IBM 7090 Simulator Usage

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Introduction

The follow up to the IBM704. Utilizing ideas learned from the Stretch IBM enhanced the 704 by adding multiple communications channels to speed up processing I/O devices. This allowed the machine to continue processing while the tapes or card readers transfered data.

Also this was one of the first machines to feature indirect addressing. Also added was an indicator register to hold flags and other information.

The IBM 709 was announced January 2, 1957 withdrawn April 7, 1960. Originally the IBM 709T later to be named the IBM 7090 by customers, the machine was a faster version of the IBM 709 implemented in transistors instead of tubes.

The IBM 7090 was announced December 30, 1958 withdrawn July 14, 1969.

The IBM 7090 also was built out of the same modules as the Stretch and used the same memory modules. The final enhancement was the IBM 7094, this added double percision arithmetic, faster processing, and 4 more index registers. The machine looked like a 7090 until extra indexing mode was entered, then instead of 3 registers begin or-ed together, the 3 bits selected one of 7 index registers.

It was latter upgraded to the 7094/II which was still faster.

The IBM 7094 & IBM 7094/II were announced January 15, 1962 withdrawn July 14, 1969.

IBM also developed two transistorized versions of the IBM 704, these were slower then the IBM 7090, and did not feature an indicator register or indirect addressing. But they came optionally with double precision floating point, and special character operating instructions.

It was also possible to purchase a 7040 without index registers or floating point. The machines were meant to be front ends to the IBM 7094, and a direct couple devices was sold, along with the ability to share 1301 drives between systems.

Unfortunately no software has been found for the IBM 7040/44.

The IBM 7094 was also one of the first machines to be modified to run time sharing. The Compatible Time Sharing System (CTSS) was developed by MIT to allow for the IBM 7094 to be shared by multiple people while still being compatible with FMS.

Simulator Files

To compile the IBM 7090, you must define USE_INT64 as part of the compilation command line.

Subdirectory	File	Contains
I7000	i7000_defs.h	IBM 7000 simulators general definitions
	i7090_defs.h	IBM 7090 simulator specific definitions
	i7000_chan.c	Generic channel interface.
	i7090_cpu.c	7090 CPU, Channel, interface
	i7090_chan.c	7090 Channel.
	i7090_sys.c	7090 System interface
	i7090_cdr.c	711 Card reader
	i7090_cdp.c	721 Card punch
	i7090_lpr.c	716 Line printer
	i7090_drum.c	733 Drum memory interface.
	i7000_com.c	7750 Communications Controller*
	i7000_dsk.c	1301/2302 disk and 7238 drum controller.*
	i7000_ht.c	7340 Hypertape controller.*
	i7090_hdrum.c	CTSS High Speed Drum*
	i7000_mt.c	729 Tape controller.
	i7000_chron.c	Chrono Clock.*

If so desired instead of defining I7090, I704 can be defined and the files marked with '*' above can be removed. This produces a smaller executable that will only emulate a IBM 704 computer.

IBM 7090 Features

The IBM 7090 simulator is configured as follows:

Device Name(s)	Simulates
CPU	7090 CPU with 32Kw/64Kw of memory
CH0	704 Unit record devices
CH1..8	7607/7909/7289 Channels
MT	729 Magnetic Tape Controller (On CH0)
MTA	729 Magnetic Tape Controller
MTB	729 Magnetic Tape Controller
MTC	729 Magnetic Tape Controller
MTD	729 Magnetic Tape Controller
MTE	729 Magnetic Tape Controller
CHRON	Chrono Clock
HTA	7340 Hypertape, default not included.
HTB	7340 Hypertape, default not included.
CDR	711 Card Reader
CDP	721 Card Punch
LP	716 Line Printer
DR	Drum memory.
HD	CTSS High Speed Drum.

Device Name(s)	Simulates
DK	1301/2302/7304 disk.
COM	7750 communications controller.
COML	7750 Communications lines.

Channels A through H, the corresponding magnetic tape controllers, and the file control, drum control , and communications control are initially set DISABLED.

The file control, drum control, and communications control can be assigned to any channel in the range B through H.

Stop conditions

The 7090 simulator implements several unique stop conditions:

- Undefined CPU instruction
- Undefined channel instruction
- XEC nesting exceeds limit
- Divide check on a divide and halt instruction
- Select of a non-existent channel
- 7607 select of a 7909 channel
- Write select of a write protected device
- Invalid file control format
- Invalid message to 7750
- No buffer storage available for input character on 7750
- No buffer storage available for output character on 7750

The LOAD command will load a card binary image file into memory.

CPU

The CPU options include setting memory size and cpu type. Also the special features required for used by the CTSS project:

```
SET CPU STANDARD          Standard CPU
SET CPU CTSS              Adds extra core memory for CTSS
SET CPU 704              Sets CPU to emulate a 704
SET CPU 709              Sets CPU to emulate 709 instructions
SET CPU 7090             Sets CPU to emulate 7090.
SET CPU 7094             Sets CPU to emulate 7094.
SET CPU 4K               Sets memory to 4K
SET CPU 8K               Sets memory to 8K
SET CPU 16K              Sets memory to 16K
SET CPU 32K              Sets memory to 32K
SET CPU TRUEIO           CPU executes I/O in CPU time.
SET CPU FASTIO           CPU detects I/O waits and shortens them
```

```
SET CPU NOEFP            Disables extended precision floating point.
SET CPU EFP              Enables extended precision floating point.
SET CPU NOFPSM           Disables floating point significance mode.
SET CPU FPSM             Enables floating point significance mode.
SET CPU TIMER            Enables interval timer and interrupt.
SET CPU NOTIMER          Disables interval timer.
```

Memory size is 32KW on a standard CPU, 64KW on a CTSS CPU. Set notes below on setting up for CTSS.

The 7090 supported many options which were called RPQ's, these include extended precision floating point instructions. These were similar to the later 7094 double precision floating point instructions. Significance mode allowed for better detection of bits during floating point operations.

FASTIO mode detects when the CPU is in a loop waiting for a channel to become available and then sets the simulation interval to run any pending I/O. This results in faster simulations without the CPU being aware of this. If the Timer is used, this might result in incorrect timing intervals.

CPU registers include the visible state of the processor as well as the control registers for the interrupt system.

Name	Size	Comments
IC	15	Program Counter
AC	38	Accumulator
MQ	36	Multiplier Quotient
ID	36	Indicators register
KEYS	36	Front panel keys
XR1..XR7	15	Index registers
SW1..SW6	1	Sense Switches 1..6
SW	6	Sense Switches
SL1..4	4	Sense Lights 1..4
ACOVF	1	Accumulator Overflow Indicator
MQOVF	1	MQ Overflow Indicator.
DVC	1	Divide Check indicator
IOC	1	I/O Check indicator
TM	1	Transfer Trap mode
CTM	1	Copy Trap mode
STM	1	Select Trap mode
FTM	1	Floating Trap mode
NMODE	1	Storage nullification mode
MTM	1	Multiple Tag mode
ENB	36	Interrupt enable register
INST_BASE	1	(CTSS) B core instruction execution
DATA_BASE	1	(CTSS) B core data access
BASE	14	(CTSS) relocation base block

Name	Size	Comments
LIMIT	14	(CTSS) address limit block

The CPU can maintain a history of the most recently executed instructions.

This is controlled by the SET CPU HISTORY and SHOW CPU HISTORY commands:

```
SET CPU HISTORY          clear history buffer
SET CPU HISTORY=0        disable history
SET CPU HISTORY=n        enable history, length = n
SHOW CPU HISTORY         print CPU history
SHOW CPU HISTORY=n       print first n entries of CPU history
```

Instruction history trace shows the Instruction counter for the instruction, the AC and MQ before the execution, the computed Effective Address, the word read from storage, and the three index registers XR1, 2 and 4.

I/O Channels (CH0..CH8)

The 7090 supports up to 8 channels. Channel models include

```
7607                     standard multiplexer channel
7289                     high speed drum channel
7909                     advanced capabilities channel
```

Channel A is required and is always a 7607.

Channels are represented by a number: A=1, B=2, C=3, D=4, E=5, F=6, G=7, H=8.

Channel 0 is for 704 devices.

```
SET CHn 7607             Sets channel to be a 7607 type.
SET CHn 7909             Sets channel to be a 7909 type.
SET CHn 7289             Sets channel to be a 7289 type. (For CTSS Drum).
SET CHn FIXED            Fixes channel to specific type.
SET CHn AUTO             Default, channel configures based on devices on it.
```

Generally there is no need to worry about channel configurations, in auto mode they will configure to correct type to support devices attached to them. Or you will get an error when you attempt to run the simulation if there is a conflict.The default layout of devices will work for IBSYS and CTSS.

A show channel command will list out the devices currently assigned to this channel, or all channels if no specific channel is selected.

Channel 0 is a pseudo channel for 704 devices. Currently unit CR3, CP3, LP3,

DR0, and MT are set to this device.

Registers   Channels have the following registers:

Name	Type	Size	Comments
ADDR	All	16	Channel Data Address
CMD	All	6	Channel Command.
WC	All	15	Channel Word Count
ASM	All	36	Assembly Register
LOCATION	All	16	Channel Location Counter
STATUS	All	16	Channel Device Status
SENSE	7909	16	Channel Sense Data
COUNTER	7909	6	Channel Counter
SMS	7909	7	Channel SMS Register

For meaning of bits in STATUS and SENSE see i7000_defs.h.

Channel 7607 Devices and 704 devices.

These devices can only be attached to 7607 channels or to the Programed I/O
channel 0.

711 Card Reader (CDR)

The card reader (CDR) reads data from a disk file.

Cards are simulated as ASCII lines with terminating newlines.

Card reader files can either be text (one character per column) or column binary
(two characters per column). The file type can be specified with a set command:

```
SET CDRn FORMAT=TEXT        Sets ASCII text mode
SET CDRn FORMAT=BINARY      Sets for binary card images.
SET CDRn FORMAT=BCD         Sets for BCD records.
SET CDRn FORMAT=CBN         Sets for column binary BCD records.
SET CDRn FORMAT=AUTO        Automatically determines format.
```

or in the ATTACH command:

```
ATTACH CDRn <file>                  Attaches a file
ATTACH CDRn -f <format> <file>      Attaches a file with the given format
ATTACH CDRn -s <file>               Added file onto current cards to read
ATTACH CDRn -e <file>               After file is read in, the reader will
                                    receive and end of file flag
```

The card reader can be attached to either a 704 PIO channel or a 7607 channel.
The channel can be changed by the following command:

```
SET CDRn CHAN=c         Set this device to channel c.
```

The default assignments are:

```
CDR0                            Channel A(1)
CDR1                            Channel C(3)
CDR2                            Disabled
CDR3                            704 PIO.
```

If the simulator is compiled for only 704 then there is only one Card Reader called CDR.

The card reader can be booted with the:

```
BOOT CDRn                  Loads first 3 words of card.
```

Error handling is as follows:

error	processed as
not attached	report error and stop
end of file	out of cards
OS I/O error	report error and stop

721 Card Punch (CDP)

The card reader (CDP) writes data to a disk file. Cards are simulated as ASCII lines with terminating newlines. Card punch files can either be text (one character per column) or column binary (two characters per column). The file type can be specified with a set command:

```
SET CDPn FORMAT=TEXT       Sets ASCII text mode
SET CDPn FORMAT=BINARY     Sets for binary card images.
SET CDPn FORMAT=BCD        Sets for BCD records.
SET CDPn FORMAT=CBN        Sets for column binary BCD records.
SET CDPn FORMAT=AUTO       Automatically determines format.
```

or in the ATTACH command:

```
ATTACH CDPn <file>                Attaches a file
ATTACH CDPn -f <format> <file>    Attaches a file with the given format.
```

The card punch can be attached to either a 704 PIO channel or a 7607 channel. The channel can be changed by the following command:

```
SET CDPn CHAN=c            Set this device to channel c.
```

The default assignments are:

```
CDP0                            Channel A(1)
CDP1                            Channel C(3)
CDP2                            Disabled
CDP3                            704 PIO.
```

If the simulator is compiled for only 704 then there is only one Card Punch called CDP.

Error handling is as follows:

error	processed as
not attached	report error and stop
OS I/O error	report error and stop

716 Line Printer (LP)

The line printer (LP) writes data to a disk file as ASCII text with terminating newlines. Currently set to handle standard signals to control paper advance.

```
SET LPn NO/ECHO          Sets echoing to console of line-printer output
SET LPn CHAN=n           sets channel for this device
SET LPn LINESPERPAGE=lpp Sets number of lines per page on printer.
```

The default assignments are:

```
LP0                      Channel A(1)
LP1                      Channel C(3)
LP2                      Disabled
LP3                      704 PIO.
```

The Printer supports the following SPRA n selection pulses for controlling spacing (spacing occurs before the line is printed):

SPRA	Action
SPRA 1	To top of form.
SPRA 2	Single space.
SPRA 3	Double space. Before printing line.
SPRA 4	Triple space. Before printing line.
SPRA 9	Suppress linefeed after print. Prints characters 73-120
SPT	Will skip if any printer line has been pulsed.

Default with no SPRA is to single space before printing.

Error handling is as follows:

error	processed as
not attached	report error and stop
OS I/O error	report error and stop

729 Magnetic Tape (MTA-D)

These come in groups of 10 units each. The controller defines which channel the devices will be on. MTx0 is unit 10.

```
SET MTx CHAN=n             Set mag tape to channel n.
```

Each individual tape drive support several options: MTA used as an example.

```
SET MTAn ONLINE           Sets the mag tape drive on-line.
SET MTAn OFFLINE          Sets the mag tape drive off-line and not ready.
SET MTAn REWIND           Sets the mag tape to the load point.
SET MTAn LOCKED           Sets the mag tape to be read only.
SET MTAn WRITEENABLE      Sets the mag tape to be writable.
SET MTAn LOW              Sets mag tape to low density.
SET MTAn HIGH             Sets mag tape to high density.
```

Options: Density LOW/HIGH does not change format of how tapes are written. And is only for informational purposes only.

Online/Offline is part of a optional RPQ for the 7090 which adds the DRS/TRS instructions.

Instr.	Function
DRS drive	Will set drive to off-line after current command is finished. Drive is not unloaded and can be re-enabled by setting it on-line.
TRS drive	Tests to see if the drive is on-line. If the drive is there and on-line it will skip the next instruction otherwise it takes the next instruction.

These instructions were put in since accessing a unloaded tape drive would hang the CPU.

Tape drives can be booted with:

```
BOOT MTxn                 Read in first three words of record.
```

ChronoClock

Disabled by default. This is a special 729 tape drive which returns the current time. It supports the option of setting the channel and drive that it will occupy.

Note: You must disable the real 729 drive that is is replacing.

The clock responds to Read and Backspace commands. A read results in a 10 character buffer being generated that has the Month, Day, Hour, Minutes, Seconds and Milliseconds.

This time is taken from the local computer time.

```
SET CHRON CHAN=n          Set channel for chrono clock.
SET CHRON UNIT=n          Sets the unit for the chrono clock.
```

Example: To set Chronoclock to unit A9 do the following:

```
SET MTA9 DISABLE
SET CHRON UNIT=9 CHAN=A
```

733 Drum (DR)

This is the drum for 704/709 and possible 7090. Up to 16 units can be attached to the CPU, all are on pseudo channel 0. Each drum is 2048K words in size. They are all stored in one file.

```
SET DR0 UNITS=n          Set number of units to of storage to attach.
```

Drum unit 0 can be booted with:

```
BOOT DR0                 Read in first three words of record.
```

Drum unit can be assigned to a 7607 channel, but this is unsupported by the operating systems. Drum channel is changed with:

```
SET DR0 CHAN=n           Set Drum to channel n.
```

7909 Devices

These devices must be attached to a 7909 channel to work.

1301/1302/2302/7320 Disk devices

The 7631 file control supports up to ten devices, which can be 7320 drums, 1301 disks, 1302 disks, or 2302 disks. Unit types are specified with the SET command.

```
SET DKn TYPE=7320        Unit n is a drum
SET DKn TYPE=7320-2      Unit n is a drum (two modules).
SET DKn TYPE=1301        Unit n is a 1301 disk
SET DKn TYPE=1301-2      Unit n is a 1301-2 disk (two modules).
SET DKn TYPE=1302        Unit n is a 1302 disk
SET DKn TYPE=1302-2      Unit n is a 1302-2 disk (two modules).
SET DKn TYPE=2302        Unit n is a 2302 disk
```

Units can be SET ENABLED or DISABLED. In addition, units can be set to enable or disable formatting:

```
SET DKn FORMAT           Enable formatting
SET DKn NOFORMAT         Disable formatting
SET DKn HA2              Enable writing of home address 2
SET DKn NOHA2            Disable writing of home address 2
SET DKn MODULE=n         Sets modules for unit, modules can only be even. 0 to 8.
SET DKn CHAN=n           Sets channel for unit (A-H)
SET DKn SELECT=n         Sets select on channel (0 or 1).
SET DKn CTSS             Sets disk to use CTSS bootstrap.
SET DKn IBSYS            Sets disk to use IBSYS bootstrap.
```

Formatting is disabled by default.

All Disk units support bootstrapping with boot command. Bootstrap code is build based on whether CPU is in CTSS mode or not.

```
BOOT DKn                    Insert custom Loader into lower memory and start.
```

Error handling is as follows:

error	processed as
not attached	report error and stop
OS I/O error	report error and stop

Hypertape 7340 Tape drive (HTA/B)

These come in groups of 10 units each. The controller defines which channel the devices will be on.

```
SET HTA CHAN=n              Sets channel for unit (A-H).
SET HTA SELECT=n            Sets select on channel (0 or 1).
```

Each individual tape drive support several options: HTA used as an example.

```
SET HTAn LOCKED      Sets the mag tape to be read only.
SET HTAn WRITEENABLE Sets the mag tape to be writable.
```

NOTE: Hypertape drives may not be working correctly since there is very little documentation available on them.

Hypertape drives support bootstrapping with boot command.

```
BOOT HTAn                   Insert custom Loader into lower memory and start.
```

7750 Communications Controller (COM and COML)

The 7750 is modeled as a terminal multiplexer with 33 lines. It consists of two device: COM is the multiplexer controller, and COML is the individual lines.

For the first 32 lines, the 7750 performs input and output through Telnet sessions connected via a user-specified listening port.

The 33rd line is permanently attached to the simulator console window.

The ATTACH command specifies the port to be used for Telnet sessions:

```
ATTACH COM <port>          set up listening port
```

where port is a decimal number between 1 and 65535 that is not being used other TCP/IP activities.

Each line (each unit of COML) can be set to one of twp modes: KSR-35 and KSR-37. In KSR-35 mode, lower case input and output characters are converted

automatically to upper case, and parity is ignored. In KSR-37 mode, lower case characters are left alone, and even parity is generated on input. KSR-37 is the default.

Once COM is attached and the simulator is running, the 7750 listens for connections on the specified port. It assumes that any incoming connection is a Telnet connections. The connections remain open until disconnected either by the Telnet client, a SET COM DISCONNECT command,or a DETACH COM command.

```
SET COM DISCONNECT=n        Disconnect line n
SET COM CHAN=n              Set channel for com controller.
```

The 7750 implements the following special SHOW commands

```
SHOW COM CONNECTIONS        Displays current connections to the 7750
SHOW COM STATISTICS         Displays statistics for active connections
```

The 7750 implements the following special SET commands:

```
SET COMLn LOG=filename      Log output of line n to filename
SET COMLn NOLOG             Disable logging and close log file
SET COMLn KSR35             Set line *n* to ksr-35
SET COMLn KSR37             Set line *n* to ksr-37
SET COMLn 2741              Set line *n* to 2741
```

Registers   The controller (COM) implements these registers:

Name	Size	Comments
ENABLE	1	Enable flag
STATE	6	Controller state
MSGNUM	12	Input message sequence number

7289 High-Speed Drum (HD)

The 7289 (also known as the 7320A) high-speed drum was a late addition to CTSS. Very little is known about the device, other than what is used in the CTSS sources.

The drum can be changed to different channels with the:

```
SET HD0 CHAN=n              Set Drum to channel n.The channel must be
                           configured as a 7289 type channel. Otherwise
                           the drum will not work.
SET HD0 UNITS=n            Sets the number of 256K drums on the unit.
```

Error handling is as follows:

error	processed as
not attached	report error and stop

Drum data files are buffered in memory; therefore, end of file and OS I/O errors cannot occur.

Symbolic Display and Input

The IBM 7090 simulator implements symbolic display and input. Display is controlled by command line switches:

```
-c                      Display/Enter as BCD character
-m                      Display/Enter instruction mnemonics
-l                      Display as lisp pointer.
(none)                  Display/Enter as octal number.
```

Instruction input uses standard 7090 assembler syntax. There are two basic instruction classes: memory reference and index reference.

Memory reference instructions have the format

```
memref{*} address{,tag}
```

Index reference instructions have the format

```
idxref{*} address,{tag},decrement
```

Specific instructions may disallow indirect addressing or limit the size of the tag, address, or decrement fields.

Channel (I/O) instructions have the same basic two formats.

Sim Load

The load command looks at the extension of the file to determine how to load the file.

Ext.	Format/Action
.crd	Loads a card image file into memory.standard 709 format + 1 card loader.
.oct	Loads an octal deck:address <blank> octal <blank> octal. . .
.sym	Loads a 709 symbolic deck.address instruction..address BCD stringaddress OCT octaloctal

Character Codes

This is the mapping between character codes used by the simulator:

Commercial	Scientific	ASCII	BCD	Card	Remark
			00		Blank
1		0	01	1	
2		0	02	2	
3		0	03	3	
4		0	04	4	
5		0	05	5	
6		0	06	6	
7		0	07	7	
8		0	10	8	
9		0	11	9	
0		0	12	10	
#	=	=	13	3-8	
@	'	'/@	14	4-8	
:		:	15	5-8	
>		>	16	6-8	
√		"	17	7-8	Tape Mark
ƀ		_	20	2-8	
/		/	21	10-1	
S		S	22	10-1	
T		T	23	10-2	
U		U	24	10-3	
V		V	25	10-4	
W		W	26	10-5	
X		X	27	10-6	
Y		Y	30	10-7	
Z		Z	31	10-8	
#		#	32	10-2-8	Word Mark
,		,	33	10-3-8	
%	(	%/(	34	10-4-8	
`		`	35	10-5-8	
\		\	36	10-6-8	
⧧		{	37	10-7-8	Segment Mark

Commercial	Scientific	ASCII	BCD	Card	Remark
-		-	40	11	also -0
J		J	41	11-1	
K		K	42	11-2	
L		L	43	11-3	
M		M	44	11-4	
N		N	45	11-5	
O		O	46	11-6	
P		P	47	11-7	
Q		Q	50	11-8	
R		R	51	11-9	
!		!	52	11-2-8	
$		$	53	11-3-8	
*		*	54	11-4-8	
]		]	55	11-5-8	
;		;	56	11-6-8	
△		∧	57	11-7-8	
&	+	&/+	60	12	also +0
A		A	61	12-1	
B		B	62	12-2	
C		C	63	12-3	
D		D	64	12-4	
E		E	65	12-5	
F		F	66	12-6	
G		G	67	12-7	
H		H	70	12-8	
I		I	71	12-9	
?		?	72	12-2-8	
.		.	73	12-3-8	
□	)	)	74	12-4-8	Lozenge
[		[	75	12-5-8	
<		<	76	12-3-8	
⧧*		|	77	12-7-8	Group Mark

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