z/VM System Limits

April 14, 2025

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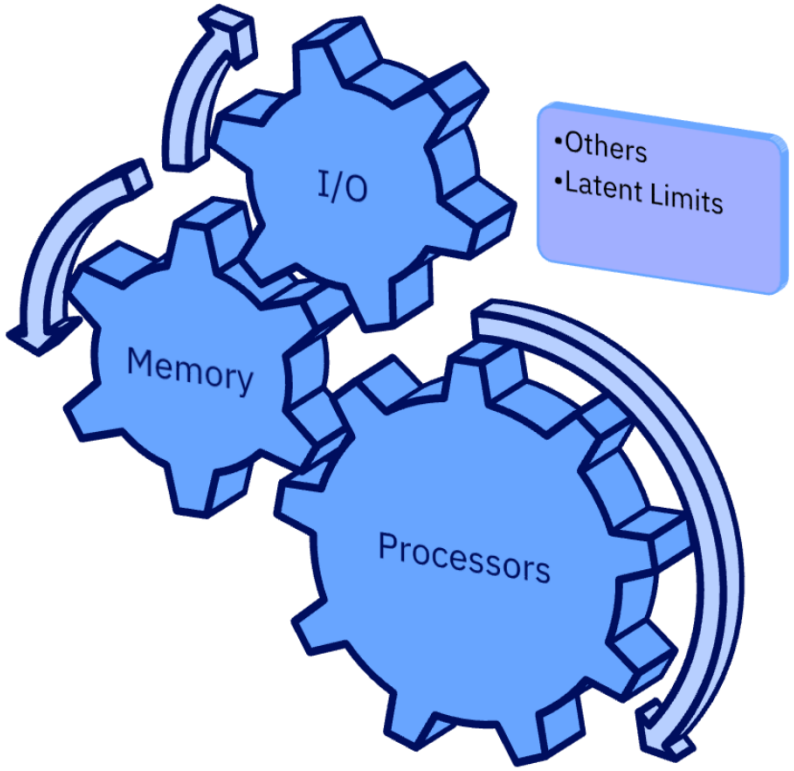
Agenda:

- Describe various limits
  - Architected
  - Supported
  - Consumption
  - Latent
- Show which limit-related performance metrics to review
- Discuss limits that may be hit first

Acknowledgments:
- Tim Greer, Xenia Tkatschow, Bill Bitner, Jacob Gagnon, Emily Hugenbruch, Kerry Wilson

Limits



ADDITIONAL DISCLAIMERS:

- This presentation looks at individual limits; it is quite possible that you will hit one limit before you hit the next. We do it this way to help illustrate which limits Development will address first, but then to set expectations as to how much greater can one run before hitting that next limit.

- This presentation talks about limits that are sometimes beyond the supported limits. This is meant to let the audience know what IBM did to determine where the supported limited should be and why it is the supported limit. It is not meant to imply it is safe to run up to that limit or that IBM knows everything that will go wrong if you do. So please stay at or below the supported limit.

Key Notes for Presentation

7.2 | 7.2+ | 7.3 | 7.3+ | 7.4 | 7.4+

- z/VM Continuous Delivery Strategy
- Presentation will show limits affected based on:

7.2 z/VM 7.2 GA November 11, 2020 – EOS March 31, 2025

7.2+ z/VM 7.2 plus service – EOS March 31, 2025

7.3 z/VM 7.3 became GA September 16, 2022

7.3+ z/VM 7.3 plus service

7.4 z/VM 7.4 became GA September 20, 2024

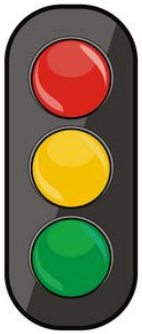
7.4+ z/VM 7.4 plus service

- Recent End of Service releases:
  - z/VM 6.4 went End of Service March 31, 2021
  - z/VM 7.1 went End of Service March 31, 2023

- IBM Z references apply to equivalent LinuxONE machines except if noted separately

Key Notes for Presentation

- Throughout this presentation, limits highlighted in:



RED are PRACTICAL Limits

YELLOW are SUPPORTED limits

GREEN are ARCHITECTED limits

IBM Z - z/VM Hardware Support

- z/VM 7.4 hardware requirements:
  - IBM z15 Models T01 and T02
  - IBM z16 Models A01, A02, AGZ
  - IBM z17 Model ME1

- z/VM 7.3 hardware requirements:
  - IBM z14 Models M01, M02, M03, M04, M05, and ZR1
  - IBM z15 Models T01 and T02
  - IBM z16 Models A01, A02, AGZ
  - IBM z17 Model ME1

- **EOS March 31, 2025** - z/VM 7.2 hardware requirements:
  - IBM z13, IBM z13s
  - IBM z14 Models M01, M02, M03, M04, M05, and ZR1
  - IBM z15 Models T01 and T02
  - IBM z16 Models A01, A02, AGZ

IBM LinuxONE - z/VM Hardware Support

- z/VM 7.4 hardware requirements:
  - IBM LinuxONE III LT1, LT2
  - IBM LinuxONE III Express
  - IBM LinuxONE Emperor 4 LA1, LA2
  - IBM LinuxONE Rockhopper 4 AGL

- z/VM 7.3 hardware requirements:
  - IBM LinuxONE Emperor II
  - IBM LinuxONE Rockhopper II
  - IBM LinuxONE III LT1, LT2
  - IBM LinuxONE III Express
  - IBM LinuxONE Emperor 4 LA1, LA2
  - IBM LinuxONE Rockhopper 4 AGL

Processors (Part 1 of 2)

7.3

- Processors hardware architected:
  - Includes all processor types (CP, zIIP, IFL, etc)
- Processors hardware available to customer:
  - z17: **208** (model ME1)
  - z16: **200** (model A01 only; A02 and AGZ support **68** max)
  - z15: **190** (model T01 only)
  - z14: **170** (model M05 only)
  - z13: **141**
  - zEC12: **101**
  - z196: **80**
- PR/SM Logical processors:
  - Logical processors in a z/VM partition supported:
    - is **80** on z14 and newer with z/VM 7.3 and newer
  - **Note:** with SMT-1 or SMT-2, the limit to number of cores supported is half the logical processors as each possible logical processor would be associated with a thread on an IFL core. So logical 80-way would be a limit of 40 IFL cores even with SMT-1.

Processors (Part 2 of 2)

7.3

- z/VM primary processor (z/VM design): 1
  - Some z/VM work is serialized by running on a “primary” processor
  - Watch for 100%-utilized, rare in Linux workloads
  - z/VM will elect a new primary if the designated primary processor fails or is varied off
  - Primary may be reassigned to keep it as a vertical high processor when running in vertical polarization mode

- Virtual CPUs in a single virtual machine (z/VM design): **64**
  - But $N_{Virtual} > N_{Logical}$ is usually not practical
  - Most interrupts presented to just 1 virtual CPU

- Number of logical partitions
  - z196 **60**
  - zEC12 **60**
  - z13 **85**
  - z14 **85**
  - z15 **85**
  - z16 **85**
  - z17 **85**

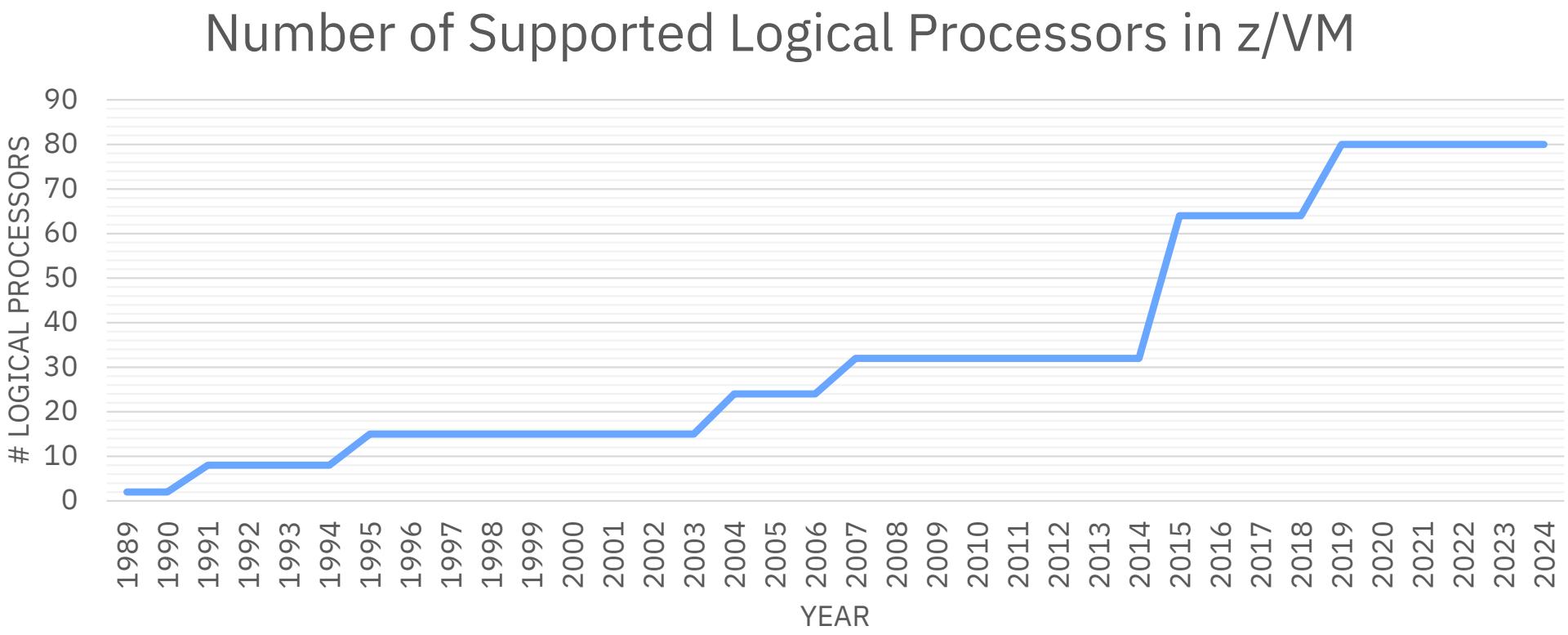
Topology and Vertical CPU Management

How much REAL processor is my LOGICAL processor guaranteed?

VH – Vertical High CPUs are entitled to 100% of a real CPU
VM – Vertical Medium CPUs are entitled to some of a real CPU (50%-100%)
VL – Vertical Low CPUs are not entitled to any real CPU

PR/SM tries to map LOGICAL processors to REAL processors as closely as possible and move those mappings as little as possible.

Processor Scaling



Processors: FCX100 CPU

```
1FCX100  Run 2019/06/13 09:30:42          CPU                                                    Page   15
                                          General CPU Load and User Transactions
 From 2019/06/13 03:51:22                                                          A10Z6040
 To   2019/06/13 04:01:52                                                          CPU 3906-M05   SN 146E7
 For    630 Secs 00:10:30                  Result of A10Z6040 Run                 z/VM   V.7.1.0 SLU 0000
```

CPU Load

PROC	TYPE	%CPU	%CP	%EMU	WT	%SYS	%SP	%SIC	%LOGLD	%PR	%ENT	Status or ded. User
P00	IFL	42	14	28	58	3	0	97	42	0	100	Alternate
P01	IFL	42	14	28	58	3	0	97	42	0	100	Alternate
P02	IFL	42	14	28	58	3	0	97	42	0	100	Alternate
P03	IFL	42	14	28	58	3	0	96	42	0	100	Alternate
P04	IFL	42	14	28	58	3	0	96	42	0	100	Alternate
P05	IFL	42	14	28	58	3	0	96	42	0	100	Alternate
P06	IFL	41	14	27	59	3	0	96	41	0	100	Alternate
P07	IFL	42	14	27	58	3	0	96	42	0	100	Alternate
P08	IFL	36	14	22	64	3	0	94	36	0	100	Master

1. T/V ~ 42/28 = 1.5 a good chunk of CP overhead here
2. Primary does not seem unduly burdened

Processors: FCX304 PRCLOG

```
1FCX304  Run 2019/06/13 09:30:42          PRCLOG                                                                    Page    5
                                          Processor Activity, by Time
 From 2019/06/13 03:51:22                                                                          A10Z6040
 To   2019/06/13 04:01:52                                                                          CPU 3906-M05   SN 146E7
 For    630 Secs 00:10:30                  Result of A10Z6040 Run                                 z/VM   V.7.1.0 SLU 0000
 ------------------------------------------------------------------------------------------------------------------------

                                        <--- Percent Busy ----> <-- Rates per Sec. ---> <----- Paging --------> <Co> < Di>
                                   Pct                                                                  Fast  Page <mm> < ag>
 Interval                          Park                                    Inst                  <2GB  PGIN Path  Read Msgs X'9C' Core/
 End Time CPU Type PPD Ent. DVID   Time %Susp Total  User  Syst  Emul  Siml  DIAG  SIGP  SSCH     /s    /s    %    /s   /s    /s Thrd
 >>Mean>>  00 IFL  VhD  100 0000    0    .0  42.4  39.4   3.0  27.9 28954  1749 16254 445.7     .0    .0 ....  4186   .0    .0 00/0
 >>Mean>>  01 IFL  VhD  100 0001    0    .0  42.2  39.4   2.8  27.9 29114  1775 15636 466.4     .0    .0 ....  4031   .0    .0 01/0
 >>Mean>>  02 IFL  VhD  100 0002    0    .0  41.7  38.9   2.8  27.6 28751  1763 15329 491.7     .0    .0 ....  3893   .0    .0 02/0
 >>Mean>>  03 IFL  VhD  100 0003    0    .0  41.9  39.1   2.7  27.7 28826  1736 15070 492.2     .0    .0 ....  3974   .0    .0 03/0
 >>Mean>>  04 IFL  VhD  100 0004    0    .0  41.8  39.0   2.8  27.7 28805  1748 15120 496.7     .0    .0 ....  3971   .0    .0 04/0
 >>Mean>>  05 IFL  VhD  100 0005    0    .0  41.7  38.8   2.9  27.5 28540  1727 14901 535.1     .0    .0 ....  3930   .0    .0 05/0
 >>Mean>>  06 IFL  VhD  100 0006    0    .0  41.4  38.5   3.0  27.3 28326  1722 14889 542.0     .0    .0 ....  3820   .0    .0 06/0

 03:51:52  00 IFL  VhD  100 0000    0    .0  23.9  22.2   1.7  16.3 14930 727.6  8259 225.0     .0    .0 ....  4708   .1    .0 00/0
 03:51:52  01 IFL  VhD  100 0001    0    .0  23.5  21.9   1.6  16.0 15068 741.5  8051 239.8     .0    .0 ....  4390   .5    .0 01/0
 03:51:52  02 IFL  VhD  100 0002    0    .0  22.7  21.1   1.6  15.5 14345 754.6  7977 241.1     .0    .0 ....  4116   .0    .0 02/0
 03:51:52  03 IFL  VhD  100 0003    0    .0  23.3  21.8   1.5  16.0 14793 734.9  7730 234.0     .0    .0 ....  4361   .0    .0 03/0
 03:51:52  04 IFL  VhD  100 0004    0    .0  23.4  21.7   1.7  16.0 14671 755.0  7794 240.0     .0    .0 ....  4273   .1    .0 04/0
 03:51:52  05 IFL  VhD  100 0005    0    .0  23.3  21.7   1.6  16.0 14741 730.8  7605 262.0     .0    .0 ....  4200   .0    .0 05/0
 03:51:52  06 IFL  VhD  100 0006    0    .0  22.9  21.2   1.6  15.7 14196 745.5  7698 274.1     .0    .0 ....  4023   .0    .0 06/0
```

Processors: FCX114 USTAT

```
FCX114  Run 2007/09/06 14:00:28          USTAT                                          Page  186
                                         Wait State Analysis by User
From 2007/09/04 09:07:00
To   2007/09/04 10:00:00                                                          CPU 2094-700
For   3180 Secs 00:53:00                                                  z/VM   V.5.3.0 SLU 0701
```

									<-SVM and->								<--%Time spent in-->				Nr of
Userid	%ACT	%RUN	%CPU	%LDG	%PGW	%IOW	%SIM	%TIW	%CFW	%TI	%EL	%DM	%IOA	%PGA	%LIM	%OTH	Q0	Q1	Q2	Q3	E0-3	Users
>System<	64	1	0	1	0	0	0	83	0	0	0	3	0	0	0	10	1	29	10	57	0	211
TCPIP	100	0	0	0	0	0	0	0	0	3	0	97	0	0	0	0	3	0	0	0	0	
RSCSDNS1	100	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	
SNMPD	100	0	0	0	0	0	0	0	0	2	0	98	0	0	0	0	2	0	0	0	0	
SZVAS001	100	2	0	0	0	0	0	97	0	0	0	0	0	0	0	1	0	3	12	85	0	

1. %CPU wait is very low – nobody is starved for engine
2. %TIW is “test idle wait” – we are waiting to see if queue drop happens
3. %LIM is limit list and Resource Pool related

Processors: FCX302 PHYSLOG Report

```
1FCX302  Run 2019/06/13 09:30:42          PHYSLOG
                                          Real Core Utilization Log

 From 2019/06/13 03:51:22
 To   2019/06/13 04:01:52
 For    630 Secs 00:10:30                  Result of A10Z6040 Run
```

Interval End Time	Type	<PhCore> Conf	Ded	Shrd Log.	Total Weight	%LgclC	%Ovrhd	LCoT/L	%LPmgt	%Total	TypeT/L
>>Mean>>	CP	4	0	0	0	.000	.000	...	.000	.000	...
>>Mean>>	IFL	128	16	0	0	1599.8	.038	1.000	.040	1599.8	1.000
>>Mean>>	ICF	4	0	0	0	.000	.000	...	.000	.000	...
>>Mean>>	ZIIP	4	0	0	0	.000	.000	...	.000	.000	...
>>Mean>>	>Sum	140	16	0	0	1599.8	.038	1.000	.040	1599.8	1.000
03:51:52	CP	4	0	0	0	.000	.000	...	.000	.000	...
03:51:52	IFL	128	16	0	0	1596.2	.035	1.000	.031	1596.3	1.000
03:51:52	ICF	4	0	0	0	.000	.000	...	.000	.000	...
03:51:52	ZIIP	4	0	0	0	.000	.000	...	.000	.000	...
03:51:52	>Sum	140	16	0	0	1596.2	.035	1.000	.031	1596.3	1.000

Memory (Part 1 of 6)

7.3

Real Memory (Central Storage)

- CPC Total maximum customer memory:
  - z17 **56 TB**
  - z16 **40 TB***
  - z15 **40 TB**
  - z14 **32 TB**
  - z13 **10 TB**
  - zEC12 **3 TB**
  - z10 EC **1.5 TB**
- Maximum LPAR size:
  - z17 **32 TB**
  - z16 **32 TB**
  - z15 **16 TB**
  - z14 **16 TB**
  - z13 **10 TB**
  - zEC12 **1 TB**
  - z196 **1 TB**
  - z10 EC **1 TB**
- *CPC total maximum customer memory for IBM LinuxONE 4 LA1 increased from 40 to **48 TB**.

Memory (Part 2 of 6)

7.3+

z/VM virtual machine size supported: **1 TB; guidelines for 2 TB guests**

- Practical limit can be gated by performance of:
  - **Dumping** a VM system
  - **Live Guest Relocation** requirements
  - **Production level performance** requirements
  - More information and limitations: https://www.vm.ibm.com/memman/gt1guest.html
    - z/VM 7.3 APAR VM66673 Large Guest LOGOFF Reset Time Mitigation is strongly recommended

Active, or instantiated, total virtual machines limit imposed by DAT structure limits:

- **64 TB**
  - 128 PTRM pre-allocated spaces each 2 GB-space can map 512 GB of guest-real memory (host-virtual).

Memory (Part 3 of 6)

7.3

- Virtual to real memory ratio (z/VM design): **64 TB : 2 TB = 32:1**
  64 TB : 4 TB = 16:1
- Virtual to real memory ratio (practical): about **2:1** or **3:1**
  - Warning: Different people have different definitions for “Virtual to real memory”. Here we are using total virtual machine size of started virtual machines to real memory configured to z/VM.
  - **1:1** if you want to eliminate performance impact for production workloads.
  - Consider maximum ratio due to:
    - Workload growth
    - Live Guest Relocation
  - Practical over commitment dependent on:
    - Active:Idle virtual machines
    - Workload/Service Level Agreement sensitivity to delays
    - Performance of paging subsystem (e.g. flash, HyperPAV, channels, etc.)
    - Accuracy of sizing of the virtual machines
    - Exploitation of memory saving/exploitation capabilities (e.g. CMM, DIM)

Memory (Part 4 of 6)

7.3

- z/VM design CP Owned volumes: **255**
  - Only a subset can be used for paging
  - SSI configurations paging is not shared, but other CP-owned slots are.

- Maximum paging space design limits (if you could use all volumes):
  - ECKD (3390): **202 TB**
  - EDEV (SCSI): **15.9 TB**

- Concurrent paging I/Os per paging volume:
  - ECKD without HyperPAV: **1**
  - ECKD with HyperPAV: **8**
  - EDEV: >1 (Have observed average of 1.6 in heavy workloads)

Memory (Part 5 of 6)

- Rules of thumb:
  - Do not cheat on calculating paging space required!
  - Do not allow page space to become full (avoid PGT004 abends)
- Do not mix ECKD and EDEV paging volumes on same system
- Keep volumes dedicated to paging
- In environments with virtual to real ratio of 1, consider turning off early writes and keep slot
  - CP command: **SET AGELIST EARLYWRITES NO KEEPSLOT NO**
  - In system config file: **STORAGE AGELIST EARLYWRITES NO KEEPSLOT NO**

Memory (Part 6 of 6)

7.3

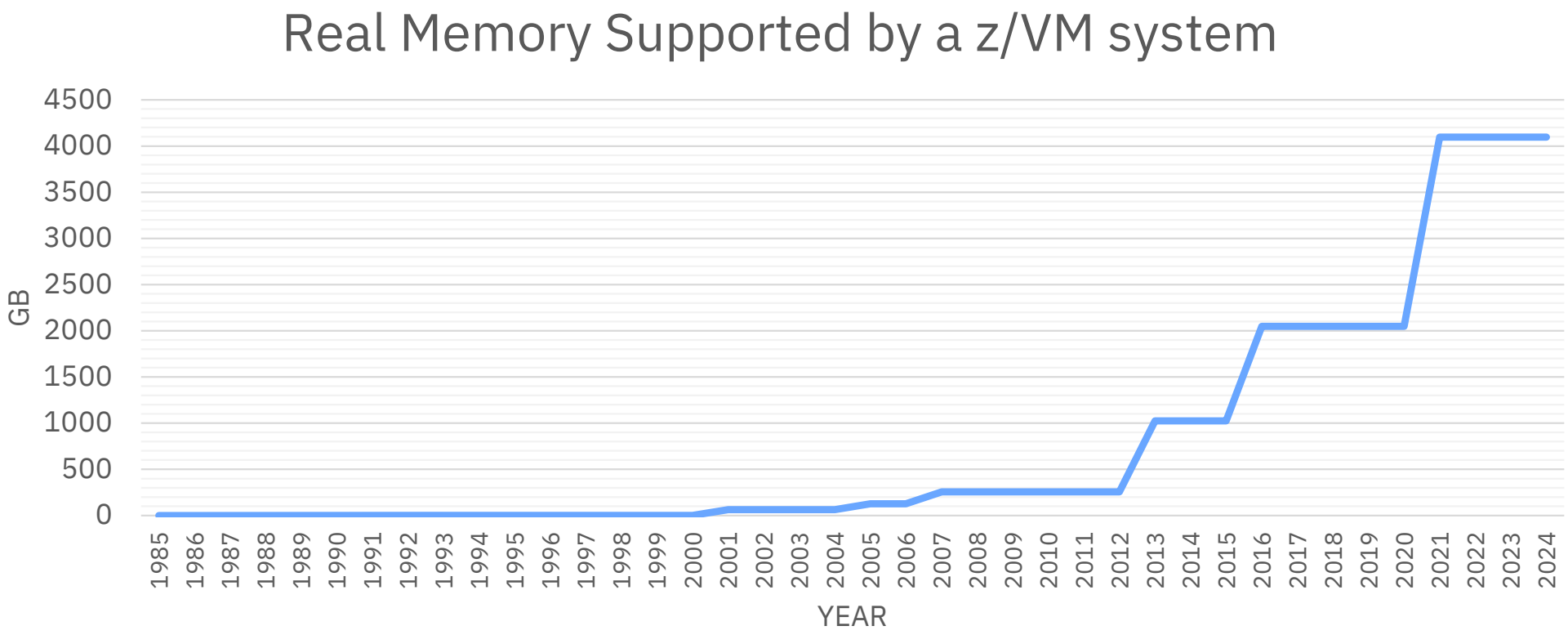
- System Execution Space (SXS) z/VM design limit: **2 GB**
  - For practical purposes it is 2GB, but there are structures in the space placed above 2GB
- DCSS
  - Individual Segments up to 2047 MB
    - Segments must end prior to one 4KB page below 512GB
- Minidisk Cache (z/VM design): **8 GB**
  - Recommended limit **2 GB**
  - Recommend fixing MDC size rather than letting arbiter change it dynamically
- Installing z/VM: minimum of **768 MB**
- Minimum memory to install or IPL z/VM second level: **128 MB**

Memory References

Memory over commitment
– http://www.vm.ibm.com/perf/tips/memory.html

Paging in general
– http://www.vm.ibm.com/perf/tips/prgpage.html

Real Memory Scaling



VIR2REAL Tool

- Displays the ratio of total virtual storage to LPAR real storage of your z/VM system.
  - Too high a ratio, and your system my underperform
  - Too low a ratio, you may be able to handle more workload.

- Displays your defined paging space (Indicates if paging or dump space is inadequate)

- Great as a quick check tool.

- Does not indicate HOW your system is paging.

NOTE: VIR2REAL is an aid but it can’t tell you everything!

Page Slots: FCX146 AUXLOG

```
FCX146  Run 2007/09/06 14:00:28          AUXLOG
                                         Auxiliary Storage Utilization, by Time
From 2007/09/04 09:07:00
To   2007/09/04 10:00:00
For   3180 Secs 00:53:00
```

	<Page Slots>		<Spool Slots>		<Dump Slots>		<----- Spool Files ----->				<Average MLOAD>	
Interval	Total	Used	Total	Used	Total	Used	<-Created-->		<--Purged-->		Paging	Spooling
End Time	Slots	%	Slots	%	Slots	%	Total	/s	Total	/s	msec	msec
>>Mean>>	87146k	44	5409096	52	0	..	54	.02	54	.02	2.8	.8
09:08:00	87146k	44	5409096	52	0	..	1	.02	1	.02	2.3	.8
09:09:00	87146k	44	5409096	52	0	..	1	.02	1	.02	3.9	.8
09:10:00	87146k	44	5409096	52	0	..	1	.02	1	.02	3.6	.8
09:11:00	87146k	44	5409096	52	0	..	1	.02	1	.02	2.8	.8
09:12:00	87146k	44	5409096	52	0	..	1	.02	1	.02	2.9	.8

DASD I/O: FCX109 DEVICE CPOWNED

```
1FCX109  Run 2019/06/13 09:30:42         DEVICE   CPOWNED                                                    Page   34
                                         Load and Performance of CP Owned Disks
 From 2019/06/13 03:51:22                                                                    A10Z6040
 To   2019/06/13 04:01:52                                                                    CPU 3906-M05   SN 146E7
 For    630 Secs 00:10:30                 Result of A10Z6040 Run                             z/VM   V.7.1.0 SLU 0000
```

Page / SPOOL Allocation Summary

PAGE slots available	2642m	SPOOL slots available	7810920
PAGE slot utilization	3%	SPOOL slot utilization	0%
T-Disk space avail. (MB)	.....	DUMP slots available	23587k
T-Disk space utilization	...%	DUMP slot utilization	21%

< Device Descr. ->				Used	<---------- Rate/s ---------->					I/O	Queue	Serv Time	MLOAD Resp	Block Page	%Used for	I O
Addr	Devtyp	Volume Serial	Area Type	Area Extent	%	<--Page---> P-Rds	P-Wrt	<--Spool--> S-Rds	S-Wrt	Total	SSCH +RSCH	Inter feres	Lngth	/Page	Time	Size	Alloc	M
C005	3390-9	ATP033	PAGE	11793420	3	359.1	373.4	...	...	732.4	40.4	0	148.9	.9	24.8	18	100	C
CD03	3390-9	ATP213	PAGE	11793420	3	363.3	374.9	...	...	738.2	39.3	0	137.5	1.0	16.6	18	100	C
C600	3390-9	ATP112	PAGE	11793420	3	362.1	373.5	...	...	735.6	41.3	0	133.1	.8	76.8	18	100	C
C70A	3390-9	ATP136	PAGE	11793420	3	362.2	375.9	...	...	738.0	40.6	0	126.6	1.0	33.2	18	100	C
C20A	3390-9	ATP066	PAGE	11793420	3	361.1	371.2	...	...	732.3	38.9	0	125.5	.8	53.3	18	100	C
CA0A	3390-9	ATP178	PAGE	11793420	3	364.4	372.1	...	...	736.5	40.7	0	123.8	.9	53.1	18	100	C
C80D	3390-9	ATP153	PAGE	11793420	3	364.0	370.3	...	...	734.3	39.6	0	122.7	.9	27.7	18	100	C
CB0A	3390-9	ATP192	PAGE	11793420	3	364.0	375.8	...	...	739.8	40.3	0	122.0	1.1	77.5	18	100	C

Report FCX292 UPGUTL

```
FCX292  Run 2013/04/10 07:38:36         UPGUTL                                                                  Page  103
                                        User Page Utilization Data
From 2013/04/09 16:02:10                                                                                SYSTEMID
To   2013/04/09 16:13:10                                                                                CPU 2817-744   SN A6D85
For    660 Secs 00:11:00                "This is a performance report for SYSTEM XYZ"                   z/VM   V.6.3.0 SLU 0000
```

```
 ______        .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .     .
                <---------------------------------------------- Storage ----------------------------------------------->
                                      <------------------------- Resident ------------------------->
           Data                                                    <----- Invalid But Resident ------>               Base
          Spaces                      <---- Total ----> <-Locked--> <-- UFO --> <-- PNR --> <-AgeList->              Space Nr of
Userid     Owned   WSS  Inst Resvd T_All  T<2G  T>2G  L<2G  L>2G  U<2G  U>2G  P<2G  P>2G  A<2G  A>2G XSTOR   AUX   Size Users
>>Mean>>     .0 5284M 6765M  5611 5286M   27M 5259M  1010  232K  6565 2238K 59588   26M 53080  107M    .0 1815M  7108M    73
User Class Data:
CMS1_USE     .0 3320K   19M    .0  484K    .0  484K    .0  4096    .0 69632    .0  244K    .0  344K    .0   19M  2047M     1
LCC_CLIE     .0  364M  485M    .0  365M 11264  365M    .0  208K    .0  325K    .0 2686K    .0 8177K    .0  164M  1024M     8
LXA_SERV     .0 7974M   10G    .0 7978M   41M 7937M    .0  206K  9984 3327K 90624   39M 80725  161M    .0 2719M 10240M    48

User Data:
DISKACNT     .0 4976K 5156K     0    4K     0    4K     0     0     0    4K     0     0     0     0     0 5152K    32M
DTCVSW1      .0  184K   11M     0  196K    8K  188K    8K    4K     0    4K     0     0     0  168K     0   11M    32M
DTCVSW2      .0  180K   11M     0  184K     0  184K     0    4K     0    4K     0     0     0  164K     0   10M    32M
EREP         .0 4912K 4944K     0    4K     0    4K     0     0     0    4K     0     0     0     0     0 4940K    32M
FTPSERVE     .0   84K 5764K     0   88K     0   88K     0    4K     0    4K     0     0     0   76K     0 5760K    32M
GCSXA        .0  204K  208K     0    8K     0    8K     0    4K     0    4K     0     0     0     0     0  200K    16M
LCC00001     .0  364M  488M     0  365M     0  365M     0  204K     0  228K     0 2884K     0 8660K     0  192M  1024M
LCC00002     .0  369M  492M     0  371M   20K  371M     0  204K     0  224K     0 2312K     0 7736K     0  159M  1024M
LCC00003     .0  363M  484M     0  364M     0  364M     0  204K     0  252K     0 2852K     0 8372K     0  215M  1024M
LCC00004     .0  363M  483M     0  363M   16K  363M     0  204K     0  228K     0 2724K     0 8512K     0  185M  1024M
```

- Look for the new concepts: Inst IBR UFO PNR AgeList
- Amounts are in bytes, suffixed. Not page counts!
- FCX113 UPAGE is still produced.

Zoom in on FCX292 UPGUTL report new for z/VM 6.3

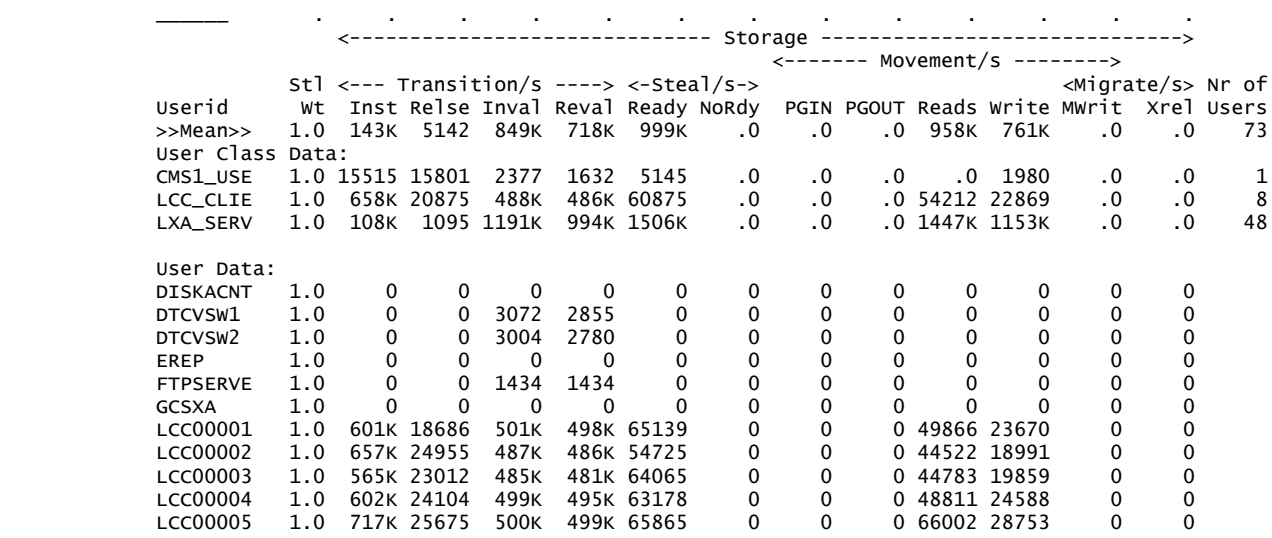
```
    .     .     .     .     .     .     .     .     .     .     .     .     .     .     .
------------------------------------ Storage -----------------------------------------
           <------------------------- Resident ------------------------------>
                                        <----- Invalid But Resident ------>
           <---- Total ----> <-Locked--> <-- UFO --> <-- PNR --> <-AgeList->
 Inst Resvd T_All  T<2G  T>2G  L<2G  L>2G  U<2G  U>2G  P<2G  P>2G  A<2G  A>2G XSTOR   AUX
6765M  5611 5286M   27M 5259M  1010  232K  6565 2238K 59588   26M 53080  107M    .0 1815M

 19M    .0  484K    .0  484K    .0  4096    .0 69632    .0  244K    .0  344K    .0   19M
485M    .0  365M 11264  365M    .0  208K    .0  325K    .0 2686K    .0 8177K    .0  164M
 10G    .0 7978M   41M 7937M    .0  206K  9984 3327K 90624   39M 80725  161M    .0 2719M 1
```

- Look for the concepts: Inst IBR UFO PNR AgeList
- Amounts are in bytes, suffixed. Not page counts!

Report FCX290 UPGACT

```
FCX290  Run 2013/04/10 07:38:36         UPGACT                                                    Page
102
                                        User Page Activity
From 2013/04/09 16:02:10                                                                  SYSTEMID
To   2013/04/09 16:13:10                                                                  CPU 2817-744   SN
A6D85
For    660 Secs 00:11:00                "This is a performance report for SYSTEM XYZ"             z/VM   V.6.3.0 SLU
0000
```



Userid	Stl Wt	<--- Transition/s ----> Inst	Relse	Inval	Reval	<-Steal/s-> Ready	NoRdy	PGIN	PGOUT	Reads	Write	<Migrate/s> MWrit	Xrel	Nr of Users
>>Mean>>	1.0	143K	5142	849K	718K	999K	.0	.0	.0	958K	761K	.0	.0	73
User Class Data:														
CMS1_USE	1.0	15515	15801	2377	1632	5145	.0	.0	.0	.0	1980	.0	.0	1
LCC_CLIE	1.0	658K	20875	488K	486K	60875	.0	.0	.0	54212	22869	.0	.0	8
LXA_SERV	1.0	108K	1095	1191K	994K	1506K	.0	.0	.0	1447K	1153K	.0	.0	48
User Data:														
DISKACNT	1.0	0	0	0	0	0	0	0	0	0	0	0	0	
DTCVSW1	1.0	0	0	3072	2855	0	0	0	0	0	0	0	0	
DTCVSW2	1.0	0	0	3004	2780	0	0	0	0	0	0	0	0	
EREP	1.0	0	0	0	0	0	0	0	0	0	0	0	0	
FTPSERVE	1.0	0	0	1434	1434	0	0	0	0	0	0	0	0	
GCSXA	1.0	0	0	0	0	0	0	0	0	0	0	0	0	
LCC00001	1.0	601K	18686	501K	498K	65139	0	0	0	49866	23670	0	0	
LCC00002	1.0	657K	24955	487K	486K	54725	0	0	0	44522	18991	0	0	
LCC00003	1.0	565K	23012	485K	481K	64065	0	0	0	44783	19859	0	0	
LCC00004	1.0	602K	24104	499K	495K	63178	0	0	0	48811	24588	0	0	
LCC00005	1.0	717K	25675	500K	499K	65865	0	0	0	66002	28753	0	0	

- Look for the concepts: Inst Relse Inval Reval Ready NoRdy

Zoom in on Report FCX290 UPGACT

```
FCX290  Run 2013/04/10 07:38:36          UPGACT                                                    Page
102                                      User Page Activity
From 2013/04/09 16:02:10                                                                  SYSTEMID
To   2013/04/09 16:13:10                                                                  CPU 2817-744   SN
A6D85
For    660 Secs 00:11:00                 "This is a performance report for SYSTEM XYZ"           z/VM   V.6.3.0 SLU
0000
```

	Stl	<--- Transition/s ---->				<-Steal/s->	
Userid	Wt	Inst	Relse	Inval	Reval	Ready	NoRdy
>>Mean>>	1.0	143K	5142	849K	718K	999K	.0
User Class Data:							
CMS1_USE	1.0	15515	15801	2377	1632	5145	.0
LCC_CLIE	1.0	658K	20875	488K	486K	60875	.0
LXA_SERV	1.0	108K	1095	1191K	994K	1506K	.0

LCC00001	1.0	601K	18686	501K	498K	65139	0	0	0	49866	23670	0	0
LCC00002	1.0	657K	24955	487K	486K	54725	0	0	0	44522	18991	0	0
LCC00003	1.0	565K	23012	485K	481K	64065	0	0	0	44783	19859	0	0
LCC00004	1.0	602K	24104	499K	495K	63178	0	0	0	48811	24588	0	0
LCC00005	1.0	717K	25675	500K	499K	65865	0	0	0	66002	28753	0	0

- Look for the concepts: Inst Relse Inval Reval Ready NoRdy

PTRM Space: FCX134 DSPACESH

	<--------- Rate per Sec. --------->							<------------------Number of Pages------------------>							
								<--Resid-->		<-Locked-->		<-Aliases->			
Data Space Name	Pgstl	Pgrds	Pgwrt	X-rds	X-wrt	X-mig	Total	Resid	R<2GB	Lock	L<2GB	Count	Lockd	XSTOR	DASD
--------	.075	.093	.015	.043	.074	.022	147k	1842	93	0	0	0	0	75	2998
FULL$TRACK$CACHE$1	.000	.000	.000	.000	.000	.000	524k	0	0	0	0	0	0	0	0
ISFCDATASPACE	.000	.000	.000	.000	.000	.000	524k	112	74	100	74	112	100	0	41
PTRM0000	14.79	1.733	.752	14.05	14.43	.039	1049k	596k	30116	0	0	0	0	5879	54074
REAL	.000	.000	.000	.000	.000	.000	40M	0	0	0	0	0	0	0	0
SYSTEM	.023	.000	.037	.019	.023	.004	524k	41	1	0	0	41	0	17	6410

1. PTRM space = (596,000 + 5879 + 54,074) = 655,953 = 2.5 GB

Report FCX295 AVLA2GLG

```
FCX295  Run 2013/04/10 07:38:36          AVLA2GLG
                                         Available List Data Above 2G, by Time
From 2013/04/09 16:02:10
To   2013/04/09 16:13:10
For    660 Secs 00:11:00                 "This is a performance report for SYS
```

	<---------- Storage ---------->						<--Times-->		<-Frame Thresh-->		
Interval	<Available>		<Requests/s>		<Returns/s>		<-Empty/s->		Sing	<-Contigs->	
End Time	Sing	Cont	Sing	Cont	Sing	Cont	Sing	Cont	Low	Low	Prot
>>Mean>>	23M	267M	47M	59M	47M	51M	.0	.0	1310	15	15
16:02:40	0	938M	32M	126M	502K	30310	.0	.0	1332	15	15
16:03:10	152K	4556K	50M	89M	49M	59M	.0	.0	1168	15	15

- Times Empty/s should be zero
- FCX254 AVAILLOG is no longer produced in z/VM 6.3

SXS Space: FCX261 SXSAVAIL

```
FCX261  Run 2007/09/06 14:00:28        SXSAVAIL                                                    Page  261
                                       System Execution Space Page Queues Management
From 2007/09/04 09:07:00
To   2007/09/04 10:00:00                                                                  CPU 2094-700
For   3180 Secs 00:53:00                                                                  z/VM   V.5.3.0 SLU 0701
```

	<-- Backed <2GB Page Queue -->					<-- Backed >2GB Page Queue -->					<---------- Unbacked Page Queue ----------								
Interval	Avail	<-Pages/s-->		<Preferred>		Avail	<-Pages/s-->		<Preferred>		Avail	<-Pages/s-->		<Preferred>		<---- Replenishment ---->			
End Time	Pages	Taken	Return	Used	Empty	Pages	Taken	Return	Used	Empty	Pages	Taken	Return	Used	Empty	Thres	Att/s	Stolen	MinPgs
>>Mean>>	26	.513	.509	.513	.000	3	1.798	1.804	1.798	4.114	466946	130.3	130.1	126.2	.000	128	.000	128	...
09:08:00	26	.483	.383	.483	.000	0	1.650	1.650	1.650	3.667	467829	128.2	127.3	124.5	.000	128	.000	128	...
09:09:00	26	.500	.500	.500	.000	0	.583	.583	.583	3.067	465679	120.8	84.98	117.8	.000	128	.000	128	...
09:10:00	27	.517	.533	.517	.000	0	1.183	1.183	1.183	4.000	467657	109.1	142.1	105.1	.000	128	.000	128	...
09:11:00	27	.517	.517	.517	.000	0	1.633	1.633	1.633	2.917	467632	137.2	136.8	134.3	.000	128	.000	128	...
09:12:00	29	.450	.483	.450	.000	0	2.000	2.000	2.000	3.383	467654	129.9	130.2	126.5	.000	128	.000	128	...
09:13:00	27	.517	.483	.517	.000	0	2.483	2.483	2.483	3.550	467698	139.3	140.0	135.7	.000	128	.000	128	...
09:14:00	25	.550	.517	.550	.000	0	2.000	2.000	2.000	2.750	465651	119.0	84.92	116.3	.000	128	.000	128	...

1. How we touch guest pages: (1) 64-bit; (2) AR mode; (3) SXS.
2. There are 524,288 pages in the SXS.
3. This system has 466,000 SXS pages available on average.

MDC: FCX178 MDCSTOR

	<---------- Main Storage Frames ---------->							
Interval		<--Actual--->		Min	Max	Page	Steal	
End Time	Ideal	<2GB	>2GB	Set	Set	Del/s	Invokd/s	Bias
>>Mean>>	5839k	82738	1354k	0	7864k	0	.000	1.00
09:57:41	5838k	119813	1932k	0	7864k	0	.000	1.00
09:58:11	5838k	119813	1932k	0	7864k	0	.000	1.00
09:58:41	5838k	119825	1932k	0	7864k	0	.000	1.00
09:59:11	5838k	119825	1932k	0	7864k	0	.000	1.00
09:59:41	5838k	119825	1932k	0	7864k	0	.000	1.00
10:00:11	5838k	119837	1932k	0	7864k	0	.000	1.00

- Xstore not used for this configuration so edited out from report.
- Add up the pages in Main Storage and you get ~8GB

MDC Spaces: FCX134 DSPACESH (newer one with new PTRM layout)

			<----------Number of Pages---------->							
Owning		Users		<--Resid-->		<-Locked-->		<-Aliases->		
Userid	Data Space Name	Permt	Total	Resid	R<2GB	Lock	L<2GB	Count	Lockd	XSTOR	DASD
>System<	--------	0	1507k	5665	101	0	0	100	0	0	0
SYSTEM	FULL$TRACK$CACHE$1	0	524k	0	0	0	0	0	0	0	0
SYSTEM	FULL$TRACK$CACHE$2	0	524k	0	0	0	0	0	0	0	0
SYSTEM	FULL$TRACK$CACHE$3	0	524k	0	0	0	0	0	0	0	0
SYSTEM	FULL$TRACK$CACHE$4	0	524k	0	0	0	0	0	0	0	0
SYSTEM	ISFCDATASPACE	0	524k	0	0	0	0	0	0	0	0
SYSTEM	PTRM0000	0	1049k	44489	0	0	0	0	0	0	0
SYSTEM	REAL	0	7864k	0	0	0	0	0	0	0	0
SYSTEM	SYSTEM	0	524k	805	787	0	0	800	0	0	0
SYSTEM	VIRTUAL$FREE$STORAGE	0	524k	23	23	0	0	0	0	0	0

- You'll see the address spaces used for MDC (track cache)
- More than one FULL$TRACK$CACHE$# space should be investigated to see if it the MDC settings are higher than needed.

I/O Devices

- Number of subchannels in a partition (device numbers): **65,536**
- Number of devices per virtual machine: **24576 (24K)**
- GDPS environments can have secondary DASD devices defined in an alternate subchannel set with the Multiple Subchannel Set Support
- Concurrency
  - ECKD without PAV or HyperPAV: **1**
  - ECKD with PAV or HyperPAV: **8**

I/O Disk Sizes

7.3

Type	CMS	Minidisk	Dedicated	CP Use
ECKD 3390	~45GB 65,520 cylinders (practical 22 GB)[3]	~812 GB[5] 1,182,006 cylinders	~812 GB 1,182,006 cylinders	~812 GB[5] 1,182,006 cylinders ~45 GB non-paging
SCSI EDEV	381 GB (practical 22 GB[3])	1023 GB[2]	1023 GB[2]	64 GB[4]
SCSI Dedicated	n/a	n/a	?????	n/a

[1] – Sizes listed above are in powers of 2
[2] – Exact value is 1024 GB minus 4 KB
[3] – Due to file system structure under 16MB, unless there are very few files
[4] – CP can use, but PAGE, SPOL, DRCT must be below 64 GB on the volume
[5] – Requires z/VM 7.2 or higher

I/O – Other Limits

7.3

- Virtual Disk in Storage (VDISK) size z/VM design: **2 GB** (minus eight 512-byte blocks)

- Total VDISK z/VM design: **1 TB**
  - "Infinite" = 2,147,483,648 512-byte blocks

Single Virtual Switch OSAs: **8**

Real HiperSockets VLAN IDs: **4096**

DASD I/O: FCX108 DEVICE

```
FCX108  Run 2007/09/06 14:00:28        DEVICE                                                  Page  110
                                       General I/O Device Load and Performance
From 2007/09/04 09:07:00
To   2007/09/04 10:00:00                                                        CPU 2094-700   SN
For   3181 Secs 00:53:01                                                         z/VM   V.5.3.0 SLU 0701
```

<-- Device Descr. -->			Mdisk	Pa-	<-Rate/s->	<------- Time (msec) ------->					Req.	<Percent>		SEEK	Recov	<-Throttle->	
Addr	Type	Label/ID	Links	ths	I/O	Avoid	Pend	Disc	Conn	Serv	Resp	CUWt	Qued	Busy	READ	Cyls	SSCH	Set/s	Dly/s
>> All DASD <<			....		.5	.4	.2	.1	3.4	3.7	3.7	.0	.0	0	17	1173	0	...	.0
F024	3390	VS2426	1	4	12.9	147.0	.2	.7	.4	1.3	1.3	.0	.0	2	91	193	0	...	...
0C20	CTCA		...	1	12.6	...	.3	.2	.6	1.1	1.1	.0	.0	1	..	...	0	...	...
F685	3390	VS2W01	290	4	11.8	.3	.2	.0	.3	.5	.5	.0	.0	1	84	89	0	...	...
F411	3390	VS2613	1	4	10.6	.5	.2	.3	.4	.9	.9	.0	.0	1	1	1303	0	...	...

Other Limits – Spool and CMS Files

7.3

- Number of spool files (z/VM design):
  - Limit **9999** per virtual machine
    - If using a 4-member SSI: **2499**
    - If using an 8-member SSI: **1249** (8-member SSI requires z/VM 7.3 or higher)
  - Limit **1.6 million** spool files per system

- 1024 files per warm start block * (180 blocks * 9 cylinders)

- Number of logged-on virtual machines (design point): **about 100,000**

- CMS Files
  - Maximum Records: 2,147,483,647 ($2^{31} – 1$) records, each of which consist of from one to 2^{31} -1 bytes of data (a record in a file with variable-length records is further restricted to 65,535 bytes of data).

Other Limits

7.3

- 255 CP-owned slots
- 16 ISFC links between a pair of systems
  - No limit on total number of ISFC links
- 1 GB Distributed IUCV maximum message size
- 8 Alternate Operators
- Password length: 8 characters, 100 characters with RACF
- 1000 System Environment Variables
  - Minus those defined as CP New Function environment variables.
  - Up to 63 character named
  - Up to 255 character values
- HyperPAV aliases:
  - 254 per pool
  - 160,000 pools per system

No Hard Limits, but Potential Soft Limits

- **Virtual Switch**
  - Users into hundreds, broadcast group limited to 1000
  - Better performance when users spread over multiple virtual switches

- ISFC
  - Network topology important if network is large
  - Propagation effects in large, sparse network
  - Internal structure stresses in large, dense network

- Guest levels
  - **7th level** z/VM system is impractically slow
  - Diagnose x'00' returns up to **5 levels** of information

LOCKACT report example

```
1FCX326  Run 2019/06/13 09:30:42          LOCKACT                                                                    Page   58
                                          Spin Lock Activity
 From 2019/06/13 03:51:22                                                                                  A10Z6040
 To   2019/06/13 04:01:52                                                                                  CPU 3906-M05   SN 146E7
 For    630 Secs 00:10:30                  Result of A10Z6040 Run                                         z/VM   V.7.1.0 SLU 0000
 ------------------------------------------------------------------------------------------------------------------------------------
```

LockName	<------- Combined ---------> CCol/s	CAvSpn	C%Busy	CCAD/s	<------- Exclusive --------> ECol/s	EAvSpn	E%Busy	ECAD/s	<-------- Shared ----------> SCol/s	SAvSpn	S%Busy	SCAD/s
>>Total>	3805.5	.923	.351	.000	2151.7	.602	.129	.000	1653.8	1.340	.222	.000
SRMSLOCK	1952.1	1.211	.236	.000	298.29	.498	.015	.000	1653.8	1.340	.222	.000
HCPPGDAL	105.08	4.315	.045	.000	105.08	4.315	.045	.000	.000	...	.000	.000
FSDVMLK	151.01	1.198	.018	.000	151.01	1.198	.018	.000	.000	...	.000	.000
HCPPGDPL	27.429	1.570	.004	.000	27.429	1.570	.004	.000	.000	...	.000	.000
DSV_0000	125.64	.332	.004	.000	125.64	.332	.004	.000	.000	...	.000	.000
DSV_0005	119.19	.311	.004	.000	119.19	.311	.004	.000	.000	...	.000	.000
DSV_0002	116.97	.301	.004	.000	116.97	.301	.004	.000	.000	...	.000	.000
DSV_0007	112.18	.314	.004	.000	112.18	.314	.004	.000	.000	...	.000	.000
DSV_0004	111.59	.310	.003	.000	111.59	.310	.003	.000	.000	...	.000	.000
DSV_0003	113.27	.304	.003	.000	113.27	.304	.003	.000	.000	...	.000	.000
DSV_0006	108.51	.316	.003	.000	108.51	.316	.003	.000	.000	...	.000	.000
DSV_0001	110.84	.301	.003	.000	110.84	.301	.003	.000	.000	...	.000	.000
SRMATDLK	115.12	.271	.003	.000	115.12	.271	.003	.000	.000	...	.000	.000
HCPTRQLK	31.689	.551	.002	.000	31.689	.551	.002	.000	.000	...	.000	.000

Changes in Limits with Single System Image Clusters

- Horizontal scaling through eight z/VM members (systems) in a cluster.
- Balance that with whitespace that might be required for Live Guest Relocation (LGR)
- If n-way or scaling effects for one very large z/VM system have negative impact, splitting into multiple smaller z/VM systems in an SSI Cluster could be beneficial.

SSI Cluster Effect on Processor Limits

7.3

- Real processors:
  - 80 x 8 = **640 processors** (if all members running z15 or newer)
  - Consider white space
  - Low processor requirements for cross-member communication assuming system resource (device) access is stable
  - Greater efficiency in cases with smaller n-way
  - In a sense, gives 8 primary processors

- Virtual processors:
  - If splitting z/VM system into smaller systems, remember to ensure no virtual machine has more virtual CPUs than the z/VM member (logical partition) has logical processors.

SSI Effect on Memory Limits

7.3

- Real Memory:
  - 4 TB x 8 = **32 TB**
  - Consider white space, cannot share like processors
  - Low memory costs to duplicate z/VM kernel and most control structures

- Virtual Memory:
  - No change for individual virtual machine
  - 64 TB x 8 = **512 TB** (aggregate)

- Paging Space:
  - Some CP-owned slots lost due to sharing across members
  - But can reuse paging slots on each member, so it scales well

Other SSI Cluster Effects on Limits

- Distance limit on DASD and FICON CTC in the Cluster is 100km with repeater technology
- Distance limit on Network on SSI cluster from OSA to switches is 10km with repeater technology.
- For virtual machines using Virtual Switch and being relocated, those virtual switches need to be in the same LAN segment (or segments).

Latent Limits

- Sometimes it’s not an architected limit

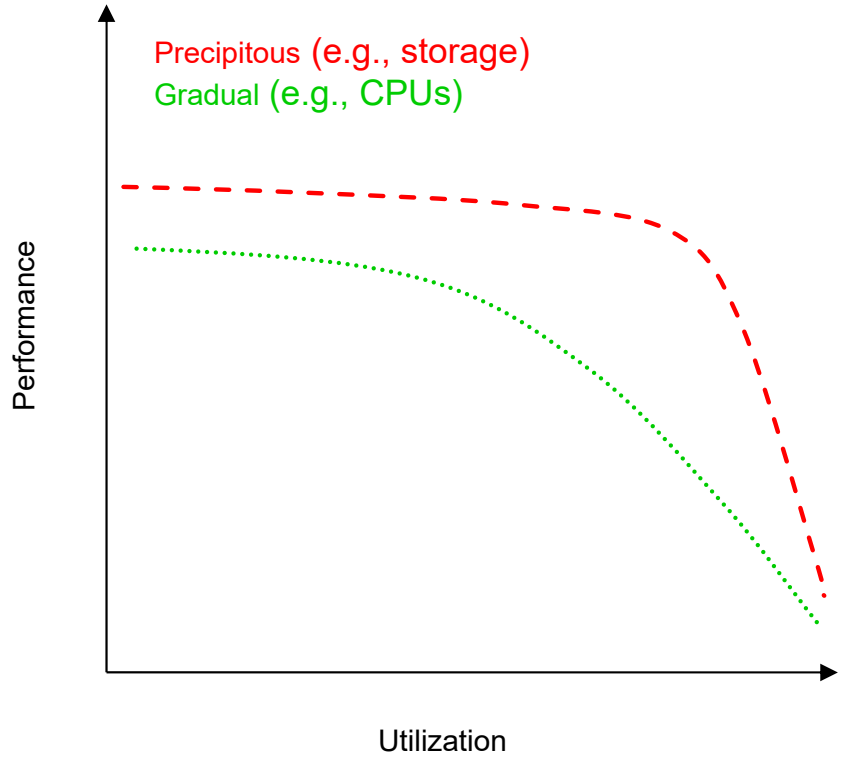
- Sometimes it’s just “your workload won’t scale past here, because…”
  - Contention for certain locks
  - Search algorithms with scaling issues

- Because of the above, we often publish supported limits that are less than the designed or architected limits.

Other Notes on z/VM Limits

Limits we've tested, tend to have two distinct shapes

- Performance drops off slowly
- Performance drops off rapidly when a wall is hit.



Keeping Tabs on Consumption Limits (update)

- Processor
  - CPU utilization: FCX100 CPU, FCX114 USTAT

- Memory & Paging
  - Page slots in use: FCX146 AUXLOG
  - DASD I/O: FCX109 DEVICE CPOWNED
  - V:R Memory ratio: FCX113 UPAGE
  - PTRM space consumed: FCX134 DSPACESH
  - Storage in use for segment tables: FCX113 UPAGE
  - Consumption of SXS space: FCX261 SXSAVAIL
  - MDC: FCX178 MDCSTOR, FCX134 DSPACESH
  - Consumption of real memory: FCX103 STORAGE, FCX254 AVAILLOG
  - Consumption of expanded storage: FCX103 STORAGE

- I/O
  - DASD I/O: FCX108 DEVICE
  - Concurrency on FICON chpids: FCX131 DEVCONF, FCX215 INTERIM FCHANNEL, FCX168 DEVLOG

What Consumption Limits Will We Hit First?

7.3

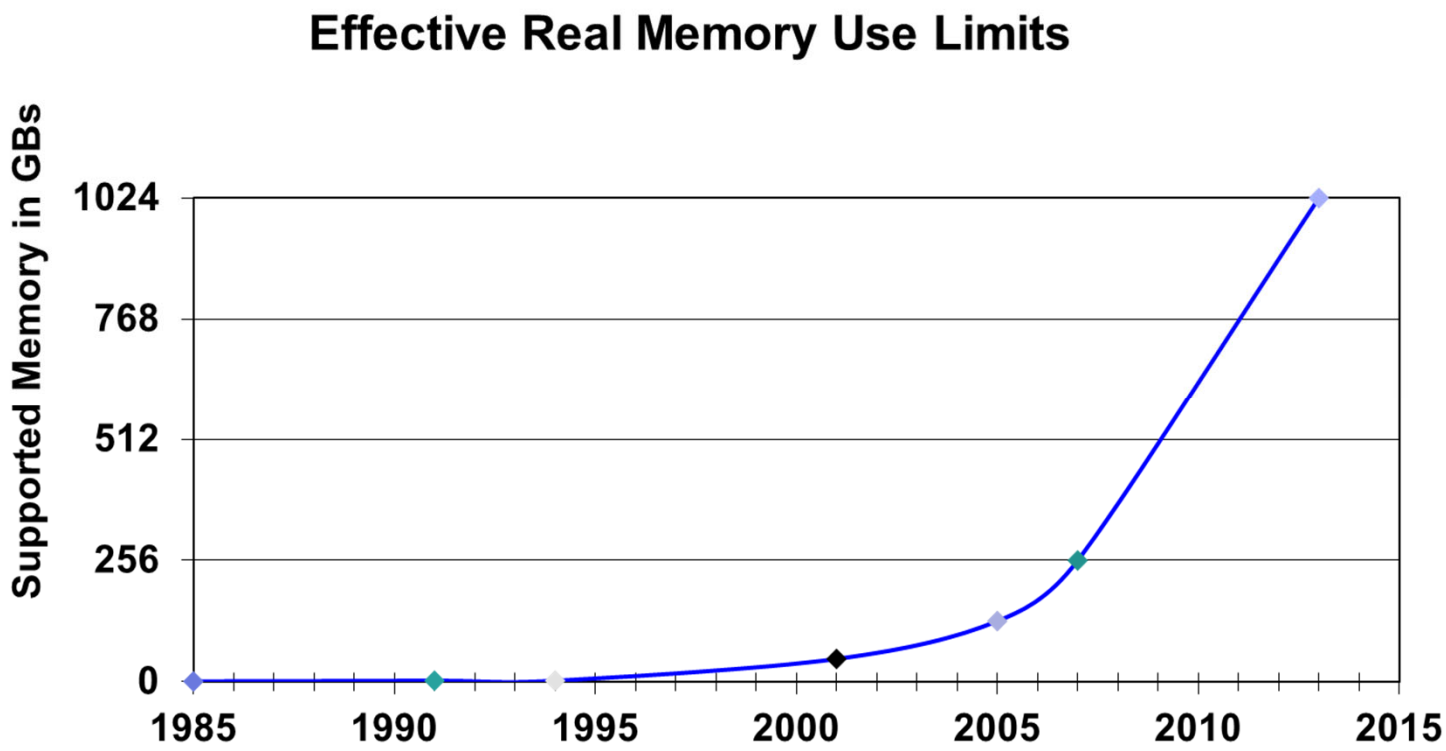
- Depends on workload
  - Memory-intensive:
    - 1:1 overcommit gated by real storage limit (4TB on z/VM 7.2 with VM66173)
    - Larger overcommit ratios gated by your paging subsystem
    - Mitigation by application tuning or by using CMM
  - CPU-intensive:
    - FCX100 CPU and FCX 114 USTAT will reveal CPU limitations
    - Mitigation by application tuning
  - I/O-intensive:
    - Device queueing: consider whether PAV or HyperPAV might offer leverage
    - Chpid utilization: add more chpids per storage controller
  - Ultimately partitions can be split, but we would prefer you not have to do this (too complicated)
- Without trend data (repeated samples) for *your* workloads it is difficult to predict which of these limits *you* will hit first

Summary

- Knowing Limits:
  - Real resource consumption
  - Limits to managing the virtualization of real resources
- Measuring Limits:
  - Knowing where to watch for these limits
  - Including these in capacity planning
- Managing Limits
  - Tuning and configuring
  - Planning for growth

APPENDIX

Memory Scaling



Older Limits from non-supported releases / hardware

Maximum LPAR size z9: 512 GB minus your HAS

Maximum LPAR size z10: 1 TB

Total maximum memory z900: 256 GB

Total maximum memory z990: 256 GB

Total maximum memory z9: 1 TB

Total maximum memory z10: 8 TB

Expanded storage architected limit: 16 TB

Expanded storage z/VM limit supported: 128 GB

Expanded storage z/VM design unsupported: ~660 GB dependent on other factors

z/VM 6.3 and older RoT: Keep paging space under 50% allocated for best performance.

V:R Ratio: FCX113 UPAGE (move to appendix)

	<--------- Paging Activity/s --------->							<---------- Number of Pages ---------->							
	<Page Rate>		Page	<-Page Migration-->				<-Resident->		<--Locked-->					Stor
Userid	Reads	Write	Steals	>2GB>	X>MS	MS>X	X>DS	WSS	R<2GB	R>2GB	L<2GB	L>2GB	XSTOR	DASD	Size
Nr of Users															
>System<	1.7	1.1	4.1	.0	2.4	3.7	1.4	122050	2347	106962	6	24	12240	179131	1310M
212															
DATAMOVF	.0	.0	.0	.0	.0	.1	.0	13	0	0	0	0	483	254	32M
DATAMOVA	.0	.0	.0	.0	.5	.5	.0	147	0	0	0	0	220	368	32M
DATAMOVB	.0	.0	.0	.0	.6	.6	.0	192	0	0	0	0	220	366	32M
DATAMOVC	.0	.0	.0	.0	.6	.6	.0	191	0	0	0	0	220	369	32M
DATAMOVD	.0	.0	.0	.0	.6	.6	.0	189	0	0	0	0	220	362	32M

1. Resident Guest Pages = (2347 + 106962) * 212 = 88.3 GB

- V:R = (1310 MB * 212) / 91 GB = 2.98
- For z/VM 6.2 and older

Real Memory: FCX254 AVAILLOG

```
FCX254  Run 2007/09/06 14:00:28        AVAILLOG                                                    Page  190
                                       Available List Management, by Time
From 2007/09/04 09:07:00
To   2007/09/04 10:00:00                                                          CPU 2094-700
For   3180 Secs 00:53:00                                                          z/VM   V.5.3.0 SLU 0701
```

	<---------- Available List Management ---------->																	
	<---- Thresholds ----->				<---------- Page Frames ---------->						<-Times->		<---------- Replenishment ---------->					Perct
Interval	<---Low--->		<--High--->		<Available>		<Obtains/s>		<Returns/s>		<-Empty->		<--Scan1-->		<--Scan2-->		<-Em-Scan->	Scan	Emerg
End Time	<2GB	>2GB	<2GB	>2GB	<2GB	>2GB	<2GB	>2GB	<2GB	>2GB	<2GB	>2GB	Compl	Pages	Compl	Pages	Compl	Pages	Fail	Scan
>>Mean>>	20	7588	5820	13388	5130	7678	323.3	857.4	311.5	844.8	0	0	27	1381k	63	1380k	58	84490	82	88
09:08:00	20	7680	5820	13480	6665	15122	353.3	838.5	353.2	1007	0	0	0	43091	3	26491	0	0	3	100
09:09:00	20	7680	5820	13480	3986	5496	163.1	640.2	108.9	442.7	0	0	1	14528	0	0	0	0	0	0
09:10:00	20	7681	5820	13481	6622	9542	222.4	556.1	257.0	598.3	0	0	0	30103	2	8868	0	0	1	100
09:11:00	20	7681	5820	13481	4982	6710	292.1	615.2	248.8	533.6	0	0	0	21246	0	8547	1	3989	1	100
09:12:00	20	7681	5820	13481	4769	1560	284.9	946.9	254.4	830.0	0	0	0	18253	0	22438	2	656	1	100

1. Pct ES = 88% generally this system is tight on storage
2. Scan fail >0 generally this system is tight on storage
3. Times Empty = 0 this indicates it isn't critical yet (you do not need to wait for things to be critical).
4. Meant for z/VM 6.2 and older.

IOPROCLG

```
1FCX232  Run 2019/06/13 09:30:42          IOPROCLG                                                                    Page   37
                                          I/O Processor Activity by Time
 From 2019/06/13 03:51:22                                                                                  A10Z6040
 To   2019/06/13 04:01:52                                                                                  CPU 3906-M05   SN 146E7
 For    630 Secs 00:10:30                  Result of A10Z6040 Run                                         z/VM   V.7.1.0 SLU 0000
 ------------------------------------------------------------------------------------------------------------------------------
```

Interval End Time	Proc Number	<-Activity/Sec--> Beg_SSCH	I/O_Int	Proc %Busy	<- Busy conditions per SSCH -> Channel	Switch	CU	Device
>>Mean>>	00	216.4	.2	.224	.000	.000	.000	.000
>>Mean>>	01	216.3	2576	.727	.002	.000	.000	.000
>>Mean>>	02	216.3	3.4	.166	.000	.000	.000	.000
>>Mean>>	03	216.4	.2	.190	.000	.000	.000	.000
>>Mean>>	04	216.4	.2	.173	.000	.000	.000	.000
>>Mean>>	05	216.3	.0	.149	.000	.000	.000	.000
>>Mean>>	06	216.4	.0	.146	.000	.000	.000	.000
>>Mean>>	07	216.3	.0	.157	.000	.000	.000	.000
>>Mean>>	08	216.4	.0	.157	.000	.000	.000	.000
>>Mean>>	09	216.3	2274	.665	.002	.000	.000	.000
>>Mean>>	0A	216.4	3.1	.163	.000	.000	.000	.000
>>Mean>>	0B	216.4	.5	.148	.000	.000	.000	.000
>>Mean>>	0C	216.4	.4	.145	.000	.000	.000	.000
>>Mean>>	0D	216.4	.5	.180	.000	.000	.000	.000
>>Mean>>	0E	216.4	.4	.174	.000	.000	.000	.000
>>Mean>>	0F	216.3	.0	.176	.000	.000	.000	.000