

VM/370

ORGANIZATION AND OPERATION

JULY 14 - 15, 1975

VM ORGANIZATION AND OPERATION

JULY 14 AND 15

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TEXTS:

- IBM Virtual Machine Facility/370 Planning Guide (GC20-1801)
- IBM Virtual Machine Facility/370 System Programmer (GC20-1807)

PREREQUISITE:

- Introduction to VM/370 (July 7 and 8)

VM/370

CONTROL FLOW

## VM/370 INITIALIZATION

- PRESS LOAD
- READ 24 BYTES IN LOCATION 0
- THIS READS THE CHECKPOINT MODULE INTO LOCATION X'800'
- THE SAVE AREA IS CHECKED FOR 'CPCP' OR 'WARM'
- CHECKPOINT OR A COLD START IS PERFORMED
- IF 'CPCP' THEN WAIT PSW IS LOADED
- IF NOT 'CPCP' LOAD PAGE IMAGE COPY OF CP INTO REAL STORAGE STARTING AT PAGE 0
- PERFORM WARM START FUNCTION
- CHECKS FOR REAL STORAGE SIZE LARGE ENOUGH FOR VM
- FINDS CONSOLE AND AUTOMATICALLY LOGS ON OPERATOR
- DISPATCHER LAODS WAIT PSW UNTIL WORK STARTS

## ATTACHING A USER

- OPERATOR ENABLES THE COMMUNICATION LINES
- WHEN INITIAL INTERRUPT COMES FROM TERMINAL, CP DETERMINES TERMINAL DEVICE TYPE, WRITES ONLINE MESSAGE, AND PUTS TERMINAL LINE WAITING FOR AN ATTENTION
- USER HITS ATTENTION KEY AND CP BUILDS A SKELETON VMBLOK WITH USERID LOGONXXX (XXX = TERMINAL REAL DEVICE ADDRESS)
- CP TYPES A SINGLE BLANK AND ISSUES READ TO TERMINAL
- USER TYPES FIRST COMMAND (I.E., LOGON, MSG, DIAL)
- IF TERMINAL IS 2741, CODE SET IS IDENTIFIED AND TRANSLATE TABLES ARE SET
- INVALID FIRST COMMAND RESULTS IN A RESTART MESSAGE

## USER LOGON

- LOGON PROCESSING PERFORMS THE FOLLOWING:
  - \* INSURES NUMBER OF USERS DOES NOT EXCEED MAXIMUM ALLOWED
  - \* CHECKS USERID FOR PASSWORDS AND OPTIONAL PARAMETERS
  - \* CHECKS USERID AND PASSWORD AGAINST CP'S DIRECTORY
  - \* INSURES THAT USER IS NOT SIGNED ON ALREADY
  - \* RECONNECTS USER IF RUNNING IN DISCONNECT MODE
  - \* OBTAINS INFORMATION ABOUT USER VIRTUAL MACHINE FROM THE USER'S DIRECTORY
  - \* STORES USERID, VIRTUAL STORAGE SIZE IN USER'S VMBLOK
  - \* ALLOCATES AND INITIALIZES PAGE AND SWAP TABLES
  - \* ALLOCATES EXTENDED VMBLOK WHEN USER IS IN EC MODE

- \* ALLOCATES AND INITIALIZES DEVICE BLOCKS, CONTROL UNIT BLOCKS, AND CHANNEL BLOCKS
  - \* ESTABLISHES LINKS TO DASD DEVICES
  - \* INITIALIZE VIRTUAL DEVICE BLOCKS (I.E., READER, PUNCH, PRINTER)
  - \* MAPS ALL VIRTUAL DEVICES TO REAL DEVICES
  - \* PERFORMS ACCOUNTING
  - \* INFORMS USER OF DATE AND TIME OF MOST RECENT LOGMSG REVISION AND OF ANY QUEUED SPOOL FILES IN VIRTUAL READER, PUNCH, OR PRINTER
  - \* SENDS A READY MESSAGE TO USER AND A MESSAGE TO THE SYSTEM OPERATOR INDICATING USER IS LOGGED ON
- 
- AT COMPLETION OF LOGON USER IS PLACED IN CONSOLE FUNCTION MODE UNLESS USER HAS A NAMED SYSTEM OR DEVICE ADDRESS -- AUTOMATIC IPL
  - STOP OPTION OF IPL COMMAND ALLOWS IPL OF AN ALTERNATE NUCLEUS

## USER I/O RECONFIGURATION

### - COMMANDS

- \* ATTACH -- AVAILABLE ONLY TO SYSTEM  
OPERATOR (*any Class A operator*)
- \* DETACH -- AVAILABLE TO USER
- \* DEFINE -- AVAILABLE TO USER

USED AFTER USER IS LOGGED ON

## ATTACHING A REAL DEVICE

- SYSTEM OPERATOR DEDICATES A DEVICE TO A USER
- ALL I/O REQUESTS ARE HANDLED BY CCW TRANSLATION
- I/O SUPERVISOR DOES NOT QUEUE OPERATIONS FOR THE DEVICE OR RESTART THE DEVICE OR PERFORM ORDERED SEEK QUEUEING ON THE DEVICE
- TAPE DRIVES MUST BE ATTACHED (NON-SHARABLE DEVICES)
- THE UNIT ATTACHED CAN HAVE A VIRTUAL ADDRESS DIFFERENT FROM ITS REAL ADDRESS
- REAL DEVICES CANNOT BE ATTACHED IF THEY:
  - \* ARE CURRENTLY ATTACHED TO ANOTHER USER
  - \* CONTAIN MINIDISKS IN USE BY ANOTHER USER
  - \* ARE SYSTEM OWNED FOR PAGING OR SPOOLING

## DEFINING A VIRTUAL DEVICE

- CAN DEFINE:
  - \* CONSOLES
  - \* SPOOLED READERS, PUNCHES AND PRINTERS
  - \* DIALABLE TP LINES
  - \* VIRTUAL CHANNEL-TO-CHANNEL ADAPTERS
  - \* PSEUDO TIMERS
  - \* TEMPORARY DISKS
  
- CAN CHANGE ANY VIRTUAL DEVICE ADDRESS
  
- DEFINE VIRTUAL CHANNEL MODE (I.E., SELECTOR OR BLOCK MULTIPLEXER)
  
- CTCA CHANNEL DEFAULTS TO SELECTOR CHANNEL
  
- DEFINE WITH CHANNELS OPERAND GENERATES A VIRTUAL MACHINE RESET
  
- TEMPORARY DISKS EXIST UNTIL THEY ARE DETACHED

## DETACHING A VIRTUAL DEVICE

- USE DETACH COMMAND
- A USER CAN DETACH HIS OWN DEVICES
- SYSTEM OPERATOR CAN DETACH A REAL DEVICE FROM A USER
- A DEVICE MUST BE DEDICATED TO A SINGLE USER OR TO THE SYSTEM AND NOT BE IN USE, TO BE DETACHED  
↳ NO ACTIVE CCW'S

## DISCONNECTING A USER

### - PERMANENT DISCONNECT

- \* USER ISSUES LOGOFF OR LOGOUT COMMAND,  
TERMINATES VIRTUAL MACHINE,  
RELEASES STORAGE USED BY THE VIRTUAL MACHINE,  
DISCONNECTS TELEPROCESSING LINE

- \* LOGOFF WITH HOLD OPTION -- TELEPROCESSING  
LINE REMAINS CONNECTED

- \* SYSTEM OPERATOR CAN USE FORCE COMMAND

- \* AUTOMATIC LOGG OFF:

- TIME FOR READ OF PASSWORD EXPIRES  
(28 SECONDS)

- CONNECTION WITH NO LOGON

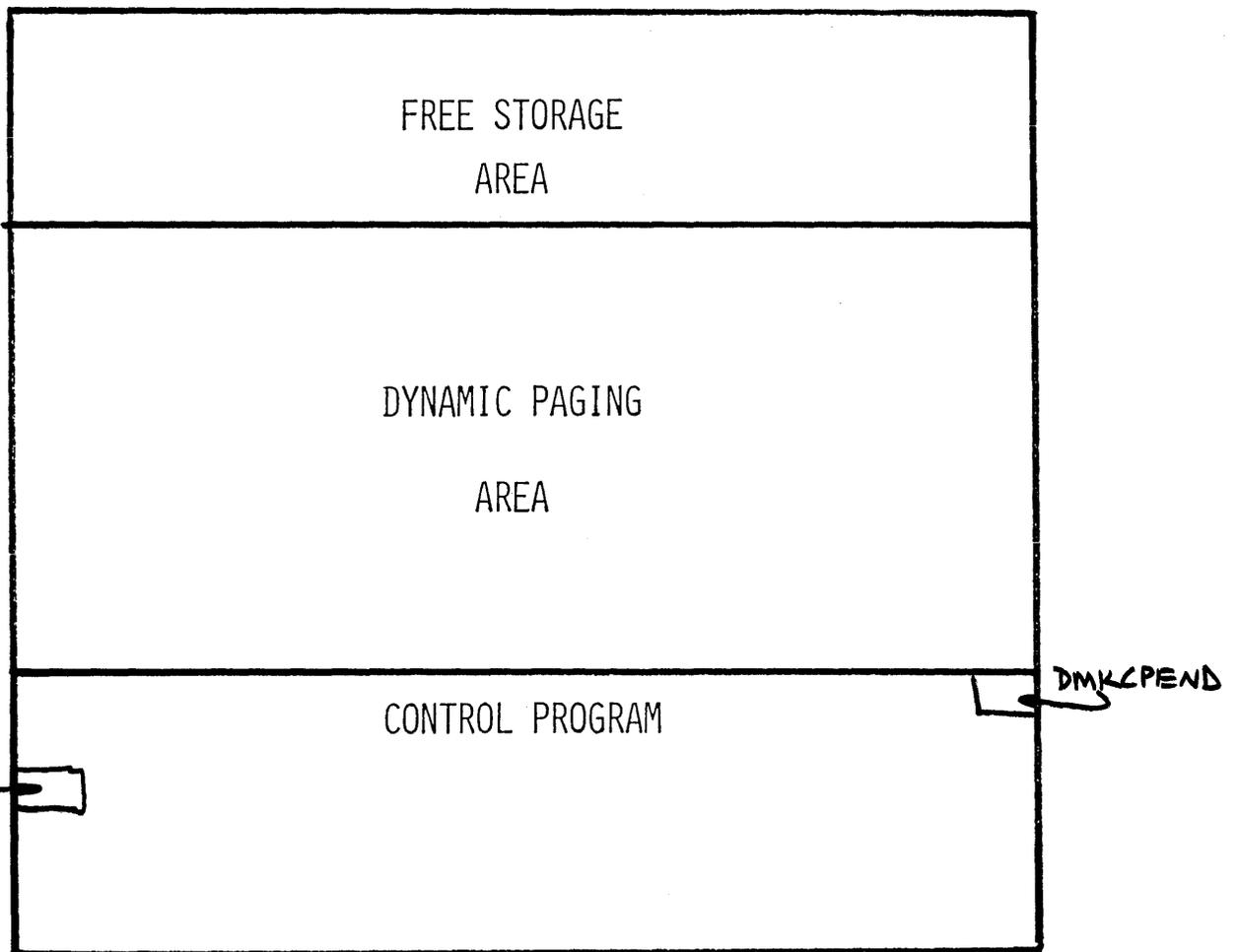
- RUN DISCONNECTED AND VIRTUAL TERMINAL  
ATTEMPTS A READ OR ENTERS A DISABLED  
WAIT STATE

IF IN VM MODE, CP WILL ISSUE A  
READ AFTER 15 MIN. TO SEE IF  
CONSOLE STILL THERE  
(#CP TERMINAL MODE CP)

- TEMPORARY DISCONNECT
  - \* USER ISSUES DISCONN COMMAND
  - \* VIRTUAL MACHINE CONTINUES TO RUN
  - \* RELEASES USER'S TERMINAL AND TELEPROCESSING LINE
  - \* HOLD OPTION -- LINE REMAINS ENABLED
  - \* DISABLED WAIT OR TERMINAL READ CAUSES SYSTEM FORCE
  - \* CP CAN BIAS SYSTEM IN FAVOR OF INTERACTIVE USERS (DISCONNECT PENALTY)
- SYSTEM OPERATOR CAN DISCONNECT A USER
- A LOGON TO A STILL RUNNING DISCONNECTED MACHINE RESULTS IN A RECONNECT

THEORY OF  
STORAGE MANAGEMENT

VM STORAGE MAP



From DMKCPSEC to DMKCPEND IS RESERVED FOR TRANSIENT PAGEABLE CP STUFF

## NORMAL PAGING REQUESTS

- VIRTUAL STORAGE MANAGEMENT
- REAL STORAGE MANAGEMENT
- AUXILIARY STORAGE MANAGEMENT

## VIRTUAL STORAGE MANAGEMENT

### SEGMENT AND PAGE TABLES

- \*INDEXABLE BY VIRTUAL ADDRESS
- \*POINTS TO REAL STORAGE ADDRESS
- \*REFERENCED DIRECTLY BY DAT FEATURE

### SWAP TABLES

- \*INDEXABLE BY VIRTUAL ADDRESS
- \*POINTS TO A PAGE ON DASD OR INDICATES PAGE IS NOT YET REFERENCED
- \*HOLDS STORAGE PROTECT KEY
- \*STATUS OF PAGE (I.E. IN TRANSIT)
- \*USED BY PAGE MANAGEMENT

### DEMAND PAGING

- \*IMPLICIT DEMAND  
USER ATTEMPTS TO REFERENCE A PAGE  
NOT AVAILABLE IN REAL MAIN STORAGE
- \*EXPLICIT REQUEST  
MADE BY CP (I.E. TRANSLATING A CCW WHICH  
REFERENCES A PAGE NOT RESIDENT IN REAL  
STORAGE)

## RELEASE PAGING

### \*IMPLICIT

WHEN USER IPL'S A NEW OPERATING  
SYSTEM OR LOGS OFF

### \*EXPLICIT

USE OF DIAGNOSE INSTRUCTION TELLS  
CP TO RELEASE PAGES

## CP VIRTUAL STORAGE

\*VIRTUAL STORAGE BUFFERS FOR SPOOLING AND  
SYSTEM DIRECTORY OPERATIONS

\*CP DOES NOT RUN IN RELOCATE MODE

## REAL STORAGE MANAGEMENT

- PAGE FRAME IS A 4096 BYTE BLOCK
- PAGE STATES
  - \* NOT-PAGEABLE
    - TEMPORARY
    - PERMANENT (LOCK, UNLOCK)
  - \* PAGEABLE
    - FREELIST - RELEASED OR PAGED OUT
    - FLUSHLIST - USER PAGES OUT OF QUEUE (IN E1 & E2)
    - USERLIST (Q1 & Q2)
- PAGING MANAGER RESPONSIBILITY
  - \* VIRTUAL STORAGE PAGES RESIDENT ARE THOSE MOST LIKELY TO BE USED
  - \* NUMBER OF CPU CYCLES FOR USED PROGRAMS IS SUFFICIENT

- REQUEST FOR REAL STORAGE
  - \* REQUEST SPACE FOR A PAGE OF VIRTUAL STORAGE
  - \* REQUEST PAGE FRAME FOR OWN USE  
(HIGH PRIORITY)
- CALLER SUPPLIES VIRTUAL ADDRESS AND OPTIONS
- CHECK FOR UNAVAILABLE PAGE STILL RESIDENT
- CAN RECLAIM A PAGE BY REMOVING IT FROM THE FREELIST
- PAGE IN TRANSIT, USE DEFERRED RETURN OPTION

## PAGE LIST OPERATION

### - FREELIST

NUMBER OF PAGES MAINTAINED ABOVE  
VALUE EQUAL TO  $Q1 + Q2 + 1$

PAGES RELEASED BY USERS GO TO FREELIST

CAN RETRIEVE PAGES FROM FLUSHLIST

### - FLUSHLIST

CHANGED PAGES GO TO PAGING FILE

UNCHANGED PAGES ARE PLACED ON FREELIST (*only on request from paging manager when free list is low*)

### - USERLIST

LEAST RECENTLY USED PAGE IS SELECTED - *upon request when flushlist is empty*

### - PAGE REQUEST FOR LOCK REMOVES PAGE FROM USERLIST

### - CP TRACKS USER PAGE-IN, PAGE-OUT, PAGE-WAIT,

TOTAL PAGES RESIDENT

*USE FLAG*  
LRU → *RESET EVERY 30ms,*  
ANY PAGE w/o USE FLAG SET  
IS ELIGIBLE FOR PAGEOUT

## VIRTUAL = REAL

- ONE FOR ONE MAPPING OF VIRTUAL STORAGE TO REAL STORAGE
- TWO VIRTUAL MACHINES WITH VIRTUAL = REAL CANNOT OCCUPY THE SAME SPACE AT THE SAME TIME
- BYPASS CCW TRANSLATION (NO I/O TO PAGE 0) I/O BEYOND BOUNDS OF VIRTUAL ADDRESSING SPACE IS NOT CHECKED
- SET NOTRANS ON ISSUED AFTER VIRTUAL MACHINE IPL
- VIRTUAL 270X LINES USE CCW TRANSLATION
- SIZE OF VIRTUAL = REAL AREA IS DETERMINED AT VM NUCLEUS GENERATION TIME

## DASD STORAGE MANAGEMENT

- DASD PAGE SPACE IS SELECTED ON PAGE-OUT
- SLOT ALLOCATION
  - \*CP MAINTAINS CYLINDER MAPS FOR VIRTUAL STORAGE OR SPOOL FILE PAGING
  - \*FINDS AVAILABLE CYLINDER AND CONSTRUCTS A PAGE ALLOCATION BLOCK
- CYLINDER ALLOCATION
  - \*CYLINDERS ARE ALLOCATED EVENLY ACROSS ALL AVAILABLE CHANNELS AND DEVICES
  - \*DEVICE TYPE, DEVICE ADDRESS, PREFERRED STATES ARE CONSIDERATIONS IN ALLOCATION
  - \*PREFERRED DEVICES
    - SPECIFIED AT VM GEN
    - DEVICES WITH SMALL SEEK TIMES
    - ALLOCATION STARTS AT RELATIVE CENTER OF VOLUME (ZIG-ZAG)

- MOVEABLE HEAD DEVICES

\*FIRST TRY TO ALLOCATE SLOT ON CYLINDER

WHERE ARM IS

\*THEN ALLOCATE ON CYLINDER FOR WHICH

PAGING I/O IS QUEUED

\*OTHERWISE ALLOCATE AS CLOSE TO CENTER

OF VOLUME AS POSSIBLE

PAGING CHANNEL PROGRAMS ARE SLOT SORTED  
AND CHAINED

## PAGING I/O

HANDLES BOTH VIRTUAL STORAGE PAGING AND SPOOLING PAGING

USES ROTATIONAL POSITION SENSING IF APPLICABLE

(3330 &  
3340)

### PAGING RATES

AFTER 200 PAGES HAVE BEEN MOVED, PAGE RATE IS CALCULATED IN PAGE MOVES/SECOND

### PAGING LOAD

PERCENTAGE OF TIME THAT MORE THAN HALF OF THE SYSTEM'S PAGES WERE IDLE DUE TO PAGE WAIT

Call CM resident page for virt.  
Mask Waiting for page.

### PROJECTION OF LOAD

RECENT PAGING LOAD IS AVERAGED WITH PREVIOUS PAGING LOAD

VIRTUAL STORAGE PAGING  
ERROR RECOVERY

- SOFT ERRORS

\*PAGE SWAP-OUT I/O ERROR

\*NEW PAGE SLOT IS ALLOCATED

\*OLD SLOT IS NOT DE-ALLOCATED

- HARD ERRORS

\*PAGE READ I/O ERROR

\*SYSTEM PAGING OR SPOOLING SPACE  
EXHAUSTED

\*PAGE READ: VIRTUAL MACHINE IS PLACED  
IN CONSOLE FUNCTION MODE  
AND USER IS NOTIFIED

\*PAGING SPACE EXHAUSTED: OPERATION OF  
VIRTUAL MACHINES PROGRESSIVELY SLOWS DOWN -  
PAGING REQUESTS CANNOT BE SATISFIED

## VIRTUAL RELOCATION

- FIRST LEVEL STORAGE

PHYSICAL STORAGE OF REAL CPU

- SECOND LEVEL STORAGE

VIRTUAL STORAGE AVAILABLE TO A VIRTUAL MACHINE

- THIRD LEVEL STORAGE

VIRTUAL STORAGE SPACE DEFINED BY THE SYSTEM OPERATING IN SECOND LEVEL STORAGE

- PAGE AND SEGMENT TABLES

LOGICAL MAPPING - SECOND TO FIRST LEVEL STORAGE

- VIRTUAL PAGE AND SEGMENT TABLES

LOGICAL MAPPING - THIRD TO SECOND LEVEL STORAGE

- SHADOW PAGE AND SEGMENT TABLES

LOGICAL MAPPING - THIRD TO FIRST LEVEL STORAGE

- NONRELOCATING VIRTUAL MACHINE HAS 1 CONTROL REGISTER FOR: (OS/MVT, MFT, ETC)
  - \*EXTENDED MASKING OF EXTERNAL INTERRUPTS
  - \*SPECIAL INTERRUPT TRAPS FOR SSM
  - \*ENABLING VIRTUAL BLOCK MULTIPLEXING
  
- RELOCATING VIRTUAL MACHINE HAS 16 CONTROL REGISTERS FOR: (VM, OS/VS)
  - \*VIRTUAL MONITOR CALLS
  - \*EXTENDED CHANNEL MASKING
  - \*PER
  - \*DYNAMIC ADDRESS TRANSLATION
  
- SIMULATION OF RELOCATION INSTRUCTIONS
  - LCTL } ALLOWED FOR VIRTUAL MACHINES
  - STCTL } NOT IN EC MODE
  - PTLB
  - RRB
  - LARA
  
- SHADOW TABLES SIMULATE DAT FOR:
  - VIRTUAL MACHINES IN EC MODE WITH
  - TRANSLATE BIT IN PSW ON

IN VIRTUAL TRANSLATE MODE:

REQUEST FOR PAGE CAN RESULT IN A  
SEGMENT EXCEPTION

A FULL SEGMENT OF SHADOW PAGES IN THE  
FORMAT SPECIFIED BY SHADOW CONTROL REGISTER  
Q IS BUILT. ALL PAGES ARE MARKED, NOT IN  
STORAGE

THIS RESULT, IN A PAGE INTERRUPT THIRD  
LEVEL ADDRESS, IS TRANSLATED TO SECOND LEVEL  
ADDRESS. IF PAGE-IN REQUIRED, SECOND LEVEL  
ADDRESS IS TRANSLATED TO FIRST LEVEL ADDRESS

IF VIRTUAL MACHINE DROPS OUT OF EC MODE, THE  
SHADOW PAGE AND SEGMENT TABLES ARE RELEASED

## FREE STORAGE MANAGEMENT

- BLOCKS OF 30 DOUBLEWORDS OR LESS GROUPED INTO 10 SUB-POOL SIZES
- USE LIFO PROTOCOL
- CHAINED LIST FOR BLOCKS OF GREATER THAN 30 DOUBLEWORDS
- SUB-POOL EXHAUSTION
  - \*SMALL SIZE BLOCKS ARE OBTAINED FROM FIRST LARGER SIZED BLOCK
  - \*LARGE BLOCKS ARE OBTAINED FROM HIGH END OF LAST LARGER BLOCK
  - \*AVOIDS FRAGMENTING OF STORAGE
- CAN ACQUIRE STORAGE IN DYNAMIC PAGING AREA AS LAST RESORT
- NUMBER OF FREE STORAGE PAGES IS DETERMINED BY:
  - 3 PAGES FOR FIRST 256K REAL STORAGE PLUS
  - 6 PAGES FOR EVERY 256K REAL STORAGE THEREAFTER

THEORY OF

SPOOLING

## SPOOLING FUNCTIONS

- SIMULATE VIRTUAL UNIT RECORD DEVICES (VIRTUAL SPOOLING EXECUTIVE).
- OPERATE REAL UNIT RECORD DEVICES (REAL SPOOLING EXECUTIVE).
- PROVIDE INTERFACE FOR CONTROLLING LOCATION, FORMAT, PRIORITY, AND UTILIZATION OF SPOOLING DATA AND RESOURCES.

## SPOOL DATA FORMAT

- ONE PAGE (4096 BYTE) BUFFERS CONTAIN DATA AND CCW'S.
- DATA IS IN REQUIRED FORMAT WITH TRAILING BLANKS SUPPRESSED.
- EACH SPOOL LOGICAL RECORD IS AS FOLLOWS:

DATA MOVING CCW	TIC TO NEXT CCW	DATA
--------------------	--------------------	------

- CARD PUNCH FILES HAVE BACK CHAINS FOR ERROR RECOVERY.
- FOR PRINTERS, IMMEDIATE OPERATION CODES ARE FOLLOWED IN THE SAME LOGICAL RECORD BY THE NEXT CCW.

## SPOOL FILE FORMAT

- FIRST SPOOL BUFFER (4096 BYTES)

PTR	PTR					
NEXT	PREVIOUS		TAG RECORD	CCW1	TIC1	DATA1
<hr/>						
CCW2	TIC2	DATA2		CCWN	TICN	DATAN
<hr/>			<hr/>			

- CONTENTS OF TAG MAY BE INTERROGATED WITH 'TAG QUERY' COMMAND.
- TAG

NOP	CCW	TIC	136 BYTES
<hr/>			

- SPOOL FILE CONTROL BLOCKS.
- ONE FILE CHAIN EACH FOR PRINTER, CARD READER, AND PUNCH.

## SPOOL BUFFER MANAGEMENT

- CP OWNS POOL OF VIRTUAL STORAGE BUFFERS (1 PAGE EACH).
- STORAGE SIZE DETERMINES NUMBER OF BUFFERS:

256K TO 655,360 BYTES	128 BUFFERS
655,360 BYTES TO 1.1 MEGABYTES	320 BUFFERS
ABOVE 1.1 MEGABYTES	640 BUFFERS
- USER IS PLACED IN WAIT IF NO VIRTUAL STORAGE FOR BUFFERS IS AVAILABLE.
- BUFFER IS ALLOCATED WHEN USER TRIES TO ISSUE SIO.
- CP LOCKS BUFFER ONLY DURING TIME OF DATA TRANSFER.
- LOW USAGE SPOOL FILE BUFFERS CAN BE TREATED AS NORMAL PAGES.

## VIRTUAL SPOOLING MANAGER

- SIMULATES OPERATION OF SPOOLED UNIT RECORD DEVICES USED BY THE VIRTUAL MACHINE.
  
- SUPPORTS SPOOLING ON:
  - \* 2540 (EXCEPT PUNCH FEED READ AND COLUMN BINARY)
  - \* 1403 MOD 2 AND N1 (132 POSITIONS)
  - \* 3211 PRINTER (150 POSITIONS)
  - \* 3505 CARD READER (EXCEPT MARK SENSE READING)
  - \* 3525 CARD PUNCH (EXCEPT CARD READ, PRINT, AND DATA PROTECT)
  
- SPOOLS ON VIRTUAL SSYSTEM CONSOLE:
  - \* 1052 MOD 7
  - \* 3210 CONSOLE MOD 1 AND 2
  - \* 3215 CONSOLE MOD 1 (145)
  - \* 3066 CONSOLE MOD 1 AND 2 (168)

\* 3277 DISPLAY MOD 2

\* 3275 DISPLAY MOD 2

- FOR PRINTERS:

\* UCS FEATURE ASSUMED

\* UCS BUFFER COMMANDS ISSUED BY VIRTUAL  
MACHINE ARE IGNORED

\* FCB (3211 PRINTER) COMMANDS ARE SIMULATED

\* OPERATOR IS RESPONSIBLE FOR REAL RCB AND  
FORMS

- READ DEVICE CAN BE ATTACHED DIRECTLY FOR USE OF  
UNSUPPORTED FEATURES.

## OUTPUT FILE PROCESSING

- SPOOLING MANAGER OPENS NEW SPOOLING FILE.
- WRITES TAG RECORD.
- USER CCW'S ARE TESTED FOR VALIDITY.
- DATA AND CCW'S ARE MOVED FROM USER VIRTUAL STORAGE SPACE TO THE BUFFER IN SPOOLING VIRTUAL STORAGE.
- FULL BUFFERS ARE WRITTEN TO A PAGE OF SECONDARY DASD STORAGE.
- USER IS IN PSEUDO-WAIT DURING INTERPRETATION OF CHANNEL PROGRAM.
- OUTPUT FILE IS CLOSED BY AN INVALID CCW COMMAND CODE OR CP CONSOLE FUNCTION CLOSE.
- FILE IS QUEUED FOR OUTPUT TO THE REAL DEVICE OR FOR INPUT TO ANOTHER USER (XFER).

## INPUT FILE PROCESSING

- CP SCANS READERS FOR A FILE WHICH MATCHES USER ID.
- NO FILE FOUND RESULTS IN UNIT CHECK/INTERVENTION REFLECTED TO USER.
- AT END OF INPUT, UNIT EXCEPTION IS REFLECTED TO THE USER UNLESS:
  - \* USER REQUESTS CONTINUOUS SPOOLING.
  - \* USER REQUESTS NO EOF REFLECTED.
- FILE IS DELETED UNLESS USER SPECIFIES SAVE.

## VIRTUAL CONSOLE SPOOLING

- HARD COPY SUPPORT FOR CMS BATCH VIRTUAL MACHINES.
- HARD COPY FOR DISPLAYS USED AS SYSTEM OR VIRTUAL MACHINE CONSOLES.
- DISCONNECTED VIRTUAL MACHINES CAN SPOOL CONSOLE OUTPUT WITHOUT LOSING IT.
- PERFORMANCE IMPROVEMENT FOR VIRTUAL MACHINES, <sup>WHICH</sup> PRODUCE A LARGE AMOUNT OF CONSOLE OUTPUT.

- CONSOLE SPOOLING IS SAME AS PRINTER SPOOLING EXCEPT FOR:
  - \* SKIP TO CHANNEL 1 EVERY 60 LINES.
  - \* VIRTUAL CONSOLE SPOOL BUFFER IS WRITTEN OUT EVERY 16 LINES OF OUTPUT.
  - \* VIRTUAL SPOOL BUFFER IS WRITTEN TO SPOOL DEVICE WHEN FIRST CCW IS PUT IN BUFFER.
  - \* EACH BUFFER CONTAINS A CLOSE FILE FOR CHECKPOINTING.
  
- VIRTUAL SYSTEM RESET, DEVICE RESET, OR IPL WILL NOT CLOSE THE VIRTUAL CONSOLE SPOOL FILE.
  
- THE SHUTDOWN COMMAND WILL CLOSE THE OPERATORS CONSOLE SPOOL FILE.
  
- THE LOGOFF, FORCE, OR DETACH OF VIRTUAL CONSOLE WILL CLOSE THE VIRTUAL CONSOLE SPOOL FILE.

## REAL SPOOLING MANAGER

- OPERATES REAL UNIT RECORD DEVICES.
- OPTIMIZES USE OF MAIN STORAGE AND CPU.
- SPOOL FILES ARE NOT DOUBLE BUFFERED.
- COMMAND CHAINING IS USED.

## OUTPUT FILE PROCESSING

- PSEUDO INTERRUPTS ARE USED TO START PROCESSING.
- WHEN CP RECEIVES A DEVICE END FOR A PRINTER OR PUNCH, THE FILE CHAIN IS SEARCHED FOR A QUEUED OUTPUT.
- A PAGE OF REAL STORAGE IS OBTAINED FOR A BUFFER. *from free area (?)*
- THE OUTPUT SEPARATOR ROUTINE PRINTS SEPARATOR.
- THE CCW'S IN THE BUFFER ARE TRANSLATED TO REAL ADDRESSES.
- THE FORWARD CHAIN PRINTER IS USED TO FIND THE NEXT BUFFER AND IT IS READ INTO THE REAL STORAGE BUFFER.
- THE OPERATOR CAN BACKSPACE OR RESTART A FILE.
- FILES CAN BE HELD OR RELEASED.

## INPUT FILE PROCESSING

- INITIATED BY DEVICE END INTERRUPT FROM A SPOOLING CARD READER.
- CP OBTAINS VIRTUAL, REAL, AND DASD BUFFER SPACE.
- CHANNEL PROGRAM READS 41 CARDS.
- FIRST CARD IS CHECKED FOR USER ID.
- UNIT EXCEPTION SIGNALS END OF FILE TRIGGERS WRITING OF FINAL BUFFER TO THE SPOOLING FILE.
- OWNER IS SENT NOTIFICATION IF LOGGED ON.
- IF OWNER HAS AN AVAILABLE CARD READER, IT IS POSTED WITH A DEVICE END INTERRUPT.

## ACCOUNTING CARD PROCESSING

- FORMATS AN 80-COLUMN CARD.
- USER MAY GENERATE ACCOUNTING CARDS IF THE ACCOUNT OPTION (ACCT) IS IN THE VIRTUAL MACHINE DIRECTORY.
- USER ISSUES DIAGNOSE INSTRUCTION X'4C' WITH A POINTER TO 70 BYTES OF INFORMATION.

## SPOOLING COMMAND SYSTEM

### - SPOOL FILE ATTRIBUTES

- \* FILE NAME AND TYPE -- 24 CHARACTERS EACH
- \* SPOOL ID -- SYSTEM ASSIGNED; 1 TO 9900
- \* NUMBER OF LOGICAL RECORDS; 1 TO 16 MILLION
- \* ORIGINATING USER -- FILE'S CREATOR
- \* NUMBER OF COPIES (OUTPUT); 1 TO 99
- \* DEVICE TYPE -- USED BY DIAGNOSE FOR A TRANSFERRED FILE
- \* CLASS FOR REAL OUTPUT OR VIRTUAL INPUT; A TO Z OR 0 TO 9

### - VIRTUAL DEVICE SPOOLING COMMANDS:

- \* CLOSE -- TERMINAL ~~IS~~ SPOOLING
- \* SPOOL -- ESTABLISHED FILE ATTRIBUTES FOR FILES READ BY A GIVEN DEVICE

- REAL DEVICE SPOOLING COMMANDS:

- \* BACKSPAC           BACKSPACE FILE N PAGES OR  
                          TO BEGINNING
  
- \* DRAIN               STOPS OPERATION OF SPECIFIED  
                          INPUT OR OUTPUT DEVICE
  
- \* START               RESTART A DEVICE AFTER  
                          DRAINING
  
- \* FLUSH               IMMEDIATELY HALT OUTPUT ON  
                          A DEVICE
  
- \* REPEAT              SUPPLEMENT NUMBER OF COPIES  
                          SPECIFIED BY USER
  
- \* LOADBUF             LOAD UCS BUFFER OR FCB
  
- \* SPACE               FORCE OUTPUT ON PRINTER TO  
                          BE SINGLE SPACED

- SPOOL FILE MANAGEMENT COMMANDS:

- \* CHANGE CHANGE FILE NAME AND TYPE,  
NUMBER OF COPIES. CLASS OF  
FILE
- \* HOLD PLACE A FILE IN HOLD STATUS
- \* FREE MAKE A FILE OR GROUP OF  
FILES AVAILABLE FOR PROCESSING  
*≡ HASP RELEASE*  
*≡ HOLD*
- \* PURGE REMOVES SPOOL FILES BEFORE  
PRINTING OR PUNCHING
- \* ORDER REORDER INPUT FILES IN A  
VIRTUAL CARD READER
- \* TRANSFER TRANSFER VIRTUAL INPUT TO  
ANOTHER USER'S VIRTUAL READER  
(CHANGE USER ID)

## SPOOLING ERROR RECOVERY

- CP FIRST RETRIES OPERATION.
  
- FOR UNRECOVERABLE ERROR CONTROL IS TURNED OVER TO THE REAL SPOOLING EXECUTIVE.
  - \* READER ERRORS -- PROCESSING IS TERMINATED AND PARTIAL FILE IS PURGED.
  
  - \* PRINTER OR PUNCH ERRORS -- OUTPUT IS REQUEUED FOR ANOTHER AVAILABLE DEVICE.
  
- FAILING DEVICE IS MARKED LOGICALLY OFFLINE.
  
- OPERATOR MUST USE VARY COMMAND TO RESTORE USE.

THEORY OF

I/O

MANAGEMENT

## I/O MANAGEMENT

REAL I/O

- EACH CHANNEL

CONTROL UNIT

DEVICE

AVAILABLE TO CP

- EACH CHANNEL PROGRAM
- I/O OPERATIONS QUEUE ON REAL DEVICE
- CONTROL IS PASSED TO INTERRUPT

RETURN ADDRESS

## VIRTUAL I/O

- EACH CHANNEL

CONTROL UNIT

DEVICE

DEFINED IN USER DIRECTORY AND VALIDATED  
AT LOGON TIME

- A VIRTUAL MACHINE ISSUING SIO GENERATES  
PRIVILEGED OPERATION EXCEPTION
- IF VIRTUAL MACHINE IS IN VIRTUAL SUPERVISOR  
STATE CONTROL, GOES TO PRIVILEGED INSTRUCTION  
SIMULATOR
- LOCATE VIRTUAL I/O BLOCKS
- ISSUE REAL SIO AND TEST STATUS
- SIMULATE SUCCESSFUL VIRTUAL SIO

## DEVICE CLASSES

TERMINAL OR CONSOLE SPOOLED UNIT-RECORD  
DEVICE REAL DEVICE ON SYSTEM

REQUESTS FOR CLASS 1 DEVICES ARE FULLY  
SIMULATED

SPOOLING MANAGER HANDLES CLASS 2 DEVICES

FOR CLASS 3 DEVICES

- CCW's ARE TRANSLATED
- REAL CHANNEL PROGRAM IS CONSTRUCTED
- DATA PAGES ARE LOCKED IN REAL STORAGE
- USER IS PUT IN PSEUDO-WAIT
- CONTROL TO REAL I/O SCHEDULER

AT COMPLETION OF ANY I/O, THE VM DISPATCHER GETS  
CONTROL

## VIRTUAL SELECTOR CHANNEL

- TRANSLATE USER SIO REQUEST INTO REAL CCW'S
- READ OR WRITE COMMAND SPECIFYING DATA CROSSING A PAGE BOUNDARY RECEIVES AN IDA FLAG
- DATA PAGES ARE LOCKED
- VIRTUAL CCW'S HAVING IDA FLAG ARE CONVERTED TO USE TRANSLATED ADDRESSES
- WITH ISAM OPTION, TIC COMMANDS ARE TRANSLATED

OS ISAM

(SELF MODIFYING CHANNEL PROGRAM)

TRANSLATION

VIRTUAL		REAL	
0	8	0	8
A	READ C+7 L=10	1	READ C+7 L=10
B	TIC TO E	2	TIC TO 3
C			
D		3	SEEK HEAD ON 6
E	SEEK HEAD ON D	4	SEARCH ON D+2
F	SEARCH ON D+2	5	
		6	

MODIFICATION

VIRTUAL		REAL	
0	8	0	8
A	READ C+7 L=10	1	READ C+7 L=10
B	TIC TO E	2	TIC TO E
C			
D		3	
E	SEEK ON HEAD D	4	SEARCH ON D+2
F	TIC TO 4	5	
		6	

## I/O COMPONENT STATES

### DISABLED

VM OPERATOR OR SYSTEM HAS TAKEN THE  
COMPONENT OFFLINE

### BUSY

COMPONENT IS TRANSFERRING DATA OR  
IS IN PHYSICAL MOTION

### SCHEDULED

NOT CURRENTLY BUSY, BUT WILL BE BUSY  
WHEN A HIGHER LEVEL COMPONENT IN THE  
SUBCHANNEL PATH FREES UP

### AVAILABLE

COMPONENT AND SUBCHANNEL PATH ARE  
FREE

## I/O REQUEST SCHEDULING

- TASK REQUESTING I/O SPECIFIES DEVICE AND DESCRIBES OPERATION
  
- REQUESTS ARE QUEUED FIFO EXCEPT:
  - \*MOVEABLE HEAD DASD DEVICES
  - \*RELEASE THE AFFECTED COMPONENT AFTER INITIATION (*SIOF command*)
  
- ORDERED SEEK QUEUEING
  - \*ASSUMES FEW CHAINED SEEKS
  - \*DEVICE SEEKS UP UNTIL REQUESTS ARE SATISFIED; THEN SEEKS DOWN
  - \*QUEUES ARE SORTED IN THE DIRECTION OF SEEK
  
- DEDICATED CHANNEL
  - \*ONE OR MORE FOR A VIRTUAL MACHINE
  - \*VIRTUAL MACHINE DEVICE ADDRESSES MUST BE IDENTICAL TO REAL MACHINE DEVICE ADDRESSES
  - \*USES VM/370 CP ERROR RECORDING AND CHANNEL RECOVERY

## VIRTUAL CONSOLE SIMULATION

### READ

- \*CAN EDIT AND TRANSLATE TO EBCDIC

### WRITE

- \*PROVIDES LENGTH, TRANSLATION, FORMAT FUNCTIONS

### CONTROL

- \*USED FOR NOP AND ALARM
- \*CONSTRUCTS MESSAGE FOR ALARM FOR LOW SPEED T.P. DEVICES

### VIRTUAL SENSE

- \*SENSE DATA MOVED FROM VIRTUAL DEVICE BLOCK TO LOCATION SPECIFIED BY CCW

### VIRTUAL TIC

- \*FETCHES VIRTUAL CCW SPECIFIED

THEORY OF  
TIME MANAGEMENT

TIMING FACILITIES  
IN S/370 EC MODE

- INTERVAL TIMER (X'50')
- TIME OF DAY CLOCK
- TIME OF DAY CLOCK COMPARATOR
- CPU TIMER

## VM/370 USE OF REAL TIMERS

- INTERVAL TIMER:
  - \* TIME SLICING ONLY.
  
- TIME OF DAY CLOCK:
  - \* TIME STAMPING MESSAGES.
  - \* ELAPSED IN QUEUE TIME FOR DISPATCHING PRIORITY.
  
- TIME OF DAY CLOCK COMPARATOR:
  - \* SCHEDULING TIMER DRIVEN EVENTS FOR CP AND VIRTUAL MACHINES.
  
- CPU TIMER IS:
  - \* ACCUMULATION OF CP OVERHEAD.
  - \* DETECTION OF IN-QUEUE TIME SLICE END.
  - \* VIRTUAL CPU TIMER SIMULATION.

## REAL TIMING

- ACCUMULATION OF CP OVERHEAD:
  - \* TIMER FIELD IS INITIALIZED TO X'7FFFFFFF FFFFFFFF'
  - \* CURRENT VALUE OF TIMER FIELD IS LOADED INTO CPU TIMER. ( $1\mu s$ )
  - \* CPU OVERHEAD = MAXIMUM INTEGER-TIMER FIELD.
  
- IN-QUEUE TIME SLICE END:
  - \* ALLOWABLE PROBLEM STATE TIME SLICE IS LOADED INTO CPU TIMER.
  - \* VALUE DEPENDS ON QUEUE ENTERED AND CPU MODEL (I.E., Q1 FOR 370/145 IS 300 MILLISECONDS, AND Q2 IS 2 SECONDS).
  - \* AT END OF EACH PROBLEM STATE TIME SLICE, THE PROBLEM TIME USED IS ADDED TO TOTAL PROBLEM TIME.
  
- VIRTUAL CPU TIMER SIMULATION:
  - \* ~~TIMER RUNOUT IN THIS SLICE~~ ONLY IF VALUE IN VIRTUAL CPU TIMER IS LESS THAN ALLOWABLE PROBLEM STATE TIME SLICE.
  - \* VM CONTROL BLOCK FLAGGED AND CPU TIMER INTERRUPT IS INTERPRETED AS A VIRTUAL TIMER INTERRUPT, NOT AN IN-QUEUE TIME SLICE END.

## VIRTUAL TIMING

- VIRTUAL LOCATION X'50' UPDATED EACH TIME DISPATCHER HAS BEEN ENTERED AFTER A RUNNING USER IS INTERRUPTED (TIME OF INTERRUPT TO TIME OF DISPATCH).
- VIRTUAL CLOCK COMPARATOR REQUESTS ARE INSERTED INTO THE GENERAL COMPARATOR REQUEST STACK AND ARE POSTED WHEN INTERRUPT OCCURS.
- SET VIRTUAL TIMER REQUEST UPDATE TIMER FIELD.
- STORE VIRTUAL TIMER REQUEST UPDATES TIMER FIELD BY VIRTUAL CPU TIME USED TO ENTER DISPATCHER AND PASS VALUE TO USER.
- SET TIME OF DAY CLOCK ARE IGNORED.
- REAL TIMERS PROVIDE ACCURATE INTERRUPTS TO PROGRAMS WHICH DEPEND ON ELAPSED CPU AND/OR WAIT TIME.
- ONLY THE TIME OF DAY CLOCK CAN MEASURE WALL CLOCK TIME.

## VIRTUAL TIMING -- REAL TIMER

- AN EC MODE VIRTUAL MACHINE WITH REAL TIMER OPTION HAS BOTH REAL INTERVAL TIMER AND REAL CPU TIMER.
- REAL TIMER REQUESTS FOR WAITING MACHINES ARE MAINTAINED IN CLOCK COMPARATOR STACK.
- CPU TIMER REQUESTS DEPEND ON THE TIME OF DAY CLOCK.
- IF VIRTUAL CPU TIMER HAS A LARGE NEGATIVE VALUE, A REAL TIMER REQUEST IS SCHEDULED TO OCCUR WHEN THE VIRTUAL TIMER GOES POSITIVE.
- COMPARATOR REQUESTS FOR MACHINES IN SELF-IMPOSED WAIT ARE ADDED TO REAL COMPARATOR STACK AND ARE REMOVED WHEN USER RESUMES PROCESSING OR GOES INTO PSEUDO WAIT.

HIERARCHICAL ORGANIZATION

OF VM/370

## DISPATCHER/SCHEDULER

### - USER CATEGORIES:

#### \* INTERACTIVE USER: Q1

REGULAR AND FREQUENT I/O.

ELIGIBLE FOR THIS CATEGORY ANY TIME  
A VIRTUAL CONSOLE CHANNEL PROGRAM  
COMPLETES OR I/O FOR DEDICATED OR  
DIALED VIRTUAL TP LINE COMPLETES.

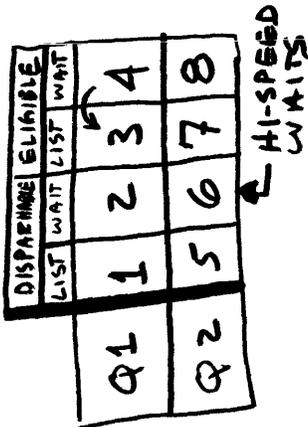
#### \* NON-INTERACTIVE USER: Q2

IDLE STATE DUE TO ENTERING CP  
CONSOLE FUNCTION MODE

LOAD WAIT STATE PSW NOT ENABLED  
FOR ANY BUSY CHANNEL

- VIRTUAL MACHINE STATES:

- 1 INTERACTIVE AND DISPATCHABLE  
(Q1 + DISPATCH LIST)  
**FROM (**
- 2 INTERACTIVE AND NON-DISPATCHABLE
- 3 INTERACTIVE AND ELIGIBLE FOR Q1 AND  
Q1 IS FULL (WAITING Q1 + ELIGIBLE LIST)  
**FROM (4) TO (1)**
- 4 IN WAIT STATE AND TERMINAL READ OR  
WRITE ACTIVE
- 5 NON-INTERACTIVE AND DISPATCHABLE  
(Q2 + DISPATCH LIST)  
**FROM (6, 7, 8)**
- 6 NON-INTERACTIVE AND NON-DISPATCHABLE
- 7 NON-INTERACTIVE AND ELIGIBLE FOR Q2  
BUT Q2 IS FULL (WAITING Q2 AND ELIGIBLE  
LIST) **FROM (1, 2, 5, 8) TO (5)**
- 8 IDLE -- WAITING FOR ASYNCHRONOUS I/O  
OR EXTERNAL INTERRUPT OR STOPPED  
**FROM (1, 5)  
TO (5, 7)**



- DISPATCH LIST

- \* VM BLOKS FOR VIRTUAL MACHINE STATES 1 AND 5
- \* USERS WHICH CAN BE RUN AT ANY TIME
- \* SORTED BY DISPATCH PRIORITY (CPU TIME/WAIT TIME OVER LIFE OF CURRENT TASK)
- \* STATE 1 USERS HAVE PRIORITY 0 (TOP of LIST)
- \* PRIORITY IS REPROJECTED EACH TIME A USER IS DROPPED FROM A QUEUE

- ELIGIBLE LIST

- \* USERS IN STATE 3 AND 7
- \* DUE TO LOAD ON CPU THESE USERS ARE NOT ALLOWED TO COMPETE FOR CPU
- \* HIGHEST PRIORITY USER IN ELIGIBLE LIST REPLACES USER DROPPED FROM DISPATCH LIST
- \* ELIGIBLE LIST HAS TWO SORTED COMPONENTS, Q1 ELIGIBLE AND Q2 ELIGIBLE
- \* SCHEDULING PRIORITY IS DETERMINED WHEN VIRTUAL MACHINE IS ADDED TO ELIGIBLE LIST
- \* PRIORITY BASED ON

A = PAGING BIAS FACTOR X PROJECTED WORKING SET (%)

B = USER BIAS FACTOR X VIRTUAL MACHINE'S USER PRIORITY

$$C = \frac{A + B}{\text{PAGING BIAS FACTOR} + \text{USER BIAS FACTOR}}$$

$$D = C + \text{TO D SHIFTED VALUE}$$

↳ Time of Day

OVER BIAS

IF ENTERING Q2 AFTER BEING DROPPED FROM Q1  
PRIORITY = D - INTERACTIVE BIAS FACTOR

ELSE PRIORITY = D

- \* PAGING AND USER BIAS FACTORS SET THE RELATIVE IMPORTANCE OF ASSIGNED PRIORITY AND STORAGE REQUIREMENT
- \* PRIORITY DELAY FACTOR SETS THE AMOUNT OF EFFECT THE PAGING AND USER BIASES ARE TO HAVE
- \* INTERACTIVE BIAS FACTOR HELPS IMPROVE COMMAND RESPONSE FOR Q1 USERS WHO MAY SPEND SOME TIME IN Q2

- BASIC VM SCHEDULER USES THE FOLLOWING BIAS:

PAGING BIAS FACTOR	0
USER BIAS FACTOR	1
PRIORITY DELAY FACTOR	0
INTERACTIVE BIAS FACTOR	0

IF ENTERING Q2 AFTER BEING DROPPED FROM Q1  
PRIORITY = D - INTERACTIVE BIAS FACTOR

ELSE PRIORITY = D

- \* PAGING AND USER BIAS FACTORS SET THE RELATIVE IMPORTANCE OF ASSIGNED PRIORITY AND STORAGE REQUIREMENT
- \* PRIORITY DELAY FACTOR SETS THE AMOUNT OF EFFECT THE PAGING AND USER BIASES ARE TO HAVE
- \* INTERACTIVE BIAS FACTOR HELPS IMPROVE COMMAND RESPONSE FOR Q1 USERS WHO MAY SPEND SOME TIME IN Q2

- BASIC VM SCHEDULER USES THE FOLLOWING BIAS:

PAGING BIAS FACTOR	0
USER BIAS FACTOR	1
PRIORITY DELAY FACTOR	0
INTERACTIVE BIAS FACTOR	0

WIDTH  
~~DEPTH~~ OF MULTIPROGRAMMING

- SCHEDULER MONITORS PAGING ACTIVITY OF ALL USERS AND OF SYSTEM.
- USER'S WORKING SET MUST NOT EXCEED THE SYSTEMS REMAINING CAPACITY IF USER IS TO BE MOVED TO THE DISPATCH LIST.
- USER'S WORKING SET = ACTUAL WORKING SET IF ACTUAL IS CONTINUOUSLY GREATER THAN OR LESS THAN PROJECTION.

OTHERWISE: USER'S WORKING SET = ~~2.5~~

[ 0.5 • (ACTUAL WORKING SET + CURRENT PROJECTED WORKING SET) ]

ACT. WS. = MIN(PAGES REFERENCED)

- IF SUM OF USER'S WORKING SET IS LESS THAN MAXIMUM NUMBER OF PAGES IN DYNAMIC PAGING AREA -- USER IS ADDED TO THE DISPATCHING LIST.
- ACTUAL WORKING SET IS THE SMALLER OF:
  - \* PAGES REFERENCED
  - \* AVERAGE NUMBER OF PAGES RESIDENT AT ANY GIVEN READ WHILE IN QUEUE PLUS NUMBER OF TIMES PAGE WAIT WAS ENTERED DUE TO A STOLEN PAGE

- SKEWING CONDITIONS:

- \* NO PAGING LOAD RESULTS IN A WORKING SET EQUAL TO APPROXIMATELY HALF THE RESIDENT

PAGE TOTAL

$$\sum_{i=1}^n \frac{PR_i}{n}$$

$PR_i = \# \text{ of pages res within } i \text{ th page paged in}$

- \* EXCESSIVE PAGING CONDITIONS RESULT IN A WORKING SET EQUAL TOTAL NUMBER OF PAGES REFERENCED WHILE IN QUEUE

- DISPATCHING PRIORITY

- \* RUNNING AVERAGE OF CPU TIME/WAIT TIME
- \* USERS MOST LIKELY TO GO INTO WAIT HAVE A HIGHER DISPATCHING PRIORITY

- USER IS DEFINED BY VM/370 AS COMPUTE BOUND IF HE EXECUTES FOR 50 MILLISECONDS WITHOUT ENTERING WAIT STATE

- INTERACTIVE USERS ARE AT TOP OF DISPATCHABLE LIST  
Disp. LIST  $\Sigma Q1 \& Q2$ ; Q1 on top

- DISPATCHER HAS A FAST DISPATCH PATH FOR VIRTUAL MACHINES WHICH HAVE ISSUED PRIVILEGED INSTRUCTION NOT HANDLED BY VMA

## FAVORED EXECUTION

- BASIC FAVORED EXECUTION OPTION
  - \* USER IS NEVER DROPPED FROM A QUEUE
  - \* RESULTS IN AN IMPLICIT COMMITMENT OF MAIN STORAGE
  - \* REDUCES TIMESHARING ELAPSED TIME INCREASE
  
- FAVORED EXECUTION PERCENTAGE OPTION
  - \* ONLY ONE VIRTUAL MACHINE CAN HAVE A PERCENTAGE SPECIFIED
  - \* USER REMAINS IN QUEUE AND RECEIVES A MINIMUM PERCENTAGE OF TOTAL CPU TIME
  
- PERCENTAGE OF TOTAL CPU ASSURANCE
  - \* IN QUEUE TIME SLICE IS MULTIPLIED BY PERCENTAGE
  - \* FAVORED USER IS AT TOP OF DISPATCHABLE LIST UNTIL GUARANTEE IS REACHED
  - \* USER GOES TO NORMAL DISPATCHING PRIORITY AFTER GUARANTEE AND BEFORE INTERVAL HAS EXPIRED

## INTERNAL TRACE TABLE

- FOR EACH 256K BYTES OF REAL STORAGE ONE PAGE IS ALLOCATED TO TRACE TABLE.
- EACH ENTRY IS 16 BYTES (FIRST BYTE IS IDENTIFIER).
- TRACE ENTRIES:

01	EXTERNAL INTERRUPTS
02	SVC INTERRUPTS
03	PROGRAM INTERRUPTS
04	MACHINE CHECK INTERRUPTS
05	I/O INTERRUPTS
06	FREE STORAGE REQUESTS
07	RELEASE FREE STORAGE
08	ENTRY INTO DISPATCH
09	QUEUE DROP
0A	RUN USER REQUESTS
0B	START I/O
0C	UNSTACK I/O INTERRUPT
0D	STORING VIRTUAL CSW
0E	TEST I/O
0F	HALT DEVICE
10	UNSTACK IOBLOK OR TROBLOK
11	NCP BASIC TRANSMISSION UNIT

- MONITOR START CP TRACE AND  
MONITOR STOP CP TRACE CONTROL RECORDING
  
- AFTER VM/370 IPL, CP INTERNAL TRACE IS ALWAYS ACTIVE
  
- TRACE DATA IS RECORDED FROM LOWEST TO HIGHEST ENTRY  
IN TABLE, THEN OVERLAYS TABLES
  
- ABEND DUMP CONTAINS CP INTERNAL TRACE TABLE

VM / 370

I N T E R R U P T    H A N D L I N G

## INTERRUPT HANDLING

I/O INTERRUPT

PROGRAM INTERRUPT

MACHINE CHECK INTERRUPT

SVC INTERRUPT

EXTERNAL INTERRUPT

## I/O INTERRUPT

### - ASYNCHRONOUS

- \* CHANGE IN STATUS OF I/O DEVICE (I.E., BUSY TO NOT BUSY)
- \* PENDING REQUESTS ARE RESTARTED
- \* DEVICE END IS PASSED TO USER IF IT IS A DEDICATED DEVICE

### - SYNCHRONOUS

- \* INTERRUPTING DEVICE HAS AN ACTIVE I/O CONTROL BLOCK
- \* IF UNIT CHECK, CP SCHEDULES SENSE AND THEN ERROR RECOVERY PROGRAM IS CALLED
- \* IF INCOMPLETE OPERATION (I.E., CHANNEL END, NO DEVICE END), CONTROL UNIT AND CHANNEL ARE RESTARTED
- \* IF COMPLETE OPERATION, I/O CONTROL BLOCK IS TAKEN OFF DEVICE AND DEVICE, CONTROL UNIT, AND CHANNEL ARE RESTARTED

## VIRTUAL I/O INTERRUPT

- VIRTUAL ADDRESS OF UNIT AND VIRTUAL DEVICE CONTROL BLOCKS ARE LOCATED
- IF SIO FAILED, THE VIRTUAL CONTROL BLOCK CONTAINS REAL CONDITION CODE (CHANNEL BUSY IS DETECTED BY CP BEFORE I/O AND SHOULD NOT BE SEEN BY VIRTUAL MACHINE)
- IF CSW STORED (CC=1), STATUS IS REFLECTED TO USER AND VIRTUAL COMPONENTS ARE MARKED AVAILABLE
- IF UNIT CHECK BIT IS ON IN STATUS, SENSE INFORMATION IS SAVED SO THAT THE VIRTUAL MACHINE CAN ISSUE SENSE
- A BIT IN THE INTERRUPT MASK IS SET DESIGNATING THE RELATIVE DEVICE ADDRESS ON THE CONTROL UNIT
- FOR PCI OR CE (CHANNEL CLASS) INTERRUPTS, THE ADDRESS (CUU) IS STORED

## PROGRAM INTERRUPT

- CPU IN SUPERVISOR STATE
  - \* SYSTEM FAILURE IN CP NUCLEUS
  - \* ABEND
  
- CPU IN PROBLEM STATE
  - \* VIRTUAL MACHINE IS EXECUTING
  - \* IF DAT EXCEPTION, VIRTUAL MACHINE ISSUED A PRIVILEGED INSTRUCTION OR PROTECTION EXCEPTION OCCURRED FOR A SHARED SEGMENT SYSTEM

## PRIVILEGED INSTRUCTIONS

- I/O PRIVILEGED INSTRUCTIONS
  - \* HANDLED BY VIRTUAL I/O EXECUTOR
  
- NON-I/O PRIVILEGED INSTRUCTIONS
  - \* SIMULATED BY CP
  
  - \* INVALID PRIVILEGED INSTRUCTIONS: CP REFLECTS INVALID INTERRUPT TO VIRTUAL MACHINE
  
  - \* CS AND CDS ARE NOT STANDARD ON 370/135 AND 370/145 BUT CP WILL SIMULATE THEM
  
  - \* SOME SIMULATE INSTRUCTIONS ARE:
    - LPSW
    - SSM
    - SSK
    - ISK
    - DC (DIAGNOSE)

SOME SYSTEM/370 EC MODE PRIVILEGED SIMULATION:

SCK	SET CLOCK
SCKC	SET CLOCK COMPARATOR
STCKC	STORE CLOCK COMPARATOR
SPT	SET CPU TIMER
STPT	STORE CPU TIMER
STNSM	STORE AND <u>AND</u> SYSTEM MASK
STOSM	STORE AND <u>OR</u> SYSTEM MASK
STIDP	STORE CPU IDENTIFICATION
STIDC	STORE CHANNEL IDENTIFICATION
LCTL	LOAD CONTROL
STCTL	STORE CONTROL
LRA	LOAD REAL ADDRESS
RRB	RESET REFERENCE BIT
PTLB	PURGE TABLE LOOK-ASIDE BUFFER
IPK	INSERT PSW KEY
SPKA	SET PSW KEY FROM ADDRESS

## DIAGNOSE INTERFACE

- USED FOR COMMUNICATION BETWEEN A VIRTUAL MACHINE AND VM/370 CP
- MUST HAVE STORAGE ADDRESSES REAL TO THE VIRTUAL MACHINE SPECIFIED
- DIAGNOSE CODE MUST BE A MULTIPLE OF FOUR
- USER SHOULD RUN WITH INTERRUPTS DISABLED WHEN ISSUING DIAGNOSE
- DIAGNOSE CODES:
  - 0 STORE EXTENDED IDENTIFICATION CODE
  - 4 EXAMINE DATA FROM REAL STORAGE
  - 8 EXECUTE VM/370 CP CONSOLE FUNCTION
  - C PSEUDO TIMER FACILITY
  - 10 RELEASE VIRTUAL STORAGE PAGES
  - 14 MANIPULATE INPUT SPOOL FILES
  - 18 STANDARD DASD I/O

- DIAGNOSE CODES (CONTINUED):

1C	CLEAR I/O AND MACHINE CHECK RECORDING
20	GENERAL VIRTUAL I/O WITHOUT INTERRUPT
24	VIRTUAL DEVICE TYPE INFORMATION
28	DYNAMIC TIC MODIFICATION
2C	RETURN DASD START OF LOGREC AREA
30	READ ONE PAGE OF LOGREC DATA
34	READ SYSTEM DUMP SPOOL FILE
38	READ SYSTEM SYMBOL TABLE
3C	DYNAMICALLY UPDATE SYSTEM USER DIRECTORY
4C	GENERATE ACCOUNTING CARDS FOR VIRTUAL USER
50	SAVE 3704/3705 CONTROL PROGRAM IMAGE
58	VIRTUAL CONSOLE INTERFACE FOR 3270
5C	ERROR MESSAGE EDITING

## MACHINE CHECK INTERRUPT

- CP RECOVERY MANAGEMENT SUPPORT (RMS) SAVES DATA FOR FE MAINTENANCE
  
- DAMAGE ASSESSMENT
  - \* SYSTEM TERMINATION
  
  - \* VIRTUAL USER TERMINATION
  
  - \* REFRESH DAMAGED INFORMATION  
NO CHANGE ON CONFIGURATION
  
  - \* REFRESH DAMAGED INFORMATION  
DEFECTIVE STORAGE PAGE REMOVED
  
  - \* ERROR RECORDING ONLY
  
- OPERATOR IS INFORMED OF RMS ACTIONS

## SVC INTERRUPT

### - MACHINE IN PROBLEM STATE

- \* IF ADSTOP (X'B3') : OVERLAID INSTRUCTION REPLACED AND VIRTUAL MACHINE IS PLACED IN CONSOLE FUNCTION MODE
- \* ERROR RECORDING INTERFACE (76) : CP CONVERTS VIRTUAL INFORMATION TO REAL
- \* VIRTUAL MACHINE IN EC MODE OR PAGE 0 NOT IN REAL STORAGE : ALL GENERAL AND FLOATING POINT REGISTERS ARE SAVED AND INTERRUPT IS REFLECTED TO THE VIRTUAL MACHINE
- \* VIRTUAL MACHINE IN BC MODE AND PAGE 0 IN MAIN STORAGE : THE SVC OLD PSW IS STORED AND INTERRUPT IS REFLECTED TO THE VIRTUAL MACHINE

## MACHINE IN SUPERVISOR STATE

- SVC 0
  - \* FATAL ERROR -- ABEND
  
- SVC 4
  - \* RESERVED
  
- SVC 8
  - \* LINK REQUEST (REGISTER 15)
  - \* SAVE REGISTERS 12 AND 13
  - \* BRANCH DIRECTLY IF IN CP NUCLEUS
  - \* PAGEABLE MODULE -- TRANSLATE ADDRESS
  - \* PLACE ADDRESS IN REGISTER 12
  
- SVC 12
  - \* RETURN REQUEST
  - \* RESTORE REGISTERS 12 AND 13
  - \* RETURNS CONTROL VIA OLD PSW
  - \* UNLOCKS ANY PAGEABLE AREA IN ISSUING MODULE

- SVC 16

- \* RELEASE CURRENT SAVE AREA FROM ACTIVE CHAIN
- \* ADDRESS OF NEXT HIGHER SAVE AREA PLACED IN REGISTER 13
- \* UNLOCKS ANY PAGEABLE AREA IN ISSUING MODULE

- SVC 20

- \* OBTAIN NEW SAVE AREA
- \* ADDRESS OF NEXT AVAILABLE SAVE AREA PLACED IN REGISTER 13
- \* 35 SAVE AREAS SET UP INITIALLY

## EXTERNAL INTERRUPTS

- TIMER INTERRUPT
  - \* MACHINE IN WAIT: CONTROL GOES TO DISPATCH WHICH WAITS FOR ANOTHER INTERRUPT
  - \* MACHINE IN PROBLEM STATE: CURRENT USER PSW IS UPDATED FROM EXTERNAL INTERRUPTION. OLD PSW: CONTROL IS TRANSFERRED TO DISPATCHER
  
- EXTERNAL INTERRUPT
  - \* PRESS CONSOLE INTERRUPT BUTTON
  - \* CURRENT SYSTEM OPERATOR IS REFERENCED
  - \* OPERATOR'S VIRTUAL MACHINE IS DISCONNECTED
  - \* CAN LOG ON AN ALTERNATE OPERATOR'S CONSOLE
  
- EXTENDED VIRTUAL INTERRUPT FACILITY
  - \* EXTERNAL INTERRUPTS ARE CHAINED TO THE VIRTUAL MACHINE BLOCK
  - \* DIRECT INTERRUPTS (CPU TIMER, CLOCK COMPARATOR) ARE REFLECTED TO VIRTUAL MACHINE AND LEFT CHAINED

SYSTEM MAINTENANCE

# PRE-SYSGEN PROCEDURES

PREPARE DIRECTORY CARDS

PREPARE SYSTEM DESCRIPTION

PREPARE REAL IO DESCRIPTION

\*\*  
FORMAT VOLUMES TO BE USED FOR SYSGEN

RESTORE STARTER SYSTEM

\*\*OPTIONAL

PREPARE SAVED SYSTEM TABLE DESCRIPTIONS

PREPARE FORMS CONTROL BUFFER DESCRIPTIONS

Handwritten mark

# CASE STUDY REAL I/O DECK

DMKRIO	CSECT		
	RDEVICE	ADDRESS=00B,DEVTYPE=1403, FEATURE=(UNVCHSET),CLASS=A	X
	RDEVICE	ADDRESS=00C,DEVTYPE=2540R	
	RDEVICE	ADDRESS=00D,DEVTYPE=2540P,CLASS=(B)	
	RDEVICE	ADDRESS=00E,DEVTYPE=1403, FEATURE=(UNVCHSET),CLASS=C	X
	RDEVICE	ADDRESS=01F,DEVTYPE=3215	
	RDEVICE	ADDRESS=(030,14),DEVTYPE=3705,ADAPTER=IBM1, BASEADD=030,MODEL=3,CPTYPE=EP	X
	RDEVICE	ADDRESS=(150,4),DEVTYPE=3330	
	RDEVICE	ADDRESS=(180,2),DEVTYPE=3420	
	RDEVICE	ADDRESS=(270,3),DEVTYPE=3277	
	RDEVICE	ADDRESS=(2D0,8),DEVTYPE=2305,MODEL=2	
	RCTLUNIT	ADDRESS=008,CUTYPE=2821	
	RCTLUNIT	ADDRESS=018,CUTYPE=3215	
	RCTLUNIT	ADDRESS=030,CUTYPE=3705,FEATURE=16-DEVICE	
	RCTLUNIT	ADDRESS=150,CUTYPE=3830	
	RCTLUNIT	ADDRESS=180,CUTYPE=3803	
	RCTLUNIT	ADDRESS=270,CUTYPE=3272,FEATURE=16-DEVICE	
	RCTLUNIT	ADDRESS=2D0,CUTYPE=2835	
	RCHANNEL	ADDRESS=0,CHTYPE=MULTIPLEXOR	
	RCHANNEL	ADDRESS=1,CHTYPE=BLKMPXR	
	RCHANNEL	ADDRESS=2,CHTYPE=BLKMPXR	
	<b>RIOGEN</b>	<b>CONS=01F,ALTCONS=032</b>	
	<b>END</b>		

## CASE STUDY SYSTEM PARAMETER DECK

DMKSYS

CSECT

SYSOWN (VM DRM1,PAGE),VMDSK1,VMDSK2

SYSRES SYSVOL=VMDSK1,SYSRES=150,SYSTYPE=3330, X

SYSERR=2,SYSWRM=4,SYSNUC=5

SYSCOR RMSIZE=512K

SYSOPR

SYSTIME ZONE=5,LOC=WEST,ID=EST

SYSLOCS

END

# DIRECTORY

DIRECTORY 150 3330 VMDSK1

- 
- 
- 

USER MAINT MAINT 320K 1M EG

CONSOLE 009 3215

SPOOL 00C 2540 READER

SPOOL 00D 2540 PUNCH A

SPOOL 00E 1403 A

MDISK 190 3330 6 40 VMDSK1 R RPASS WPASS

- 
- 
- 

USER OPERATOR OPERPQ 256K 1M ABCDEG

- 
- 
- 

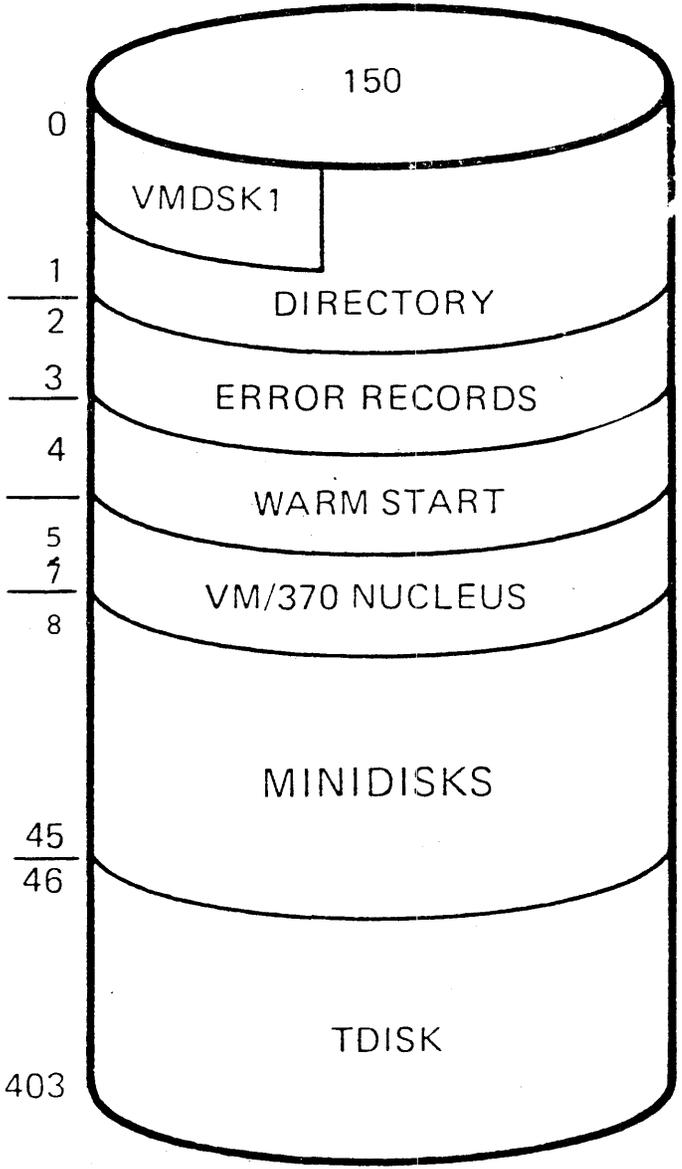
USER USER1 PASS1

- 
- 
- 

USER USER2 PASS2

- 
- 
-

# FORMATTING NEW SYSRES VOLUME

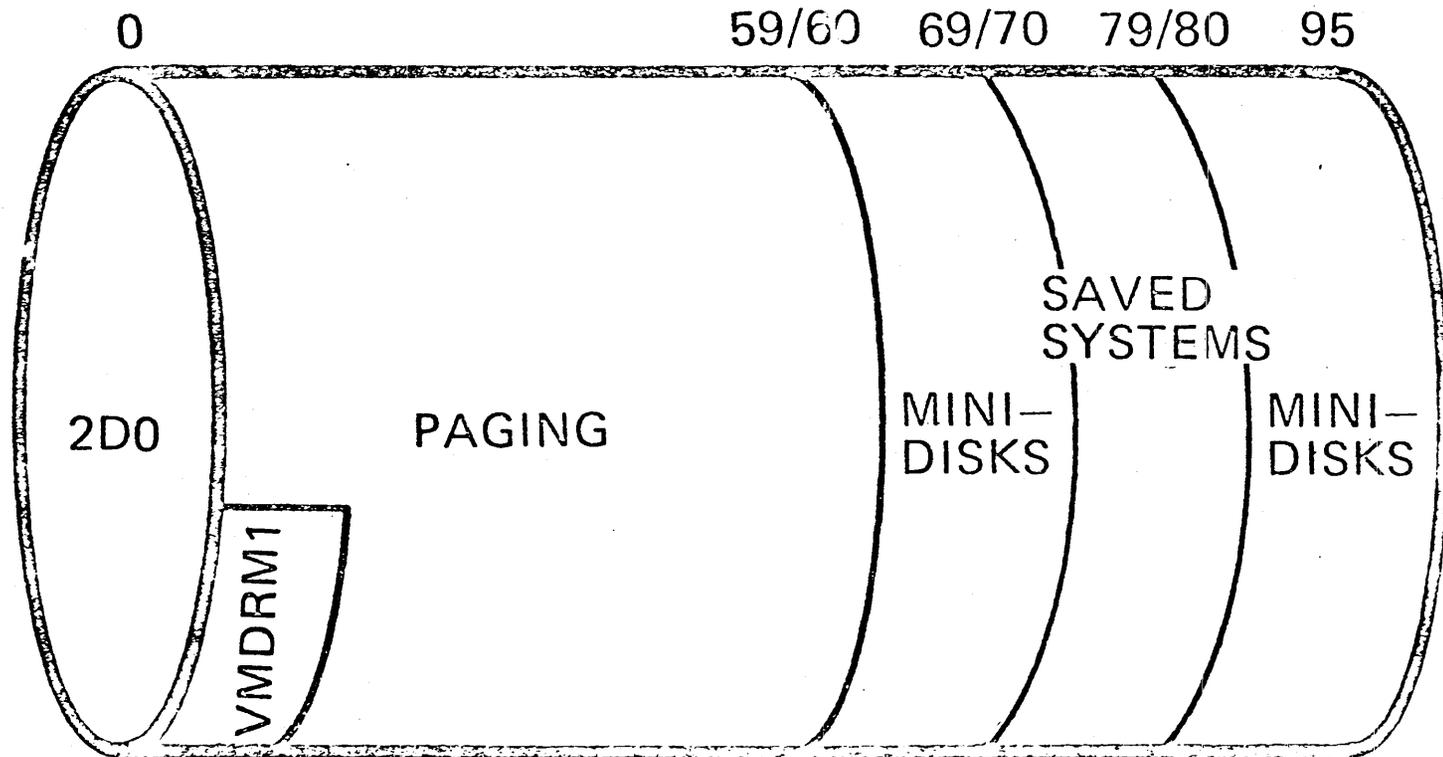


```
FORMAT, 150, 3330, VMDSK1, 000, 007  
ALLOCATE, 150, 3330, VMDSK1  
DRCT, 000, 001  
PERM, 002, 007  
PERM, 008, 045  
TDSK, 046, 403  
END
```

7.5V43

VII. 6

# FORMATTING PAGING VOLUME



FORMAT, 2D0, 2305-2, VM DRM1, 070, 079

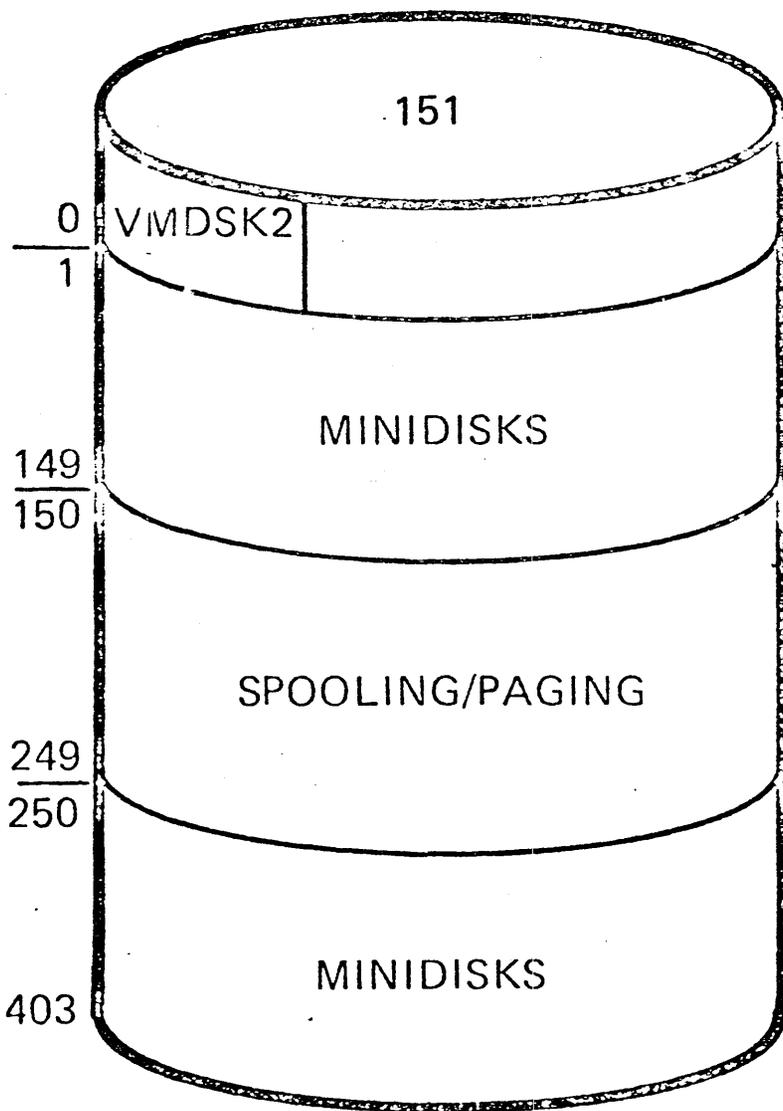
FORMAT, 2D0, 2305-2, VM DRM1, 000, 059

ALLOCATE, 2D0, 2305-2, VM DRM1

TEMP, 000, 059

PERM, 060, 095

# FORMATTING SPOOLING VOLUME



7.5V45

```
FORMAT, 151, 3330, VMDSK2, 000, 000
FORMAT, 151, 3330, VMDSK2, 150, 249
ALLOCATE, 151, 3330, VMDSK2
PERM, 000, 149
TEMP, 150, 249
PERM, 250, 403
END
```

7.5V45

7

# SYSGEN PROCEDURES

IPL VM/370

IPL CMS

PUNCH UTILITY PROGRAMS

CREATE DIRECTORY

ASSEMBLE SYSTEM AND IO DESCRIPTION

\*\*\*  
SELECT V=R OPTION

BUILD NEW SYSTEM

\*\*\* OPTIONAL

ASSEMBLE SAVED SYSTEM NAME TABLE AND/OR FORMS CONTROL DESCRIPTIONS

# TESTSYS VIRTUAL MACHINE CONFIGURATION

USER TESTSYS PASSWORD 512K  
OPTION ECMODE  
CONSOLE 01F 3215  
SPOOL 00C 2540 READER A  
SPOOL 00D 2540 PUNCH A  
SPOOL 00E 1403 A  
LINK MAINT 190 190 R  
MDISK 150 3330 380 10 CPV2L0  
MDISK 151 3330 390 13 CPV2L0  
LINK MAINT 190 152 R  
MDISK 191 3330 255 5 VMDSKI  
MDISK 2D0 2305 60 10 VMDRM1  
SPECIAL 030 2701 IBM

# CREATING A VIRTUAL DIRECTORY

```
LOGIN TESTSYS PASSWORD
DEFINE 01F AS 009
IPL 190
EDIT VIRTDRCT DIRECT
INPUT
DIRECTORY 150 3330 VMDSK1
USER OPERATOR OPERATOR 512K 1M ABCDEG
CONSOLE 009 3215
SPOOL 00C 2540 READER A
SPOOL 00D 2540 PUNCH A
SPOOL 00E 1403 A
MDISK 190 3330 0 76 CMS190 R
MDISK 191 3330 10 1 VMDSK2
MDISK 150 3330 0 2 VMDSK1
USER VUSER VUSER 320K
CONSOLE 009 3215
SPOOL 00C 2540 READER A
SPOOL 00D 2540 PUNCH A
SPOOL 00E 1403 A
LINK OPERATOR 190 190 R
MDISK 191 3330 11 1 VMDSK2

FILE
DIRECT VIRTDRCT DIRECT
DEFINE 009 AS 01F
```

## RUNNING CP IN A VIRTUAL MACHINE

```
login testsys password
msg op mount cp nucleus and attach 181
TAPE 181 ATTACHED
ipl 181
NUCLEUS LOADED ON VMDSK1
DMKDSP450W CP ENTERED; DISABLED WAIT PSW
CP
```

```
ipl 150
```

```
VM/370 VERSION n LEVEL 0 12/04/72 15:56:10
```

```
NOW 15:57:04 EST MONDAY 12/04/72
CHANGE TOD CLOCK (YES|NO):no
15:57:54 LOGON AT 15:57:54 EST MONDAY 12/04/72
15:57:54 LINE 01F LOGON AS OPERATOR USERS=001
15:57:54 START ((COLD|WARM) (DRAIN))|(SHUTDOWN):cold
15:58:17 FILES: NO RDR, NO PRT, NO PUN
!
15:58:27 set dump 00e
!
15:59:05 query users
15:59:12 001 USERS, 000 DIALED
!
CP
query users
015 USERS, 000 DIALED
begin
```

# SETTING THE CLOCK

VM/370 VERSION n LEVEL 0 11/30/7n

NOW 17:23:41 EST THURSDAY 11/30/7n

CHANGE TOD CLOCK (YES/NO) : yes

SET DATE MM/DD/YY : 12/01/7n

SET TIME HH:MM:SS : 08:28:00

PRESS "TOD ENABLE SET" KEY AT DESIGNATED INSTANT

TOD

NOW 08:28:00 EST FRIDAY 12/01/7n

CHANGE TOD CLOCK (YES/NO) : no

REMOTE SPOOLING

COMMUNICATIONS SUBSYSTEM

## RSCS AND VM/370 CP

- RUNS UNDER CP AS A VIRTUAL MACHINE.
- CONSISTS OF:
  - \* VIRTUAL MACHINE OPERATOR CONSOLE
  - \* RSCS SYSTEM DISK
  - \* VIRTUAL TELECOMMUNICATIONS LINES
- VIRTUAL PUNCHES, PRINTERS, AND CARD READERS ARE DEFINED DYNAMICALLY.
- RUNS IN 512K VIRTUAL STORAGE.
- EACH REMOTE STATION HAS A UNIQUE LOCATION IDENTIFIER.
- EACH TRANSMISSION PATH (LINK) HAS AN ID WHICH DEFINES A LOCATION IDENTIFIER.
- SUPPORTS BISYNC PROGRAMMABLE AND NON-PROGRAMMABLE REMOTE STATIONS.

## RSCS AND DIAGNOSE

### - ISSUES DIAGNOSE INSTRUCTIONS

- 08 EXECUTE VM/370 CP COMMAND
- 0C GET CURRENT TIME AND DATE
- 14 MANIPULATE INPUT SPOOL FILES
- 20 PERFORM GENERAL I/O WITHOUT INTERRUPT
- 24 DETERMINE VIRTUAL DEVICE TYPE  
INFORMATION
- 5C ERROR MESSAGE EDITING

# RSCS SUPERVISOR

## - SERVICES

- \* TASK MANAGEMENT
- \* I/O MANAGEMENT
- \* INTERRUPT HANDLING
- \* VIRTUAL STORAGE MANAGEMENT

## TASK MANAGEMENT

- TASK EXECUTION CONTROL
  - \* DISPATCHER
  - \* INITIATE AND TERMINATE TASKS
  
- TASK SYNCHRONIZATION
  - \* MECHANISM TO MAKE TASKS READY OR NOT READY FOR EXECUTION
  - \* SERVICE REQUESTOR MAY BE SUSPENDED WHILE REQUEST IS PROCESSED
  
- TASK-TO-TASK COMMUNICATION
  - \* ALERT -- IMMEDIATELY INTERRUPT A TASK WHICH HAS AN ASYNCHRONOUS EXIT ROUTINE
  - \* GIVE/TAKE -- TASK EXCHANGE INFORMATION BUFFERS WITH OTHER TASKS

## I/O MANAGEMENT

- HANDLES REQUESTS FOR I/O OPERATIONS
- HANDLES I/O INTERRUPTS
- STARTS I/O OPERATION
- COMPLETES I/O REQUEST
- USES I/O REQUEST TABLE
  - \* SYNCHRONIZATION LOCK FOR I/O COMPLETION
  - \* ADDRESS OF DEVICE FOR I/O
  - \* NUMBER OF SENSE BYTES
  - \* ADDRESS OF CHANNEL PROGRAM
- AFTER I/O RETURNS
  - \* CONDITION CODE FOR SIO
  - \* CSW
  - \* ANY SENSE BYTES

## INTERRUPT HANDLING

- SVC INTERRUPTS

- \* SUSPENDS DISPATCHING OF A TASK
- \* PASS CONTROL TO SUPERVISOR

- EXTERNAL INTERRUPTS

- \* SEARCHES FOR ASYNCHRONOUS EXIT REQUESTS

- I/O INTERRUPTS

- \* ACTIVE I/O REQUEST -- UPDATE STATUS
- \* ELSE LOOK FOR ASYNCHRONOUS EXIT REQUEST

## VIRTUAL STORAGE MANAGEMENT

- REQUESTS FOR MAIN STORAGE
- RESERVES PAGES FOR TASK
- TASKS FREE MAIN STORAGE
- MANAGES REQUESTS FOR FREE ELEMENTS OF SUPERVISOR STATUS QUEUE

## LINE DRIVER

- MANAGES I/O ON BSC LINE
- MANAGES TRANSMISSION OF SPOOL FILE DATA
- PROVIDES GIVE/TAKE REQUESTS
- TWO TYPES
  - \* SUPPORT REMOTE 2770, 2780, 3770 (IN 2770 MODE), 3780 TERMINALS
  - \* SUPPORT HASP AND ASP SYSTEMS OR WORK STATIONS

VIRTUAL MACHINE ASSIST

AND

OS AND VS

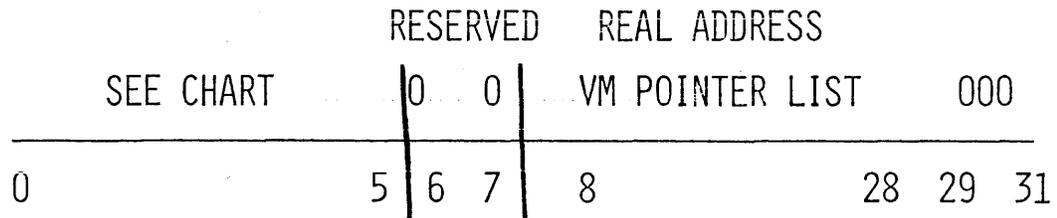
## VMA

- AVAILABLE ON SYSTEM/370 MODELS 135, 145, 158.
- INTERCEPTS AND HANDLES:
  - \* INTERRUPTS CAUSED BY SVCS.
  - \* INVALID PAGE CONDITIONS.
  - \* PRIVILEGED INSTRUCTIONS:

LRA	LOAD REAL ADDRESS
STCTL	STORE CONTROL
RRB	RESET REFERENCE BIT
<u>ISK</u>	INSERT STORAGE KEY
<u>SSK</u>	SET STORAGE KEY
IPK	INSERT PSW KEY
STNSM	STORE THEN <u>AND</u> SYSTEM MASK
STDSM	STORE THEN <u>OR</u> SYSTEM MASK
<u>SSM</u>	SET SYSTEM MASK
<u>LPSW</u>	LOAD PSW
SPKA	SET PSW KEY FROM ADDRESS

— = BC MODE  
E8E8 . EC MODE ALSO

- CONTROLLED BY REAL CONTROL REGISTER 6, LOADED BEFORE EACH VIRTUAL MACHINE IS DISPATCHED.



BIT	VALUE
0	1 VMA ON 0 VMA OFF
1	1 VIRTUAL MACHINE IN PROBLEM STATE 0 VIRTUAL MACHINE IN SUPERVISOR STATE
2	1 ISK AND SSK NOT HANDLED BY VMA 0 ISK AND SSK HANDLED BY VMA
3	1 360 AND 370-NON DAT ONLY 0 370 DAT ALLOWED (EC MODE)
4	1 SVC INTERRUPTS NOT HANDLED BY VMA 0 SVC INTERRUPTS HANDLED BY VMA
5	1 SHADOW TABLE MODE 0 SHADOW TABLE FIXUP NOT ALLOWED

- POINTER LIST IS CREATED AT USER LOGON AND CONTAINS:
  - \* REAL SEGMENT TABLE POINTER AND LENGTH, PAGE SIZE, SEGMENT SIZE
  - \* POINTER TO REAL ADDRESS OF VIRTUAL CONTROL REGISTER 0
  - \* POINTER TO REAL ADDRESS OF CURRENT VIRTUAL PSW
  - \* POINTER TO 64- BYTE WORKSPACE FOR VMA

## VMA AND PROGRAM EVENT RECORDING (PER)

- FOR ALL INSTRUCTIONS IN VMA EXCEPT SVC AND LPSW, PER ACTS AS THOUGH THEY ARE EXECUTED IN SUPERVISOR STATE.
- CHANGES MADE TO VIRTUAL PSW OR SWAP TABLE ENTRIES IN VM/370 REAL STORAGE ARE NOT INDICATED AS STORAGE ALTERATION EVENTS.
- VIRTUAL SVC INTERRUPT, PER MONITORING SPECIFIED IN CURRENT REAL PSW, CURRENT VIRTUAL PSW, OR VIRTUAL NEW SVC PSW CAUSES REAL SVC INTERRUPT.
- VIRTUAL LPSW RESULTS IN A REAL PRIVILEGED INSTRUCTION INTERRUPT.
- PER MONITORING SPECIFIED IN REAL PSW CAUSES VM/370 PAGE INVALID INTERRUPT TO BE INACTIVE.
- PRIVILEGED INSTRUCTION INTERRUPTS FROM VIRTUAL INSTRUCTIONS MAY SHOW PER EVENT FOR INSTRUCTION FETCH.

## RESTRICTIONS OF VMA

- VMA IS TURNED OFF IF VIRTUAL MACHINE:
  - \* HAS INSTRUCTION ADDRESS STOP SET  
(~~ONLY~~ SVC HANDLING OFF)
  - \* HAS SHARED SEGMENT
  - \* TRACES SVC AND PROGRAM INTERRUPTS.

HANDSHAKING

AND VS

## HANDSHAKING AND VS

- VIRTUAL MACHINE FEATURE FOR VS1 HAS THE FOLLOWING FUNCTIONS:
  - \* CLOSE CP SPOOL FILES WHEN VS1 JOB OUTPUT FROM DSO, TERMINATOR, AND OUTPUT WRITER IS COMPLETE.
  - \* PROCESSES VS1 PSEUDO PAGE FAULTS.
  - \* PROVIDES NON-PAGING MODE FOR VS1 UNDER VM/370.
  
- VS1 DETERMINES THAT IT IS RUNNING UNDER VM/370 BY ISSUING STORE PROCESSOR ID (STIDP).
  
- IF FINDS VERSION CODE X'FF' (VM/370), VS1 ISSUES DIAGNOSE X'00' TO STORE VM/370 EXTENDED IDENTIFICATION CODE.
  
- IF VM/370 RETURNS A CODE, THEN VS1 RUNS UNDER HANDSHAKING.
  
- ISSUE SET PAGEX ON COMMAND TO ENABLE PSEUDO PAGE FAULT HANDLING.

- CLOSING CP SPOOL FILES.
  - \* VS1 ISSUES DIAGNOSE X'08' TO PASS CP CLOSE COMMAND DURING JOB TERMINATION.
  - \* VS1 ISSUES THIS COMMAND FOR EACH SPOOL FILE.
  
- PSEUDO PAGE FAULTS:
  - \* MULTIPROGRAMMING VS1 MACHINE CAN DISPATCH ONE TASK WHILE WAITING FOR A PAGE REQUEST FOR ANOTHER TASK.
  - \* VM/370 PASS PSEUDO PAGE FAULT TO VS1 (INTERRUPT CODE X'14').
  - \* VM/370 STORES VIRTUAL MACHINE ADDRESS THAT CAUSED PAGE FAULT AT LOCATION X'90' IN VS1 (TRANSLATION EXCEPTION ADDRESS).
  - \* VM/370 REMOVES THE VS1 VIRTUAL MACHINE FROM PAGE WAIT AND EXECUTION WAIT.
  - \* WHEN PAGE IS AVAILABLE, VM/370 INTERRUPTS VS1 AND TURNS ON HIGH ORDER BIT IN THE TRANSLATION EXCEPTION ADDRESS FIELD.

- VS1 NON-PAGING MODE:
  - \* REQUIRES THAT:
    - VIRTUAL STORAGE SIZE IS EQUAL TO THE SIZE OF THE VM/370 VIRTUAL MACHINE.
    - VIRTUAL MACHINE SIZE IS AT LEAST ONE MEGABYTE.
    - VM/VS HANDSHAKING FEATURE IS AVAILABLE.
  - \* AVOID DUPLICATE PAGING; VS1 FIXES ALL PAGES.
  - \* USES LESS PRIVILEGED INSTRUCTIONS.
  - \* WORKING SET SIZE MAY INCREASE.
  
- HANDSHAKING AVOIDS:
  - \* INSERT STORAGE KEY (ISK) -- USE KEY TABLE.
  - \* SEEK SEPARATION FOR 2314.
  - \* ENABLE/DISABLE IN VS1 I/O SUPERVISOR.
  - \* TEST CHANNEL (TCH) PRECEDING SIO.

VM/370

RECOVERY AND RESTART

3350

8.4 ms LAT.

317 E6 BYTES

555 CYLS

3344

10.1 ms LAT.

280 E6 BYTES

2784 CYLS (LOGICAL)

## RECOVERY MANAGEMENT SUPPORT (RMS)

- AT COLD OR WARM START, RMS DECIDES IF VM/370 IS RUNNING IN A VIRTUAL OR REAL MACHINE.
- A VERSION CODE OF X'FF' RETURNING FROM A STORE CPU ID COMMAND SAYS THAT VM/370 IS RUNNING IN A VIRTUAL MACHINE.
- FOR VM/370 RUNNING IN A VIRTUAL MACHINE, RMS ONLY SETS THE WAIT BIT IN THE VIRTUAL MACHINE CHECK NEW PSW ON.
- MACHINE CHECK INTERRUPTS AND CHANNEL ERRORS (EXCEPT CHANNEL DATA CHECKS) ARE NOT REFLECTED TO A VIRTUAL MACHINE.
- FOR VM/370 RUNNING IN A REAL MACHINE, STORE CHANNEL ID GETS EACH CHANNEL TYPE ONLINE.
- MACHINE LOGOUT AND EXTENDED I/O LOGOUT AREAS ARE OBTAINED AND INITIALIZED.
- VM/370 ASSUMES INTEGRATED CHANNELS FOR ALL CPU MODELS EXCEPT 370/165 II AND 370/168.

## MACHINE CHECK HANDLER

- A CORRECTED CPU, REAL STORAGE, OR CONTROL STORAGE MALFUNCTION GENERATES A MACHINE CHECK INTERRUPT.
- THE CPU FORMATS THE DATA IN THE FIXED AND EXTENDED LOGOUT AREAS.
- THE MACHINE CHECK HANDLER WRITES THIS AREA TO THE ERROR RECORDING CYLINDER ON SYSRES.
- AN UNCORRECTED MALFUNCTION GENERATES A MACHINE CHECK INTERRUPT AND INTERRUPT CODE DESIGNATING UNSUCCESSFUL RECOVERY.
- FOUR RECOVERY LEVELS:
  - \* FUNCTIONAL RECOVERY
  - \* SYSTEM RECOVERY
  - \* SYSTEM SUPPORTED RESTART
  - \* SYSTEM REPAIR

- FUNCTIONAL RECOVERY
  - \* BY CPU RETRY, ECC FACILITY, MACHINE CHECK HANDLER
  - \* MCH CORRECTS STORAGE PROTECT FEATURE KEYS AND INTERMITTENT ERRORS IN REAL STORAGE
  
- SYSTEM RECOVERY
  - \* INTERRUPTED USER IS TERMINATED
  
- SYSTEM-SUPPORTED RESTART
  - \* MACHINE CHECK IN A CRITICAL ROUTINE
  - \* AUTOMATIC RELOAD OF SYSTEM IS INITIATED
  
- SYSTEM REPAIR
  - \* HARDWARE ERROR FORCES AUTOMATIC RELOAD TO BE UNSUCCESSFUL

## MCH INITIAL ANALYSIS

- DISABLES INTERRUPTS TO ~~AUDIO~~ <sup>AVOID</sup> RECURSIVE MACHINE CHECKS.
- DISABLES FOR SOFT MACHINE CHECK INTERRUPTS.
- SAVES CONTENTS OF FIXED AND EXTENDED LOGOUT AREAS IN THE MACHINE CHECK RECORD.
- ALTERS MACHINE CHECK NEW PSW TO POINT TO TERM SUBROUTINE.
- ENABLES FOR HARD MACHINE CHECK INTERRUPTS.
- SAVES RUNNING STATUS OF USER IN USER VMBLOK.
- EXAMINES MACHINE CHECK DATA FOR:
  - \* MCIC = ZERO
  - \* PSW INVALID
  - \* SYSTEM DAMAGE
  - \* TIMING FACILITIES DAMAGE

THESE ARE UNCORRECTABLE AND INITIATE AUTOMATIC SHUTDOWN/RESTART

- WHEN INSTRUCTION PROCESSING DAMAGE BIT IS ON, CHECKS FOR:

\* MULTIPLE-BIT ERROR IN MAIN STORAGE

\* SPF KEY ERROR

\* RETRY FAILED

VM/370 TERMINATED IF IN SUPERVISOR STATE --  
USER RESET OR TERMINATED IF VM/370 IN  
PROBLEM STATE

- CPU RETRY OR ECC SUCCESSFUL ON SOFT ERRORS, CONTROL GOES TO SOFT RECORDING SUBROUTINE.

- EXTERNAL DAMAGE, CONTROL TO SOFT ERROR RECORDING.

## MAIN STORAGE ANALYSIS SUBROUTINE

- ENTERED DUE TO MULTIPLE BIT STORAGE ERROR.
- MACHINE CHECK NEW PSW IS SET UP TO POINT TO ROUTINE INDICATING SOLID MACHINE CHECK.
- MULTIPLE BIT ERRORS IN CP NUCLEUS CAUSE VM/370 SHUTDOWN AND AUTOMATIC RESTART.
- OTHERWISE MAIN STORAGE IS EXERCISED FOR HARD OR SOFT ERROR.
- SOLID ERROR, 4K PAGE FRAME IS MARKED UNAVAILABLE:
  - \* IF UNALTERED, BACKUP COPY IS PAGED-IN TO A NEW PAGE FRAME.
  - \* IF ALTERED, VM/370 RESETS OR TERMINATES USER WITH A MESSAGE TO VIRTUAL CONSOLE.

## STORAGE PROTECT FEATURE ANALYSIS SUBROUTINE

- CONTROL WHEN THERE IS AN SPF ERROR.
- DETERMINES IF FAILURE IS IN CP NUCLEUS OR USER STORAGE.
- FOR CP, SPF ROUTINE EXERCISES ALL 16 KEYS IN THE FAILING 2K OF STORAGE, FIVE TIMES EACH.
  - \* HARD FAIL -- VM/370 SHUTDOWN AND AUTOMATIC RESTART.
  - \* SOFT FAIL -- ZERO KEY IS RESTORED.
- FOR USER, ALL 16 KEYS ARE EXERCISED, FIVE TIMES EACH.
  - \* HARD FAIL -- RESET OR TERMINATION AND 4K PAGE FRAME IS REMOVED AS AVAILABLE.
  - \* SOFT FAIL -- STORAGE KEY IS OBTAINED FROM SWAP TABLE AND STORED IN THE FAILING 2K FRAME.

- RECOVERY FACILITY MODE SWITCH
  - \* CLASS F USER
  - \* CHANGE MODE OF CPU RETRY AND ECC RECORDING
  - \* SET MODE (RETRY/MAIN) (QUIET/RECORD)
  - \* VM/370 RUNNING UNDER VM/370 IGNORES THIS COMMAND
  
- VM/370 LAST MESSAGE
  - \* CATASTROPHIC ERROR AND UNABLE TO RECORD
  - \* IF SYSTEM OPERATOR IS LOGGED ON AS USER AND IS CONNECTED, A MESSAGE IS SENT
  - \* OTHERWISE, CPU IS PUT IN DISABLED WAIT AND INSTRUCTION COUNTER IS LOADED WITH A WAIT STATE CODE
  
- VIRTUAL USER TERMINATION
  - \* USER IS MARKED NON-DISPATCHABLE.
  - \* MACHINE CHECK RECORD IS FORMATTED.
  - \* USER IS NOTIFIED OF TERMINATION.
  - \* SYSTEM OPERATOR IS NOTIFIED.
  - \* IF VIRTUAL = REAL, USER IS LOGGED OFF WITH HOLD OPTION.
  - \* VIRTUAL USER IS PUT INTO CONSOLE FUNCTION MODE.

## SOFT RECORDING SUBROUTINE

- TWO FUNCTIONS
  - \* FORMAT AND RECORD MACHINE CHECK RECORD.
  - \* MAINTAIN THRESHOLD FOR CPU RETRY AND ECC ERRORS AND ~~INVOKE~~ QUIET MODE AUTOMATICALLY.
- CPU RETRY MODE
  - \* NORMAL OPERATING STATE OF VM/370.
  - \* CHANGE BY USING SET COMMAND.
  - \* 12 SOFT MACHINE CHECKS CAUSE SHIFT TO QUIET.
- CPU RETRY QUIET ~~EN~~ MODE
  - \* CPU RETRY AND ECC REPORTING ARE DISABLED.
- ECC REPORTING MODE
  - \* 370/135 -- 168 NORMAL STATE IS QUIET.
  - \* 370/155 II -- 165 II NORMAL STATE IS RECORD.
  - \* AUTOMATIC RESTART DOES NOT RESET MODE.
- TERMINATION ROUTINE
  - \* IF SOFT ERROR -- RESTORE SYSTEM STATUS AND RETURN CONTROL TO POINT WHERE ERROR OCCURRED.
  - \* IF HARD ERROR -- GO TO OPERATOR COMMUNICATION SUBROUTINE.

## CHANNEL CHECK HANDLER

- ENTERED WHEN THERE IS:
  - \* A CHANNEL DATA CHECK
  - \* A CHANNEL CONTROL CHECK
  - \* AN INTERFACE CONTROL CHECK
  
- ENTERED WHEN AN ERROR IS DETECTED FOLLOWING:
  - \* SIO
  - \* TIO
  - \* HIO
  - \* I/O INTERRUPTION
  
- SAVES INFORMATION FOR DEVICE DEPENDENT ERROR RECOVERY.
  
- IF SYSTEM INTEGRITY IS DAMAGED, CP ISSUES MESSAGE TO SYSTEM OPERATOR AND PUTS CPU IN DISABLED WAIT WITH WAIT STATE CODE IN THE INSTRUCTION COUNTER.
  
- NO RECOVERY FOR CHANNEL ERRORS ON I/O EVENTS ISSUED BY VIRTUAL USERS.
  
- ERROR RECOVERY PROGRAM (ERP) FOR THE DEVICE ATTEMPTS TO RETRY AND RECOVER.

## CHANNEL CONTROL SUBROUTINE

- ENTERED WHEN:
  - \* SIO WITH FAILING STATUS.
  - \* I/O INTERRUPT FROM CHANNEL CONTROL CHECK.  
INTERFACE CONTROL CHECK  
CHANNEL DATA CHECK
- BUILDS CHANNEL CHECK RECORD AND I/O ERROR BLOCK.
- I/O ERROR BLOCK IS USED BY:
  - \* ERP ON CP INITIATED I/O FOR RECOVERY.
  - \* ERROR CORRECTION CODE FOR RECORDING  
CHANNEL CHECK RECORD.
- IF CP TERMINATION FLAG IS SET (LOGOUT PENDING),  
MESSAGE IS SENT TO THE LOGGED ON AND CONNECTED  
SYSTEM OPERATOR.
- IF NO REAL DEVICE BLOCKS EXIST, CP RECORDS THE  
CHANNEL CHECK RECORD AND SYSTEM CONTINUES.

ERROR RECORDING INTERFACE  
FOR VIRTUAL MACHINES

- VIRTUAL USER ISSUES SVC 76 TO INDICATE THAT RECORDING OF AN ERROR IS NEEDED.
- IF SVC PASSED VALID PARAMETERS, THE ERROR RECORD IS EXAMINED.
- ERROR RECORD INVALID, SVC IS REFLECTED TO THE VIRTUAL MACHINE AS AN SVC INTERRUPT FOR OPERATING SYSTEM ACTION.
- VALID ERROR RECORD, VIRTUAL INFORMATION IS CHANGED TO REAL AND IS RECORDED.
- CONTROL IS RETURNED TO INSTRUCTION FOLLOWING SVC 76.
- ELIMINATES DUPLICATE ERROR RECORDING.

## ERROR RECORDING

- RECORDS:
  - \* UNIT CHECKS
  - \* MACHINE CHECKS
  - \* CHANNEL CHECKS
  - \* HARDWARE ENVIRONMENTAL SENSE DATA
- DATA FORMAT USED BY CPREP PROGRAM.
- ERROR RECORDING CYLINDER HAS PAGE RECORDS.
- EACH PAGE HAS:
  - \* HEADER (CYLINDER AND PAGE NUMBER)
  - \* NEXT AVAILABLE SPACE FOR RECORDING WITHIN PAGE
  - \* PAGE IN USE INDICATOR
  - \* FLAG BYTE
  - \* LENGTH PREFIX
- ONE CYLINDER FOR I/O ERRORS.
- ONE CYLINDER FOR MCH AND CCH ERRORS.
- OPERATOR IS NOTIFIED WHEN EITHER CYLINDER IS 90% FULL AND 100% FULL.

## DASD ERROR RECOVERY

- RECOVERY IS ATTEMPTED FOR:
  - \* CP INITIATED I/O TO ITS DEVICES
  - \* USER INITIATED I/O TO CP SUPPORTED DEVICES USING DIAGNOSE INTERFACE
  
- CHANNEL ERRORS:
  - \* CHANNEL CONTROL CHECK
  - \* INTERFACE CONTROL CHECK
  - \* CHANNEL DATA CHECK
  
- UNIT CHECK ERRORS
  - \* EQUIPMENT CHECK
  - \* NO RECORD FOUND AND MISSING ADDRESS MARKS
  - \* NO RECORD FOUND
  - \* SEEK CHECK
  - \* INTERVENTION REQUIRED
  - \* BUS OUT CHECK
  - \* DATA CHECK
  - \* OVERRUN
  - \* MISSING ADDRESS MARKER
  - \* COMMAND REJECT
  - \* CHAINING CHECK
  - \* ENVIRONMENTAL DATA PRESENT
  - \* TRACK CONDITION CHECK

- THE ORIGINAL ERROR CSW AND SENSE INFORMATION ARE PRESERVED FOR RECORDING.

- IOB INDICATORS:

IOBSTAT	IOBFLAG	IOBSTAT	
IOBERP	IOBRSTRT	IOBFATAL	
1	0	0	RETURN CONTROL WHEN SOLICITED DEVICE END ARRIVES
1	1	0	RESTART
0	0	1	PERMANENT I/O ERROR
0	0	0	RETRY SUCCESS

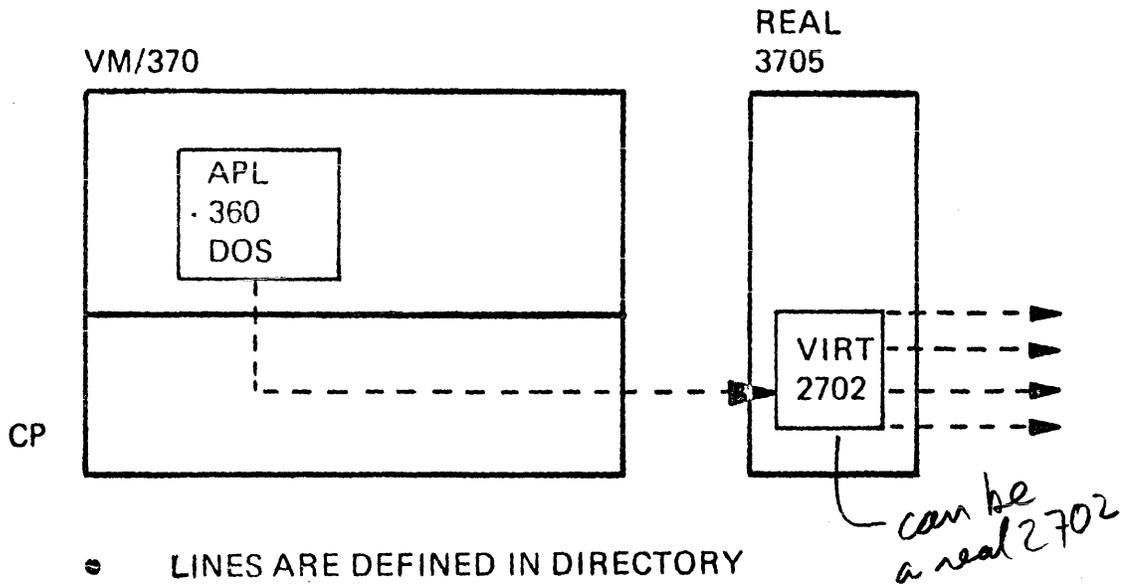
## TAPE ERROR RECOVERY

- RECOVERY IS ATTEMPTED FOR USER INITIATED I/O USING THE DIAGNOSE INTERFACE TO CP SUPPORTED TAPE UNITS.
- TAPE ERP PRESERVES ORIGINAL ERROR CSW AND SENSE INFORMATION FOR RECORDING.
- ERP FLAGS HANDLE PATHS OF RETRY FOR SPECIFIC ERRORS (I.E., DATA CHECK ON WRITE REQUIRES REPOSITION, ERASE, AND REISSUE ORIGINAL CHANNEL PROGRAM).

PACK ACCESS REQUEST	PACK ACCESS STATUS		
	N.I.U.	READ	WRITE
R	R	R	NO
RR	R	R	R
W	W	NO	NO
WR	W	R	R
M	W	W	NO
MR	W	W	R
MW	W	W	W

IN ALL CASES, IF THE APPROPRIATE PASSWORD IS NOT ASSIGNED OR GIVEN THEIR IS NO ACCESS TO THE VOLUME.

## SHARED TCU



- LINES ARE DEFINED IN DIRECTORY

```

USER APLSYS PWRD 256K
SPECIAL 080 2702 IBM
SPECIAL 081 2702 IBM
SPECIAL 082 2702 IBM
SPECIAL 083 2702 IBM
MDISK 190 2314 000 202 SYSRES
MDISK 191 2314 000 202 SYSWRK
    
```

- OPERATOR LOGS IN AS APLSYS
  - IPL'S 190
  - DISCONNECTS
- USER DIALS IN ON A VM/370 LINE

ISSUES DIAL APLSYS

DIAL APLSYS [083]

*can specify if desired*

## ATTENTION KEY HANDLING

MODE	TERMINAL STATE	ATTN	ACTION
6 CP	IDLE, LOCKED	N	UNLOCKS, CP READS
	UNLOCKED, NO DATA	N	VM STARTED, ATTN PENDING (REQ
	UNLOCKED, DATA	N	INPUT CANCELLED, CP READS
	RECEIVING OUTPUT	N	CP FUNCTION ENDS, CP READS
VM	IDLE, LOCKED	1	REQ (ATTN) TO VM, VM READS
		2	VM STOPS. CP READS
	UNLOCKED, NODATA	1	EOB FOLLOWED BY ATTN, VM READ
		2	CANCEL KEY TO VM, CP READS
	UNLOCKED, DATA	1	CANCEL KEY, VM READS
		2	EOB, CP READS
	RECEIVING OUTPUT	1	REQ TO VM, VM READS
		2	VM STOPS, CP READS

THE PAGING GAME

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Rules

1. Each player gets several million things.
2. Things are kept in crates that hold 4096 things each. Things in the same crate are called crate-mates.
3. Crates are stored either in the workshop or a warehouse. The workshop is almost always too small to hold all the crates.
4. There is only one workshop but there may be several warehouses. Everybody shares them.
5. Each thing has its own thing number.
6. What you do with a thing is to zark it. Everybody takes turns zarking.
7. You can only zark your things, not anybody else's.
8. Things can only be zarked when they are in the workshop.
9. Only the Thing King knows whether a thing is in the workshop or in a warehouse.
10. The longer a thing goes without being zarked, the grubbier it is said to become.
11. The way you get things is to ask the Thing King. He only gives out things in multiples of eight. This is to keep the royal overhead down.
12. The way you zark a thing is to give its thing number. If you give the number of a thing that happens to be in the workshop it gets zarked right away. If it is in a warehouse, the Thing King packs the crate containing your thing back into the workshop. If there is no room in the workshop, he first finds the grubbiest crate in the workshop, whether it be yours or somebody else's, and packs it off with all its crate-mates to a warehouse. In its place he puts the crate containing your thing. Your thing then gets zarked and you never knew that it wasn't in the workshop all along.
13. Each player's stock of things have the same numbers as everybody else's. The Thing King always knows who owns what thing and whose turn it is, so you can't ever accidentally zark somebody else's thing even if it has the same thing number as one of yours.

Notes

1. Traditionally, the Thing King sits at a large, segmented table and is attended to by pages (the so-called "table pages") whose job it is to help the king remember where all the things are and who they belong to.
2. One consequence of Rule 13 is that everybody's thing numbers will be similar from game to game, regardless of the number of players.
3. The Thing King has a few things of his own, some of which move back and forth between workshop and warehouse just like anybody else's, but some of which are just too heavy to move out of the workshop.
4. With the given set of rules, oft-zarked things tend to get kept mostly in the workshop while little-zarked things stay mostly in a warehouse. This is efficient stock control.
5. Sometimes even the warehouses get full. The Thing King then has to start piling things on the dump out back. This makes the game slower because it takes a long time to get things off the dump when they are needed in the workshop. A forthcoming change in the rules will allow the Thing King to select the grubbiest things in the warehouses and send them to the dump in his spare time, thus keeping the warehouses from getting too full. This means that the most infrequently-zarked things will end up in the dump so the Thing King won't have to get things from the dump so often. This should speed up the game when there are a lot of players and the warehouses are getting full.

LONG LIVE THE THING KING