z/VM Storage Analysis and Tuning

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"If you can't Measure it,

I am Just Not Interested ™"

VELOCITY SOFTWARE

PROVEN PERFORMANCE

Storage Subsystem Objectives

Objectives:

- Understand Storage Requirements
- Know how/where to measure
- Understand Demand Paging
- Determine Requirements
- Understand Measurements
- Suggest tuning measures

Storage Subsystem Overview

Storage Requirements

- System functions require storage
- Work requires programs and data
- More data in storage improves response time

Overcommit (sharing)

- “Expensive” storage is shared in virtual environment
- Storage often used once (initialization), not needed after
- Unreferenced pages of virtual machine can be paged out
- Idle applications and data can be paged out
- Overcommit is the key metric for capacity planning

Linux is challenging

Sharing Storage

To “share” requires paging out:

- Inactive storage
- Inactive applications
- Initialization pages
- Inactive servers

Linux Storage management is worst case to virtualize

- “Round robin” keeps all storage active
- Oldest unreferenced page
- Most likely to be paged out
- Most likely to be next used by Linux
- All storage is used to buffer data, programs
- Small “available list”

The problem: What pages to page out?

Inactive storage? Linux Storage is not idle

- Extra storage used to cache data and programs

Inactive servers? Linux servers are not idle

- Linux applications poll at 200 times per second
- Which servers are actually doing work if all are “active”
- What pages can legitimately paged out of real storage?

The page most likely to be needed by Linux:

- Is most likely to have been paged out

Linux is NOT virtual friendly, changes requirements

Determining pages for page out:

- **Active server?** Can not know if server is working or **polling**
- Take least recently used, non modified, non referenced
- If server is working, will re-use storage most likely paged out
- Fast page-in very important

z/VM Storage and Paging Architecture - Moving Targets

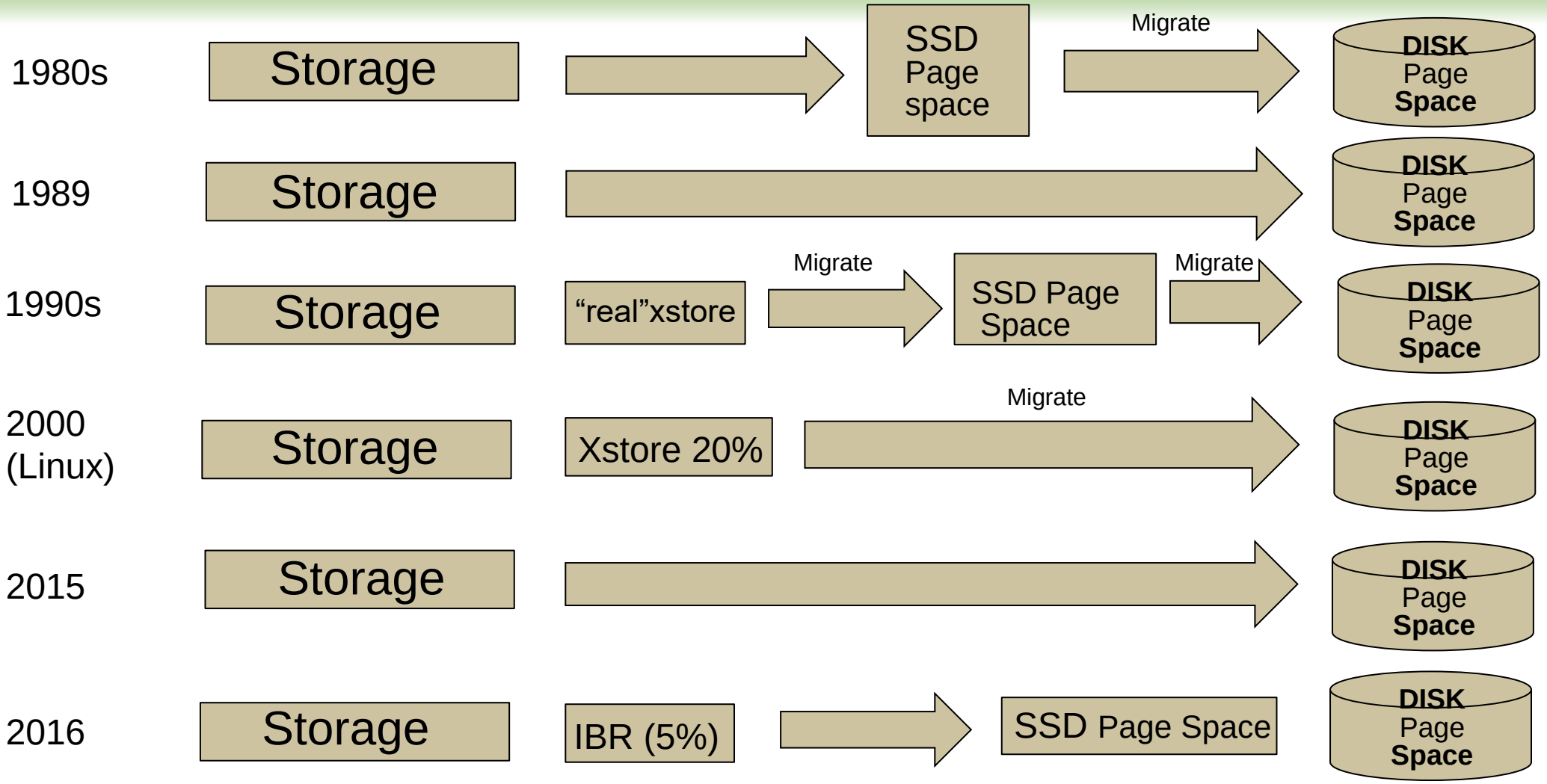
z/VM shared storage / Overcommit

- Objective: Page unused pages out to allow re-use
- Need optimal test before paging to slow disk
- Optimize page-in when needed (block paging)
- ~~Page migration from fast to slow as age out (gone)~~

Architectures to choose from:

- Excessive Storage – enough so no paging (expensive)
- ~~Expanded Storage – Very fast page-in, gone…~~
- Solid State paging device – sort of fast
- Disk paging devices – not fast
- Block paging to group pages for faster load

Storage / Paging Architecture Evolution



Strategy / Best practices in past if overcommit high

- Need high speed page recovery

Expanded Storage was used for “30 second test case”

- Pages migrated to disk after 30 seconds
- Minimum 20% of storage reconfigured to Expanded Storage
- Page-in from expanded storage was synchronous and FAST
- Pages migratable to disk after 30 seconds unreferenced

“New” strategy is IBR (z/VM 6.3).

- VERY LIMITED. 5% is the max
- 2% is the default, Go the max!

z/VM User Storage “test” Replaces ExStore

Virtual machines have “resident pages”

- Active pages
- IBR (Marked Invalid But Resident)

IBR Pages (the heart of current paging architecture)

- Invalidated, so not addressable by address space
- Pages “stolen” from end of sorted IBR page list
- IBR pages optionally “pre-written”

Re-Referenced pages “validated”

- Page fault causes page to move to “Active Pages”
- Reclaim of “test invalidated page” very fast

Storage management functions

- IBR – Invalid But Resident
- Global Aging list – sorts pages LRU
- Saved segments (shared storage) can be protected

IBR List – pages belonging to user in "test" mode

- Pages marked IBR (Invalid But Resident) as a "test" - Pages are reclaimed if referenced
- Referenced pages go to top of frame list
- **Size or IBR list is configurable (to 5%)**

Global Aging List – list ready to page out

- Pages moved from IBR to sorted Global Aging list
- Pages can be reclaimed if referenced
- Pages will be oldest pages to be paged out

System Age List

- Maximum 5%
- Recommend 5% always
- SET AGELIST SIZE 5% EARLYWRITES YES KEEPSLOT YES

```
-Set--AGELIST---.-SIZE--.-n.n--PERCent-.-.
                |       |-n.n%---------| |
                |       '-storsize-----' |
                |-EARLYWrites--.-Yes-.---|
                |              '-No--'   |
                '-KEEPSlot--.-Yes-.------'
                            '-No--'
```

- CP QUERY AGELIST (defaults)

```
Target size    =          280576K (274M)      2.0% of pageable storage
In use         =          271712K
Pending writes =          120296K
Early writes   = Yes
Sizing         = Variable
Keep slot      = Yes
```

Each page of storage has a key (4 bits)

- 3 status bits - usually expressed as two hex digits with the last bit always 0
- For storage alteration, the key on the page must match the key in the PSW (bits 8-11)

Flags

- F – fetches are protected as well
- R – some location has been referenced
- C – some location has been changed

CP Storage Management – Frame Table

The Frame Table (CP Fixed Storage) is the usage map of REAL (main) storage

- One entry (32 bytes) for each page (2 page per MB Real)
- All entries chained on specific list for (current) type of page
- If 196 GB of storage, 1,536 MB free storage for page frame tables

Resident pages for a user are dynamic Frame Table entries chained together in a List: The User Frame Owned List (UFOL).

CP address spaces and Shared Segment (NSS/DCSS) pages are similarly chained: (SUFO) (not stolen so much)

z/VM 6.3 adds VUFO (virtual disk frame owned list)

When storage is needed by ANY process, it is acquired from the Available List – another chain of Frame Table entries.

If available list empty, big problem….

z/VM Storage “Case Study”

Project to install OpenStack:

- VSIVM4 is demonstration LPAR
- Alerts set for high paging rate
- Alerts set for page space thresholds

Started with an emailed alert

- `Alert on 2021/04/15 at 20:02:11`
- `System paging rate is 113855 (above 10000 for 30 minutes)`

Process:

- ESAXACT to see impact
- Storage analysis to understand why

User Wait analysis – ESAXACT

- System page wait spikes from one interval to next
- Openstack server consuming storage and CPU

```
Report: ESAXACT      Transaction Delay Analysis                    Velocity Sof
Monitor initialized: 04/15/21 at 00:00:00 on 8562 serial 040F78    First record
-------------------------------------------------------------------------------
                     <-----Percent non-dormant (Wait states)-------------------
UserID   <-Samples->                          E-  D-  T-      Tst <Asynch>
/Class   Total  In Q Run Sim CPU SIO Pag SVM SVM SVM  CF Idl I/O Pag Ldg Oth
-------- ----- ----- --- --- --- --- --- --- --- --- --- --- --- --- --- ---
18:15:00  1697   610 2.3 0.5 3.8   0 1.1   0   0 5.1   0  79 3.0   .   .   1
Hi-Freq:  110K 34022 2.9 0.1 1.0   0 0.0   0  10 3.7   0  87 0.0   0 0.2 0.0
-------------------------------------------------------------------------------
18:30:00  1738   658 2.0 0.8 2.0   0  14   0   0 3.8   0  69 1.8   .   .   2
Hi-Freq:  119K 40387 3.5 0.8 3.4 0.0 9.4   0 9.3 2.2 0.0  58 0.2 0.9  16 0.0
 ***Key User Analysis ***
TCPIP      900   376   0   0 0.8   0 2.1   0   0   0   0  96   0   0 1.3   0
 ***User Class Analysis***
Velocity  7200  1812 3.1 0.8 0.8   0 4.0   0 5.4  32   0  44   0   0  15   0
REDHAT    8100  6222 0.5 0.0 1.7   0  10   0   0   0   0  78   0 1.5 8.6   0
SUSE      6300  5190 3.8 0.4 1.9   0  11   0   0   0   0  48   0 0.6 8.5   0
ORACLE    2700  2694 1.3 0.1 4.9   0  12   0   0   0   0  61   0 2.3  18   0
GPFS      2700  2700 5.9 0.0 2.6   0  21   0   0   0   0  48   0 0.1  22   0
TheUsrs  37605 17585 5.2 0.7 4.8 0.0 8.4   0  10 0.2 0.0  56 0.4 1.0  20 0.0
 ***Top User Analysis***
RHOSBOOT  3600  1873  22 0.3  13   0 2.5   0   0   0   0  52 1.0 4.5 5.0 0.1
```

User Storage – Case Study

Overall Subsystem Activity: ESASSUM/ESAMAIN

- Changes: Paging rates at 18:30 / CPU 18:45
- User “Resident” drops?

Report: **ESASSUM** **Subsystem Activity** Velocity Sof
Monitor initialized: 04/15/21 at 00:00:00 on 8562 serial 040F78 First record

	<---Users---->			Transactions	<Processor>		Storage (MB)		<-Paging-->	<----
	<-avg number->			Per	Avg.	Utilization	Fixed	Active	<pages/sec>	<-DAS
Time	On	Actv	In Q	Minute	Resp	Total Virt.	User	Resid.	XStore	DASD Rate
17:00:00	111	73	41.1	439.4	0.468	141 133	81.5	13219	0	90 139
17:15:00	111	74	38.1	449.5	0.410	132 125	81.5	13209	0	114 147
17:30:00	111	72	40.7	427.7	0.391	142 134	81.5	13202	0	75 137
17:45:00	111	72	39.5	446.8	0.563	146 139	81.5	13194	0	83 139
18:00:00	111	74	41.7	449.3	0.420	143 136	81.6	13202	0	120 157
18:15:00	113	75	40.7	445.1	0.494	101 95	81.5	13206	0	119 146
18:30:00	116	76	43.9	385.4	0.631	179 134	81.5	13078	**0**	**43K 12K**
18:45:00	116	80	57.2	303.8	0.833	**341 270**	81.2	**12861**	0	69K 22K
19:00:00	116	79	57.1	275.2	0.930	445 352	81.1	12863	0	81K 29K
19:15:00	115	80	54.7	307.7	0.748	313 249	81.2	12878	0	50K 17K
19:30:00	116	80	61.7	204.7	1.691	465 349	81.2	12863	0	101K 38K

User Storage analysis – ESAUSR2

- Totals of all users to understand system impact
- Changes: resident, paging allocated, paging I/O
- User resident dropped?
- “Reserved” is for zWRITE to ensure performance data

Report: **ESAUSR2** User Resource Utilization Velocity S

	<---CPU time-->			<**Main Storage (pages)**>			<**------Paging (pages)-------**>				
UserID	<(seconds)>	T:V	<**Resident**>	Lock			<---**Allocated**--->		<---I/O--->		
/Class	Total	Virt	Rat	Totl	Activ	-ed	Resrvd	Total	ExStg	**Disk**	**Read**	**Write**
17:30:00	1230	1209	1.0	3.4M	3380K	6956	5000	7853K	0	7853K	17840	7098
17:45:00	1268	1247	1.0	3.4M	3378K	6906	5000	7852K	0	7852K	24890	9267
18:00:00	1243	1221	1.0	3.4M	3380K	6896	5000	7854K	0	7854K	44857	19867
18:15:00	877.0	857.8	1.0	3.4M	3381K	6906	5000	7857K	0	7857K	39079	26947
18:30:00	1307	1205	1.1	3.3M	3348K	7048	5000	9147K	0	9147K	24M	14M
18:45:00	**2589**	**2431**	**1.1**	**3.3M**	**3292K**	**7182**	**5000**	**13M**	**0**	**13M**	**43M**	**19M**
19:00:00	3384	3171	1.1	3.3M	3293K	7103	5000	16M	0	16M	54M	19M
19:15:00	2406	2244	1.1	3.3M	3297K	7198	5000	17M	0	17M	32M	12M
19:30:00	3391	3137	1.1	3.3M	3293K	7278	5000	17M	0	17M	66M	24M

User Storage analysis – ESAUSP2

- Same data - rates / percents vs total counts
- Totals of all users
- Changes: resident, paging allocated, paging I/O

```
Report: ESAUSP2      User Resource Rate Report                        Velocity
Monitor initialized: 04/15/21 at 00:00:00 on 8562 serial 040F78       First re
-------------------------------------------------------------------------------
         <---CPU time--> <----Main Storage (pages)-----> <-Paging (pages)->
UserID   <(Percent)> T:V <Resident> Lock <-----WSS-----> Paged <Pgs/Second>
/Class   Total  Virt Rat Totl Activ  -ed Totl Activ  Avg 2Disk  Read Write
-------- ----- ----- --- ---- ----- ---- ---- ----- ---- -----   ---- -----
17:30:00 136.6 134.3 1.0 3.4M 3380K 6956 4.0M 3957K  36K 7853K  19.8   7.9
17:45:00 140.9 138.6 1.0 3.4M 3378K 6906 4.0M 3962K  36K 7852K  27.7  10.3
18:00:00 138.1 135.6 1.0 3.4M 3380K 6896 4.0M 3948K  36K 7854K  49.8  22.1
18:15:00 97.43 95.29 1.0 3.4M 3381K 6906 4.0M 3973K  35K 7857K  43.4  29.9
18:30:00 145.3 133.9 1.1 3.3M 3348K 7048 3.9M 3909K  34K 9147K 27057 15496
18:45:00 287.6 270.1 1.1 3.3M 3292K 7182 5.4M 5363K  46K   13M 48060 21144
19:00:00 376.0 352.3 1.1 3.3M 3293K 7103 4.3M 4263K  37K   16M 59528 20806
19:15:00 267.3 249.3 1.1 3.3M 3297K 7198 3.7M 3682K  32K   17M 35972 13731
19:30:00 376.8 348.6 1.1 3.3M 3293K 7278 3.2M 3161K  27K   17M 73843 27041
```

User Storage analysis – ESAUSP2 (percent/rate)

- Analyze by user
- RHOS* users paging too much to get work done
- RHOS* is OpenShift installation

```
Report: ESAUSP2      User Resource Rate Report                      Velocit
-------------------------------------------------------------------------
         <---CPU time--> <----Main Storage (pages)-----> <-Paging (pages)-
UserID   <(Percent)> T:V <Resident> Lock <-----WSS-----> Paged <Pgs/Second
/Class   Total  Virt Rat Totl Activ  -ed Totl Activ  Avg 2Disk  Read Write
-------- ----- ----- --- ---- ----- ---- ---- ----- ---- -----  ---- ----
18:30:00 145.3 133.9 1.1 3.3M 3348K 7048 3.9M 3909K  34K 9147K 27057 15496
 ***Key User Analysis ***
TCPIP     0.15  0.05 3.0 1422  1422  601  817 817.3  817  7750  43.4   8.6
***User Class Analysis***
Velocity  5.82  5.43 1.1 3763  3598    5 4593  4271  534 14472 137.4  57.0
SUSE     20.17 19.28 1.0 112K  112K 1534 193K  193K  32K 1048K  2754 828.5
ORACLE    4.66  3.84 1.2 195K  195K  734 381K  381K 190K  473K  2895 936.7
GPFS     12.51 11.68 1.1 195K  195K  975 439K  439K 146K 1332K  4008  1383
TheUsrs  95.37 89.07 1.1 2.6M 2615K 1145 2.5M 2472K  80K 5017K 12958 11022
 ***Top User Analysis***
RHOSBOOT 39.91 38.51 1.0 727K  727K   30  99K 98642  99K  454K  1175  2346
RHOSCP2   8.92  8.20 1.1 250K  250K   19 116K  116K 174K  201K 997.0  1965
RHOSCP1   8.78  8.05 1.1 252K  252K   19 126K  126K 189K  205K 967.6  2005
RHOSCP3   7.83  7.04 1.1 161K  161K   28  48K 47842  80K  125K  1230  1157
```

User Storage – Classify Servers of Interest

ESAUSPG – Group relevant users, show MB

- OpenShift class takes all storage, flushes all others
- OpenShift is just the installation, no work “yet”
- Can now quantify the impact of the “OpenShif” servers as group

```
Report: ESAUSPG      User Storage Analysis                    Velocity Software
-------------------------------------------------------------------------------
         <-Storage Occupancy in MegaBytes-> <--Main Storage page Read/Write-->
UserID   <---Main Storage---> <--Paging---> <-Page Writes to:--> <Page Reads:>
/Class    Total    >2gb    <2GB  Xstor   DASD   Xsto   Disk   Migr  Xstor  Disk
-------- ------ ------ ----- ----- ----- ----- ----- ------ ---- ------
19:55:00  12883  10948   1935      0  55185      0 406320      0       0  1130K
 ***Key User Analysis ***
TCPIP         3      3      1      0     32      0    757      0       0   4056
 ***User Class Analysis***
Servers       5      4      2      0    185      0    526      0       0   1358
KeyUsrs       4      3      1      0     97      0    400      0       0   1165
ZVPS         10      9      2      0     77      0   2948      0       0   6435
Lnx         122    102     20      0   4186      0  47575      0       0 190345
OpenShif  12308  10474   1834      0  34811      0 206426      0       0 451662
TheUsers    428    352     76      0  15748      0 147274      0       0 473648
```

User Storage Fully Instrumented (ESAUSTR)

User Resident Storage = Active + IBR + Agelist

- System thresholds maintained, source of pages changed
- UFO Active: User frame list
- IBR: Invalid But Resident
- AgeList: Ready for “steal”
- Unreferd: (Block read, no reference)
- “NoScan”: Demand scan restricted by set reserved
- DiagRlse: Diagnose 10, 214
- PreWrite: IBR already backed before reclaim
- PreWrite: Agelst – pagefaulted (heading confusing)
    - “Wasted write”, was written, but then page faulted and was needed

```
Report: ESAUSTR      User Storage Analysis                Velocity Software Corporate   ZMAP 5.1.2 04/16/21   Page  232
-------------------------------------------------------------------------------------------------------------------------
         <--------Virtual Server Storage (Pages)--------->  <Resident> Page  <-----Page Rates / Second-----> NoScan
UserID   Size  Alloc Resi- UFO   <-----IBR----> <AgeList> <Unreferd> slots Made IBR AgeLst <PreWrite> Diag  SET  Steal
/Class                dent Activ TOT  <2gb >2gb <2gb >2gb <2gb >2gb  used  IBR Refd Refd   IBR Agelst Rlse Rsrvd Weight
-------- ----- ----- ----- ----- ---- ---- ---- ---- ---- ---- ---- ----- ---- ---- ----- ---- ------ ---- ----- ------
```

User Storage Fully Instrumented (ESAUSTR)

User Resident Storage = Active + IBR + Agelist

- Just user totals, easy to see significant changes
- System thresholds maintained, source of pages changed
- UFO Active – User Frame list
- IBR – Invalid But Resident
- AgeList – Ready for “steal”
- Only few of “PreWrite Agelst” were “wasteful writes”

Report: **ESAUSTR** User Storage Analysis Velocity Software Corporate ZMAP 5.1.2 04/16/21 Page 232

	<--------Virtual Server Storage (Pages)-------->											<Resident> Page	<-----**Page Rates / Second**----->						NoScan	
UserID /Class	Size	Alloc	Resi- dent	UFO Activ	**<-----IBR----->** TOT	<2gb	>2gb	**<AgeList>** <2gb	>2gb	<Unreferd> <2gb	>2gb	slots used	Made IBR	IBR Refd	AgeLst Refd	**<PreWrite>** IBR	Agelst	Diag Rlse	SET Rsrvd	Steal Weight
17:30:00	13.4M	8785K	3383K	3307K	6334	1145	5189	13K	57K	7193	26K	7853K	3.6	1.6	1.3	1.4	0.0	8.3	2.1	111
17:45:00	13.4M	8786K	3381K	3305K	6301	1158	5143	12K	58K	6251	23K	7852K	5.5	2.4	1.8	2.4	0.0	7.9	3.3	111
18:00:00	13.4M	8790K	3383K	3307K	6698	1312	5386	12K	57K	4387	17K	7854K	7.5	3.5	2.9	3.3	0.0	17.1	4.5	111
18:15:00	16.9M	8797K	3384K	3307K	7267	1428	5839	13K	57K	4691	19K	7857K	8.6	3.2	3.2	4.2	0.0	18.9	5.3	113
18:30:00	27.3M	10.8M	3349K	3274K	5988	1178	4809	12K	57K	3759	13K	**9147K**	**3559**	**1038**	**1321**	**2401**	**19.1**	**154**	**5984**	116
18:45:00	30.2M	14.6M	3293K	3215K	7317	1394	5923	12K	58K	4502	17K	13M	5188	1540	2131	3623	38.8	213	8500	116
19:00:00	30.2M	17.2M	3293K	3218K	5637	1198	4439	13K	57K	5445	18K	16M	6438	1891	2797	4213	53.6	277	10697	116
19:15:00	32.1M	17.5M	3297K	3221K	5878	1196	4681	13K	57K	4709	16K	17M	4182	1245	1854	2613	27.0	182	6246	115

Tuning User Storage

Tuning process:

- Evaluate requirements of virtual machine
- Evaluate value from business perspective

Options for tuning user storage:

- Use SET REServed to fence storage for a user
- If TCPIP is paged out, who is delayed?

If ZWRITE paged out, what happens?

- CP SET RESERVED ZWRITE 500
- CP LOCK USERID ZWRITE 0 1000 TO LOGICAL

What servers or users should have locked storage?

- Servers/Users that have time dependencies
- Servers with multi-user impact

Reserved Storage

Protect a user:

- CP LOCK USERID ZWRITE 0 1000 logical
- CP SET RESERVED ZWRITE 4500

```
Screen: ESAUSR2  Velocity Software - VSIVM4      ESAMON 5.121 05/15 17:55-17
1 of 3  User Resource Utilization                CLASS VELOCITY USER 8562 04

                  <---CPU time--> <--------Main Storage (pages)---------->
          UserID  <(seconds)> T:V <Resident>   Lock <-----WSS----->
Time      /Class   Total  Virt Rat Total Activ   -ed Total Actv  Avg Resrvd
-------- -------- ----- ----- --- ----- ----- ----- ----- ---- ---- ------
17:56:00 ZALERT    0.95  0.94 1.0   301   301     0   301  301  301      0
         ZVWS      0.51  0.50 1.0  1229  1229     1  1228 1228 1228      0
         ZWRITE    0.12  0.11 1.0  4102  4102  3576   506  506  506   4500
         ZTCP      0.07  0.06 1.3  2154  2154     1  2132 2132 2132      0
         ESAWEB    0.00  0.00 1.4    68    68     2    66   66   66      0
         VSIMAINT  0.00  0.00 2.1   200   200     0   200  200  200      0
         ZADMIN    0.00  0.00 2.0   379   379     0   379  379  379      0
         ZSERVE    0.00  0.00 1.1   154   154     0   154  154  154      0
         ZMON         0     0   0     4     0     0     4    0    0      0
```

Saved Segments

Monitor DCSS requirements, not “82”

Monitor “storage” domain 3 is early in monitor cycle

Why is “CMS” there twice?

- If you resave CMS, only on IPL will new one be used

Report: **ESADCSS** Velocity

		<-Users->		<-------Number of Pages fo				
	Spool		Non-		Non-	<--resident-->		
Name	ID	Shrd	Shrd	Saved	Data	<2GB	>2GB	HOST
03/13/23 16:01:00								
CMS	48	9	0	1298	0	132	957	0
CMS	1	10	0	1298	0	4	1078	0
MONDCSS	38	2	0	0	16K	0	**82**	81
ZALERT	22	1	0	0	256	0	1	0
ZMON	11	3	0	0	16K	6094	0	0
Totals:		118	0	7460	33K	9930	2842	81

Saved Segment: MONDCSS

ESAHDR shows final count of each monitor sample

Protect the monitor DCSS

- SET RESERVED DCSS MONDCSS 5000

```
Report: ESAHDR       z/VM Monitor Analysis                          Velo
-------------------------------------------------------------------------
Monitor Segment Analysis
Sample Configuration DCSS used:   1676 pages, 147456K -154159K  ( 91%)
Sample DCSS storage used:         4268 pages, 154800K -171869K  ( 67%)
Event Configuration DCSS used:       1 pages, 180224K -180225K  (  1%)
Event  DCSS storage used:         1680 pages, 180248K -186965K
Times Event storage wrapped:         1
```

User Summary Storage Measurement

Virtual Machine Storage requirements provided:

- For system
- For user class / workload
- For virtual machine

Page rates provided

Process:

- ESAXACT – review impacts
- ESAUSR2 / ESAUSP2 / ESAUSPG for VM requirements

Review:

- Virtual machine sizes (many are too large)
- VDISK (very very fast)
- Set reserved / locked
- Set Agelist 5%

Mapping Storage

Storage types:

- CP Fixed Storage (no tuning options)
- CP Non Pageable: Storage made non–pageable by CP (some tuning)
- The remaining pages are Dynamic Paging Area(DPA)

Dynamic Paging Area:

- Virtual Machines
- Shares storage (DCSS/NSS)
- System address spaces
- Virtual Disks
- MDC
- Available

Storage Map – CP Areas

System Storage – total storage assigned to LPAR

CP Fixed Storage (no tuning options)

- Nucleus
- Frame table (32 byte frame table entry per real page about 0.78%)

CP Non-Pageable: Storage made non–pageable by CP

- Free storage (control blocks, EREP)
- Prefix pages (2 per processor / IFL)
- SNTBKs (one per DCSS/NSS)
- SAVBKs (CP save areas, 32 per page)
- VMDBKs (2 pages per guest virtual processor)
- QDIO Buffers
- DIAG98 Buffers

The remaining pages are Dynamic Paging Area (DPA)

Storage Map - ESASTR1

Storage Map to show storage (14GB) utilizations

- User resident should be major use

Capture ratio shows accuracy

Overcommit means paging will happen

```
Report: ESASTR1      Main Storage Analysis                          Velocity Software Corporate   ZMAP 5.1.2 04/16/21   Pg   2
Monitor initialized: 04/15/21 at 00:00:00 on 8562 serial 040F78     First record analyzed: 04/15/21 00:00:00
-------------------------------------------------------------------------------------------------------------------------
         Users <----------------------------Pages-----------------------------------------------------------> Over
         Loggd System  Fixed Non-  Free Frame <Available> Systm  User  NSS/DCSS  <-AddSpace> VDISK <MDC> Diag Commit    Capt-
Time        On Storage Store Pgble Stor Table <2gb  >2gb  ExSpc Resdnt Resident  Systm User  Rsdnt Rsdnt  98  Ratio     Ratio
-------- ----- ------- ----- ----- ---- ----- ----- ----- ----- ------ --------  ----- ----- ----- ----- ---- -----     -----

04/15/21
17:00:00   111 3670016  2878 20879 1153 28672  3170  2501 52291  3387K    35061  75702     0  4729 15418  16K 3.653     0.988
17:15:00   111 3670016  2878 20882 1152 28672  3099  2421 52296  3384K    35078  75713     0  4441 18566  16K 3.653     0.988
17:30:00   111 3670016  2878 20883 1166 28672  3164  2669 52296  3383K    35077  75714     0  4307 19741  16K 3.653     0.988
17:45:00   111 3670016  2878 20872 1147 28672  3195  2389 52298  3381K    35074  75716     0  4270 21989  16K 3.653     0.988
18:00:00   111 3670016  2878 20889 1146 28672  3128  2851 52306  3383K    35079  75722     0  4103 19648  16K 3.653     0.988
18:15:00   113 3670016  2878 20876 1141 28672  3077  2508 52316  3384K    35099  75776     0  4028 19283  16K 4.609     0.988
18:30:00   116 3670016  2878 20880 1075 28672  3137  2544 52360  3349K    32071   122K     0  2118 12337  16K 7.354     0.988
18:45:00   116 3670016  2878 20808 1038 28672  3051  2234 52407  3293K    29914   196K     0     0    47  16K 8.227     0.988
19:00:00   116 3670016  2878 20765 1028 28672  3056  2245 52414  3293K    29082   196K     0     0   127  16K 8.227     0.988
19:15:00   115 3670016  2878 20797 1040 28672  3063  2232 52409  3297K    29522   192K     0    22    73  16K 8.754     0.988
19:30:00   116 3670016  2878 20809 1031 28672  3069  2235 52450  3293K    29065   196K     0     0     6  16K 9.363     0.988
```

Capture Ratio Storage Drill Downs

Capture ratio is accumulation of knowns / total storage

Drill downs for all columns:

- System execution space: ESASXS
- User Resident (by user): ESAUSPG, ESAUSR2, ESAUSP2
- NSS/DCSS Resident (shared storage by segment): ESADCSS
- System/User address Space (by address space): ESAASPC
- VDISK Resident (by user): ESAUSPG
- MDC: ESAMDC

Storage Map – What changed at 18:30?

- 3.67M pages – 1.5TB
- System Address space use increased – page tables
- VDISK Resident – went down, paged out
- MDC Resident – went down, freed
- Over Commit Ratio – went up, more virtual machines
- User resident went down, no room

Result of large virtual machines logging on

Report: ESASTR1 Main Storage Analysis Velocity Software Corporate ZMAP 5.1.2 04/16/21 Pg 2

Time	Users Loggd On	System Storage	Fixed Store	Non-Pgble	Free Stor	Frame Table	Pages <Available> <2gb	Pages <Available> >2gb	Systm ExSpc	User Resdnt	NSS/DCSS Resident	<-AddSpace> Systm	<-AddSpace> User	VDISK Rsdnt	<MDC> Rsdnt	Diag 98	Over Commit Ratio	Capt-Ratio
17:00:00	111	3670016	2878	20879	1153	28672	3170	2501	52291	3387K	35061	75702	0	4729	15418	16K	3.653	0.988
17:15:00	111	3670016	2878	20882	1152	28672	3099	2421	52296	3384K	35078	75713	0	4441	18566	16K	3.653	0.988
17:30:00	111	3670016	2878	20883	1166	28672	3164	2669	52296	3383K	35077	75714	0	4307	19741	16K	3.653	0.988
17:45:00	111	3670016	2878	20872	1147	28672	3195	2389	52298	3381K	35074	75716	0	4270	21989	16K	3.653	0.988
18:00:00	111	3670016	2878	20889	1146	28672	3128	2851	52306	3383K	35079	75722	0	4103	19648	16K	3.653	0.988
18:15:00	113	3670016	2878	20876	1141	28672	3077	2508	52316	3384K	35099	75776	0	4028	19283	16K	4.609	0.988
18:30:00	116	3670016	2878	20880	1075	28672	3137	2544	52360	3349K	32071	122K	0	2118	12337	16K	7.354	0.988
18:45:00	116	3670016	2878	20808	1038	28672	3051	2234	52407	3293K	29914	196K	0	0	47	16K	8.227	0.988
19:00:00	116	3670016	2878	20765	1028	28672	3056	2245	52414	3293K	29082	196K	0	0	127	16K	8.227	0.988
19:15:00	115	3670016	2878	20797	1040	28672	3063	2232	52409	3297K	29522	192K	0	22	73	16K	8.754	0.988

Shared Storage (DCSS) Requirements

“Pages resident” show how many pages in storage

32k pages in shared storage for monitoring:

- Linux servers
- 4 z/OS, 5 VSE, 10 CICS regions/partitions
- z/VM

Report: **ESADCSS** NSS/DCSS Analysis Vel
Monitor initialized: 04/15/21 at 00:00:00 on 8562 serial 040F78 Fir

		<-Users->		<---------Number of Pages for DCSS---------->								
	Spool		Non-		Non-	<--resident-->			<Locked>		<PagedOut>	
Name	ID	Shrd	Shrd	Saved	Data	<2GB	>2GB	HOST	<2G	>2GB	DASD	XSTOR
18:30:00												
CMS	40	74	0	1298	0	77	389	0	0	0	1298	0
CMSFILES	9	8	0	768	0	11	126	0	0	0	639	0
CMSPIPES	36	79	0	512	0	18	84	0	0	0	512	0
CMSVMLIB	6	79	0	256	0	6	46	0	0	0	256	0
EAGRTSEG	13	4	0	80	0	0	16	0	0	0	80	0
GCS	1	2	0	120	917	2	18	0	0	0	1037	0
INSTSEG	5	79	0	768	0	29	81	0	0	0	768	0
MONDCSS	11	3	0	0	16K	9	100	109	0	102	0	0
SCEE	23	11	0	256	0	0	15	0	0	0	256	0
SCEEX	39	11	0	2304	0	12	169	0	0	0	2304	0
TCPIP	24	4	0	0	256	2	3	0	0	0	255	0
ZMON	12	25	0	0	16K	15K	1797	7409	0	0	0	0
ZOSMON	16	2	0	0	4096	69	2037	2044	0	0	4096	0
ZVWS	29	25	0	0	768	1	74	0	0	0	164	0
Totals:		427	0	6362	52K	**16K**	**16K**	9562	0	102	12K	0

Pageable PGMBKs

PGMBK is page table for virtual storage

PGMBK storage per referenced 1MB segment:

- Two 4k page PGMBK per 1mb segment (8mb/gb)
- 2048 pages/gb (100mb virtual requires 800mb real)
- (1gb Linux server: 8mb PGMBKs)

Locates all user pages in

- ~~Expanded Storage (pre z/VM 6.3)~~
- DASD Paging (and IBR list)
- Main Storage

A pageable PGMBK is eligible for page-out when it maps no virtual pages into real storage

Maximizing Pageable Storage

Limit virtual machine sizes

- PGMBKs – cost 8mb (PTRM address space) per virtual GB
- PTRM address space is pageable

Limit the amount of main storage used by MDC:

- SET MDCACHE STORAGE **min**M maxM

CP Page Tables Requirements

The CP address spaces reported on Shared Address Space Analysis

- Resident page tables relative to active pages.
- 128 PTRM (4gb) address spaces defined in z/VM 6.3
- Only PTRM address spaces in use are displayed, there are more

```
Report: ESAASPC      Shared Address Space Analysis velocity Software Corporate
Monitor initialized: 04/15/21 at 00:00:00    first record analyzed: 04/15/21
-------------------------------------------------------------------------------
                                 <--Size---> <-----Address Space Pages----->
                                 <-(pages)-> <Resident> <Locked-> <PagedOut>
Owner    Space Name                Avg   Max <2GB >2GB  <2GB >2GB DASD XSTOR
-------- ----------------------- ----- ----- ---- ----- ---- ---- ---- -----
18:30:00
SYSTEM   ISFCDATASPACE            245K  524K    1    12    0    0   60     0
SYSTEM   PTRM0000               1049K 1049K  224 37861    0    0 9448     0
SYSTEM   PTRM0001               1049K 1049K 1434 50706    0    0 7365     0
SYSTEM   PTRM0002               1049K 1049K   46 14021    0    0 3529     0
SYSTEM   PTRM0003               1049K 1049K  123 17804    0    0 6004     0
SYSTEM   SYSTEM                  315K  524K   15    67    0    0    3     0
```

CP Page Tables Requirements

Report: **ESAASPC** Shared Address Space

Owner	Space Name	<--Size---> <-(pages)-> Avg	Max	<-----Address Space Pages-----> <Resident> <2GB	>2GB	<Locked-> <2GB	>2GB	<PagedOut> DASD	XSTOR
18:30:00									
SYSTEM	ISFCDATASPACE	245K	524K	1	12	0	0	60	0
SYSTEM	PTRM0000	1049K	1049K	224	37861	0	0	9448	0
SYSTEM	PTRM0001	1049K	1049K	1434	50706	0	0	7365	0
SYSTEM	PTRM0002	1049K	1049K	46	14021	0	0	3529	0
SYSTEM	PTRM0003	1049K	1049K	123	17804	0	0	6004	0
SYSTEM	SYSTEM	315K	524K	15	67	0	0	3	0
DSA0001	VDISK$DSA0001$$0202$04F7	2730	8192	1	22	0	0	0	0
DSA0001	VDISK$DSA0001$$0203$04F8	10748	32256	87	0	0	0	0	0
MONGO01	VDISK$MONGO01$$0202$0075	15050	32256	75	337	0	0	13K	0
ORACLE	VDISK$ORACLE$$$0203$0227	15050	32256	3	42	0	0	13K	0
RHOSBOOT	VDISK$RHOSBOOT$0202$04F1	3822	8192	2	29	0	0	0	0
RHOSBOOT	VDISK$RHOSBOOT$0203$04F2	15050	32256	18	104	0	0	0	0
RHOSCP1	VDISK$RHOSCP1$$0202$04F9	1092	8192	0	9	0	0	0	0
RHOSCP1	VDISK$RHOSCP1$$0203$04FA	4302	32256	33	2	0	0	0	0
RHOSCP2	VDISK$RHOSCP2$$0202$04FB	1092	8192	0	9	0	0	0	0
RHOSCP2	VDISK$RHOSCP2$$0203$04FC	4302	32256	6	29	0	0	0	0
RHOSCP3	VDISK$RHOSCP3$$0202$04FD	546	8192	0	5	0	0	0	0
RHOSCP3	VDISK$RHOSCP3$$0203$04FE	2151	32256	0	17	0	0	0	0
RHOSWK1	VDISK$RHOSWK1$$0202$04F3	1639	8192	0	13	0	0	0	0
RHOSWK1	VDISK$RHOSWK1$$0203$04F4	6452	32256	37	15	0	0	0	0
SLES12	VDISK$SLES12$$$0203$000E	59841	128K	71	1059	0	0	60K	0
S11S2ORA	VDISK$S11S2ORA$0202$0008	29980	64256	21	68	0	0	30K	0
System Totals:		**140M**	**140M**	**2200**	**122K**	**0**	**0**	**408K**	**0**
Virtual Disk_Subset		**1363K**	**1369K**	**356**	**1762**	**0**	**0**	**381K**	**0**

Virtual disks are system-owned address spaces

- Rarely consume much storage, paged out when inactive
- PTRM are not used unless needed

Minidisk cache defaults to “all of it”

- MUST BE CONTROLLED!!! Very common configuration error

Example is “very constrained”, why?

- MDC consumes almost 1m pages (4gb) out of total 2m pages….
- Set to 128m - SET MDC STORAGE 128M 128M

```
Report: ESASTR1      Main Storage Analysis                          zVM1 Prod.
-------------------------------------------------------------------------------------------------------
         Users <-----------------------------Pages-------------------------------------------------->
         Loggd System  Fixed Non-  Free Frame <Available> Systm  User  NSS/DCSS  <-AddSpace> VDISK <MDC> Diag
Time        On Storage Store Pgble Stor Table <2gb  >2gb  ExSpc Resdnt Resident  Systm User  Rsdnt Rsdnt  98
-------- ----- ------- ----- ----- ---- ----- ----- ----- ----- ------ --------  ----- ----- ----- ----- ----
01:05:12    34 2064368  2970 28013 3802 16128  3186   114  7909  1075K      783   2717 19156    24  905K 1913
01:20:12    34 2064368  2970 27954 3802 16128  2633   105  7926  1045K      569   2472 19054     5  938K 1913
01:35:12    34 2064368  2970 27721 3802 16128  3860   139  7916  1120K     1357   6683 19255   647  857K 1913
01:50:12    34 2064368  2970 27734 3802 16128  3145   111  7897  1178K     1714  20460 19571  4882  787K 1913
```

Minidisk Cache

Minidisk cache defaults to “all of it” or none of it…

Minidisk cache should be enabled for “velocity”!!!

- CMS makes good use of MDC (32m to 128m is good)
- zVPS will slow down if no MDC
- CP SET MDC STORAGE 128M 128M

```
Report: ESAMDC       Minidisk Cache Analysis                          Ve
Monitor initialized: 04/15/21 at 00:00:00 on 8562 serial 040F78       Fi
-------------------------------------------------------------------------
         <----Load---->     <IO per><Insertions> <-----Main Storage M
         <-Users-> Tran Hit <second> Usr Per Not <-Sizes (MB)--> </Se
Time     Actv In Q /sec Pct rds hits Max Min Ald Avg MIN MAX Obj Stls
-------- ---- ---- ---- --- --- ---- --- --- --- --- --- --- --- ----

18:00:00   74 41.7  7.5  96  32 30.8  2K 1.0   0  77   0 256 222  0.1
18:15:00   75 40.7  7.4  98  27 26.2  2K 1.7   0  75   0 256 244  0.1
18:30:00   76 43.9  6.4  91  27 24.6 913 2.6 1.3  48   0 256 112 25.6
18:45:00   80 57.2  5.1  72  21 15.5 150 4.2  10 0.2   0 256 1.5 20.7
19:00:00   79 57.1  4.6  75  21 16.0 150 4.0 5.3 0.5   0 256 5.8 27.5
19:15:00   80 54.7  5.1  76  23 17.5 150 4.5 7.1 0.3   0 256 1.4 15.7
19:30:00   80 61.7  3.4  68  20 13.3 150 4.2 5.3 0.0   0 256 1.3 25.4
```

CP Storage Management - Free Storage

Free storage (now in SXS) used for recording for:

EREP, Accounting, Symptom

Issue CP QUERY RECORDING

- Very common configuration error

To stop recording, free up storage:

- CP RECORDING ACCOUNT OFF PURGE
- Or disable it in SYSTEM CONFIG

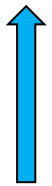
```
q recording
RECORDING     COUNT      LMT USERID   COMMUNICATION
EREP      ON  00000088   002 EREP     INACTIVE
ACCOUNT   ON  00044232   020 DISKACNT INACTIVE
SYMPTOM   ON  00000000   002 OPERSYMP ACTIVE
```

Free Storage Recording

To stop recording, free up storage:

- CP RECORDING ACCOUNT OFF PURGE
- Or disable it in SYSTEM CONFIG.

```
cp recording account off purge
HCPCRC8058I User BARTON has purged 00044234
    records from the *ACCOUNT queue.
Command complete
```



```
Screen: ESASTR1  Velocity Software
2 of 2  Main Storage Analysis
<---------------------Pages-------
         Systm  User  NSS/DCSS  <-AddSpace>
Time     ExSpc Resdnt Resident  Systm User
-------- ----- ------ --------  ----- -----
16:05:00  1059  28184     9210   3386     0
16:04:00  1060  24539     9215   3386     0
16:03:00  2279  27702     9207   3386     0
16:02:00  2274  25189     9209   3374     0
16:01:00  2259  23617     9209   3374     0
```

Free Storage analysis – zMON ESASTR1

```
Screen: ESASTR1  Velocity Software              ESAMON 4.240
        Main Storage Analysis
         <------------------Pages-----------------> Capt- <----------------------Pages---------------------->
         System  Fixed Non-  Free Frame <Available >   ure Systm User  NSS/DCSS  <-AddSpace> VDISK <MDC> Diag
Time     Storage Store Pgble Stor Table <2gb  >2gb   Ratio ExSpc Resdnt Resident  Systm User  Rsdnt Rsdnt  98
-------- ------- ----- ----- ---- ----- ----- ------ ----- ----- ------ --------  ----- ----- ----- ----- ----
16:05:00 1310720  2244  3143    4 10240  473K 694793 0.995 1059  28184     9210   3386     0     0 64966 1037
16:04:00 1310720  2244  3143    4 10240  473K 694848 0.995 1060  24539     9215   3386     0     0 64919 1037
16:03:00 1310720  2244  3146    4 10240  473K 693692 0.995 2279  27702     9207   3386     0     0 64905 1037
16:02:00 1310720  2244  3167    4 10240  473K 693716 0.995 2274  25189     9209   3374     0     0 65407 1037
16:01:00 1310720  2244  3166    4 10240  473K 693714 0.995 2259  23617     9209   3374     0     0 65407 1037
```

CP Storage Management - Trace Table

Trace table for Master processor and each other real CPU

Trace Table size: Master = Min(100 pages)

Trace table size = Master + (NCPU - 1) * .75 * Master

"CP SET TRACEFRAMES MASTER 100 ALTERNATE 75 PERCENT"

- Must be at least 3
- **Storage is "below the line" - What if 40 threads in LPAR? (12m)**
- Size displayed on ESASTRC, included in SXS

CP SET TRACEFRAMES MASTER 2000

```
Screen: ESASTR1  Velocity Software
1 of 2  Main Storage Analysis
<------------------Pages------------
         System  Fixed Non-  Free Frame <Avai
Time     Storage Store Pgble Stor Table <2gb
-------- ------- ----- ----- ---- ----- -----
13:56:00 1310720  2244  5088    4 10240  468K
13:55:00 1310720  2244  3188    4 10240  470K
13:54:00 1310720  2244  3197    4 10240  470K
```

Locked Storage > 2GB + < 2GB (see ESAUSPG)

- Originally QDIO only below 2gb line, now > 2gb
- 8mb QDIO Buffers locked per server

```
Report: ESAUSR2       User Resource Utilization
-----------------------------------------------
         <---CPU time--> <Main Storage (pages)>
UserID   <(seconds)> T:V <Resident> Lock
/Class    Total  Virt Rat Totl Activ  -ed Resrvd
-------- ----- ----- --- ---- ----- ---- ------
15:03:00 31.62 30.80 1.0  50M   50M  12K   5000
 ***Top User Analysis***
S1C7NA2Z 17.42 17.38 1.0 4.8M 4784K 2156      0
S1C7NA1Z  5.28  5.22 1.0 8.4M 8378K 1666      0
S1SSSA1Z  1.70  1.25 1.4 1.8M 1761K 53.0      0
S1BSAA1Z  1.33  1.31 1.0 2.2M 2199K 2086      0
S1SLTA1Z  1.19  1.17 1.0 3.8M 3842K  588      0
D1SAPA1Z  1.19  1.18 1.0  15M   15M  407      0
S1BSAA2Z  0.97  0.95 1.0 2.1M 2104K 2445      0
ZWRITE    0.06  0.06 1.0 1896  1896  1.0    5000
ZTCP      0.06  0.05 1.1 1430  1430  1.0       0
```

Storage Overcommit

What is the problem to solve? (cost control vs performance)

- Project storage requirements to manage paging delay
- Storage overcommit best “storage utilization” metric

Define storage overcommit

- Size of virtual machines logged on / Size of real storage
- (SUM VMDSIZE / MTRMEM.RSAGSTOR)

Ranges of overcommit?

- .9 for no paging, online/real time production
- 2-3 for development
- Arbitrarily create extra large servers, overcommit goes up
- Tune servers, overcommit goes down
- It’s only purpose is to gauge paging requirements

High Level, UCD

- Standard Linux system storage at a high level - ESAUCD2

Linux system storage

- Linux system storage details - ESALNXR

Linux process storage

- By process

Preview, Linux Storage

- Storage overview (ESAUCD2)
- Storage Details (ESALNXR)
- Process Storage (ESALNXP)

```
Report: ESAUCD2      LINUX UCD Memory Analysis Report                Velocity Sof
-------------------------------------------------------------------------------
Node/    <-------------------------Storage Sizes (in MegaBytes)----------------
Time/    <--Real Storage--> <-----SWAP Storage----> Total <-------Storage in Us
Date     Total  Avail Used  Total Avail Used  MIN   Avail CMM    Buffer Cache O
-------- ------ ----- ----- ----- ----- ----- ----- ----- ------ ------ ----- -
18:30:00
*** Nodes *******
lxsugar   999.4   7.6 991.8 154.9 151.3   3.6  15.6 158.9      0   85.7 648.1 2
mail     8112.8  2318  5795     0     0     0  15.6  2318      0  639.8 907.9
mongo01  3849.8 983.3  2866 371.9 309.6  62.3  15.6  1293      0  150.6  1130
opensuse  15846 160.1 15686  8192  8192   0.3  15.6  8352      0 1524.5  8392
REDHAT6X  996.8  13.8 983.0 495.8 380.4 115.5  15.6 394.2      0  114.7 724.1 1
redhat7   994.0 411.5 582.4  1124  1124     0  15.6  1535      0    1.1 472.6 1
rhel64v   996.1  66.3 929.8  2047  2034  12.5  15.6  2101      0  103.3  39.6 7
rhel7v   2002.3 101.2  1901  2064 766.0  1298  15.6 867.2      0      0 253.0
sles11v3  868.8  88.0 780.8  2046  1406 639.7  15.6  1494      0    3.3  27.7 7
sles11x3  493.2 132.8 360.4 867.9 867.9     0  15.6  1001      0  141.6 149.5
```

Preview - Linux Storage details

```
Report: ESALNXR      LINUX RAM/Storage Analysis Report              Velocity Sof
Monitor initialized: 04/15/21 at 00:00:00 on 8562 serial 040F78     First record
-------------------------------------------------------------------------------
Node/    <--------Memory in megabytes-------------> <-Kernel(MB)-> <-Buffers(MB
                  <---Cache----><---Anonymous---> Stack<-Slab-->
Time     Total Free Size Actv Swap Total Actv Inact Size Size SRec Size Dirty B
-------- ----- ---- ---- ---- ---- ----- ---- ----- ---- ---- ---- ---- ----- -
18:30:00
mongo01   3850  983 1130  939 26.9  1464 1333 201.3  3.5 57.3 46.3  151   0.7
opensuse 15846  160 8392 4346  0.1 915.4  426 512.0  6.2  554  477 1525   0.0
REDHAT6X 930.4 13.0  676  308  2.5  41.8 62.0 154.7  2.7 51.5 41.0  107   0.0
redhat7  994.0  412  473  328    0  40.8 40.9  56.0  2.6 46.8 26.9  1.1     0
rhel64v  996.1 66.2 39.6 74.6  1.2  14.0  1.1  13.9  1.8  101 42.9  103   0.0
rhel7v    2002  101  253  105 10.0  1437 1142 407.7  4.0  112 67.7    0   0.0
sles11v3 868.8 88.0 27.7 17.4 51.6 106.0 44.6  69.6  2.6 35.6  8.5  3.3   0.0
sles11x4 492.8  102  235  160    0  26.8 26.8   0.7  1.4 31.2 23.2 78.1   0.0
sles12    3374  124 2259 1557  2.7 534.0  483 459.6 30.8  153 51.8  110   0.1
sles12v  995.6  101  440  206  8.1 339.2  162 230.1  2.0 73.9 51.2  0.0   0.0
sles12x3 820.9  182  334  377    0  38.5 38.7  42.2  2.5 88.9 70.5  154   0.0
```

Preview - Linux Process Storage details

```
Report: ESALNXP      LINUX HOs Statistics Report          Velocity Software Co
Monitor initialized: 04/15/21:00 on 8562 serial 040F78    First record analyze
-------------------------------------------------------------------------------
node/     <-Process Ident-> N<------CPU Percents----> <---------------Storage
 Name      ID    PPID   GRP  V Tot  sys user syst usrt  Size RSS Peak Swap Data
--------- ----- ----- ----- ----- ---- ---- ---- ---- ---- ---- ---- ---- ----
18:30:00
mongo01       0     0     0  14.8 1.18 13.2 0.03 0.31 7248 1544 113K  727  78K
 mongod   10889     1 10887  5.75 0.60 5.15    0    0 2653 1307  40K  429  37K
 java     51013  8515  8515  4.94 0.31 4.62    0    0 1665  155  16K    0  14K
 java     51596  8515  8515  3.61 0.20 3.41    0    0 1743  186 8985    0 8053
opensuse      0     0     0  10.0 8.75 1.26 0.00 0.01  33K 5900 537K    0  38K
 gsd-colo  1909  1791  1776  1.13 0.00 1.13    0    0  706   84  11K    0 1773
 VBoxHead 24298 24280 24298  8.61 8.61    0    0    0 5824 4237  87K    0 2089
REDHAT6X      0     0     0  0.72 0.34 0.27 0.07 0.05  16K 1205 227K  641  14K
rhel7v        0     0     0  2.46 0.41 1.69 0.25 0.11  43K 1643 676K  20K 252K
 java      2028     1  1321  1.22 0.04 1.18    0    0 3848  865  58K 2054  55K
sles11v3      0     0     0  0.65 0.19 0.46    0    0 6526  117 105K 9009  27K
sles12        0     0     0  4.60 0.72 3.84 0.03 0.02  76K 5518 1.0M 2918 178K
 ora_mmon  2596     1  2596  3.61 0.32 3.29    0    0  896  403  11K 16.3 1155
sles12v       0     0     0  0.52 0.16 0.32 0.01 0.03  15K  379 239K  10K 144K
```

Paging subsystem, high rates, high queue, SSD

```
Report: ESAPSDV      Page And Spool Device Activity                Velo
Monitor initialized: 04/15/21 at 00:00:00 on 8562 serial 040F78    Firs
-------------------------------------------------------------------------
            <----Paging/Spooling--------->       </Sec><Device->
 Dev        <------Slots-------> <per sec>        SSCH Serv Resp %Alloc
 No. Serial Avail Used %Use  Max Read Writ Queue +RSCH Time Time Select
---- ------ ----- ---- ---- ---- ---- ---- ----- ----- ---- ---- ------
18:30:00
Page Devices
2270 VM4P1A 1803K 806K   45   1M 2329 1559   9.1 242.8  0.0  1.6  100.0
2181 VM4P11 1803K 993K   55   1M 2788 1557  28.5 238.5  0.1 13.6  100.0
2381 VM4P12 1803K 993K   55   1M 2816 1555   4.3 239.4  0.0  0.2  100.0
2182 VM4P13 1803K 997K   55   1M 2829 1556  11.7 247.5  0.0  1.4  100.0
2382 VM4P14 1803K 993K   55   1M 2787 1556  13.1 250.5  0.0  1.9  100.0
2183 VM4P15 1803K 994K   55   1M 2830 1555   2.1 240.8  0.0  0.0  100.0
2383 VM4P16 1803K 995K   55   1M 2833 1555  17.3 241.9  0.1  6.6  100.0
2184 VM4P17 1803K 990K   55   1M 2749 1556  12.3 235.6  0.0  0.4  100.0
2384 VM4P18 1803K 992K   55   1M 2815 1556  33.9 236.0  0.0  2.7  100.0
207F VM4P19 1803K 809K   45   1M 2361 1558   2.4 242.6  0.0  0.0  100.0
            ----- ---- ---- ---- ---- ---- ----- ----- ---- ---- ------
Total Page    18M  10M   53  13M  27K  16K

Spool Devices
2180 VM4S11 1803K 414K   23 439K 42.5 31.2     0  96.3  0.1  0.1  100.0
2380 VM4S12 1803K 286K   16 327K  103 82.2     0 131.2  0.1  0.1  100.0
            ----- ---- ---- ---- ---- ---- ----- ----- ---- ---- ------
Total Spl   3606K 701K   19 766K  145  113
```

Storage Summary

Full storage map available (ESASTR1)

- System
- User
- Address space / VDISK
- MDC

Manage storage to meet requirements

- Trace table reduce
- Accounting off

Tune users as able

- Reduce sizes saves control blocks, real storage
- Reserve storage for critical functions