		.3	3Ø	
Backup	2Ø	12.56	.8	1.7	61

Table 4

FAS UPDATE MEASUREMENTS

Measurements in Units of Percent

	ACTIVE	USER	RK BUSY	DPØ ACTIVE	DP1 ACTIVE	BOTH DP ACTIVE
	17.238	.256	14.691	7.794	.162	.Ø27
	19.657	.22Ø	26.681	5.293	.135	Ø
	9.289	.ØØ1	11.616	2.113	.162	.Ø27
	15.245	.119	22.369	2.113	4.938	Ø
	16.Ø7Ø	.19Ø	22.1Ø9	2.113	8.86Ø	.216
	16.333	.172	18.6Ø7	2.536	8.Ø35	.121
	28.471	.6Ø7	2Ø.272	2.115	4Ø.382	.445
Mean:	17.47	Ø.22	19.48	3.44	8.95	Ø.12
M. D.	3.77	Ø.12	3.86	1.77	8.98	Ø.12

Configuration: FAS - Toms River, 4-1Ø-75

Interval: 1 minute

Load: 1 or Ø Update terminals in use, but updates queued for transmission, 2 AICs (synchronous lines) on-line, Line printer listing batch transmission reports

Update entry delay: Less than 2 seconds

Table 5

FAS UPDATE MEASUREMENTS

Measurements in Units of Percent

	ACTIVE	USER	RK BUSY	DPØ ACTIVE	DP1 ACTIVE	BOTH DP ACTIVE
	27.311	.485	62.524	3.239	8.7Ø2	.517
	22.182	.583	42.478	5.533	5.777	Ø.
	28.295	.573	47.736	13.833	6.563	.4Ø8
	3Ø.744	.516	5Ø.869	5.653	15.527	.649
	22.487	.5Ø8	57.Ø17	7.344	3.821	.241
	15.368	.41Ø	29.34Ø	2.51Ø	2.639	Ø
	24.349	.421	41.987	2.115	19.2Ø3	.27Ø
	21.724	.325	39.945	2.114	11.6Ø9	Ø
Mean:	24.Ø6	Ø.48	46.49	5.29	9.23	Ø.26
M. D.:	3.62	Ø.Ø7	8.Ø5	2.8Ø	4.66	Ø.2Ø

Configuration: FAS - Toms River, 4-1Ø-75

Interval: 1 minute

Load: Approximately 6 Update terminals in use, 2 AICs (synchronous lines) on-line, Line printer listing batch transmission reports

Update entry delay: Less than 2 seconds

Table 6

FAS UPDATE MEASUREMENTS

Measurements in Units of Percent

	ACTIVE	USER	RK BUSY	DPØ ACTIVE	DP1 ACTIVE	BOTH DP ACTIVE
	30.883	.57Ø	8Ø.429	4.762	11.478	.277
	29.478	.544	97.244	8.391	12.53Ø	4.Ø24
Mean:	3Ø.18	Ø.56	88.84	6.58	12.ØØ	2.15
M. D.:	Ø.7Ø	Ø.Ø1	8.41	1.81	Ø.53	1.87

Configuration: FAS - Toms River, 4-1Ø-75

Interval: 1 minute

Load: Approximately 7 Update terminals in use, 2 AICs (synchronous lines) on-line, Line printer listing batch transmission reports

Update entry delay: Less than 2 seconds

Table 7

FAS UPDATE MEASUREMENTS

Measurements in Units of Percent

	ACTIVE	USER	RK BUSY	DPØ ACTIVE	DP1 ACTIVE	BOTH DP ACTIVE
	14.Ø17	.127	Ø	1Ø.514	Ø	Ø
	42.994	1.569	68.693	22.287	Ø	Ø
	56.453	1.44Ø	56.567	Ø	.327	Ø
	39.273	1.684	78.886	2.611	Ø	Ø
	18.Ø93	.276	37.325	Ø	7.816	Ø
	48.3Ø7	1.1Ø6	82.235	3.633	Ø	Ø
	1Ø.Ø88	.ØØ8	Ø	.323	.324	Ø
	63.966	.639	79.976	15.692	Ø	Ø
Mean:	36.65	Ø.86	50.46	6.88	1.Ø6	Ø.ØØ
M. D.:	16.94	Ø.59	28.51	6.96	1.69	Ø.ØØ

Configuration: FAS - Toms River, 4-1Ø-75

Interval: 5 seconds

Load: Approximately 7 Update terminals in use, 2 AICs (synchronous lines) on-line, Line printer listing batch transmission reports

Update entry delay: Less than 2 seconds

Notes: This set of measurements should be compared with those shown in Table 8, which were taken about 1 hour later. It should be noted that the increase in synchronous line activity has only slight effect on processor ACTIVE or RK BUSY.

Table 8

FAS UPDATE MEASUREMENTS

Measurements in Units of Percent

	ACTIVE	USER	RK BUSY	DP0 ACTIVE	DP1 ACTIVE	BOTH DP ACTIVE
	21.659	.147	28.932	47.196	32.264	22.477
	30.002	.576	60.222	57.645	6.914	4.518
	35.928	.764	75.837	43.632	46.677	28.618
	42.676	.888	68.688	.330	20.848	0
	26.515	.533	17.077	.123	58.943	.123
	25.309	.490	98.752	20.911	0	0
	15.583	.142	0	0	0	0
	30.289	.514	98.964	24.633	30.034	1.100
	42.624	.582	95.908	51.434	.324	.258
	22.199	.227	20.189	20.893	5.268	4.862
	26.113	.375	41.730	28.978	5.278	1.113
	9.791	.048	5.095	.323	0	0
	60.602	2.139	74.565	0	52.635	0
	80.706	1.776	59.673	37.533	0	0
	35.279	1.286	94.180	38.241	0	0
Mean:	33.69	0.70	55.99	24.79	17.28	4.20
M. D.:	12.76	0.45	29.72	17.48	18.36	5.82

Configuration: FAS - Toms River, 4-10-75

Interval: 5 seconds

Load: Approximately 7 Update terminals in use 2 AICs (synchronous lines) on-line, Line printer listing batch transmission reports

Update entry delay: Less than 2 seconds average

Notes: See Table 7

Table 9

FAS UPDATE MEASUREMENTS

Measurements in Units of Percent

	ACTIVE	USER	RK BUSY	DPØ ACTIVE	DP1 ACTIVE	BOTH DP ACTIVE
	54.155	1.098	97.378	33.440	Ø	Ø
	71.406	1.144	62.048	.323	55.005	Ø
	33.760	.575	96.990	5.068	49.902	2.368
	24.311	.449	98.867	9.789	5.034	Ø
	30.475	.682	90.091	5.067	2.755	Ø
	34.181	.494	93.940	52.370	56.323	37.250
	31.843	.432	96.616	52.669	5.282	3.363
	31.476	.436	96.447	50.560	Ø	Ø
	33.381	1.753	97.125	Ø	23.079	Ø
	27.601	.357	98.565	50.572	51.259	15.147
	40.903	1.683	95.456	51.501	Ø	Ø
	25.877	.186	98.738	49.988	Ø	Ø
	26.503	.259	97.868	48.941	39.320	19.401
	35.466	.602	96.590	.325	13.266	Ø
	26.691	.257	99.058	18.946	51.229	10.066
	21.206	.348	96.153	Ø	Ø	Ø
	38.843	.341	97.452	24.286	28.356	8.730
	32.470	.445	98.837	13.009	51.240	8.420
	62.721	.912	48.319	16.093	53.271	14.534
Mean:	35.96	Ø.66	92.45	25.42	25.54	6.28
M. D.:	9.29	Ø.35	8.Ø9	19.65	21.69	7.33

Configuration: FAS - Toms River, 4-1Ø-75

Interval: 5 seconds

Load: Approximately 11 Update terminals in use, 2 AICs (synchronous lines) on-line, Line printer listing batch transmission reports

Update entry delay: 3 to 4 seconds average, occasionally going as high as 1Ø seconds

Table 10

FAS UPDATE MEASUREMENTS - ENHANCED CONFIGURATION

Measurements in Units of Percent

	ACTIVE	USER	RK BUSY	DP0 ACTIVE	DP1 ACTIVE	BOTH DP ACTIVE	RK COUNT
	54.5	1.712	56.7	13.6	7.6	2.5	77
	80.3	1.856	81.0	22.1	30.5	4.4	110
	50.8	1.148	83.5	2.7	12.8	0	106
	45.3	1.255	87.0	2.4	48.5	.5	113
	49.2	1.597	77.7	31.7	56.9	18.1	105
	68.5	1.842	96.4	9.7	57.0	6.5	106
	46.3	1.489	95.7	9.5	54.8	6.3	110
Mean:	56.41	1.56	82.57	13.10	38.30	5.47	103.86
M. D.:	10.28	0.22	9.23	8.03	18.29	4.14	7.67

Configuration: FAS - Toms River with 32K words additional core memory, 5-13-75

Interval: 10 seconds

Load: Approximately 18 Update terminals in use, 2 AICs (synchronous lines) on-line, line printer listing batch transmission reports

Update entry delay: No noticeable delay

Notes: RK COUNT is number of reads and writes issued to the RK disk

Table 11

FAS UPDATE MEASUREMENTS - ENHANCED CONFIGURATION

Measurements in Units of Percent

	ACTIVE	USER	RK BUSY	DPØ ACTIVE	DP1 ACTIVE	BOTH DP ACTIVE	RK COUNT
1 AIC	17.2	.28Ø	12.6	*	11.5	*	1716
2 AICs	26.7	.59Ø	2Ø.5	9.2	14.5	1.6	2654

Configuration: FAS - Toms River with 32K words additional core memory, 5-13-75

Interval: 1Ø minutes

Load: No Update terminals in use, 1 or 2 AICs (synchronous lines) on-line, line printer listing batch transmission reports

Notes: These measurements were made to determine the effect of transmitting to additional AICs.