IBM Systems & Technology Group

z/VM System Limits

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IBM z/VM Performance Evaluation
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  - Bill Holder
  - Virg Meredith

Agenda

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

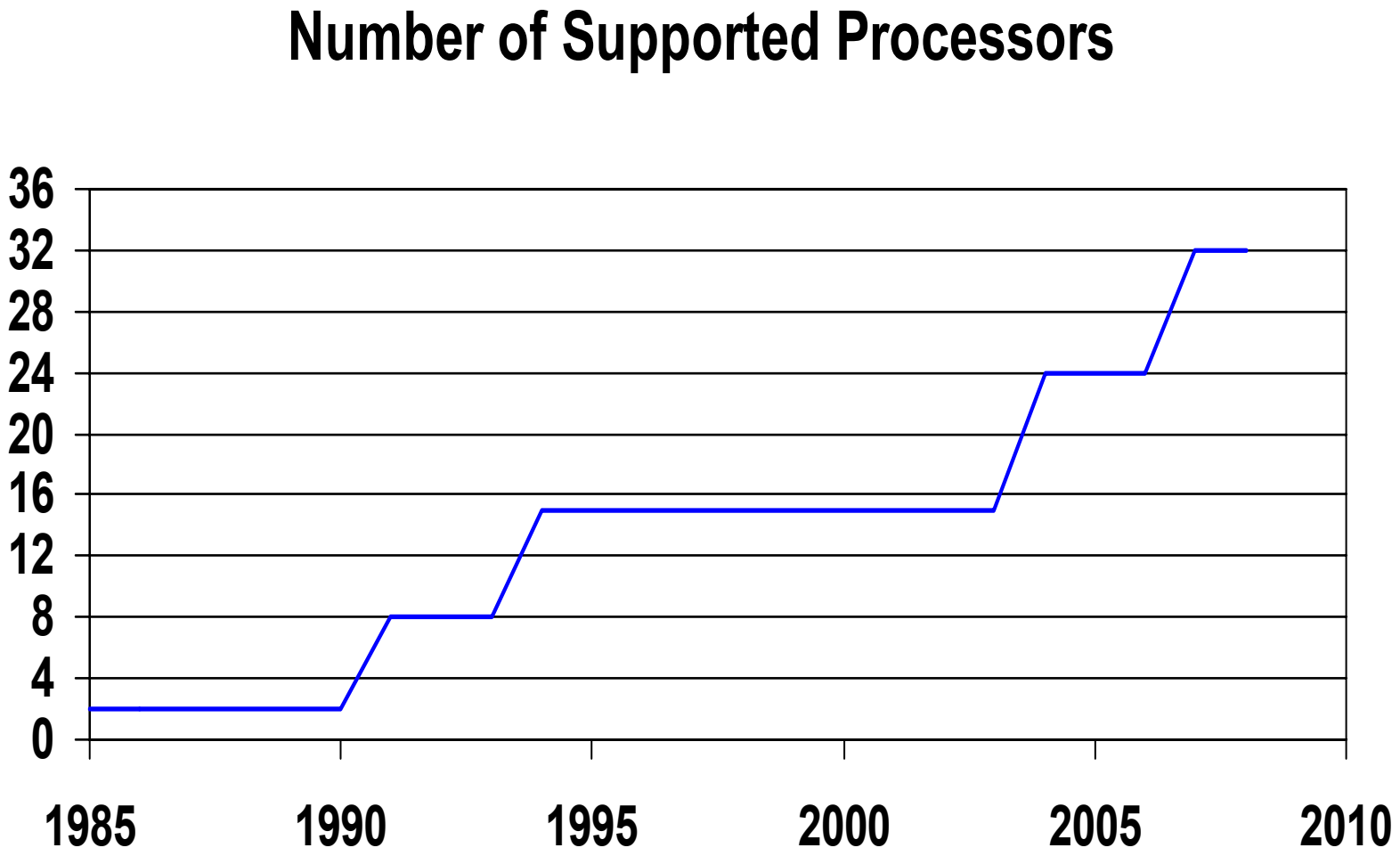
Limits

- **Processors**
- **Memory**
- **I/O**
- **Others**
- **Latent limits**

Processors

- **Processors (architected): 64**
  - Includes all engine types (CP, zAAP, zIIP, IFL…)
- **Processors (hardware): 64 (z10 EC); 54 (z9 EC)**
- **Logical processors (unsupported): 64 (z10 EC); 54 (z9 EC)**
- **Logical processors (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
- **Number of partitions: 60 (z9 EC & z10 EC)**

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 %LOCKLD  %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: 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

																	<--%Time spent in-->					Nr of
									<-SVM and->													
Userid	%ACT	%RUN	%CPU	%LDG	%PGW	%LOW	%SIM	%TIW	%CFW	%TI	%EL	%DM	%LOA	%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 (1 of 3)

- **Central storage**
  - Supported central storage: 256 GB
  - Unsupported central storage:
    - 512 GB minus your HSA (z9 EC)
    - 1 TB (z10 EC)
  - The largest we ever managed (as of Sep 2007) was 440 GB
- **Expanded storage (architected): 128 GB**
- **Virtual machine size (hardware):**
  - On z9 and z10, 1 TB (2^{40})

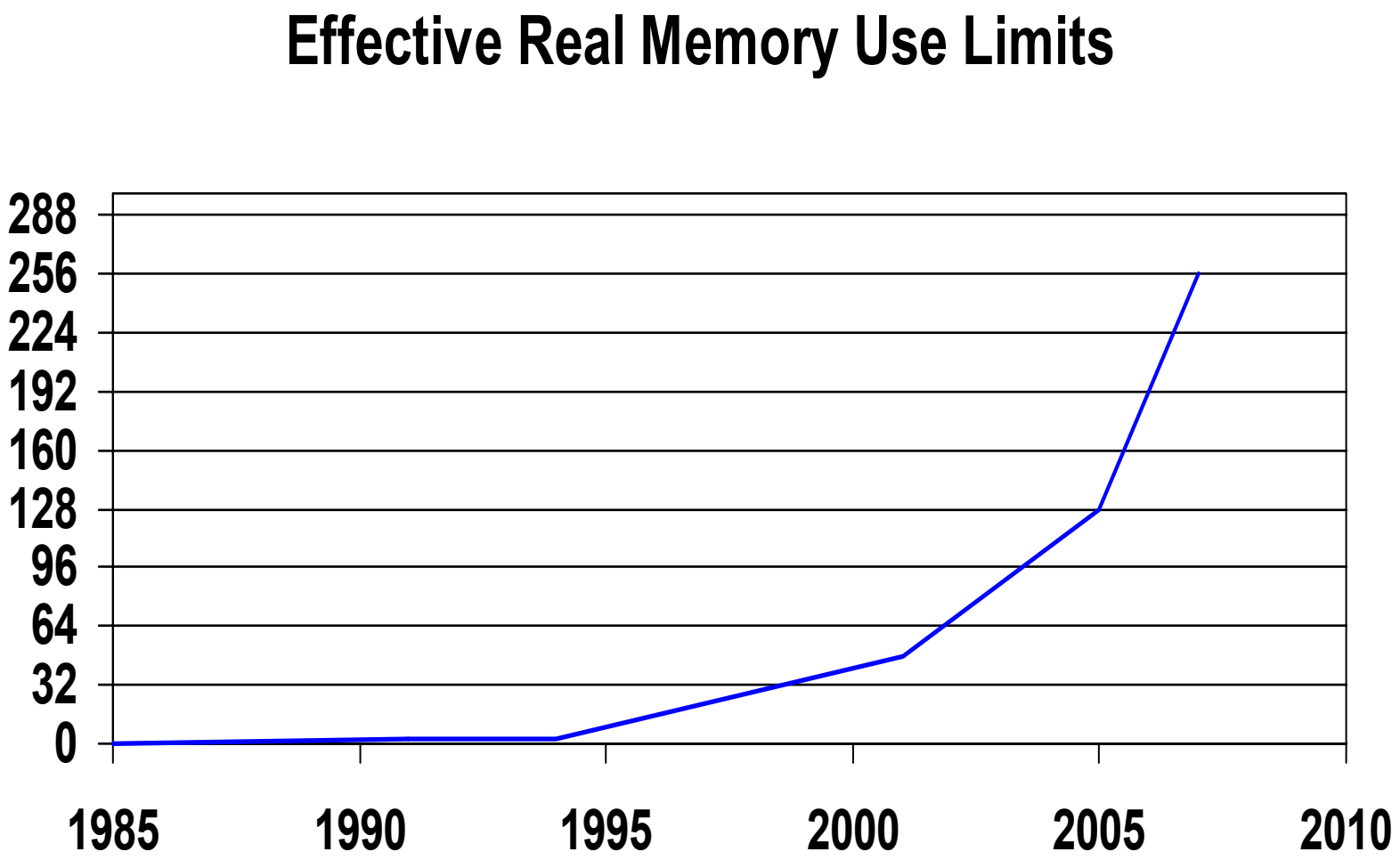
Memory (2 of 3)

- **Active 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
- **Logged-on guest real limit imposed by segment tables (architected): 256 TB**
  - 4 pages per ST; each ST maps 2 GB; all segment tables must fit under the 2 GB bar
- **Virtual to real ratio (practical): about 3:1**
  - Assumes guests that tend to use all of their memory
  - Unless you really, really do your homework on your paging subsystem
  - VMRM-CMM can help with this too (it encourages Linux to Diag x'10' its guest real)

Memory (3 of 3)

- **Paging space (architected) (optimal when <= 50% allocated):**
  - 11.2 TB for ECKD
  - 15.9 TB for Emulated FBA on FCP SCSI
- **Paging volumes: 255**
- **Concurrent paging I/Os per paging volume: 1 for ECKD, >1 for EDEV (have observed 1.6)**
- **System Execution Space (SXS) (architected): 2 GB**
  - For practical purposes it is 2 GB, but there are structures in the space placed above 2 GB
- **DCSS aggregate size (architected): 2047 MB**
  - (DCSSs must map into < 2 GB guest real)
- **Minidisk Cache (architected): 8 GB**

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

Interval End Time	<Page Slots> Total Slots	Used %	<Spool Slots> Total Slots	Used %	<Dump Slots> Total Slots	Used %	<----- Spool Files -----> <-Created--> Total	/s	<--Purged--> Total	/s	<Average MLOAD> Paging msec	Spooling 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.
2. 87146k slots / (256 slots/MB) = 332 GB of paging space.

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-Wt	S-Rds	S-Wt	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

Interesting fields: slot utilization, MLOAD, Queue Lngth.

V:R Ratio and Segment Tables: FCX113 UPAGE

FCX113 Run 2007/09/06 14:00:28 UPAGE Page 173
User Paging Activity and Storage Utilization

From 2007/09/04 09:07:00 VS2
To 2007/09/04 10:00:00 CPU 2094-700 SN 2BFBD
For 3180 Secs 00:53:00 z/VM V.5.3.0 SLU 0701

	Data	<--------- Paging Activity/s ---------->							<---------- Number of Pages ---------->								
	Spaces	<Page Rate>		Page	<--Page Migration-->						<-Resident->		<--Locked-->				Stor	Nr of
Userid	Owned	Reads	Write	Steals	>2GB>	X>MS	MS>X	X>DS	WSS	Resrvd	R<2GB	R>2GB	L<2GB	L>2GB	XSTOR	DASD	Size	Users
>System<	.0	1.7	1.1	4.1	.0	2.4	3.7	1.4	122050	0	2347	106962	6	24	12240	179131	1310M	212
ABCDEFGH	.0	.0	.0	.0	.0	.0	.1	.0	13	0	0	0	0	0	483	254	32M	
DATAMOVA	.0	.0	.0	.0	.0	.5	.5	.0	147	0	0	0	0	0	220	368	32M	
DATAMOVB	.0	.0	.0	.0	.0	.6	.6	.0	192	0	0	0	0	0	220	366	32M	
DATAMOVC	.0	.0	.0	.0	.0	.6	.6	.0	191	0	0	0	0	0	220	369	32M	
DATAMOVD	.0	.0	.0	.0	.0	.6	.6	.0	189	0	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 (FCX103 shows 91 GB central)
3. Segment table pages: hard to say. Conservatively:
   212 guests * (4 ST/guest * 4 pg/ST) = 13 MB

PTRM Space: FCX134 DSPACESH

```
FCX134   Run 2007/09/06 14:00:28          DSPACESH
                                 Shared Data Spaces Paging Activity

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
```

_

Owning Userid	Data Space Name	Rate per Sec. Pgstl	Pgrds	Pgwrt	X-rds	X-wrt	X-mig	Total	Number of Pages Resid	Resid R<2GB	Locked Lock	Locked L<2GB	Aliases Count	Aliases Lockd	XSTOR	DASD
>System<	--------	.026	.016	.001	.015	.026	.000	103k	1208	51	0	0	0	0	34	4981
SYSTEM	FULL$TRACK$CACHE$1	.000	.000	.000	.000	.000	.000	524k	0	0	0	0	0	0	0	0
SYSTEM	ISFCDATASPACE	.000	.000	.000	.000	.000	.000	524k	113	8	8	8	113	100	0	27
SYSTEM	PTRM0000	4.257	.492	.442	3.957	4.036	.000	1049k	386k	15885	0	0	0	0	5195	683k
SYSTEM	REAL	.000	.000	.000	.000	.000	.000	24M	0	0	0	0	0	0	0	0
SYSTEM	SYSTEM	.080	.001	.034	.079	.080	.000	524k	45	10	0	0	44	0	47	510k

1. PTRM space = 386,000 pages = 1.47 GB of PGMBKs.
2. This maps 128 * 1.47 GB = 188.5 GB of guest storage.
3. Be careful with this report on z/VM 5.1 and z/VM 5.2.

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
For 3180 Secs 00:53:00

CPU 2094-700
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

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
For 3180 Secs 00:53:00

CPU 2094-700
z/VM V.5.3.0 SLU 0701

	<-- Backed <2GB Page Queue -->					<-- Backed >2GB Page Queue -->					<---------- Unbacked Page Queue ---------->					<---- Replenishment ---->			
Interval	Avail	<-Pages/s-->		<Preferred>		Avail	<-Pages/s-->		<Preferred>		Avail	<-Pages/s-->		<Preferred>		Thres	Att/s	Stolen	MinPgs
End Time	Pages	Taken	Return	Used	Empty	Pages	Taken	Return	Used	Empty	Pages	Taken	Return	Used	Empty				
>>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.

FCX178 Run 2008/04/15 10:00:22 MDCSTOR Page 76

Minidisk Cache Storage Usage, by Time

From 2008/04/15 09:47:11
To 2008/04/15 10:00:11
For 780 Secs 00:13:00

CPU 2084-320 SN 17F2A
z/VM V.5.3.0 SLU 0000

	<---------- Main Storage Frames ---------->						
Interval	<--Actual--->			Mn	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 about 8 GB in use for MDC.

FCX134 Run 2008/04/15 10:00:22 DSPACESH
Shared Data Spaces Paging Activity

From 2008/04/15 09:47:11
To 2008/04/15 10:00:11
For 780 Secs 00:13:00 This is a performance report for system XYZ

			<-------------------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.

I/O

- **Number of subchannels in a partition (aka device numbers) (architected): 65,535**
- **CHPIDs per server (z9 EC or z10 EC):**
  - 1024 ESCON, 336 FICON Express 4, 96 OSA Express 3, 16 HiperSockets
- **Device numbers per disk volume**
  - Without PAV, 1
  - With PAV or HyperPAV, 8 (base plus seven aliases)
- **Concurrent real I/Os per ECKD disk volume: 1 usually, but 8 with PAV or HyperPAV if of guest origin**
- **Concurrent real I/Os per chpid (aka "open exchange limit")**
  - 1 for ESCON
  - 64 for FICON
- **I/O rates:**
  - Fastest FICON is a 4 Gb link
  - About 1-2 msec per I/O are required for a nominal DASD I/O from a z9 to a 2107 (500-1000/sec/device)

I/O

- **Volume sizes**
  - Largest ECKD minidisk that can contain a CMS file system (architected): 32768 cylinders (22.5 GB)
  - Largest EFBA minidisk that can contain a CMS file system (architected): 381 GB
  - Largest ECKD volume, period: 65536 cylinders (43 GB)
  - 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)
  - VDISK size (architected): 2 GB (minus eight 512-byte blocks)
- **Total VDISK (architected): 2 TB**
- **Single VSWITCH OSAs: 8**

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
For 3181 Secs 00:53:01

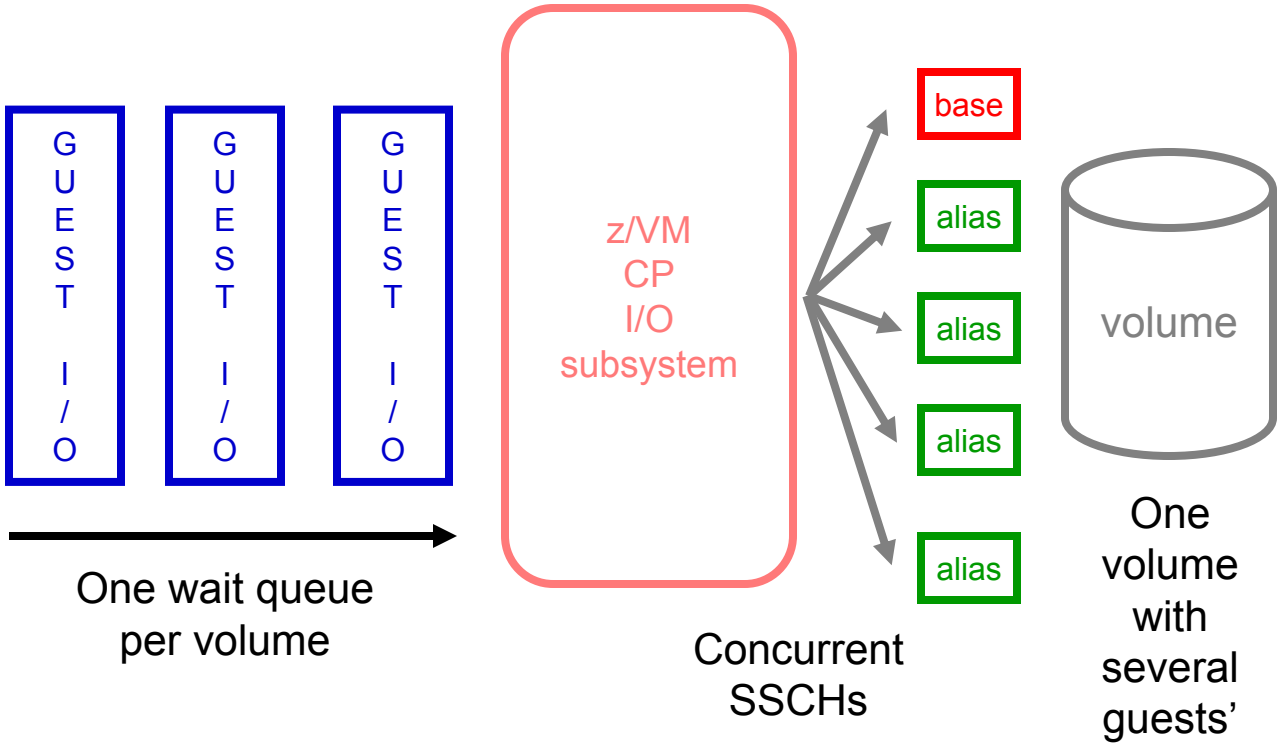
CPU 2094-700 SN
z/VM V.5.3.0 SLU 0701

<-- 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	...	...

1. Interesting columns: Avoid, Serv, Req. Qued.
2. Req. Qued > 0 is a good trigger for looking at PAV or HyperPAV.

How z/VM Exploits PAV For Its Guests

- Guests do minidisk I/O
- Old: we serialized the resultant real I/Os
- New: we use the volume's PAV aliases to drive the real I/Os concurrently
- One wait queue for the volume
- Many device numbers for the volume



Note: z/VM 5.2 plus VM63855 (UM31771) (May 2006)

FICON Open Exchange Limit

- **Parallel and ESCON: 1 I/O at a time on a chpid**
  - Pending time >0 could mean chpid contention
  - Controller disconnect was a good thing, and so they did
- **FICON: 64 (was 32) I/Os at a time on a chpid**
  - Pending time >0 probably now means slow IR
  - Little motive for controller to disconnect anymore
    - Controller cache miss is still a good reason
- **Calculating “open exchange level” is not easy**
- **Very seldom is this an issue anyway**

Calculating Open Exchange Level

- **For each device, IOs/sec * (disc/IO + conn/IO) = exchtime/sec for the device**
- **Sum over all devices in controller = exchtime/sec for the controller**
- **Divide by number of chpids = exchtime/sec per chpid**
- **For example,**
  - Suppose 500 volumes each contribute:
    - 10 IOs/sec * 2 msec disc time plus conn time per I/O
    - This gives 20 msec/sec of exchange time per device
  - This is 10000 msec/sec of exchange time altogether
  - 4 chpids to controller would give 2500 msec/sec exchange time per chpid
  - Open exchange level is 2.5
- **Per Artis z/OS stress tests, 3 to 5 is when this becomes problematic**
  - http://www.zjournal.com/index.cfm?section=article&aid=541
- **Performance Toolkit cannot report on this directly**

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

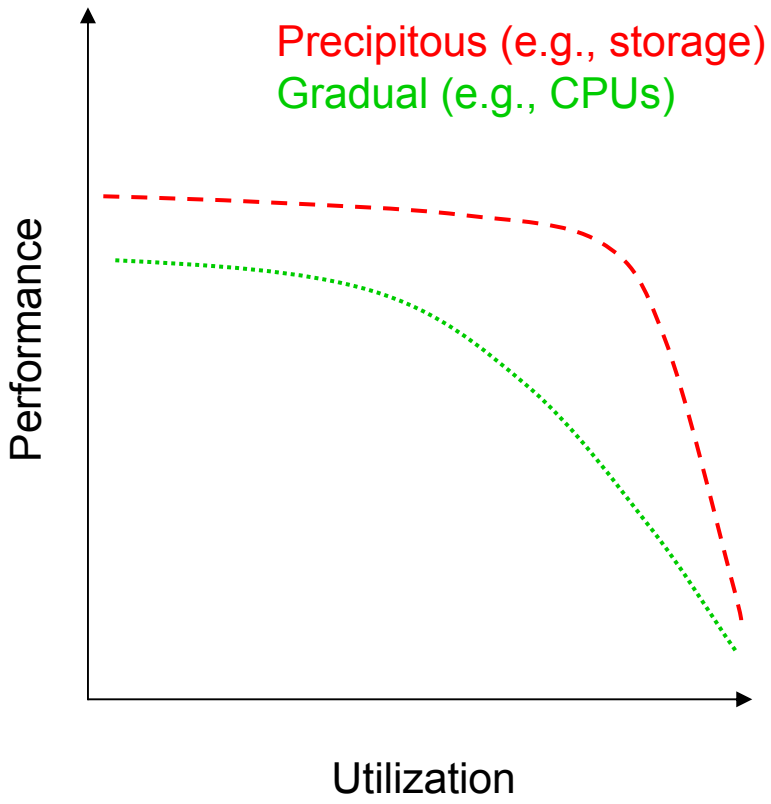
		<---------- Spin Lock Activity ---------->						
		<----- Total ----->			<--- Exclusive --->		<----- Shared ---->		
Interval		Locks	Average	Pct	Locks	Average	Pct	Locks	Average	Pct
End Time	LockName	/sec	usec	Spin	/sec	usec	Spin	/sec	usec	Spin
>>Mean>>	SRMATDLK	1.9	.539	.000	1.9	.539	.000	.0	.000	.000
>>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

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

What Consumption Limits Will We Hit First?

- **Guest-storage-intensive workload:**
  - page slots on DASD… at 5-6 TB things start to get interesting… mitigate by paging to SCSI
  - paging I/O concurrency – only 255 at a time – mitigate by paging to SCSI
  - utilization on paging volumes and chpids: watch for MLOAD elongation… mitigate by spreading I/O
  - mitigation by application tuning… perhaps smaller guests
  - segment table constraints: probably an issue at 50% (128 TB of logged-on guest real) … not anytime soon
- **Real-storage-intensive workload:**
  - 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 workload:**
  - 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 workload:**
  - 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