IBM Systems & Technology Group

# z/VM System Limits

## SHARE 118 – Session 10314

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# Agenda

- **Describe various limits**
  - Architected
  - Supported
  - Consumption
  - Latent
- **Show how to keep tabs on consumables**
- **Discuss limits that may be hit first**

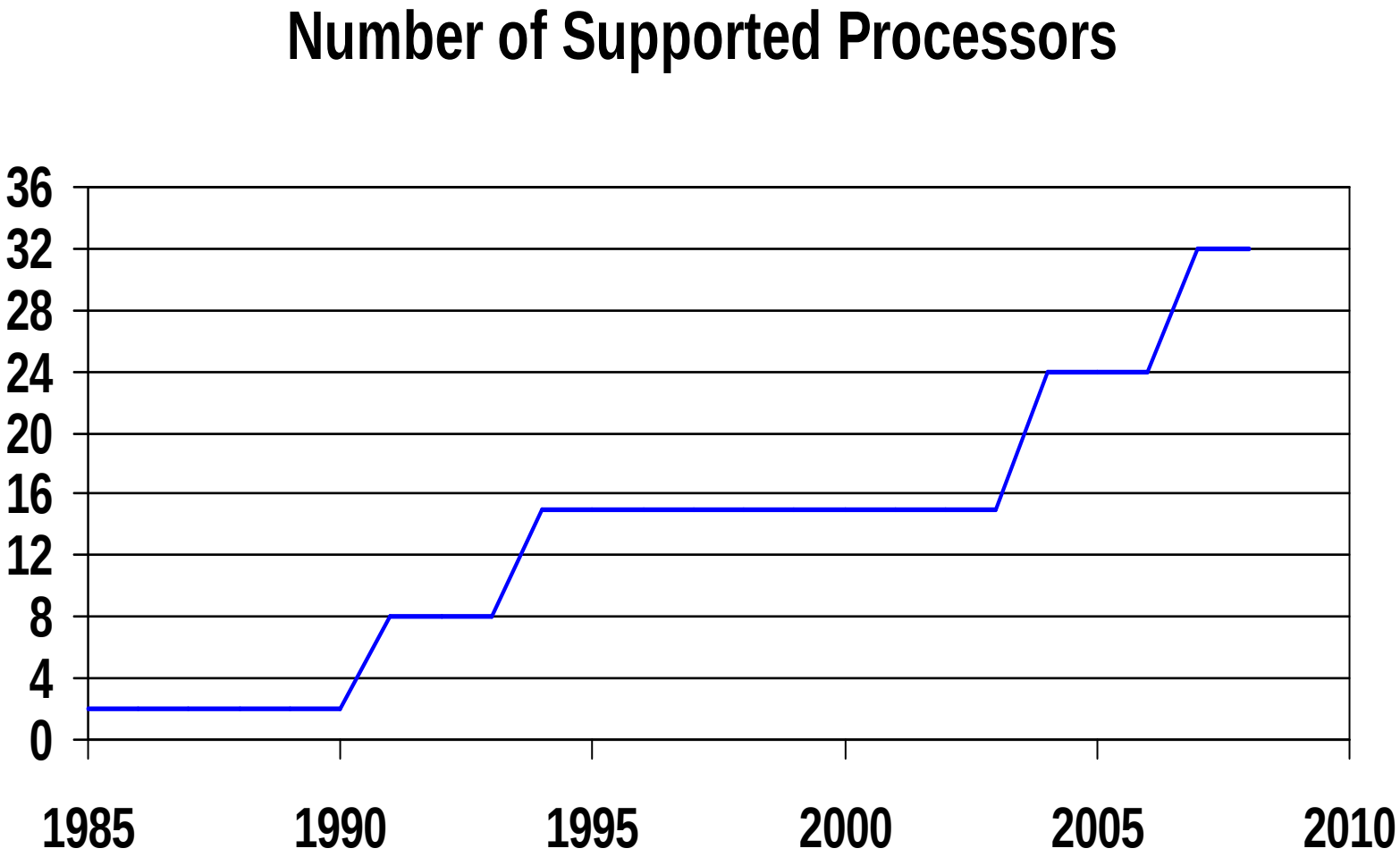
# Limits

- **Processors**
- **Memory**
- **I/O**
- **Others**
- **Latent limits**
- **Additional Disclaimer**
  - 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 some times 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.

# Processors

- **Processors (architected): 64**
  - Includes all engine types (CP, zAAP, zIIP, IFL…)
- **Processors (hardware):**
  - z9: 54
  - z10: 64
  - z196: 80
- **Logical processors (unsupported): 64 (z10 EC); 54 (z9 EC)**
- **Logical processors in z/VM partition (support statement): 32**
- **Master processor (architected): 1**
  - 100%-utilized master is the issue
  - z/VM will elect a new master if master fails
- **Virtual processors in single virtual machine (architected): 64**
  - But $N_{Virtual} > N_{Logical}$ is not usually practical
  - Interrupts presented to just 1 virtual CPU
- **Number of partitions: 60 (z9 through z196)**

# Processor Scaling



# Processors: FCX100 CPU

```
FCX100  Run 2007/09/06 14:00:28          CPU
                                         General CPU Load and User Transactions
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
```

---

```
CPU Load                                                    Vector Facility   Status or
PROC TYPE %CPU  %CP %EMU %WT %SYS %SP %SIC %LOGLD  %VTOT %VEMU  REST ded. User
P00  IFL    16   2   14  84    2   0   84     16     ..    ..   ... ........
P15  IFL    18   2   16  82    1   0   80     18     ..    ..   ... ........
P14  IFL    18   2   16  82    1   0   80     18     ..    ..   ... ........
P13  IFL    18   2   16  82    1   0   80     18     ..    ..   ... ........
P12  IFL    18   2   16  82    1   0   81     18     ..    ..   ... ........
P11  IFL    18   2   17  82    1   0   80     19     ..    ..   ... ........
 ... truncated …
```

1. T/V ~ 18/16 = 1.13  a little CP overhead here
2. Master does not seem unduly burdened

# Processors: FCX144 PROCLOG

| | | | <---- Percent Busy ----> | | | | <--- Rates per Sec.---> | | | | <--------- PLDV ----------> | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C | | | | | | | | | | Pct | Mean | VMDBK | VMDBK | To |
| Interval | P | | | | | | Inst | | | | Em- | when | Mastr | Stoln | Mastr |
| End Time | U | Type | Total | User | Syst | Emul | Siml | DIAG | SIGP | SSCH | pty | Non-0 | only | /s | /s |
| >>Mean>> | 0 | CP | 54.5 | 53.9 | .6 | 50.4 | 5608 | 28.2 | 1588 | 155.1 | 47 | 1 | 0 | 423.5 | .1 |
| >>Mean>> | 1 | CP | 61.1 | 60.7 | .5 | 56.8 | 6304 | 30.2 | 1481 | 161.5 | 99 | 1 | .... | 421.4 | .0 |
| >>Mean>> | 2 | CP | 62.3 | 61.7 | .5 | 57.7 | 6444 | 30.6 | 1475 | 160.8 | 97 | 1 | .... | 418.7 | .0 |
| >>Mean>> | 3 | CP | 63.9 | 63.5 | .4 | 59.5 | 6534 | 30.0 | 1453 | 153.4 | 99 | 1 | .... | 395.8 | .0 |
| >>Mean>> | 4 | CP | 58.3 | 57.7 | .6 | 54.2 | 5744 | 27.2 | 1520 | 152.1 | 99 | 1 | .... | 442.8 | .0 |
| >>Mean>> | 5 | CP | 60.2 | 59.8 | .4 | 56.2 | 5860 | 26.7 | 1457 | 141.5 | 99 | 1 | .... | 402.7 | .0 |
| >>Mean>> | 6 | CP | 61.8 | 61.3 | .4 | 57.4 | 6356 | 30.6 | 1552 | 156.7 | 99 | 1 | .... | 418.9 | .0 |
| >>Mean>> | 7 | CP | 60.1 | 59.7 | .4 | 55.9 | 6173 | 30.6 | 1554 | 156.3 | 98 | 1 | .... | 413.3 | .0 |
| >>Mean>> | . | CP | 60.2 | 59.8 | .4 | 55.9 | 6128 | 29.2 | 1510 | 154.6 | 92 | 1 | .... | 417.1 | .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

# Memory – Part 1

- **Central storage**
  - Supported central storage: 256 GB
  - Unsupported central storage (maximum LPAR size):
    - z9: 512 GB minus your HSA
    - z10: 1 TB
    - z196: 1TB
  - z/VM primitive tests have been run with 1TB
- **Expanded storage (architected): 16TB**
  - z/VM Limit: 128GB supported
    - Up to about 660GB unsupported (depends on other factors)
  - See http://www.vm.ibm.com/perf/tips/storconf.html

# Memory – Part 2

- **Virtual machine size:**
  - Supported/Tested 1 TB ($2^{40}$)
    - Practical limit can be gated by:
      - Reorder Processing
      - VM Dump
    - Production level performance will require adequate real memory.
  - Hardware limits
    - z196 16TB
    - z10 8TB
    - z9 1TB
    - z990 256GB
    - z900 256GB

# Memory – Part 3

- **Active, or instantiated, guest real limit imposed by PTRM space limits (architected): 8 TB**
  - 16 4-GB PTRM spaces; each PTRM space can map 512 GB of guest real
- **Virtual to real 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 central storage.
  - 1:1 if you want to eliminate performance impact for production workloads.
  - As you get above 2:1, you really need to do your homework on your paging subsystem
  - Many factors come into play here:
    - Active:Idle Virtual machines
    - Workload/SLA sensitivity to delays
    - Exploitation of shared memory
    - CMM usage
    - Other

# Memory – Part 4

- **Paging space (architected) (optimal when <= 50% allocated):**
  - 11.2 TB for ECKD (3390)
  - 15.9 TB for Emulated FBA on FCP SCSI (EDEV)
- **255 CP Owned Volumes**
  - Above numbers based on using all of those for Paging
- **Do NOT mix ECKD and EDEV paging volumes on same system**
  - Various anomalies can occur
- **Concurrent paging I/Os per paging volume: 1 for ECKD, >1 for EDEV (Have observed 1.6)**

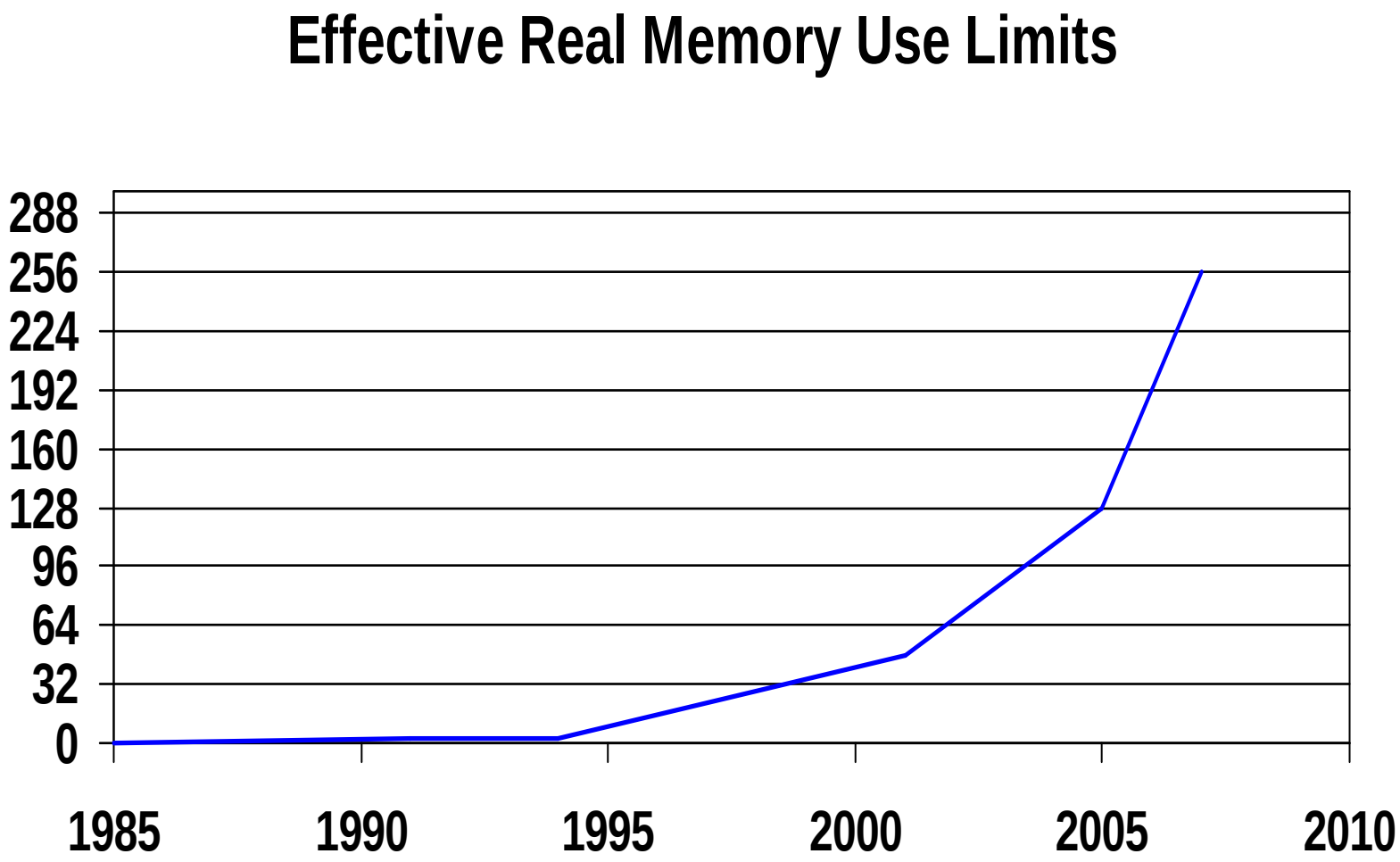
# Memory – Part 5

- **System Execution Space (SXS) (architected): 2 GB**
  - For practical purposes it is 2GB, but there are structures in the space placed above 2GB
- **DCSS aggregate size (architected):**
  - Individual Segments up to 2047 MB
  - Segments must end prior to one 4KB page below 512GB
- **Minidisk Cache (architected): 8GB**
  - Practical 2GB
- **Installing z/VM: 2GB**
  - On some machines, there is a problem with having more than 2GB Central when doing the initial install of z/VM off the DVD.

# Memory References

- **Memory Over Commit**
  - http://www.vm.ibm.com/perf/tips/memory.html
- **Paging in General**
  - http://www.vm.ibm.com/perf/tips/prgpage.html
- **Reorder Processing**
  - http://www.vm.ibm.com/perf/tips/reorder.html

# Memory Scaling



# 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 |

1. This system is using 44% of its page slots.

# DASD I/O: FCX109 DEVICE CPOWNED

```
FCX109  Run 2007/09/06 14:00:28        DEVICE   CPOWNED                                          Page  152
                                       Load and Performance of CP Owned Disks
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
```

---

```
 Page / SPOOL Allocation Summary
 PAGE slots available       87146k          SPOOL slots available      5409096
 PAGE slot utilization          44%         SPOOL slot utilization          52%
 T-Disk cylinders avail.   .......          DUMP slots available             0
 T-Disk space utilization      ...%         DUMP slot utilization           ..%
```

```
____ .            .                    .     .     .     .     .     .     .     .     .     .     .
< Device Descr. ->                      <------------ Rate/s ------------>  User        Serv MLOAD Block
   %Used
            Volume Area  Area      Used  <--Page---> <--Spool-->         SSCH Inter Queue  Time  Resp  Page   for
Addr Devtyp Serial Type  Extent       %  P-Rds P-Wrt S-Rds S-Wrt Total  +RSCH feres Lngth /Page  Time  Size Alloc
F08B 3390   VS2P49 PAGE     0-3338   45    2.6   1.7   ...   ...   4.4    1.6     1   .02   2.4   2.4     7    89
F090 3390   VS2P69 PAGE     0-3338   45    2.7   1.6   ...   ...   4.3    1.6     1     0   2.7   2.7     7    84
```

# V:R Ratio: FCX113 UPAGE

| | <--------- Paging Activity/s ---------> | | | | | | | <---------- Number of Pages ----------> | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <Page Rate> | | Page | <-Page Migration--> | | | | | <-Resident-> | | <--Locked--> | | | | Stor | Nr of |
| Userid | Reads | Write | Steals | >2GB> | X>MS | MS>X | X>DS | WSS | R<2GB | R>2GB | L<2GB | L>2GB | XSTOR | DASD | Size | 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
2. V:R = (1310 MB * 212) / 91 GB = 2.98

# 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

# 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).

# 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

| | | | <----------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)
- Values here are zero for page counts, ignore.
- More than one FULL$TRACK$CACHE$# space should be investigated to see if it the MDC settings are higher than needed.

# I/O

- **Number of subchannels in a partition (aka device numbers) (architected): 65,535**
- **Device numbers per disk volume**
  - Without PAV, 1
  - With PAV or HyperPAV, 8 (base plus seven aliases)
- **Virtual Devices per Virtual Machine:**
  - 24576 (24K)
- **Concurrent real I/Os per ECKD disk volume: 1 usually, but 8 with PAV or HyperPAV if of guest origin**

# I/O: DASD Volume Sizes

- **ECKD minidisk for a CMS file system:**
  - 32768 cylinders (22.5 GB)
  - 65520 cylinders (~45 GB) with CMS EAV APAR VM64711
- **Largest EFBA minidisk for a CMS file system: 381 GB**
  - Practical limit of 22GB due to file system structure under 16MB, unless there are very few files.
- **Largest ECKD volume:**
  - 65536 cylinders (45 GB)
  - 262,668 cylinders (~180 GB) with EAV APAR VM64709
  - CP use limited to first 64K cylinders
- **Largest EDEV CP can use: 1024 GB (but PAGE, SPOL, DRCT must be below 64 GB line on volume)**
- **Largest EDEV, period: $2^{32}$ FB-512 blocks (2048 GB)**

# I/O

- **VDISK size (architected): 2 GB (minus eight 512-byte blocks)**
- **Total VDISK (architected): 2TB**
- **Single VSWITCH 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

- **Number of spool files (architected):**
  - 9999 per user
  - 1.6 million spool files per system
    - 1024 files per warm start block * (180 * 9) warm start blocks
- **Number of logged-on virtual machines (approximate): about 100,000 (per designers)**

# Metrics for Formal Spin Locks

```
FCX265      CPU 2094  SER 19B9E  Interval 02:31:51 - 12:34:01    GDLVM7

                     <------------------- Spin Lock Activity ------------------->
                     <----- Total -----> <--- Exclusive ---> <----- Shared ---->
Interval             Locks Average   Pct  Locks Average   Pct  Locks Average   Pct
End Time LockName     /sec    usec  Spin   /sec    usec  Spin   /sec    usec  Spin
>>Mean>> SRMATDLK      1.9    .539  .000    1.9    .539  .000     .0    .000  .000
>>Mean>> RSAAVCLK       .0   2.015  .000     .0   2.015  .000     .0    .000  .000
>>Mean>> FSDVMLK        .0   24.97  .000     .0   24.97  .000     .0    .000  .000
>>Mean>> SRMALOCK       .0    .000  .000     .0    .000  .000     .0    .000  .000
>>Mean>> HCPTRQLK      4.1    .195  .000    4.1    .195  .000     .0    .000  .000
>>Mean>> SRMSLOCK     34.0   1.096  .001   32.7   1.037  .001    1.3    .001  .000
```

# Changes in Limits with z/VM 6.2.0

- **Clustering four z/VM systems allows horizontal scaling**
- **Balance that with whitespace that might be required for Live Guest Relocation (LGR)**
- **If MP or Scaling effects for one large z/VM system have negative impact, splitting into multiple smaller z/VM systems in an SSI Cluster could be benefecial.**

# z/VM 6.2 Effect on Processors Limits

- **Real Processors:**
  - 32 x 4 = 128 processors
  - Consider white space
  - Low processor requirements for cross member communication as long as system resource (device) access is stable
  - Perhaps greater efficiency by running smaller n-way
    - Example: One 32-way vs. Four 8-ways
    - Gives 4 master processors from one perception.
- **Virtual Processors:**
  - If splitting z/VM system into smaller systems, remember to ensure no virtual machine has more virtual CPUs than logicals on the system.

# z/VM 6.2 Effect on Memory Limits

- **Real Memory:**
  - 256 GB x 4 = 1 TB
  - Consider white space, cannot share like processors
  - Low memory costs to duplicate z/VM kernel and most control structures.
- **Virtual Machine Memory:**
  - No change
- **Paging Space**
  - Some slots lost due to sharing across members
  - But can reuse paging slots on each member, so it scales well.

# Other z/VM 6.2 Effects on Limits

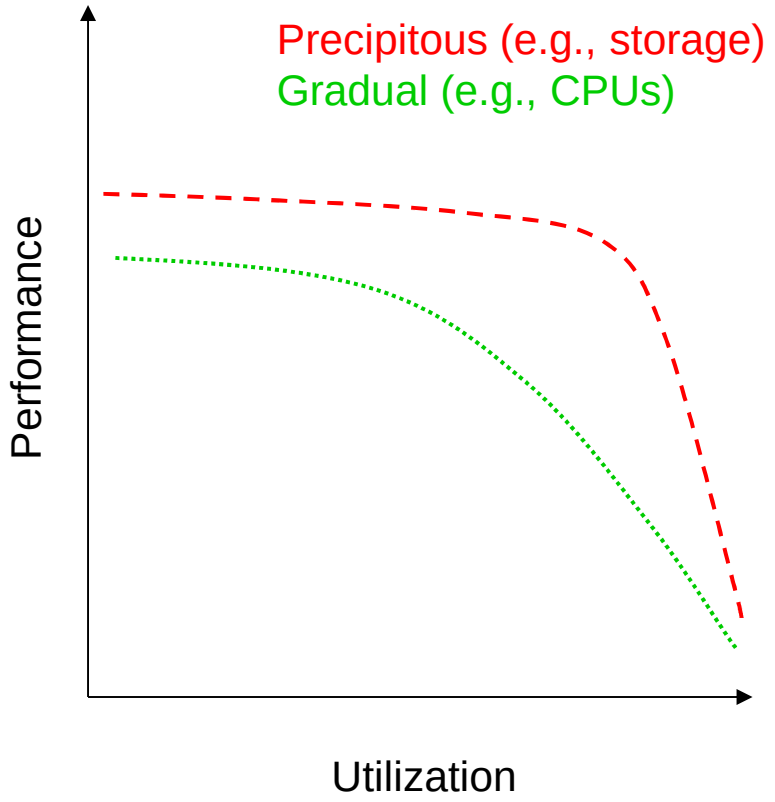
- **Distance for limit on DASD on SSI Cluster is 100km, unless using repeater technology.**
- **Distance for limit on Network on SSI Cluster is 10km, unless using repeater technology.**
  - Can double that if physical switches are placed at 10km from each CEC.
  - Remember, all members have to be in 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…"**
- **In our studies of z/VM 5.3, we found these kinds of latent limits:**
  - Searching for a below-2-GB frame in lists dominated by above-2-GB frames (storage balancing functions)
  - Contention for locks, usually the scheduler lock
- **These kinds of phenomena were the reasons we published the limits to be 256 GB and 32 engines**
  - We wanted to publish supported limits we felt would be safe in a very large variety of workloads and environments
  - Many of our measurement workloads scaled higher than this (for example, 440 GB and 54 engines)

# Other Notes on z/VM Limits

- **Sheer hardware:**
  - z/VM 5.2: 24 engines, 128 GB real
  - z/VM 5.3: 32 engines, 256 GB real
  - zSeries: 65,000 I/O devices
- **Workloads we've run in test have included:**
  - 54 engines
  - 440 GB real storage
  - 128 GB XSTORE
  - 240 1-GB Linux guests
  - 8 1-TB guests
- **Utilizations we routinely see in customer environments**
  - 85% to 95% CPU utilization without worry
  - Tens of thousands of pages per second without worry
- **Our limits tend to have two distinct shapes**
  - Performance drops off slowly with utilization (CPUs)
  - Performance drops off rapidly when wall is hit (storage)



# Keeping Tabs on Consumption Limits

- **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?

- **Depends on workload**
  - Guest-storage-intensive:
    - page slots on DASD… at 5-6 TB things start to get interesting… mitigate by paging to SCSI
    - utilization on paging volumes and chpids: watch for MLOAD elongation… mitigate by spreading I/O
    - Page Reorder Processing
    - mitigation by application tuning… perhaps smaller guests
  - Real-storage-intensive:
    - Ability of the system to page will limit you: ensure adequate XSTORE and paging capacity
    - You can define > 256 GB of real storage, but we are aware that some workloads cannot scale that high
    - Mitigation by application tuning or by using CMM
  - CPU-intensive:
    - FCX100 CPU and FCX 114 USTAT will reveal CPU limitations
    - You can define > 32 engines, but we are aware that some workloads cannot scale that high
    - 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

# Contact Information

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