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A FILE MAINTENANCE PROBLEM ON THE B-MACHINE

Supplying 705-3 and 709 Comparative Figures

CONTENTS

Report Abstract

Work for this report was done assuming a machine which is partially defined by the 3 in 1 Report. It was done in order to evaluate the machine and point out possible areas of improvement. Thus, the statements made in the following pages would assume a different character if the newest definition of the machine were considered. This is particularly true in the areas of memory utilization for instructions, computing speed, and input-output control.

The following is an abstract of the principle facts presented and points made.

Assuming an average instruction execution time of 4 microseconds and a tape speed of 60K, this problem proves to be definitely tape limited on the B machine. The computer is idle about $\frac{2}{3}$ of the total process time.

The total computing times required by the 705, 705-3, 709 and B-machine appear relatively as follows:

705	24
705-3	16
709	11
B	1

The total number of instructions required by each machine are:

705-3	869
709	1230
B	921

The total number of information bits represented by these instructions are as follows:

705-3	26,070
709	44,280
B	58,944

Input-Output programming was complicated by these factors:

1. The ambiguity of the Normal End Interrupt

2. The necessity to interrupt after each of a set of I-O commands which are logically a unit

3. The ambiguity of the " End of File " gap on tape.

Statement of Problem

The Sale Order File Maintenance problem used in comparing the 705-3 with the 709 was also coded on the B-Machine for purposes of this study. See Product Planning Technical Report #001 for details of the problem. The 705-3 and 709 programs assume prior card-to-tape and subsequent tape-to-printer peripheral runs. As the B-machine system does not include peripheral equipment, these runs would have to be accomplished through the main computer. The card-to-tape routime for transactions would include converting to a mixed 4-bit byte and 6-bit byte record and grouping 25 records. The tape-to-printer routine would entail degrouping from 10, and consulting a 6 bit code at the beginning of each record to control line spacing and heading placement. Neither of these routines have been coded and thus their effect is not reflected in the statistics of this report.

Definition of B-Machine Used

1. Processing unit as defined by the 3 in 1 Committee Report. In addition the index reset facility was also assumed

2. All 2-microsecond memory

3. Input- Output and Interrupt procedures as defined by the Harvest manual

4. 729-3 tape unit (7 channel, 60K)

5. Tape End-of-File indicated by means of a long gap

Under this definition of the machine, the following conditions cause a so-called "Normal End" Interruption.

1. Successful completion of Reading or Writing a record of data (actual Normal End)

2. Completion of a Backspace

3. Completion of a Rewind

4. Completion of a WR EOF gap

5. Completion of Writing a one-word record to indicate true End of File, or End of Reel

6. Completion of Reading this one-word record to determine true End of File or End of Reel

Method of Attack

Internally the gross logic used is similar to that used in the 705-3 and 709 programs. That is, Read and Process areas for the master records are alternated; master records are moved to one of two output areas for write-out. In the B-machine each tape unit has its own path to the computer, so that the I - O channel scheduling problem encountered in the 705-3 and 709 programs does not exist here. Input-output functions are triggered on a program demand basis. Two areas are kept for all I-O types, so that one area may be used for processing as its alternate is being read into, or written from.

The basic, non-exception, I - O Interrupt logic is built around bit indicators, one set of which tells whether or not a given area may be used for processing, and another set which tells which of the I - O tapes has caused a computing delay. One of the latter bits is set before going into an IDLE. Each Normal End Interrupt routine contains a test of one of these bits to determine whether return should be made to the IDLE (reason for computing delay not satisfied) or to the main computing.

The following conditions were allowed to cause interrupt: Normal End, Data Error, End of File and Operator Signal.

Analysis of Total Process Time

The total Process Time for the B-machine is essentailly Master Read time. As each tape unit has its own path to the computer, all tapes may be spinning simultaneously when necessary. The problem is tape limited; the computer being IDLE about 2/3 of the total process time. The 709 and 705-3 programs coded for Technical Report #001 assumed tape speeds of 15K and 22.5K, whereas the B-machine program was timed out assuming 60K. Therefore, the B-machine program will not be compared to these in this section, but will be compared to an estimate of time for a 705-3 with 2 DSU's using 60K tapes for Master File data and 15K tapes for the transaction and report Files. Estimated 705-3 time is essentially Transaction Read Time. The following chart expresses total process time in milliseconds, and other times as percentages of total process time.

Machine	Total Process Time	Read MS Time	Write MS Time	Read TRNS Time	Write Ship Time
B	338.7 ms	99%	99%	45%	35%
705-3 estimate	1950.0 ms	22%	22%	96%	37%

The time to read the Transaction file is the determining factor in the 705-3 program because:

1. Transaction volume is relatively high (125 transactions to 150 masters)

2. The file is in ungrouped form, since it is produced off-line

3. The file must be read by the computer at the 15K rate, since it is produced off-line.

Thus, DSU 1 would handle the transaction file only. DSU 2 would handle Master input and output files plus the shipment report tape. A 15% factor was added to the transaction Read time in order to arrive at total process time for the 705-3. This was thought sufficient to cover time lost because of conflicts in the use of DSU 2.

However, even presuming that the time to read transactions could be reduced by some means, 705-3 total process time could not fall below 1803.4 ms, the total compute time.

Computing Requirements

An average instruction execution time of 4 microseconds was used in timing the B machine program. The following chart gives total compute times in milliseconds, and then expresses them relatively, using the B machine for a base. The relative figures include one for the 705. This was arrived at from the following relation:

$$705\text{-}3 \text{ compute time} = \frac{2}{3}\ 705 \text{ compute time.}$$

	705	705-3	709	B
Compute time in ms	2705.1	1803.4	1284.5	112.2
Relative compute time	24	16	11	1

The heaviest computing requirements in the problem fall in two areas:

1. Report preparation
2. Creation of New Master

The following charts supply time in milliseconds and relative times for (1) setting up the print lines for a 15 feature master and (2) handling a new order involving 14 new features.

Print lines	705-3	709	B
Time in ms	15.63	14.48	2.97
Relative times	5.3	5.0	1

New Master	705-3	709	B
Time in ms	81.09	53.46	3.79
Relative times	21	14	1

The B machine looks relatively less effective in the Print line routine because this routine includes byte-by-byte analyses for zero suppression and the conversion of zeros-coded-zero to zeros-coded-ten. These analyses account for about 1.4 ms or roughly half of the 2.97 ms quoted on the previous page.

Other computing requirements easily classified on the B machine are the time spent in interrupt routines and time spent in moving master records to an output area.

Interrupt routines: 1.6 ms, or 1% of total compute time
Move Master to output: 10.0 ms, or 9% of total compute time

Master Tape Space Requirements

The master tape of the 705-3 may or may not exist in compressed form. Twenty-one characters are alphabetic and so cannot be compressed. The remainder are numeric. The total length of the master records are in either case, made a multiple of 5 where this is not naturally so. Thus high speed Transmission can be used.

The master tape of the 709 exists in mixed BCD and binary form. The alphabetic field as well as the control fields are BCD. The remainder are in binary, Where binary information is used, binary compression is used to the limit. Information on tape always represents an integral number of 709 words.

The master tape of the B machine is a mixture composed of 4-bit and 6-bit bytes. 4-bit bytes are used for the numeric fields, 6-bit bytes for the alphabetic fields. Information on tape represents an integral number of B machine words as nearly as possible. The last 6-bit code on tape may contain bits that do not represent part of the record and are not entered into memory.

The following chart expresses the number of tape positions (6-bit units) occupied by a group of 30 records each containing 15 features, for each of the above systems.

Machine System	Number of 6-bit units in grouped Master Records	Relatively Expressed
705-3 without compression	4650	1.52
705-3 with compression	3450	1.13
709	3060	1.00
B	3520	1.15

Thus, it can be seen that where some method of " compression " has been employed, the savings realized are in the same ball-park.

Appendix 1 contains the B machine tape layout for a single master record of 15 features.

Memory Space Requirements

The following chart expresses the memory space required for instructions, constants, and tables in each of the machines. Space is expressed as the number of information bits.

	INFORMATION BITS 705-3	709	B
Instructions	26,070	44,280	58,944
Constants	4,458	4,608	7,872
Tables	3,240	12,600	1,280
Total	33,768	61,488	68,096

The total numbers of instructions are as follows:

705-3 : 869
709 : 1230
B : 921

Thus, whereas the 705-3 and B machines require about the same number of instructions, the number of information bits involved is approximately twice for the B machine. The reasonsfor this fall in three areas:

1. The B machine allows for the addressing of a much larger memory than does the 705-3.

2. The B machine allows for the specification in each instruction of a memory index word.

3. Certain information which is understood in the 705-3 must be specified in the B machine. For example, the 705-3 is always decimal, variable, non-floating point, and of byte size 6.

The following chart presents an analysis of the instructions with respect to the general functions they perform.

Number of Instructions for	705-3	709	B
Initialization	49	46	72
(Non I-O Interrupt table positions)			60
Input	185	235	175
Output	164	210	183
Computing	374	558	250
Sequence checking	17	43	18
Error Messages	26	93	95
End of Job	54	45	68
TOTAL	869	1230	921

Input - Output instructions represent 40% of the total in the 705-3, 36% of the total in the 709, and 39% of the total in the B machine. Appendix 2 contains a further analysis of each of the functions in the above chart.

PROGRAMMING

Input- Output

The most difficult aspect of 709 and 705-3 programming for this problem was planning efficient input-output channel usage. On the B machine this was not a problem because each tape file has its own path to the computer. Probably the most difficult area of B machine programming was in developing the Interrupt logic network. The basic logic is not particularly complicated, but when this is added to the logic for handling errors, alternationsof tape units, and end of job conditions, the total number of conditions which must be remembered becomes rather large. Two sets of bit indications were found to be necessary to the basic Interrupt logic: one set of bits to indicate whether or not a given area could be used for processing, and another set to indicate which I-O tape had caused a computing delay. In addition, the following bit indications were found to be necessary: Whether or not -

*1. The last function triggered for the Master Input Tape was a RD ONE WORD INDICATOR
2. There has been a true End of File for the Master Input
3. There has been a true End of File for the Transactions and a REWIND has been triggered.
4. There is a program delay because typewriter is busy
5. The typewritten error message has been successfully completed
*6. The last function triggered for the Master output was a WRITE LONG GAP
*7. The last function triggered for the Master output was a WRITE ONE WORD INDICATOR
*8. The last function triggered for the Print tape was a WRITE LONG GAP
9. The last function triggered for the current Master input tape was a REWIND
10. The last function triggered for the current Master output tape was a REWIND
11. The last function triggered for the Print tape was a REWIND
12. The End of Job condition has been met (i.e., all inputs have been processed. There may still be information in memory to write out.)
13. Have received operator signal indicating that alternate Master Input unit has been loaded with next input reel
14. Are waiting for operator signal indicating that alternate Master Input tape unit has been loaded with next input reel
15. Have received operator signal indicating that alternate Master output tape unit has been loaded with fresh reel
16. Are waiting for operator signal indicating that alternate Master output tape unit has been loaded with fresh reel

17. This is the first master record to be written on this tape unit - must check bit 15.
18. Current Master Input tape has been Rewound
19. Previous Master Input tape has been Rewound
20. Current Master Output tape has been Rewound
21. Previous Master Output tape has been Rewound
22. TRN tape has been Rewound
23. Print tape has been Rewound

(18–23: For End of Job)

*24. The last function triggered for Master Input tape was a BSP
*25. The last function triggered for Master Output tape was a BSP
*26. The last function triggered for Transaction tape was a BSP
*27. The last function triggered for Print tape was a BSP.

Many of these remembering devices are necessary because of the ambiguity of the Normal End Interrupt mode mentioned above under Machine Definition.

A certain degree of complexity is unavoidable when a number of input-output functions can be executed simultaneously with computing. For then, the programming problem is analogous to multi-programming. In addition to the program which accomplishes the main processing, there is one program each for each of the I-O files. These programs are to some degree logically independent, but they must be related in some manner at some point.

Several possible improvements to the I-O system have been discussed among members of the Stretch group. One suggestion involves the introduction of " tape marks " which would cause a special type of interrupt. These marks could be coded in any desired way, and could, for example, allow for the distinction between End-of-File and End-of-Reel. Thus, the ambiguous long gap would not be used. Another suggestion would allow sequences of I-O instructions to operate as entities as far as the interrupt mechanism is concerned. Thus, when it is desired to re-read a record because of error, BSP-RD could be given as a unit and interrupt would occur only after the RD. In the same way, WRITE EOF MARK and REWIND could be issued as an entity.

Introduction of these two facilities would remove the necessity for 8 of the 27 " remembering " bits listed above (these 8 are marked with asterisks).

Computing Unit

Features in the B machine processing unit that have particular programming appeal are:

1. a practically unlimited number of index registers
2. multiple indexing (not used here above level 2)
3. bit addressing (giving variable field length)
4. index reset facility

Machine Personalities

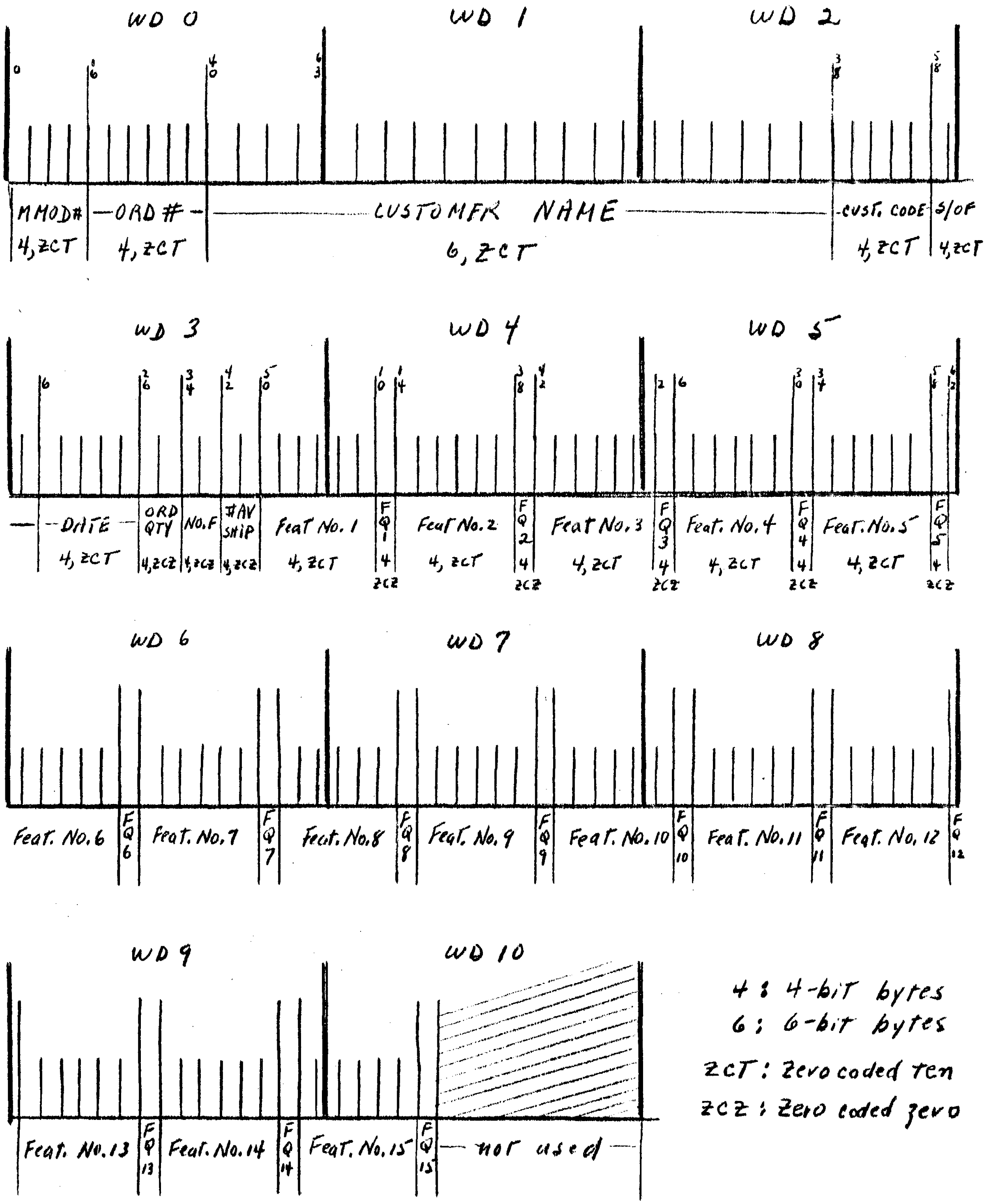
Both the 709 and the 705-3 have very definite personalities. It is true that in its growth from the 701, the 709 has made certain concessions to decimal and variable field length. It is also true that in its growth from the 702, the 705-3 has made concessions to binary and fixed word length. Still these machines retain their basic individualities. The B machine has a multiple personality. Without benefit of the veil of " automatic programming ", it will present a somewhat confused picture to the user. It has sacrificed style for flexibility. It is, perhaps, powerful, but it certainly isn't pretty. I am incapable of drawing any conclusions from this. Aesthetics appear to be irrelevant to the facts of life in machine design.

Checking

The systems checks coded into the 705-3 and 709 programs were also coded into the B machine program. The only error-checking interrupt function coded for the B machine is tape error.

Appendix 1

B-Machine Tape Layout of Master Record with 15 Features



Appendix 2-1

Break down of Number of Instructions in Major Instruction Categories

	705-3	709	B
Initialization	49	46	72
(non I-O Interrupt Table positions)			60
Input (Determination of correct routine upon Interrupt)			18
Read Master	12	12	5
Read Detail	11	10	5
Master Error Routine	9	9	10
Detail Error Routine	10	19	10
Master EOF Routine	14	48	60
Detail EOF Routine	10	15	12
Setting + Accomplishing correct input paths	119	96	55
(Check Sums)		26	
	185	235	175
Output (Determination of correct routine upon Interrupt)			18
Write Master	8	6	10
Write Report Tape	26	18	10
Master Error Routine	10	28	10
Report Tape Error Routine	9	30	10
Master End of Tape Routine	19	26	61
Move Master to Output	24	25	25
Setting and Accomplishing correct output paths	68	60	29
(check Sums)		17	
	164	210	183
Sequence checks			
Master	11	18	4
Detail	6	25	14
	17	43	18
Error Messages	26	93	95
End of Job	54	45	68

Appendix 2-2

	705-3	709	B
Processing			
Compare Master and Detail	5	10	3
(If no activity on Master)		8	2
If unmatched Detail	3	5	3
If matched Detail	16	22	13
New Order	38	47	15
Additional Order	11	16	6
New Feature	34	57	14
Additional Feature	10	36	8
Cancelled Feature, no deletion	10	39	8
Cancelled Feature, deletion	35	49	13
Cancelled Order	20	18	9
Completion	21	15	7
Shipment	171	218	132
(If Detail Sequence Step-Up		18	17
	374	558	250
TOTAL	869	1230	921