z/VM 6.3: Changes in Memory Management

Session 14686

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Agenda

- Objectives and strategies of the z/VM Large Memory enhancement
- Key features of the z/VM Large Memory enhancement
  - Algorithmic concepts: new, changed, or obsolete
  - Basic flows and data structures
  - Knobs you can twist or set
- Planning for z/VM Large Memory
  - Paging DASD calculations
  - Reminders about best practices with respect to paging I/O
- Workloads
- CP Monitor and z/VM Performance Toolkit
- Summary

Objectives and Strategies

- Objectives:
  - Support 1024 GB aka 1 TB of central memory in a partition
  - Support large guests in such a context
  - Retain ability to overcommit memory

- Strategies:
  - Repair or replace memory management algorithms that
    - do not scale well
    - are grossly unfair

- Specifically:
  - ***Page reorder*** is a real problem area. Get rid of it.
  - ***Demand scan*** has scaling problems and frame ordering problems. Repair them.
    - Introduce a new ***global aging list*** concept to add accuracy to frame reclaim decisions.
    - Improve ***fairness*** of frame steal when memory is constrained.
  - Improve effectiveness of keeping storage specified by **SET RESERVED** in memory.
  - Extend **SET RESERVED** to **DCSS**es such as MONDCSS.

New Algorithms and Behaviors

New Approach: Highlights

- Objective: keep the ***available lists*** populated just right
- New visit heuristic tries to improve occupancy fairness in the face of storage constraint
- In-use frames are tracked by a new hierarchical data structure:
  - Valid, often-touched frames are at the top
  - Demand scan pushes frames downward as they seem to increase in reclaim appeal
  - Best reclaim candidates are at the bottom
- DASD use for paging is changed to be more friendly to reclaim and to storage subsystems
  - Pages valid on DASD are not rewritten
  - Pages are rewritten to the same slots
  - Channel program can do fully discontiguous reads or writes
  - Pages can be pre-written to DASD

New Approach: Management of The Available Lists

Old way

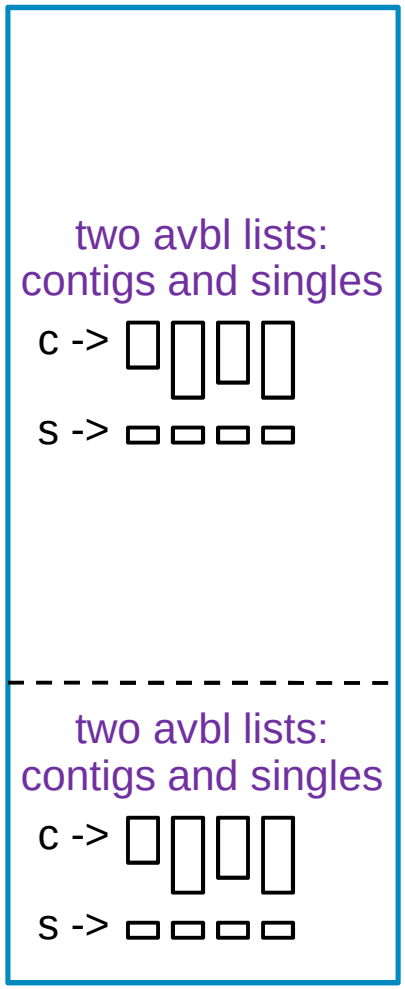
Each **list** had a low threshold and a high threshold

After every free storage request call, demand scan was kicked off if a **list** fell below its low threshold

The <2G lists were repopulated by demand scan

2 GB

<2G Use Policy:
Pre-6.2: *used <2G first*
In 6.2: *used <2G proportionally*
In 6.3: *uses <2G last*



New way

Each **kind of free storage request call** has a low and a high threshold:

- TYPE=ANY contigs
- TYPE=ANY singles
- TYPE=BELOW contigs
- TYPE=BELOW singles

Contiguous lists are protected from being completely raided by singles requests

After every request, the low threshold for **every type of request** is evaluated

If a TYPE=ANY low threshold is breached, demand scan is kicked off

If the <2G lists are empty, a frame table scan is kicked off

The Old Demand Scan Visit Policy

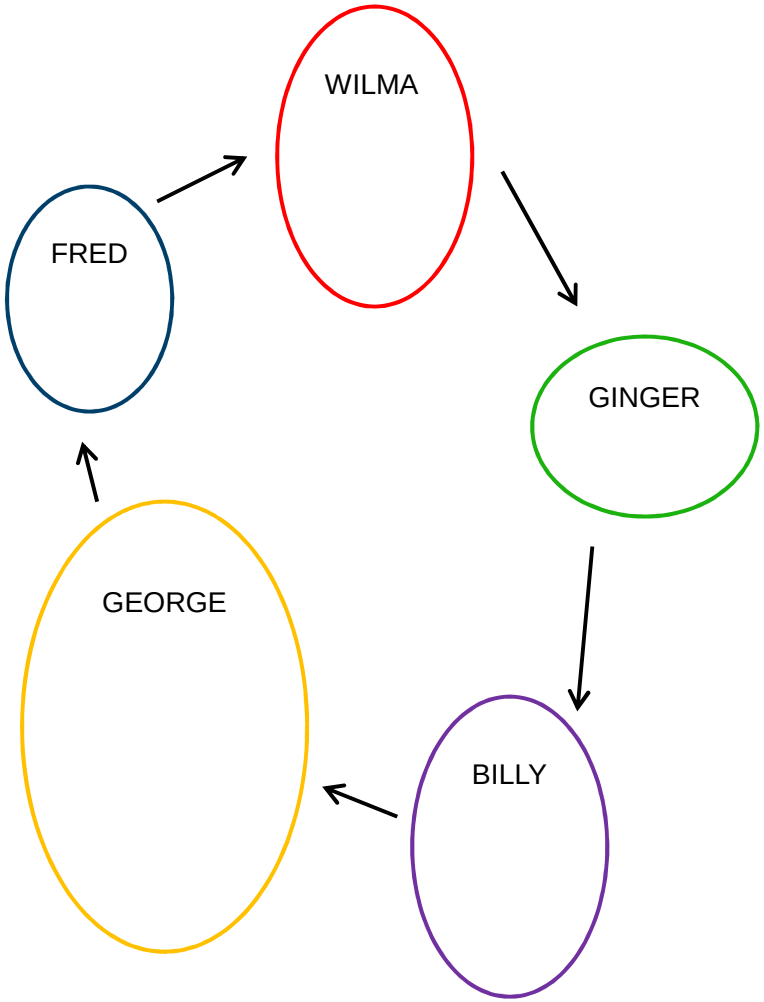
- Three-pass model:
  - **Pass 1:** tried to be friendly to dispatched users
    - Unreferenced shared-address-space pages
    - Long-term-dormant guests
    - Eligible-list guests
    - Dispatch-list guests' unreferenced pages down to Working Set Size
  - **Pass 2:** a little more aggressive… like pass 1 except:
    - Avoided shared address spaces
    - Would take from dispatch-list guests down to their SET RESERVED
  - **Pass 3:** emergency scan
    - Anything we can find

The Old Demand Scan Problems

- We found a number of problems over time, to various degrees, such as:
  - Pass 1 tended to be too soft.
  - Scheduler lists tended not to portray “active” in a way usable by storage management.
  - Stole a lot from the first few guests visited.
  - **SET RESERVED** was not being observed.

- It used the System z page reference bit R to track page changes
  - Required lots of RRBE instructions to keep track of recent reference habits
    - RRBE can be an expensive instruction
    - (Large resident frame list) + (long RRBE instruction) = problems in Reorder

New Approach: The New Demand Scan Visit Policy

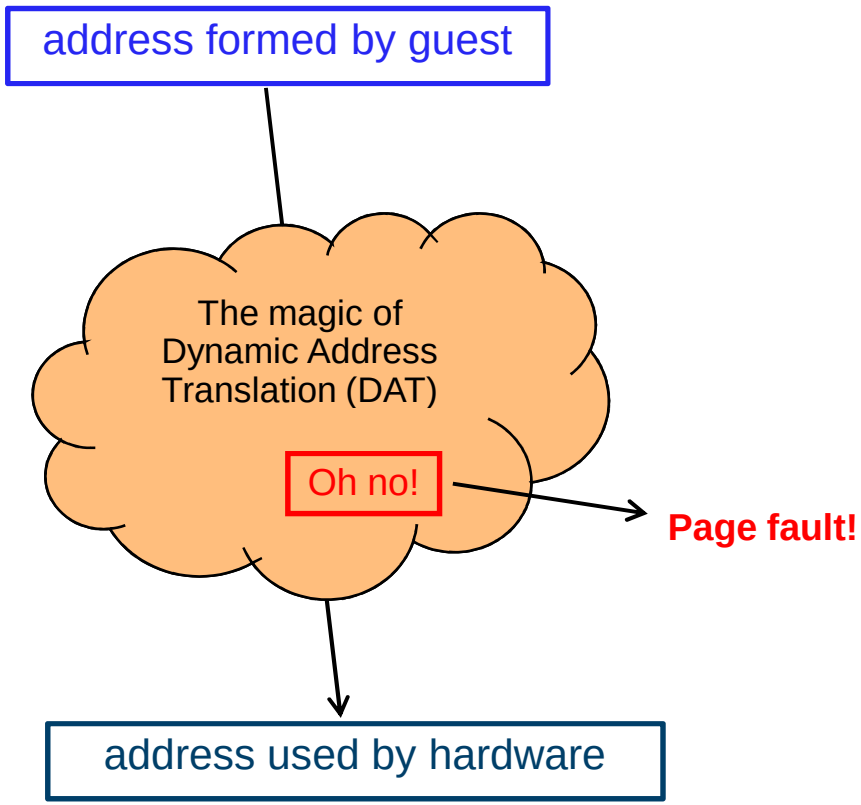


- **Used to:**
  - Visit according to scheduler lists
  - Take heavily at each visited guest
  - Start over at list tops every pass
  - Take from private VDISKs nearly last
  - A “take” was truly a ***reclaim*** of a frame
- **Now:**
  - Cyclically visits the logged-on guests
  - Keeps a visit cursor so it can resume
  - Takes a little and then moves to next
  - Takes from private VDISKs much earlier
  - A “take” is now just a push of in-use frames down toward ***eventual reclaim***
- **Effects**
  - Better equalizing in the face of storage constraint
  - Better equalizing on the notion of “hot” vs. “cold” pages

New Approach: Other New Things About Demand Scan

- Gives up control periodically
  - Lets other things happen
  - Avoids long-running “blackouts”
- Tries harder to be “fair” in the face of constraint.
- Aspects of “fairness”:
  - Use a guest’s size and estimation of its page touch rate to decide how much to take
  - Take from large guests who touch their pages less often before taking from small guests who touch their pages a lot
  - Treat identical guests identically
  - Don’t take from a guest’s working set if another guest is not stripped to its working set
  - During startup (when page touch rate data is available) take an amount of pages proportional to each guest’s size

New Approach: Trial Invalidation



- Page table entry (PTE) contains an "invalid" bit
- What if we:
  - Keep the PTE intact but set the "invalid" bit
  - Leave the frame contents intact
  - Wait for the guest to touch the page
- A touch will cause a page fault, but…
- On a fault, there is nothing really to do except:
  - Clear the "invalid" bit
  - Move the frame to the front of the frame list to show that it was recently referenced
- We call this **trial invalidation**.

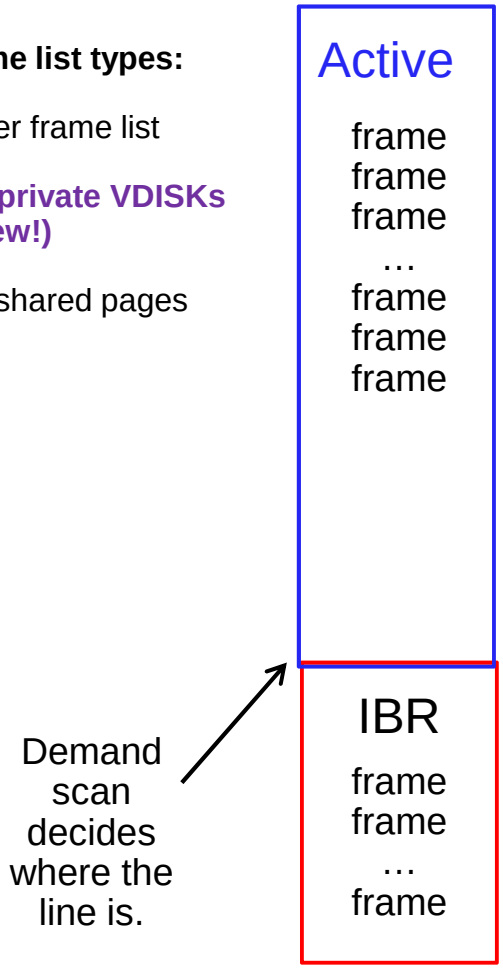
New Approach: Two-Section Frame-Owned Lists

Frame list types:

A user frame list

The private VDISKs (new!)

The shared pages



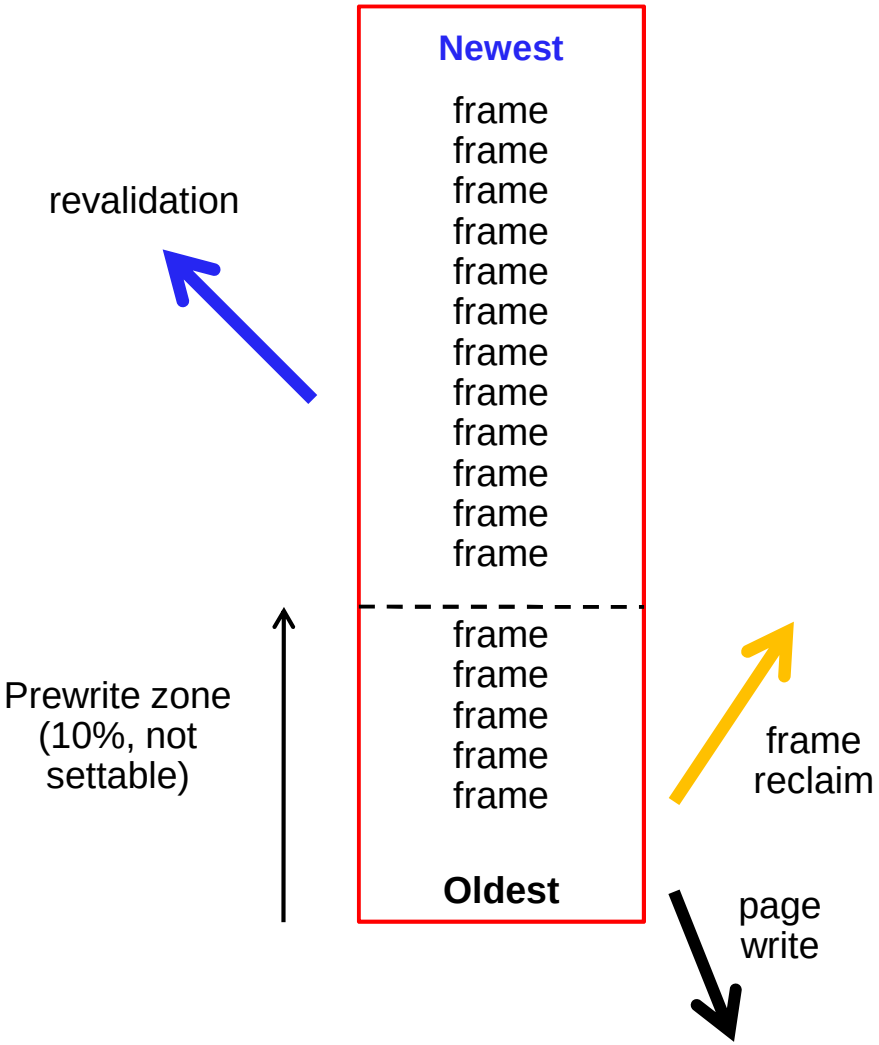
Active: frames that are in use
- Roughly in order by when they became valid.

No longer is a frame list ever searched, sorted, or reordered.

IBR: invalid but resident
- Marked invalid in page table entry
- If ever referenced, fault resolution moves to top of active
- This gives us a way to detect lack of reference

- "We try to keep [it] rather small."
- Influenced by revalidation rate.

New Approach: Global Aging List



- Size of global aging list can be specified…
  … but is best left to the system to manage

- All of the pages here are **IBR**

- Demand scan fills it from the top

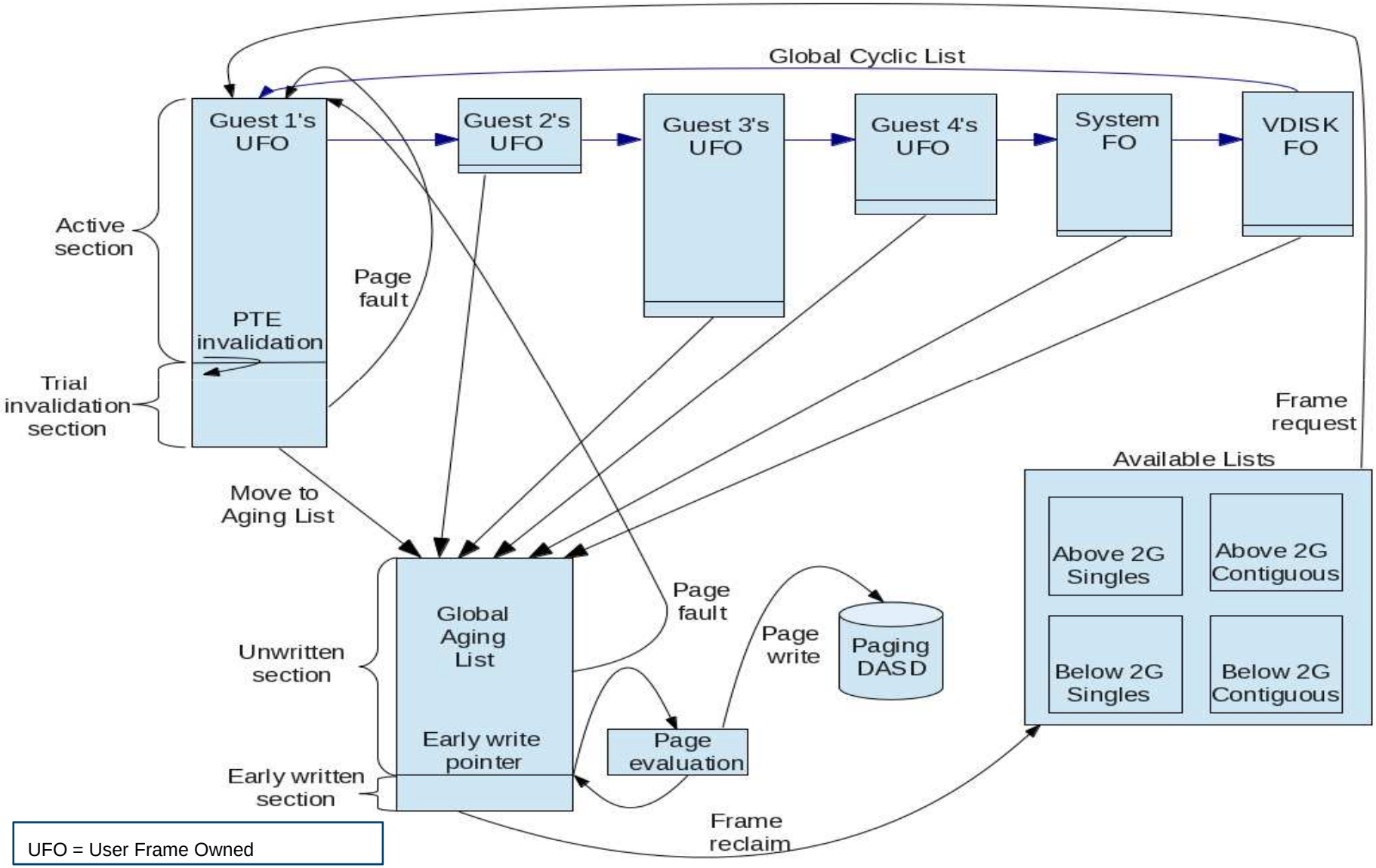
- Revalidated pages return to their owned lists

- We pre-write changed pages up from the bottom of the list.

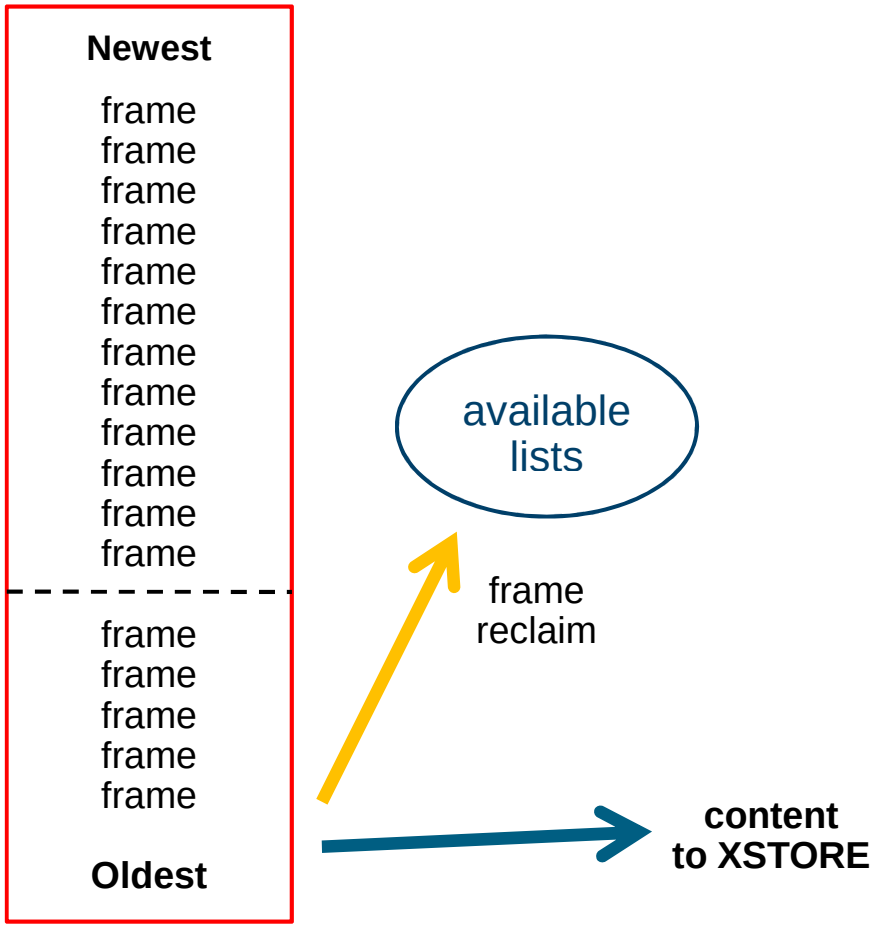
- The global aging list accomplishes the age-filtering process that XSTORE used to accomplish.

- We no longer suggest XSTORE for paging, but we will use it if it's there.

Memory Management Algorithm Visualization

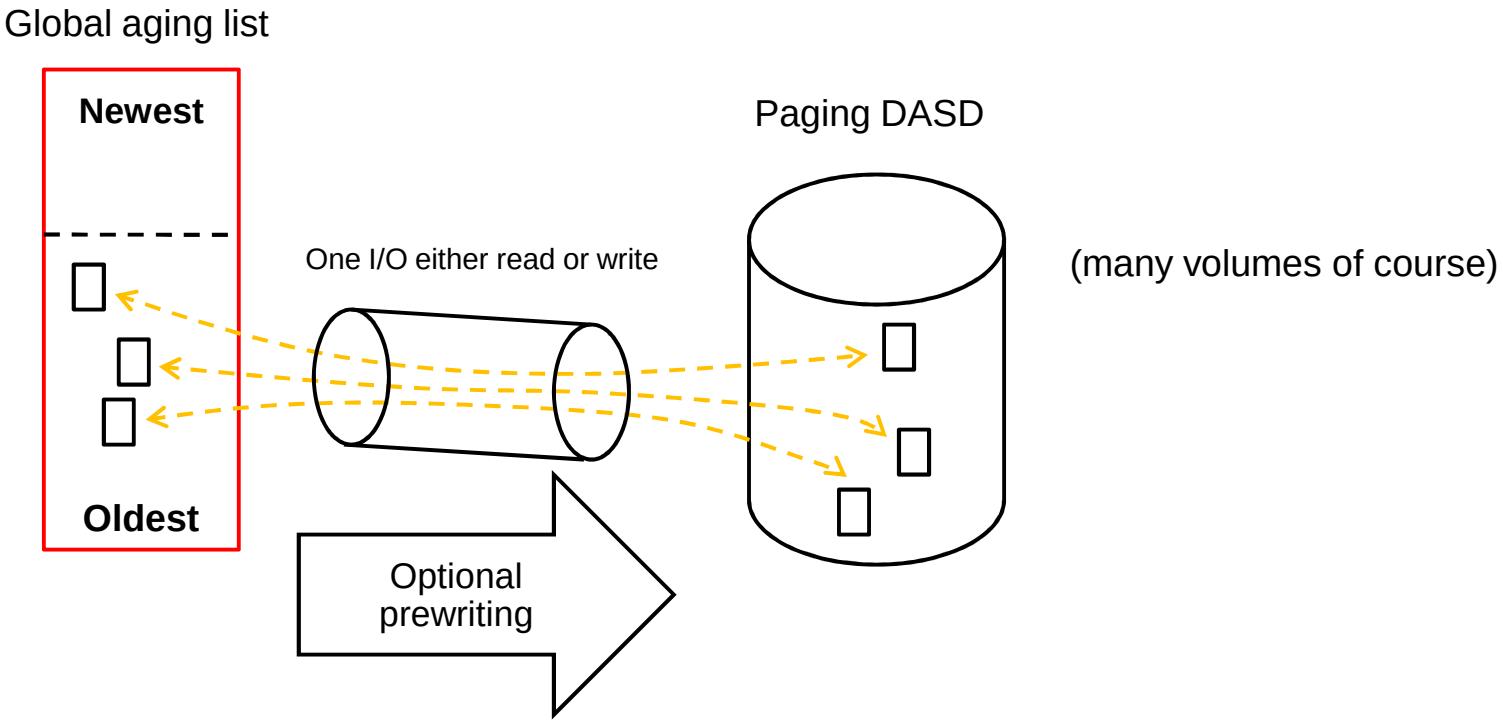


New Approach: What About XSTORE?



- We will use XSTORE if it is there.
- XSTORE is now the *second* line of defense.
- *When frame is reclaimed*, if XSTORE is present, we put a copy of the page there.
  - Even if the frame has already been prewritten
- On fault, if content is still in XSTORE, it comes back from there.
- If you decide to keep XSTORE, do NOT put MDC in XSTORE unless heavy CMS workload.

New Approach: How We Now Use Paging DASD



Highlights of new DASD techniques:

- A page almost always goes back to its same DASD slot.
  - *Exceptions: clogged or DRAINed volume*
- A page not changed since last read from DASD is almost never rewritten.
  - *Exceptions: DRAIN*
- The paging channel program can handle discontiguity on both ends, whether read or write.

New Approach: Large Real Implies Large Virtual, So…

- z/VM holds its DAT management structures in CP-owned pageable address spaces
- These *Page Table Resource Manager* address spaces are named PTRM0000, PTRM0001, …
- You will see them in the z/VM Performance Toolkit FCX134 DSPACESH report
- The number and size of these address spaces control how much logged-on guest real (aka virtual memory) the system can support

- In z/VM 6.2:
  - There were **16** of them: …, PTRM000F
  - Created as needed
  - With 16 of these, can address **8 TB** of virtual
- In z/VM 6.3:
  - There are now **128** of them: …, PTRM007F
  - All created at system initialization
  - With 128 of these, can address **64 TB** of virtual

New Behavior: CP SET RESERVED command

- We now do much better at honoring the setting
  - Revisit your uses to see whether you were trying to compensate

- Pages can be now be reserved for **NSS** and **DCSS** as well as virtual machines
  - Set ***after*** **CP SAVESYS** or **SAVESEG** of NSS or DCSS
  - Segment ***does not need to be loaded*** in order to **SET RESERVE** for it
  - A new instance of an NSS or DCSS ***does not*** inherit a pending-purge instance's RESERVED setting
  - Recommended for **MONDCSS**

- You can set a system-wide maximum (**SYSMAX**) on the number of reserved pages
- RESERVED settings ***do not*** survive IPL
  - Consider CP command in the CP directory (not for NSS or DCSS though)

Removed Behavior: Reorder

- We just don't do this anymore.
  - No longer a trade-off with larger virtual machines
- Commands remain for compatibility but have no impact
  - **CP SET REORDER** command gives RC=6005, "not supported".
  - **CP QUERY REORDER** command says it's OFF.
- You will no longer see reorder information in Monitor.
- Be aware of reorder settings when using LGR between z/VM 6.2 and z/VM 6.3

Changed Behavior: Eligible List

- One of the factors to the creation of an **eligible list** is the concept of “loading users”
  - Governed by **SET SRM LDUBUF**
  - A virtual machine is characterized as a “loading user” if its count of page faults in a dispatch slice exceeds a threshold
  - **SET SRM LDUBUF** attempts to keep the system from over-committing paging devices to the point of thrashing

- Changes in z/VM 6.3 paging algorithms can affect the number of virtual machines that are marked as “loading” users and therefore cause **eligible lists** to be formed where they had not formed prior to z/VM 6.3
  - Definition of page fault slightly different
  - Rate at which system can page fault has increased

- Recommend monitoring for eligible lists and adjusting the following as appropriate
  - **SET QUICKDSP**
  - **SET SRM LDUBUF**

- IBM is investigating improvements to avoid the unnecessary eligible list formation.

New or Changed Commands

Commands: Knobs You Can Twist

Concept	Knob	Comments
Size of the global aging list Whether early writes are allowed	Command: CP SET AGELIST … Config file: STORAGE AGELIST … Lookup: CP QUERY AGELIST	Sets the size of the global aging list, in terms of: - A fixed amount (e.g., GB) - A percent of DPA (preferred) The default is 2% of DPA. Seems OK. Sets whether early writes are allowed. (If storage-rich, say NO.)
Amount of storage reserved for a user or for a DCSS	Command: CP SET RESERVED … Config file: STORAGE RESERVED … Lookup: CP QUERY RESERVED …	You can set RESERVED for: - A user - An NSS or DCSS You can also set a SYSMAX on total RESERVED storage. Config file can only set SYSMAX.

Commands: Other Interesting “Queries”

Query or Lookup	Comments
CP INDICATE LOAD	The STEAL-nnn% field no longer appears in the output.
CP INDICATE NSS	Includes a new “instantiated” count. Number of pages that exist. Sum of locus counts might add to more than “instantiated”.
CP INDICATE USER	Includes a new “instantiated” count. Sum of locus counts might add to more than “instantiated”.
CP INDICATE SPACES	Includes a new “instantiated” count.

You Must Make a Plan

Planning for Large Memory

- **Normal best practices for migrating from an earlier release still apply.**
- **Change your paging XSTORE into central**
  - XSTORE provided an aging function. It helped catch reclaim selection "mistakes".
  - The new ***IBR*** concept and ***global aging list*** provide the same function but do so more efficiently in central.
- **Plan enough DASD paging space**
  - The system now prewrites pages to DASD.
  - See space calculation on a later slide
- **Plan a robust paging DASD configuration**
  - Use plenty of paging volumes
  - Make the volumes all the same size
  - Put only paging space on the volumes you use for paging
  - Spread the paging volumes through your logical control units
  - Avoid logical control units that you know are hot on application I/O
  - Use plenty of chpids
  - Do not use ESCON chpids
  - Do not mix ECKD paging and SCSI paging
  - Leave reserved slots in the CP-owned list

Planning for Large Memory

- Look at your **CP SET RESERVED** settings to make sure they're right.
  - Revisit scenarios where you looked at this capability and it wasn't effective

- Add **CP SET RESERVED** settings for DCSSes or NSSes if you like
  - MONDCSS is a good one to consider

- If you increase central, make sure you also increase dump space
  - More guidance available on www.vm.ibm.com/techinfo/
  - Download updated *"Allocating Space for CP Hard Abend Dumps"*

Planning DASD Paging Space

- Calculate sum of:
  - Logged-on virtual machines' primary address spaces, plus…
  - Any data spaces they create, plus…
  - Any VDISKs they use, plus…
  - Total number of shared NSS or DCSS pages, … and then …
  - Multiply this sum by 1.01 to allow for PGMBKs and friends

- Add to that sum:
  - Total number of CP directory pages (reported by DIRECTXA), plus…
  - Min (10% of central, 4 GB) to allow for system-owned virtual pages

- Then multiply by some safety factor (1.25?) to allow for growth or uncertainty

- Remember that your system will take a PGT004 if you run out of paging space

- Consider using something that alerts on page space, such as Operations Manager for z/VM

Planning to Learn About Your System's Performance

- While you are still on the earlier release, collect measurement data:
  - Know what your key success metrics are and what their success thresholds are
  - Transaction rates – *only you* know where these are on your workloads
  - MONWRITE files – some tips:
    - When: Daily peaks? Month-end processing? Quarter-end processing?

- Then go ahead and try z/VM 6.3

- When you start running on z/VM 6.3, collect the very same measurement data

- Compare z/VM 6.3 back to z/VM 6.2 to see what the effect is on your workload

Planning to Keep Your System Maintained

- Additional service has shipped, current install media includes second RSU (6302)

- Keep listening:
  - www.vm.ibm.com
  - The IBMVM listserver

- See also the PSP bucket for z/VM 6.3

Comments on Workloads

z/VM Large Memory: Amenable Workloads

- **Best benefit:** workloads highly affected by reorder or old demand scan
  - Large guests affected by reorder delays
  - Long demand scans looking for <2G frames

- **Less benefit:** workloads that were doing fine before
  - Storage-rich workloads
  - Running fine paging to only XSTORE
  - No problems with long demand scans
  - Small guests not affected by reorder

- Let's look at some examples

The “Sweet Spot” Workload

Our synthetic workload called *Sweet Spot* imitates behaviors we have seen in customer-supplied MONWRITE data.

	z/VM 6.2	z/VM 6.3	Delta	Pct. Delta
Cstore	256	384	128	
Xstore	128	**0**	-128	
External Throughput (ETR)	0.0746	0.0968	0.0222	29.8%
Internal Throughput (ITR)	77.77	105.60	27.83	35.8%
System Util/Proc	31.4	4.7	-26.7	-85.0%
T/V Ratio	1.51	1.08	-0.43	-28.5

By getting rid of both reorders and spin lock contention, we achieved huge drops in %CPU and T/V.

The “Sweet Spot” Workload

- Closer look at how the fairness and workloads may result in different results.
- Sweet Spot workload has four groups of virtual machines. Some benefit more than others.

	z/VM 6.2	z/VM 6.3	Delta	Pct. Delta
System External Throughput	0.0746	0.0968	0.0222	29.8%
User Group 1 ETR	0.0065	0.0128	0.0063	96.9%
User Group 2 ETR	0.0138	0.0236	0.0098	71.0%
User Group 3 ETR	0.0268	0.0264	-0.0004	-1.5%
User Group 4 ETR	0.0275	0.0341	0.0066	24.0%

Workload: The Apache Paging Workload

Our Linux-based workload called *Apache Paging* is built to page heavily to DASD almost no matter how much central or XSTORE we give it.

	z/VM 6.2	z/VM 6.3
Cstore (GB)	256	384
Xstore (GB)	128	0
External Throughput (ETR)	1.000	1.024
Internal Throughput (ITR)	1.000	1.017
Xstore paging / second	82489	0
DASD paging / second	33574	31376

This is an example of a workload where the limit comes from something large memory will not fix.

Large Memory Scaling Measurements

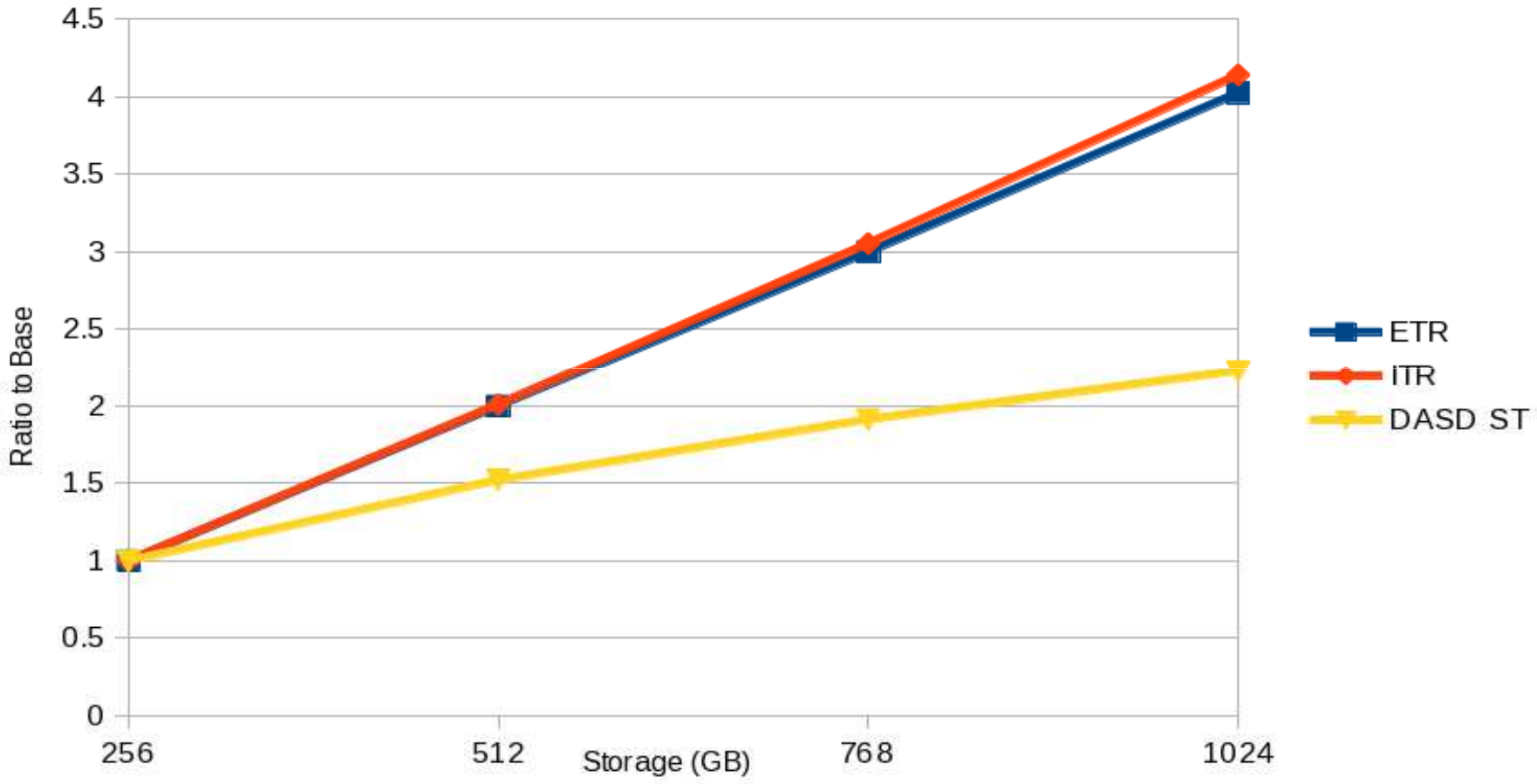
1. **VIRSTOR** – Test case system started with CMS boot strap with controls over memory reference patterns and processor usage.
   – Create workload similar to resource usage from customer Monwrite data

2. **Linux Apache Static Web serving**

- Measure and test levels of servers at peak usage for 256 GB in an overcommitted environment

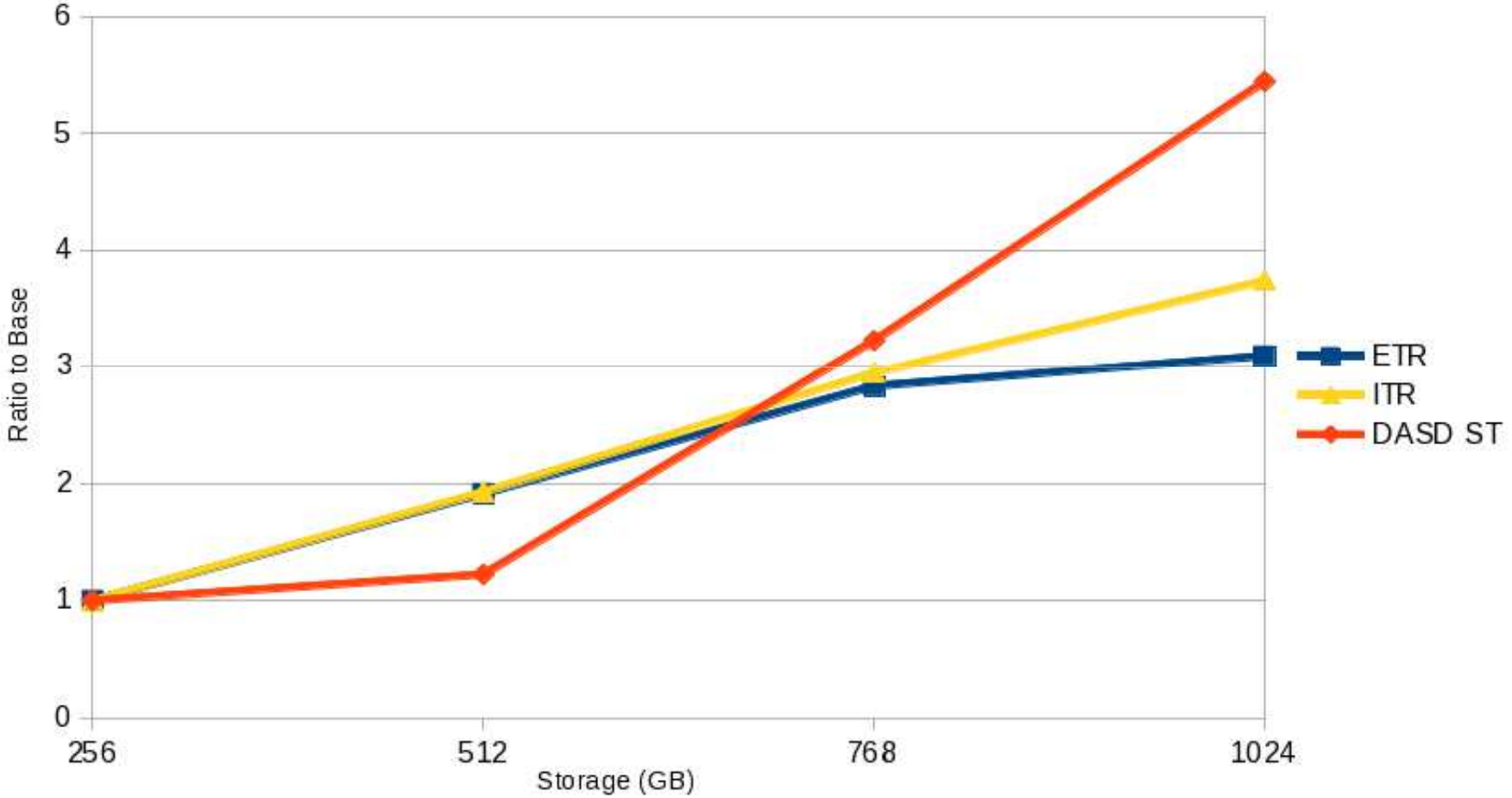
- Scale up from there to 1 TB
  – All resources scaled up, though note that while additional DASD space was provided, it was on the same storage server.

VIRSTOR Workload in Overcommitted Environment



ETR = External Throughput; ITR = Internal Throughput; DASD ST = DASD Service Time

Apache Workload in Overcommitted Environment



ETR = External Throughput; ITR = Internal Throughput; DASD ST = DASD Service Time

CP Monitor and z/VM Performance Toolkit

Session 14687: Understanding z/VM 6.3 through new Performance Toolkit Reports

Wednesday 4:30 PM - Grand Ballroom Salon G (Bill Bitner)

CP Monitor Records

No new Monitor records, only big changes….

Domain	Record	Name	Type	Title	Fields, N / D / C
D0	R3	MRSYTRSG	sample	Real Storage Data (Global)	D C
D0	R4	MRSYTRSP	sample	Real Storage Data (Per Processor)	D
D0	R6	MRSYTASG	sample	Auxiliary Storage (Global)	N C
D0	R7	MRSYTSHS	sample	Shared Storage Data	D
D0	R23	MRSYTLCK	sample	Formal Spin Lock Data	N C
D1	R7	MRMTRMEM	config	Memory Configuration Data	N
D1	R15	MRMTRUSR	config	Logged on User	C
D2	R4	MRSCLADL	event	Add User to Dispatch List	D C
D2	R5	MRSCLDDL	event	Drop User from Dispatch List	D C
D2	R6	MRSCLAEL	event	Add User to Eligible List	C
D2	R8	MRSCLSTP	event	System Timer Pop	D
D3	R1	MRSTORSG	sample	Real Storage Management (Global)	N D C
D3	R2	MRSTORSP	sample	Real Storage Activity (Per Processor)	D
D3	R3	MRSTOSHR	sample	Shared Storage Management	N C
D3	R14	MRSTOASI	sample	Address Space Information Record	N C
D3	R15	MRSTOSHL	event	NSS/DCSS/SSP Loaded into Storage	N
D3	R16	MRSTOSHD	event	NSS/DCSS/SSP Removed From Storage	N C
D4	R2	MRUSELOF	event	User Logoff Data	N D C
D4	R3	MRUSEACT	sample	User Activity Data	N D C
D4	R9	MRUSEATE	event	User Activity Data at Transaction End	D C

As usual, the Monitor records will be on www.vm.ibm.com at GA.

z/VM Performance Toolkit: Highlights

- Changed screens:
  - FCX102 SYSTEM, Some Internal System Counters
  - FCX103 STORAGE, General Storage Utilization
  - FCX133 NSS, NSS and DCSS Utilization and Paging Activity
  - FCX146 AUXLOG, Auxiliary Storage Utilization, by Time
  - FCX147 VDISKS, Virtual Disks in Storage
  - FCX265 LOCKLOG, Spin Lock Log, by Time
- Deleted screens:
  - FCX254 AVAILLOG, Available List Management, by Time
  - FCX259 DEMNDLOG, Demand Scan Details, by Time
- New screens:
  - FCX290 UPGACT, User Page Activity — *page state transition rates*
  - FCX291 UPGACTLG, User Page Activity (benchmarks a user)
  - FCX292 UPGUTL, User Page Utilization Data — *page residency counts*
  - FCX293 UPGUTLLG, User Page Utilization Data (benchmarks a user)
  - FCX294 AVLB2GLG, Available List Data Below 2G, by Time — *available list counts*
  - FCX295 AVLA2GLG, Available List Data Above 2G, by Time
  - FCX296 STEALLOG, Steal Statistics, by Time — *steal algorithm activity*
  - FCX297 AGELLOG, Age List Log, by Time — *global aging list activity*

z/VM Performance Toolkit: New Columns and Concepts

New Field	What this means
Inst	*Instantiations:* the rate at which valid memory is being created *Instantiated:* the amount of valid memory
Relse	*Releases:* the rate at which memory is being released
Inval	*Invalidations:* the rate at which demand scan is marking memory invalid as a way to determine whether it is being touched
Reval	*Revalidations*: the rate at which invalid pages are being made valid because somebody touched them
Ready	*Ready reclaims* or *ready steals:* the frame was found and selected for reclaim and had already been prewritten to auxiliary storage
Not Ready	*Notready reclaims* or *notready steals:* the frame was selected for reclaim but we had to wait for the auxiliary write (DASD) to finish before we could take it

z/VM Performance Toolkit: New Columns and Concepts

New Field	What this means
PNR	*Private, not referenced*: the page was read from aux as part of a block read, but it is still marked invalid because nobody has touched it yet
x<2G or *x*>2G	*Below 2 GB* or *Above 2 GB*: tells where the real backing frames are in real central
Sing	*Singles:* free frames surrounded by in-use frames (cannot coalesce)
Cont	*Contigs*: free frames in strings of two or more
Prot	*Protect threshold:* number of frames a singles-obtain must leave on a contigs-list

z/VM Performance Toolkit: New Report FCX292 UPGUTL

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

		Storage																
		Resident																
	Data							Invalid But Resident									Base	
	Spaces				Total		Locked		UFO		PNR		AgeList				Space	Nr of
Userid	Owned	WSS	Inst	Resvd	T_All	T>2G	L<2G	L>2G	U<2G	U>2G	P<2G	P>2G	A<2G	A>2G	XSTOR	AUX	Size	Users
>>Mean>>	.0	5284M	6765M	5611	5286M	27M	5259M	1010	232K	6565	2238K	59588	26M	53080	107M	.0	1815M	7108M	73
User Class Data:																			
CMS1_USE	.0	3320K	19M	.0	484K	.0	484K	.0	4096	.0	69632	.0	244K	.0	344K	.0	19M	2047M	1
LCC_CLIE	.0	364M	485M	.0	365M	11264	365M	.0	208K	.0	325K	.0	2686K	.0	8177K	.0	164M	1024M	8
LXA_SERV	.0	7974M	10G	.0	7978M	41M	7937M	.0	206K	9984	3327K	90624	39M	80725	161M	.0	2719M	10240M	48
User Data:																			
DISKACNT	.0	4976K	5156K	0	4K	0	4K	0	0	0	4K	0	0	0	0	0	5152K	32M	
DTCVSW1	.0	184K	11M	0	196K	8K	188K	8K	4K	0	4K	0	0	0	168K	0	11M	32M	
DTCVSW2	.0	180K	11M	0	184K	0	184K	0	4K	0	4K	0	0	0	164K	0	10M	32M	
EREP	.0	4912K	4944K	0	4K	0	4K	0	0	0	4K	0	0	0	0	0	4940K	32M	
FTPSERVE	.0	84K	5764K	0	88K	0	88K	0	4K	0	4K	0	0	0	76K	0	5760K	32M	
GCSXA	.0	204K	208K	0	8K	0	8K	0	4K	0	4K	0	0	0	0	0	200K	16M	
LCC00001	.0	364M	488M	0	365M	0	365M	0	204K	0	228K	0	2884K	0	8660K	0	192M	1024M	
LCC00002	.0	369M	492M	0	371M	20K	371M	0	204K	0	224K	0	2312K	0	7736K	0	159M	1024M	
LCC00003	.0	363M	484M	0	364M	0	364M	0	204K	0	252K	0	2852K	0	8372K	0	215M	1024M	
LCC00004	.0	363M	483M	0	363M	16K	363M	0	204K	0	228K	0	2724K	0	8512K	0	185M	1024M	

Look for the new concepts: Inst IBR UFO PNR AgeList

Amounts are in bytes, suffixed. Not page counts!

FCX113 UPAGE is still produced.

z/VM Performance Toolkit: New Report FCX292 UPGUTL

```
<------------------------- Resident ------------------------------>
                                    <------ Invalid But Resident ------>
<---- Total ----> <-Locked--> <-- UFO --> <-- PNR --> <-AgeList->
T_All  T<2G  T>2G  L<2G  L>2G  U<2G  U>2G  P<2G  P>2G  A<2G  A>2G XSTOR  AUX
 365M     0  365M     0  204K     0  228K     0 2884K     0 8660K     0 192M
```

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

z/VM Performance Toolkit: New Report FCX290 UPGACT

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

 ______      .     .     .     .     .     .     .     .     .     .     .     .     .
                <------------------------------ Storage ------------------------------>
                                                    <------- Movement/s -------->
            Stl <--- Transition/s ----> <-Steal/s->                         <Migrate/s> Nr of
Userid       Wt  Inst Relse Inval Reval Ready NoRdy  PGIN PGOUT Reads Write MWrit  Xrel Users
>>Mean>>    1.0  143K  5142  849K  718K  999K    .0    .0    .0  958K  761K    .0    .0    73
User Class Data:
CMS1_USE    1.0 15515 15801  2377  1632  5145    .0    .0    .0    .0  1980    .0    .0     1
LCC_CLIE    1.0  658K 20875  488K  486K 60875    .0    .0    .0 54212 22869    .0    .0     8
LXA_SERV    1.0  108K  1095 1191K  994K 1506K    .0    .0    .0 1447K 1153K    .0    .0    48

User Data:
DISKACNT    1.0     0     0     0     0     0     0     0     0     0     0     0     0
DTCVSW1     1.0     0     0  3072  2855     0     0     0     0     0     0     0     0
DTCVSW2     1.0     0     0  3004  2780     0     0     0     0     0     0     0     0
EREP        1.0     0     0     0     0     0     0     0     0     0     0     0     0
FTPSERVE    1.0     0     0  1434  1434     0     0     0     0     0     0     0     0
GCSXA       1.0     0     0     0     0     0     0     0     0     0     0     0     0
LCC00001    1.0  601K 18686  501K  498K 65139     0     0     0 49866 23670     0     0
LCC00002    1.0  657K 24955  487K  486K 54725     0     0     0 44522 18991     0     0
LCC00003    1.0  565K 23012  485K  481K 64065     0     0     0 44783 19859     0     0
LCC00004    1.0  602K 24104  499K  495K 63178     0     0     0 48811 24588     0     0
LCC00005    1.0  717K 25675  500K  499K 65865     0     0     0 66002 28753     0     0
```

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

z/VM Performance Toolkit: New Report FCX290 UPGACT

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

                  <------------------------------- Storage ------------------------------->
                                                  <-------- Movement/s -------->
           Stl <--- Transition/s ----> <-Steal/s->                          <Migrate/s> Nr of
```

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

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

z/VM Performance Toolkit: New Report FCX295 AVLA2GLG

```
FCX295  Run 2013/04/10 07:38:36          AVLA2GLG                                                    Page   25
                                         Available List Data Above 2G, by Time
From 2013/04/09 16:02:10                                                                  SYSTEMID
To   2013/04/09 16:13:10                                                                  CPU 2817-744   SN A6D85
For    660 Secs 00:11:00                 "This is a performance report for SYSTEM XYZ"    z/VM   V.6.3.0 SLU 0000
```

	<---------- Storage ---------->				<--Times-->		<-Frame Thresh-->		
Interval	<Available>		<Requests/s>		<Returns/s>		<-Empty/s->		Sing	<-Contigs->	
End Time	Sing	Cont	Sing	Cont	Sing	Cont	Sing	Cont	Low	Low	Prot
>>Mean>>	23M	267M	47M	59M	47M	51M	.0	.0	1310	15	15
16:02:40	0	938M	32M	126M	502K	30310	.0	.0	1332	15	15
16:03:10	152K	4556K	50M	89M	49M	59M	.0	.0	1168	15	15
16:03:40	400K	4824K	68M	82M	71M	79M	.0	.0	1321	15	15
16:04:10	0	5896K	49M	72M	52M	70M	.0	.0	2409	15	15
16:04:40	0	2124K	40M	60M	41M	59M	.0	.0	1308	15	15
16:05:10	876K	3488K	54M	52M	55M	51M	.0	.0	1118	15	15
16:05:40	0	3624K	53M	58M	54M	57M	.0	.0	1409	15	15
16:06:10	2016K	4464K	49M	57M	51M	56M	.0	.0	1273	15	15

Look for the new concepts: Singles Contigs Prot

Amounts are in bytes, suffixed. Not page counts!

FCX254 AVAILLOG is no longer produced.

z/VM Performance Toolkit: New Report FCX295 AVLA2GLG

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

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

- Look for the new concepts: Singles Contigs Prot
- Amounts are in bytes, suffixed. Not page counts!
- FCX254 AVAILLOG is no longer produced.

z/VM Performance Toolkit: New Report FCX296 STEALLOG

```
FCX296  Run 2013/04/10 07:38:36          STEALLOG                                                    Page   62
                                         Frame Steal Statistics, by Time
From 2013/04/09 16:02:10                                                              SYSTEMID
To   2013/04/09 16:13:10                                                              CPU 2817-744   SN A6D85
For    660 Secs 00:11:00                 "This is a performance report for SYSTEM XYZ"  z/VM   V.6.3.0 SLU 0000
```

	Pct	<-------- Storage/s -------->							<-Completions/s->				<-Users/s->		<- Age List --->		
Interval	Time	Total	Write	<--User--->		<-Shared-->		<Pvt Vdisk>		AgeL	Need	Time	Sys	Travs			<-Stor	Skip/s-->	
End Time	Actv	Stoln	OnDmd	Inval	Reval	Inval	Reval	Inval	Reval	Reval	Met	Limit	Req	/s	Visit	Skip	Pin	Ser	Resv
>>Mean>>	2.6	71M	.0	61M	36M	16099	1589	.0	.0	15M	115.1	.0	.0	5.8	283.1	5.8	.0	.0	.0
16:02:40	.0	.0	.0	.0	123K	.0	136.5	.0	.0	4639K	.0	.0	.0	.0	.0	.0	.0	.0	.0
16:03:10	2.4	82M	.0	3085K	45M	69632	4506	.0	.0	5301K	111.5	.1	.0	2.3	25.4	2.2	.0	.0	.0
16:03:40	3.4	102M	.0	36M	70M	39595	.0	.0	.0	11M	236.1	.0	.0	6.7	203.2	6.7	.0	.0	.0
16:04:10	3.5	94M	.0	75M	37M	13926	1092	.0	.0	18M	124.4	.0	.0	7.5	363.9	7.5	.0	.0	.0
16:04:40	3.2	84M	.0	68M	37M	9148	1092	.0	.0	15M	39.2	.0	.0	5.7	303.4	5.7	.0	.0	.0
16:05:10	3.0	80M	.0	70M	36M	16521	2867	.0	.0	16M	122.1	.0	.0	6.9	345.1	6.9	.0	.0	.0
16:05:40	2.9	80M	.0	71M	41M	11332	1092	.0	.0	17M	135.5	.0	.0	7.0	340.7	6.9	.0	.0	.0
16:06:10	2.8	78M	.0	70M	40M	11742	1092	.0	.0	16M	131.7	.0	.0	6.7	330.8	6.7	.0	.0	.0
16:06:40	2.7	74M	.0	71M	35M	10240	2731	.0	.0	17M	134.8	.0	.0	6.8	341.8	6.8	.0	.0	.0

- Look for the new concepts: Stoln Inval Reval etc.
- Amounts are in bytes, suffixed. Not page counts!

z/VM Performance Toolkit: New Report FCX297 AGELLOG

```
FCX297  Run 2013/04/10 07:38:36          AGELLOG                                                    Page   63
                                         Age List Log, by Time
From 2013/04/09 16:02:10                                                          SYSTEMID
To   2013/04/09 16:13:10                                                              CPU 2817-744   SN
A6D85
For    660 Secs 00:11:00                 "This is a performance report for SYSTEM XYZ"   z/VM   V.6.3.0 SLU
0000
```

```
_
```

					<---------- Storage ---------->					<----- Revalidation ------>			
					<-- Steal Ready --->	<--- Not Ready ---->			%Of	<------- Storage/s ------->			
Interval	Size	S	E	<-List Size-->	<--RefOnly-->	<--Changed-->	<Evaluating->		Pages	<--RefOnly-->	<--Changed-->		
End Time	%DPA	Z	W	Target	Current	NoWrt	Write	Write	PndWrt	Refd	Change	Eval	NoWrt	Write	NoWrt	Write
>>Mean>>	2.0	V	Y	7800M	7793M	177M	2K	602M	5481M	951K	98K	10	8595K	.0	6154K	359300
16:02:40	2.0	V	Y	7800M	7653M	51816K	0	725M	6620M	0	0	10	657954	.0	3919K	79736
16:03:10	2.0	V	Y	7800M	7800M	27972K	0	747M	4243M	4812K	548K	10	1079K	.0	3697K	537395
16:03:40	2.0	V	Y	7800M	7800M	21472K	0	756M	2173M	2596K	0	10	7429K	.0	3532K	36045
16:04:10	2.0	V	Y	7800M	7799M	770M	36K	10452K	3069M	0	0	10	13340K	.0	4293K	427622
16:04:40	2.0	V	Y	7800M	7799M	660M	0	120M	4756M	0	0	10	11392K	.0	3982K	3140.3
16:05:10	2.0	V	Y	7800M	7800M	218M	0	559M	5175M	2900K	276K	10	10095K	.0	5406K	534528
16:05:40	2.0	V	Y	7800M	7799M	229M	0	551M	5398M	0	0	10	10542K	.0	6067K	428851
16:06:10	2.0	V	Y	7800M	7800M	205M	0	570M	5548M	3824K	368K	10	10395K	.0	5503K	326861
16:06:40	2.0	V	Y	7800M	7800M	157M	0	623M	5648M	760K	24K	10	9115K	.0	7718K	305562

- Look for the new concepts: Write PndWrt etc.
- Amounts are in bytes, suffixed. Not page counts!

Summary

z/VM Large Memory: Summary

- **Objective was to get rid of algorithmic constraints that stopped growth**
- **Things we got rid of:**
  - Reorder
  - Using the scheduler lists to visit users
  - Taking a large amount when we visit a user
  - Excessively favoring VDISKs as regards memory residency
  - Problems in evaluating depletion of available lists
  - Excessive or unnecessary rewriting of DASD
  - Dependency on long-running System z instructions
- **Things we added:**
  - Visiting all users round-robin
  - Taking only a little when we visit
  - Visiting VDISKs sooner
  - Detecting available list depletion a little more smartly
  - Scatter-to-scatter paging channel program
  - Using trial invalidation
- **Effect: workloads constrained on z/VM 6.2 should go better on z/VM 6.3**

References

- z/VM CP Planning and Administration
- z/VM CP Commands and Utilities
- z/VM Performance Report: www.vm.ibm.com/perf/

Thanks!

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