BRANCH TRACE 1 July 30, 1962

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PURPOSE

Branch Trace 1 is a branch trace program for IBM 1401 computers with 4,000 or fewer digits of core storage. A trace program is used in testing and debugging other programs, its output consisting of information about the execution of the program being traced. Branch Trace 1 monitors each instruction of the program being traced and prints one line for each branch that occurs as that program is executed. The contents of this line are as follows:

Print positions	Information printed
1- 3	Address of the instruction at which a branch occurred.
4	Always a blank.
5- 7	Address of the instruction to which the computer branched.
8	Always a record mark.

Thus the output of Branch Trace 1 shows the programmer the sequence of instructions executed in the program being tested, which is of great help to the programmer in cases where it is suspected that the sequence taken was not the one intended. The programmer can then use Minitrace 1 to get further information if necessary.

Uses of Branch Trace 1 are therefore likely to fall into the following categories:

a) To help debug programs in which core storage limitations prevent the use of Minitrace 1.

b) To conserve computer time in obtaining a trace in cases where a fault in the sequence of instructions is the probable cause of malfunction of the program. For example, in tests of Richmond program 064, which without tracing ran for 27 seconds, Branch Trace 1 required 1 minute and 55 seconds whereas Minitrace 1 took 8 minutes.

c) In long programs, to help isolate routines where trouble is present. These can then be traced with Minitrace 1, and thus the need for running the entire program against Minitrace 1 is avoided.

MACHINE REQUIREMENTS

Branch Trace 1 uses 615 digits of core memory and may be assembled anywhere in core except the print area. For example, it may be assembled with origin at 3385 to use positions 3385-3999.

Other machine requirements are:

4,000 or fewer digits of core memory
Advanced programming feature
  Index registers
  Store address register instructions
  Move record instruction
1403 Printer

PROCEDURE

Branch Trace 1 has been designed to avoid almost all "setting-up" of the program deck to be traced. In most cases, it is merely necessary to remove the "END" card from the deck to be traced, place Branch Trace 1 behind the remainder of the deck, place any data cards used behind Branch Trace 1, and load and run the combined deck, following exactly the procedures specified for the program being traced.

SOURCE LANGUAGE

SPS

LIMITATIONS

Branch Trace 1 will trace all generally known 1401 instructions. There are several minor limitations and requirements, fully described in the Write-Up, that are imposed in order to reduce the core space used by Branch Trace 1.

CHECK-OUT STATUS

Branch Trace 1 has been used to trace a variety of programs on systems that include tape, Ramac, and 1407 console equipment. The nature of the program is such, however, that it may still contain bugs or may be unable to handle some instruction or sequence of instructions that was not anticipated by the author. The author therefore requests that each user, as a service to other users, inform him of all difficulties encountered in order that the program may be modified or that a description of the limitation may be added to the Write-Up.

OPERATING PROCEDURES

A. Standard trace

1. Remove the last card (END card) from the assembled program to be traced.

2. Place the Branch Trace 1 deck behind the program deck to be traced.

3. Place data cards, if any, behind the Branch Trace 1 deck.

4. Load and run the combined deck.

   Follow the procedures specified for the program being traced. (Check for switches, carriage control tape, etc.)

Precaution--If not altered, Branch Trace 1 will expect to find the first instruction of the program being traced in core location 333. To begin tracing at a different address, that address should be inserted as the contents of FX, the constant that occupies the first 3 digits of Branch Trace 1. For example, if Branch Trace 1 is assembled with origin at 3385, and a program is to be traced starting at R28, then R28 should be inserted into 3385-3387.

B. Trace of particular part of program

1. Remove END card from program to be traced.

2. Replace first card of Branch Trace 1 with a card which is identical except that the address at which tracing is to begin is punched into columns 24-26.

3. Put the Branch Trace 1 deck behind the program to be traced.

4. Replace the last card of Branch Trace 1 with the END card from the program to be traced.

5. Place data cards, if any, behind the combined decks.

6. Set address stop to the address at which tracing is to begin.

7. Load and run the program to the address stop. The Start button must be pressed twice at address stops during loading.

8. Set the I-address register to 3388, the address of the first instruction of Branch Trace 1.

9. Press Start to begin tracing.

To stop tracing before the execution of a given instruction, set address stop to the address of the instruction which follows that instruction. A portion or the remainder of the program being traced may then be properly executed by restarting at the address of the given instruction. Tracing may be resumed later in the program by the following procedure:

1. Set address stop to the address of the instruction at which tracing is to be resumed.

2. Press Start and run the program to the address stop.

3. Put the address of the instruction at which tracing is to be resumed into core locations 3385-3387.

4. Reset the I-address register to 3388.

5. Press Start to resume tracing.

REQUIREMENTS, LIMITATIONS, AND FURTHER EXPLANATION

A. Fully-chained instructions

Branch Trace 1 can accomodate up to 27 full-chain instructions in a row in the circumstances which place the most severe limitation on the number that can be handled. In other words, if the program being traced does not contain a string of more than 27 consecutive fully-chained instructions, it can be traced and the next paragraph can be ignored.

If the chain follows an instruction which is less than 8 digits long, the number of consecutive fully-chained instructions that can be traced is increased by one for each digit by which the instruction preceding the chain is shorter than 8. If the chain is not followed by a 4-digit instruction whose op-code is either M, L, Q, or H, or by a 4-digit constant whose first character is M, L, Q, or H, the number of consecutive fully-chained instructions that can be traced is increased by 4.

B. Branch Trace 1 sets word marks in 001, 087, and 092

Word marks are set in core locations 001, 087, and 092, and remain set during execution of the program being traced. The latter must therefore be able to function under these conditions.

C. Stacker instructions

A Select Stacker instruction given after a Read instruction will not be effective because it will not be exeucted within the necessary time limit. All cards read should be expected to fall into the normal read pocket.

D. Word marks must follow all instructions

It is recommended that programs that may be traced be written with word marks in the location following each instruction, thus extending the general requirement to the three instructions that do not ordinarily require such a word mark (the 4-digit unconditional Branch, the 7-digit Set Word Mark, and the 7-digit Clear Storage and Branch).

However, Branch Trace 1 will usually be able to execute the above instructions if a word mark occurs in core within 32 digits after the last digit of the instruction (within 35 digits of the 4-digit unconditional Branch).

The author's experience has shown that this requirement must expecially be kept in mind when writing the last instruction of the program (the instruction preceding the END card) and when patching assembled decks (also remember not to put a patch into locations used by Branch Trace 1).

E. Partial logic of Branch Trace 1

The following statement of the principal logic employed by Branch Trace 1 may be useful in determining whether programs which make unusual use of particular instructions can be traced:

1. The contents of the B-address register after execution of an instruction being traced are stored and returned to the register before execution of the next instruction if the latter is a 4-digit Move, Load, or Store B-address Register instruction. The contents of the A-address register are similarly handled if the next instruction to be traced is a 4-digit Store A-address Register instruction. These are the only cases in which the contents of the registers are stored for use by the next instruction. When a branch occurs, the address of the next sequential instruction following the Branch instruction is introduced into the B-address register prior to execution of the next instruction to be traced.

2. Branch Trace 1 recognizes the following 1-digit instructions as fully-chained instructions and causes them to be executed without tracing at the same time that the preceding unchained instruction is executed and traced:

C	□
X	!
W	?
%	L
Q	M
H	/
Z	#
@	E
P	V
D	B
Y	S
,	A

3. Branch Trace 1 recognizes that branches may occur to the A-address of instructions with the following op-codes. A trace is printed if the branch does occur.

B	3	
V	5	
W	6	
.	7	
1	K	
4	F	
2	/	(7-digit instruction only).

Sample Output of Branch Trace 1

Trace of Richmond Program 064
Inquiry into account of Transit Department
on Ramac. using 1407 Console

363 347‡

363 347‡

358 530‡

557 501‡

509 371‡

390 434‡

442 478‡

497 561‡

573 738‡

218 TRANSIT

TOTAL DEBITS	87,415,879.13
TOTAL CREDITS	22,318,508.89

	DEBITS	CREDITS
874 ‡73‡		
‡94 903‡	27.50	
	27.50	
947 862‡		
		6,321.24
947 862‡		
		7.13
947 862‡		
		1,050.00
947 862‡		
874 ‡73‡		
‡94 903‡	70,000.00	
	70,000.00	
947 862‡		
874 ‡73‡		
‡94 903‡	2,776,362.21	
	2,776,362.21	
947 862‡		

NO BOOTSTRAP CARD

PG	LIN	CT	LABEL	OP	A OPERAND	B OPERAND	D	LOC	INSTRUCTION COMMENTS BRTR
1	030	3	FX	DCW	*		333	3387	
1	040	1	BFAD	DCW	*			3388	
1	050	3	I9I	DCW	*		I9I	3391	
1	060	1	TOP	DCW	*			3392	
1	070	1	EXCUTE	DCW	*		N	3393	
1	080	3	AREG	DC	*		000	3396	
1	090	3	BREG	DC	*		000	3399	
1	100	1	A	DCW	*			3400	
1	110	1	B	DC	*			3401	
1	120	3	C	DC	*			3404	
1	130	3	F8X	DC	*			3407	
1	140	1	D	DC	*			3408	
1	150	4		DC	*			3412	
1	160	30	ENDEX	DC	*			3442	
12 1	170	4	E2	CS	ENDEX			3443	/ D42
11 1	180	4		SW	0001			3447	, 001
10 1	190	7		MCW	FX	TA &002		3451	M C87 H73
9 1	200	7		MCW	0089	INDEX1		3458	M 089 H62
8 1	210	7		MCW	0094	INDEX2		3465	M 094 H65
7 1	220	7		LCA	BLANKS&002	0089		3472	L H59 089
6 1	230	7		LCA	FX	0094		3479	L C87 094
5 1	240	7	E10	SBR	0094	0001	2	3486	H 094 0-1
4 1	250	8		BWZ	E15	0000	2 1	3493	V E12 0-0 1
3 1	260	7		SBR	0089	0001	1	3501	H 089 0≠1
2 1	270	4		B	E10			3508	B D86
	280	7	E15	MCW	0000 2	B	1	3512	M 0-0 D≠1
	290	1		LCA				3519	L
	300	7		MCW	BLANKS	B	1	3520	M H57 D≠1
	310	7		MCW	F8X -004	AFAD		3527	M D03 H77
	320	7		MCW	F8X -001	BFAD		3534	M D06 C88
	330	7	E22A	MCW	0000 2	TOP		3541	M 0-0 C92
	340	7		SBR	0094	0001	2	3548	H 094 0-1
	350	8		BWZ	TEST	0000	2 1	3555	V H79 0-0 1

PG	LIN	CT	LABEL	OP	A OPERAND	B OPERAND		D	LOC	INSTRUCTION COMMENTS	BRTR
1	360	7	WW	A	I9I	0094			3563	A C91 094	
1	370	7	ZZ	SBR	0094	0004	2		3570	H 094 0-4	
1	380	8		BWZ	MOD2	0000	2	1	3577	V E96 0-0 1	
1	390	7	E26AA	A	I9F	0094			3585	A I99 094	
1	400	4		B	E26				3592	B F50	
1	410	8	MOD2	B	E24	TOP		M	3596	B F32 C92 M	
1	420	8		B	E24	TOP		L	3604	B F32 C92 L	
1	430	8		B	E24	TOP		H	3612	B F32 C92 H	
1	440	8		B	E22A45	TOP		Q	3620	B I59 C92 Q	
1	450	4		B	E26AA				3628	B E85	
1	460	7	E24	LCA	HXXX &003	C	1		3632	L I96 D#4	
1	470	7	E26AB	SBR	0089	0004	1		3639	H 089 0#4	
1	480	4		B	E26AA				3646	B E85	
1	490	7	E26	LCA	BXXX &003	C	1		3650	L I92 D#4	
1	500	7		MCW	0094	FX			3657	M 094 C87	
1	510	7		MCW	INDEX1	0089			3664	M H62 089	
1	520	7		MCW	INDEX2	0094			3671	M H65 094	
1	530	8		B	EXCUTE	AFAD			3678	B C93 H77	
1	540	7		SBR	TXY1 &003	TABLE1			3686	H F96 G36	
1	550	7	TXY1	MCW	TABLE1	LOOK2 &007			3693	M G36 G11	
1	560	4		SAR	TXY1 &003				3700	Q F96	
1	570	8	LOCK2	B	E60	A		F	3704	B I78 D00 F	
1	580	8		B	TEST2	LOOK2 &007		B	3712	B G37 G11 B	
1	590	4		B	TXY1				3720	B F93	
1	600	1		DCW	*			B	3724		
1	610	1		DCW	*			V	3725		
1	620	1		DCW	*			W	3726		
1	630	1		DCW	*			.	3727		
1	640	1		DCW	*			1	3728		
1	650	1		DCW	*			4	3729		
1	660	1		DCW	*			2	3730		
1	670	1		DCW	*			3	3731		
1	680	1		DCW	*			5	3732		
1	690	1		DCW	*			6	3733		
1	700	1		DCW	*			7	3734		
1	710	1		DCW	*			K	3735		

PG	LIN	CT	LABEL	OP	A OPERAND	B OPERAND	D	LOC	INSTRUCTION COMMENTS	BRTR
1	720	1	TABLE1	DCW	*		F	3736		
1	730	8	TEST2	B	E59	A	/	3737	B I70 D00 /	
1	740	4		B	EXCUTE			3745	B C93	
1	750	7	E62	MCW	FX	BREG		3749	M C87 C99	
1	760	7		MCW	AFAD	FX		3756	M H77 C87	
1	770	7	COMP	MCW	0208	STORE2		3763	M 208 H70	
1	780	7		MCW	RM	0208		3770	M H56 208	
1	790	7		MCM	0201	WR		3777	P 201 H49	
1	800	7		MCW	0089	INDEX1		3784	M 089 H62	
1	810	7		SBR	0089	0201		3791	H 089 201	
1	820	7	CHAR	MCM	TA -201 1	0000 1		3798	P FX0 0#0	
1	830	4		SBR	0089			3805	H 089	
1	840	8		B	DONE3	0089	9	3809	B H21 089 9	
1	850	4		B	CHAR			3817	B G98	
1	860	2	DONE3	CC			S	3821	F S	
1	870	1		W				3823	2	
1	880	7		MCM	WR	0201		3824	P H49 201	
1	890	7		MCW	STORE2	0208		3831	M H70 208	
1	900	7		MCW	INDEX1	0089		3838	M H62 089	
1	910	4		B	E2			3845	B D43	
1	920	1	WR	DCW	*			3849		
1	930	6		DC	*			3855		
1	940	1	RM	DCW	*		#	3856		
1	950	1	BLANKS	DCW	*			3857		
1	960	2		DC	*			3859		
1	970	3	INDEX1	DCW	*			3862		
1	980	3	INDEX2	DCW	*			3865		
1	990	4	QXXX	SAR	AREG			3866	Q C96	
2	000	1	STORE2	DCW	*			3870		
2	010	1	TA	DCW	*			3871		
2	020	3		DC	*			3874		
2	030	3	AFAD	DCW	*			3877		
2	040	1		DCW	*		#	3878		
2	050	7	TEST	SBR	TXY &003	TABLE		3879	H H89 I40	
2	060	7	TXY	MCW	TABLE	LOOK1 &007		3886	M I40 I04	
2	070	4		SAR	TXY &003			3893	Q H89	

PG	LIN	CT	LABEL	OP	A OPERAND	B OPERAND	D		LOC	INSTRUCTION COMMENTS	BRTR1
2	080	8	LOCK1	B	E22A34	TOP	A		3897	B I41 C92 A	
2	090	8		B	WW	LOOK1 &007	C		3905	B E63 I04 C	
2	100	4		B	TXY				3913	B H86	
2	110	1		DCW	*			C	3917		
2	120	1		DCW	*			X	3918		
2	130	1		DCW	*			W	3919		
2	140	1		DCW	*			%	3920		
2	150	1		DCW	*			Q	3921		
2	160	1		DCW	*			H	3922		
2	170	1		DCW	*			Z	3923		
2	180	1		DCW	*			@	3924		
2	190	1		DCW	*			P	3925		
2	200	1		DCW	*			D	3926		
2	210	1		DCW	*			Y	3927		
2	220	1		DCW	*			,	3928		
2	230	1		DCW	*			□	3929		
2	240	1		DCW	*			—	3930		
2	250	1		DCW	*			&	3931		
2	260	1		DCW	*			L	3932		
2	270	1		DCW	*			M	3933		
2	280	1		DCW	*			/	3934		
2	290	1		DCW	*			#	3935		
2	300	1		DCW	*			E	3936		
2	310	1		DCW	*			V	3937		
2	320	1		DCW	*			B	3938		
2	330	1		DCW	*			S	3939		
2	340	1	TABLE	DCW	*			A	3940		
2	350	7	E22A34	LCA	TOP	B	1		3941	L C92 D#1	
2	360	7		SBR	0089	0001	1		3948	H 089 0#1	
2	370	4		B	E22A				3955	B E41	
2	380	7	E22A45	LCA	QXXX &003	C	1		3959	L H69 D#4	
2	390	4		B	E26AB				3966	B F39	
2	400	8	E59	B	EXCUTE	BFAD			3970	B C93 C88	
2	410	7	E60	SBR	F8X -004	E62			3978	H D03 G49	
2	420	4		B	EXCUTE				3985	B C93	
2	430	4	BXXX	B	E2				3989	B D43	

PG	LIN	CT	LABEL	OP	A OPERAND	B OPERAND	D	LOC	INSTRUCTION	COMMENTS	BRTR1
2	440	4	HXXX	SBR	BREG			3993	H	C99	
2	450	3	I9F	DCW	*		I9F	3999			
2	460			END	E2					/ D43 080	

144 CARDS