Taming Your Storage Hungry Linuxen Using CMM(A)

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Session 9272

Taming Storage Hungry Linux Virtual Machines

- Problem case study
- CMM 1 – software controls service machine communication
- CMMA (CMM – 2) – hardware storage key bit settings
- Descriptions
- Scenarios
- Performance data

Tools

- CP commands
  - INDICATE, QUERY, XAUTOLOG, FORCE, SET
- CMS: REXX, PIPELINES
- CP MONITOR DATA
- Velocity products
- Linux commands:
  - cat, lsmod, ls, grep, vi, top, nice, cp, mv, rm

CMM1

- Linux on System z support for CMM1 is available in:
  - Novell SUSE Linux Enterprise Server 9 (SLES9) SP3 since kernel level: kernel-s390(x)-2.6.5-7.257 dated 2006-05-16
  - Novell SUSE Linux Enterprise Server 10 (SLES10) since GA
  - Red Hat RHEL4 U7 2.6.9-73 (includes Out of Memory Notifier)
  - Red Hat RHEL5.1 2.6.18-53 (includes Out of Memory Notifier)
- In z/VM: 5.3.0 and beyond
  - In 5.2.0 CMS APAR is required, VM64085, for full functionality

CMM1

- The VM Resource Manager service machine
- Linux drivers for CMM processing and message handling.
- Used effectively can reduce Linux storage footprint

CMM Linux Mechanics

- Load the CMM module with modprobe or insmod
  - *Not compiled in kernel is Novell SLES10*
- Parameter passing
- Checking the parameters after loading
- Dynamic and static loading methods

Dynamically loading the CMM module in Linux

```
# lsmod | grep cmm

# modprobe cmm

#lsmod
Module                  Size  Used by
cmm                    33024  0
smsgiucv               24080  1 cmm
iucv                   47704  1
:
```

Dynamically loading the CMM module in Linux specifying the sender

```
# modprobe cmm sender=SOMEVM
#
# lsmod
Module                  Size  Used by
cmm                    33024  0
smsgiucv               24080  1 cmm
iucv                   47704  1
:
```

Dynamically checking the parameters

```
# cat /sys/module/cmm/parameters/sender
SOMEVM
#
```

Kernel level and distribution

```
# cat /proc/version /etc/SuSE*
Linux version 2.6.16.60-0.21-default (geeko@buildhost)
(gcc version 4.1.2 20070115 (SUSE Linux)) #1
SMP Tue May 6 12:41:02 UTC 2008

SUSE Linux Enterprise Server 10 (s390x)
VERSION = 10
PATCHLEVEL = 2

#
```

Not compiled in the kernel

```
grep -i cmm /boot/config-*
CONFIG_CMM=m
CONFIG_CMM_PROC=y
CONFIG_CMM_IUCV=y
```

In SLES SP10 cmm is not compiled into the kernel

Automatically loading the cmm module

- Train the kernel in /etc/sysconfig/kernel
- Pass parameters in /etc/modprobe.conf.local

```
~ grep -i cmm /etc/sysconfig/kernel
MODULES_LOADED_ON_BOOT="vmcp cmm“

~ cat /etc/modprobe.conf.local
#
# please add local extensions to this file
#
options cmm sender=OTHERVM
```

Checking after boot time

```
~ cat /sys/module/cmm/parameters/sender
OTHERVM
```

The VM Resource Manager

- Workload manager for z/VM
- Can be used to dynamically adjust virtual machine CPU consumption and I/O usage
- Used to message Linux virtual machines when using CMM
- Runs in the VMRMSVM service machine as supplied by IBM.
- One configuration file.
- Logs to a file.

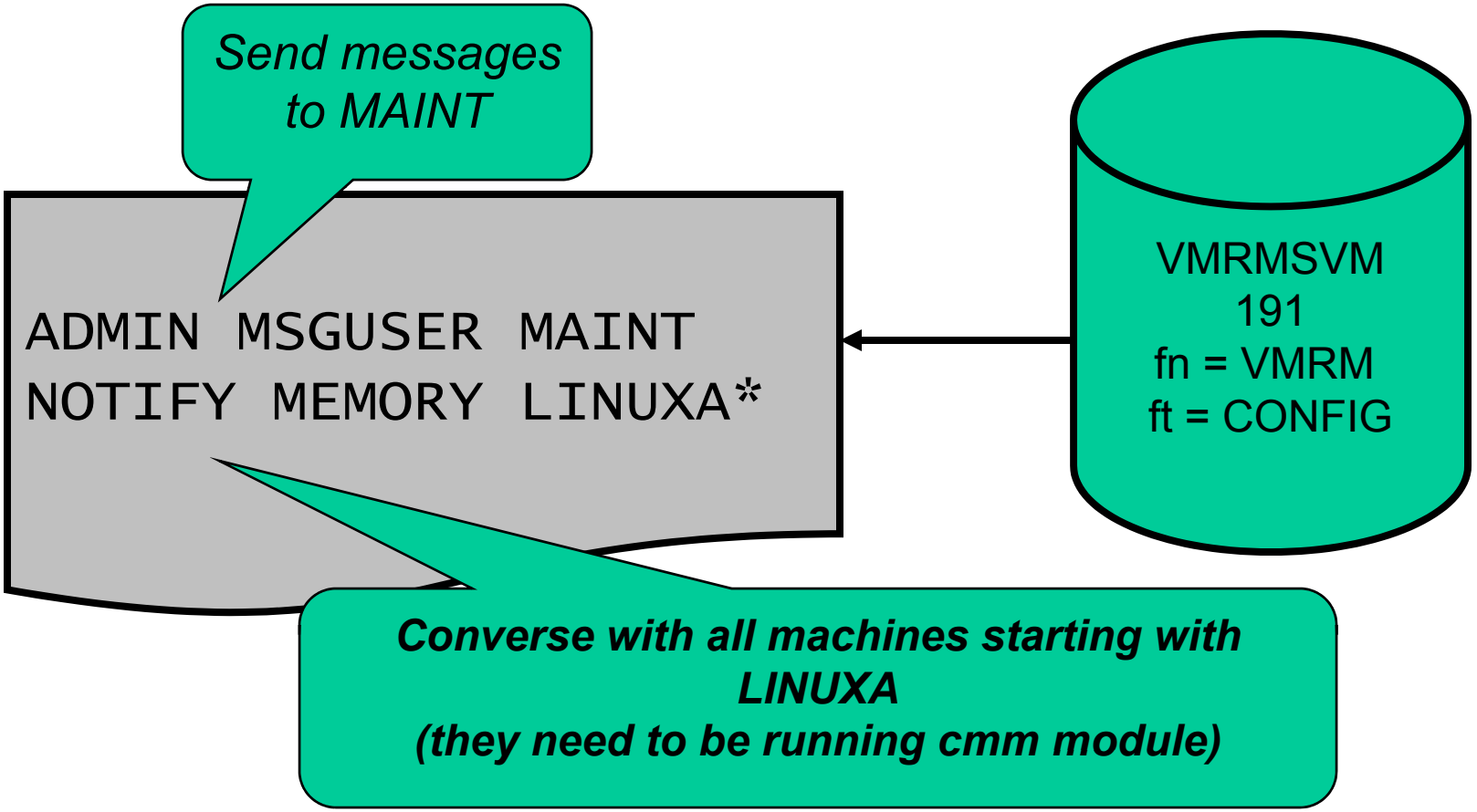
The VMRMSVM Under the Hood

- Use CP MONITOR SAMPE data to determine:
  - Memory constraints
  - How much memory to instruct its' Linux partner to release
- "Kicks in"
- Requires careful monitoring – can have profound positive impact but can also hurt

The VM Resource Manager: startup

```
xautolog vmrmsvm

Command accepted


AUTO LOGON  ***       VMRMSVM  USERS = 62

HCPCLS6056I XAUTOLOG information for VMRMSVM: The IPL command is
verified by the  IPL command processor.

 12:53:38  * MSG FROM VMRMSVM : IRMSER0023I VM Resource Manager
Service Virtual

  Machine initialization complete. Proceeding to connect to Monitor.
```

Configuration file: NOTIFY statement in the VMRM CONFIG



The VM Resource Manager: CMM notifications

1

```
query mon sample
MONITOR SAMPLE ACTIVE
                INTERVAL     1
MINUTES
                RATE      1.00
SECONDS
MONITOR DCSS NAME - MONDCSS
CONFIGURATION SIZE      1000
LIMIT           1 MINUTES
CONFIGURATION AREA IS FREE
USERS CONNECTED TO *MONITOR -
ESAWRITE VMRMSVM
:
```

2

```
:
MONITOR    DOMAIN ENABLED
SYSTEM     DOMAIN ENABLED
PROCESSOR  DOMAIN ENABLED
STORAGE    DOMAIN ENABLED
USER       DOMAIN ENABLED
   ALL USERS ENABLED
I/O        DOMAIN ENABLED
   ALL DEVICES ENABLED
NETWORK    DOMAIN ENABLED
APPLDATA   DOMAIN ENABLED
   ALL USERS ENABLED
```

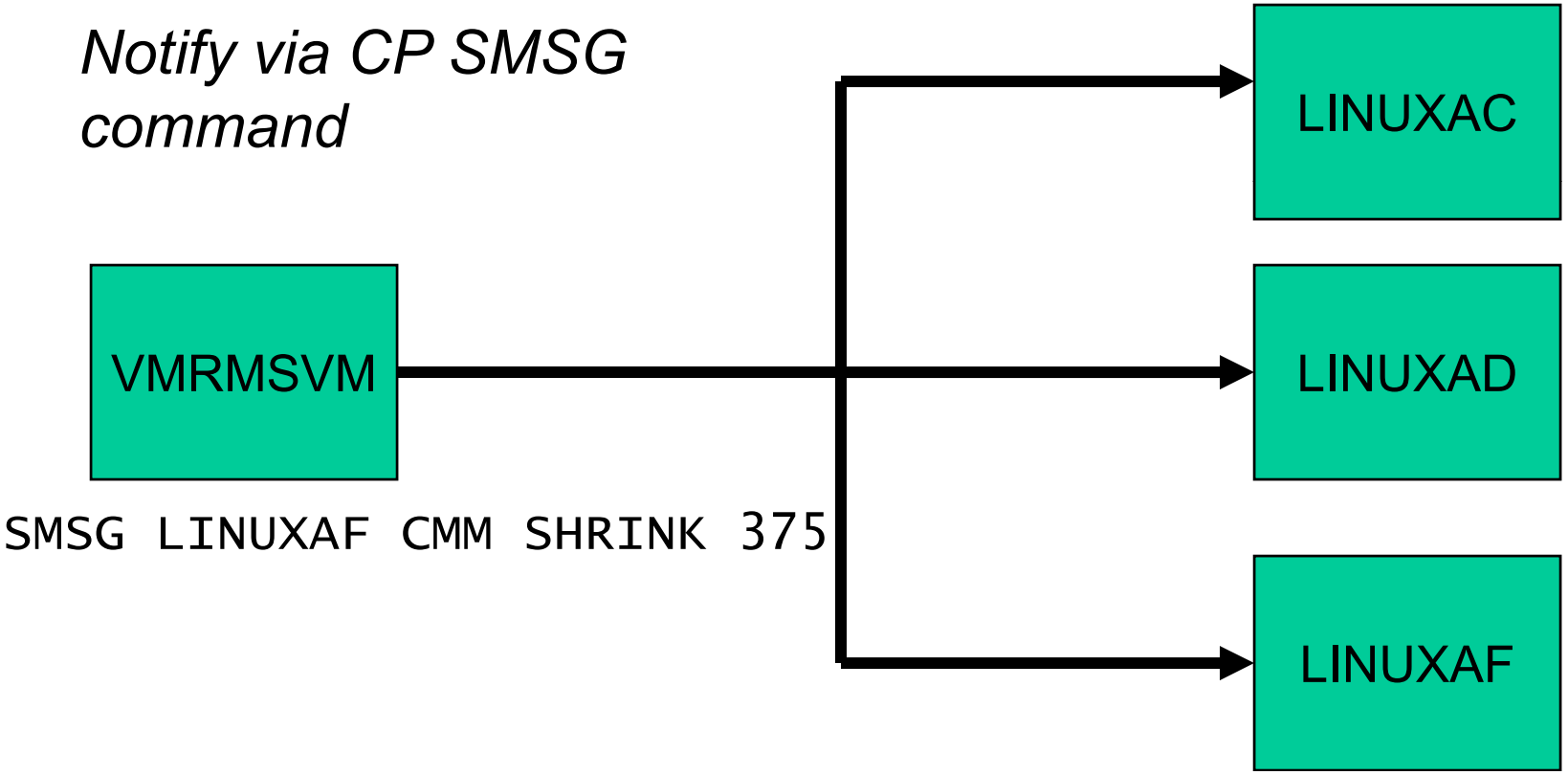
The VM Resource Manager: orderly termination

CMS immediate command

```
cp send vmrmsvm hmonitor


 12:54:28  * MSG FROM VMRMSVM : IRMMON0026I VM Resource Manager
processing of monitor records ended. Pipe RC= 0

 12:54:28  * MSG FROM VMRMSVM : IRMSER0012I VM Resource Manager
Service Virtual   Machine shutdown in progress

 12:54:28  * MSG FROM VMRMSVM : IRMSER0027I VM Resource Manager
Service Virtual   Machine shutdown complete

VMRMSVM : 12:54:28 0 RC FROM IRMSERV

VMRMSVM : 12:54:28 Ready; T=0.17/0.19 12:54:28
```

VMRMSVM and Linux interaction

Notify via CP SMSG command

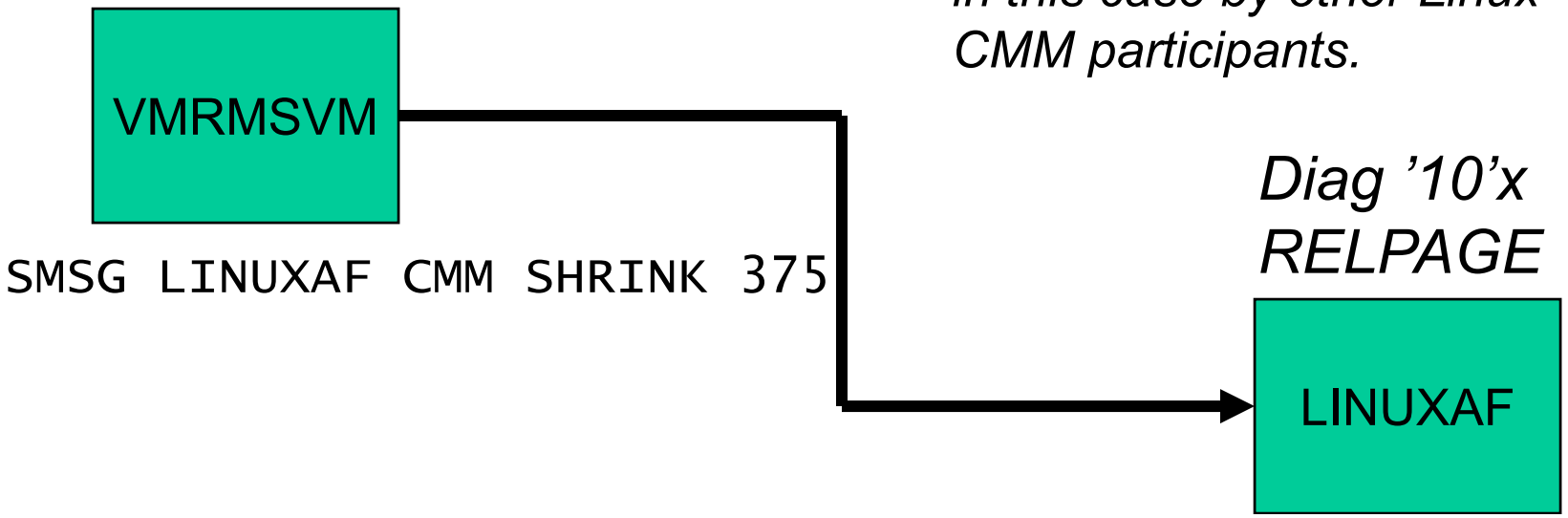



```
SMSG LINUXAF CMM SHRINK 375
```

VMRMSVM and Linux interaction

Notify via CP SMSG command

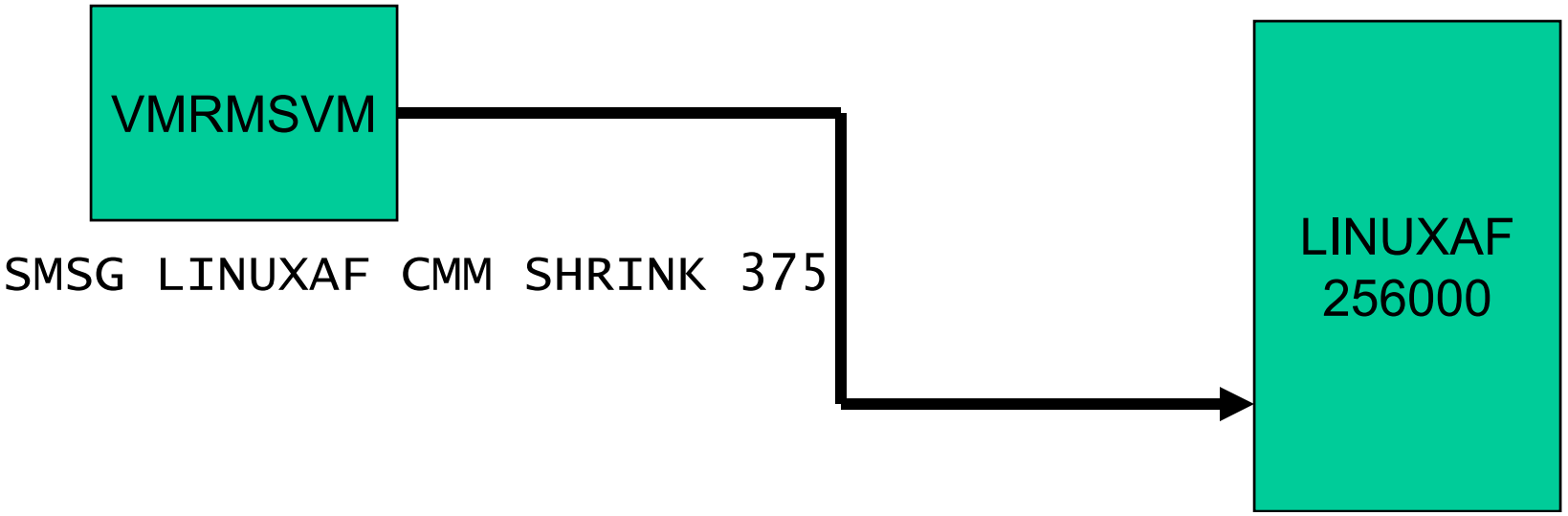
Relpage means that the virtual machine doesn't need the page backed up by CP. Therefore it can be reused; in this case by other Linux CMM participants.



Page SHRINK 1

Notify via CP SMSG command

Diag '10'x RELPAGE 375

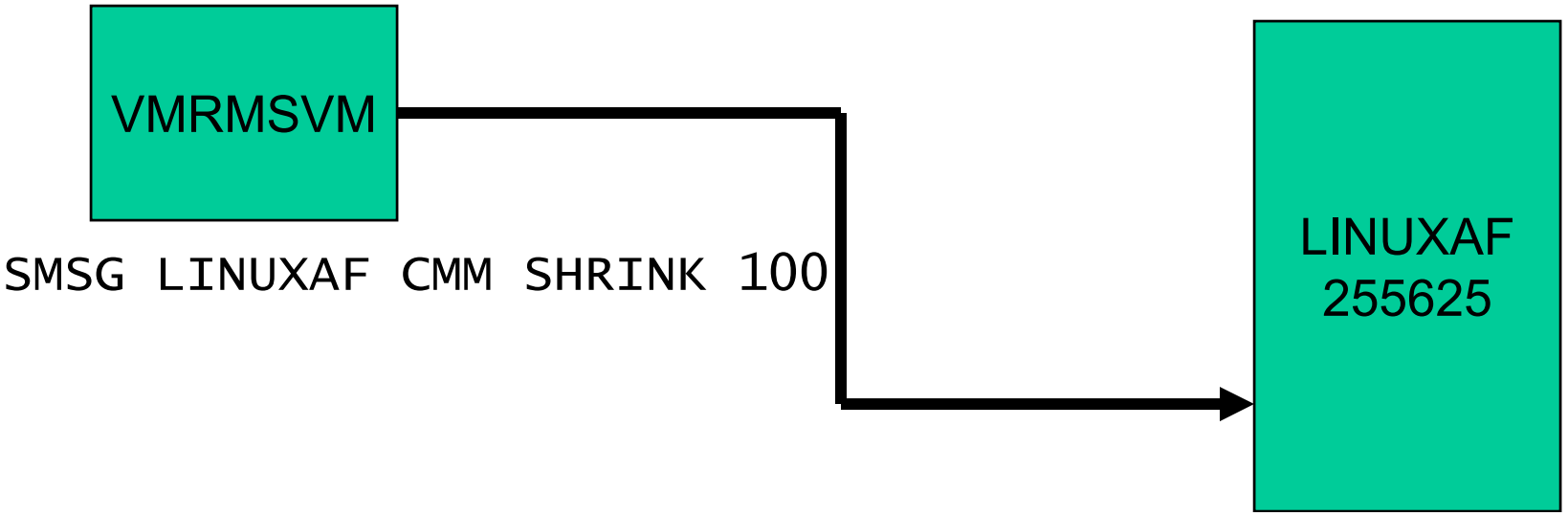


Page SHRINK: machine is now 255625 pages

after RELPAGE 375

Next: Page SHRINK 100 pages

Notify via CP SMSG command



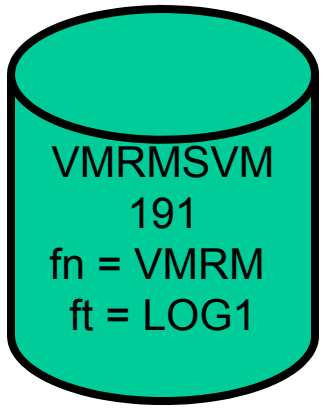
Page SHRINK: can *increase by 275* page (375-100)

Allows the guest to reclaim some of the storage previously released.

LINUXAF
255900

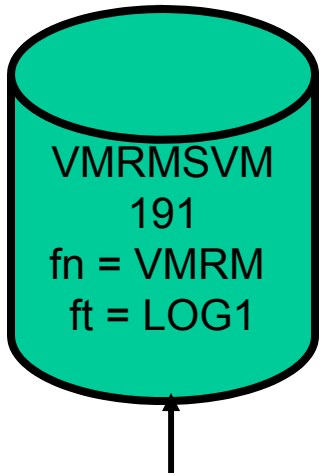
VMRMSVM logging -startup

```
2009-02-25 12:53:38 ServExe  Entry    --------------------
---------------------
2009-02-25 12:53:38 ServExe  MSG      IRMSER0022I VM
Resource Manager Service Virtual Machine initialization
started
2009-02-25 12:53:38 ServExe  PCfg     VMRM CONFIG A1
2/25/09 7:54:41
2009-02-25 12:53:38 ServExe  InitEnv  MONITOR EVENT ACTIVE
BLOCK    500     P
ARTITION    8192
2009-02-25 12:53:38 ServExe  InitEnv  MONITOR DCSS NAME -
MONDCSS
2009-02-25 12:53:38 ServExe  InitEnv  CONFIGURATION SIZE
50 LIMIT
2009-02-25 12:53:38 ServExe  MSG      IRMSER0023I VM
Resource Manager Service Virtual Machine initialization
complete. Proceeding to connect to Monitor.
```



VMRMSVM logging - termination

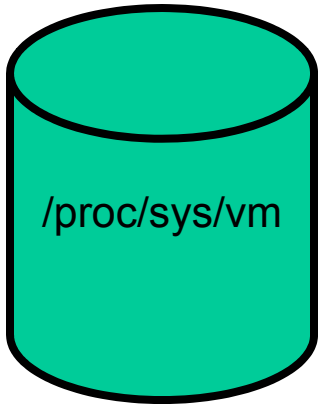
```
2009-02-25 12:53:38 MonRexx  Entry    MonIntCtr= 1 ,
Record= ENDR C3CD2331A780FC

80 , Processing this record at 25 Feb 2009 12:53:38

2009-02-25 12:54:06 MonRexx  Entry    MonIntCtr= 2 ,
Record= ENDR C3CD234C7CBE0A

:

80 , Processing this record at 25 Feb 2009 12:54:06

2009-02-25 12:54:28 MonExec  Exit     IRMMON0026I VM
Resource Manager processing of monitor records ended. Pipe
RC= 0

2009-02-25 12:54:28 ServExe  MSG      IRMSER0012I VM
Resource Manager Service Virtual Machine shutdown in
progress

2009-02-25 12:54:28 ServExe  MSG      IRMSER0027I VM
Resource Manager Service Virtual Machine shutdown complete
```



Will close after 10,000 records. Keeps 1 copy around as VMRM LOG2.

Checking how many pages are participating

```
# cat
/proc/sys/vm/cmm_pages

69362
in a 640m vm
```



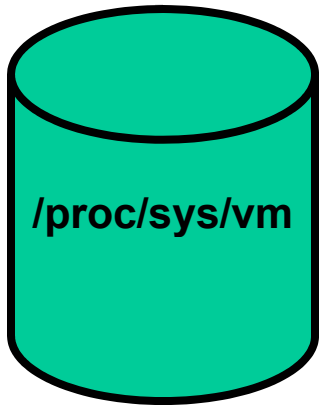
69362/256 =271 -> 271Mb release

SHRINK values as reported in the VMRMSVM log file

```
21:19:07 MonCMM   CPCMD    SMSG LINUXA8 CMM SHRINK 37987
21:19:07 MonCMM   CPCMD    SMSG LINUXA7 CMM SHRINK 135687
21:19:07 MonCMM   CPCMD    SMSG LINUXA6 CMM SHRINK 90216
21:19:07 MonCMM   CPCMD    SMSG LINUXA4 CMM SHRINK 48021
21:19:07 MonCMM   CPCMD    SMSG LINUXA3 CMM SHRINK 120483
21:20:07 MonCMM   CPCMD    SMSG LINUXA8 CMM SHRINK 69870
21:20:07 MonCMM   CPCMD    SMSG LINUXA7 CMM SHRINK 138528
21:20:07 MonCMM   CPCMD    SMSG LINUXA6 CMM SHRINK 110921
21:20:07 MonCMM   CPCMD    SMSG LINUXA4 CMM SHRINK 90267
21:20:07 MonCMM   CPCMD    SMSG LINUXA3 CMM SHRINK 128181
```

Checking how many pages are participating

```
# cat /proc/sys/vm/cmm_pages
114687
# cat /proc/sys/vm/cmm_timed_pages
0
# cat /proc/sys/vm/cmm_timeout
0 0
```



CMMA – VM and Linux levels

- z/VM 5.3 plus APAR VM64265 and APAR VM64297
- SLES10 SP1 update kernel 2.6.16.53-0.18
- Redhat – not available

CMMA – instruction level communication

- Uses storage key to describe page contents
- ESSA instruction

Bit Desc.	**Meaning**
Stable	Guest cannot recreate contents
Unused	Unused
Volatile	Useful content but may be discarded. Discard fault presented to guest
Potentially volatile	**D**irty = CP handles as **S**table **N**ot dirty = CP handles as volatile

CMMA – instruction level communication

- CP investigates the bit settings:
  - Possibly steal unused, volatile, not dirty potentially volatile pages without necessarily having to page out contents.
  - CP can use clean disk cache pages, and if Linux needs it back, CP will reflect a discard interrupt.
  - Linux marks a page for removal CP may reuse it without having to page out.
  - Assist provided (Host Page-Management Assist) to let guest reclaim discard page without CP interception (remains runnable).

System and Linux mechanics

- MEMASSIST must be on for system and virtual machine.

```
cp query memassist
ALL USERS SET - ON

USER       SETTING STATUS
MAINT      ON      INACTIVE
```

```
cp query memassist linuxa1
ALL USERS SET - ON

USER       SETTING    STATUS
LINUXA1    ON         ACTIVE
```

System and Linux mechanics

- Kernel parameter is cmma=on

```
# dmesg | grep cmma
Kernel command line: root=/dev/ram0 init=/linuxrc rw
barrier=off selinux=0 TERM=dumb elevator=cfq cmma=on
BOOT_IMAGE=2
```

CP TRACE ESSA STEP 5

Tracing the ESSA instruction in a Linux virtual machine with class G TRACE command

```
CP TRACE ESSA STEP 5
 -> 00000000001C00FA'  ESSA   B9AB2001     0000000000000000
                                            00000000159AF000     CC 2
 -> 00000000001BD4EC'  ESSA   B9AB1051     0000000000000004
                                            00000000159AF000     CC 2
 -> 00000000001BD4EC'  ESSA   B9AB1051     0000000000000004
                                            0000000015AAA000     CC 2
 -> 000000000020A596'  ESSA   B9AB6021     0000000000000000
                                            0000000015AAA000     CC 2
 -> 00000000001C00FA'  ESSA   B9AB2001     0000000000000000
                                            000000001F425000     CC 2
```

Case Study

- When running WAS “idle” Linux machines remain in Q3 forever.
- Using resource needlessly, causing storage overcrowding in the high rent district.
- Attempted to duplicate problem in test lpar.
    - *However machines do not sit in Q3 – but they still work through queues even when “idle”*

Production System Queue Reports: 03:15 – 03:30

Velocity Software report ESAUSRQ

```
1Report: ESAUSRQ      User Queue and Load Analysis                  Velocit
 Monitor initialized: 02/25/09 at 03:00:00 on 2094 serial ABCDE     First r
 ------------------------------------------------------------------------

          <-----------User Load------------>      <-----------Average Numbe
 UserID   Logged  Non-          Disc- Total  Tran <-------Dispatch List----
 /Class       on  Idle  Active  conn  InQue  /min    Q0    Q1    Q2    Q3
 -------- ------ ----- ------- ------ -----  ---- ----- ----- ----- ----- -
 03:30:00   87.0     .    70.3      .  55.9   781     0  10.5   6.3  39.1
 Hi-Freq:   87.1    70    70.3     84  55.6   780   0.2  10.6   5.6  39.2
```

Same results at 3 a.m. …

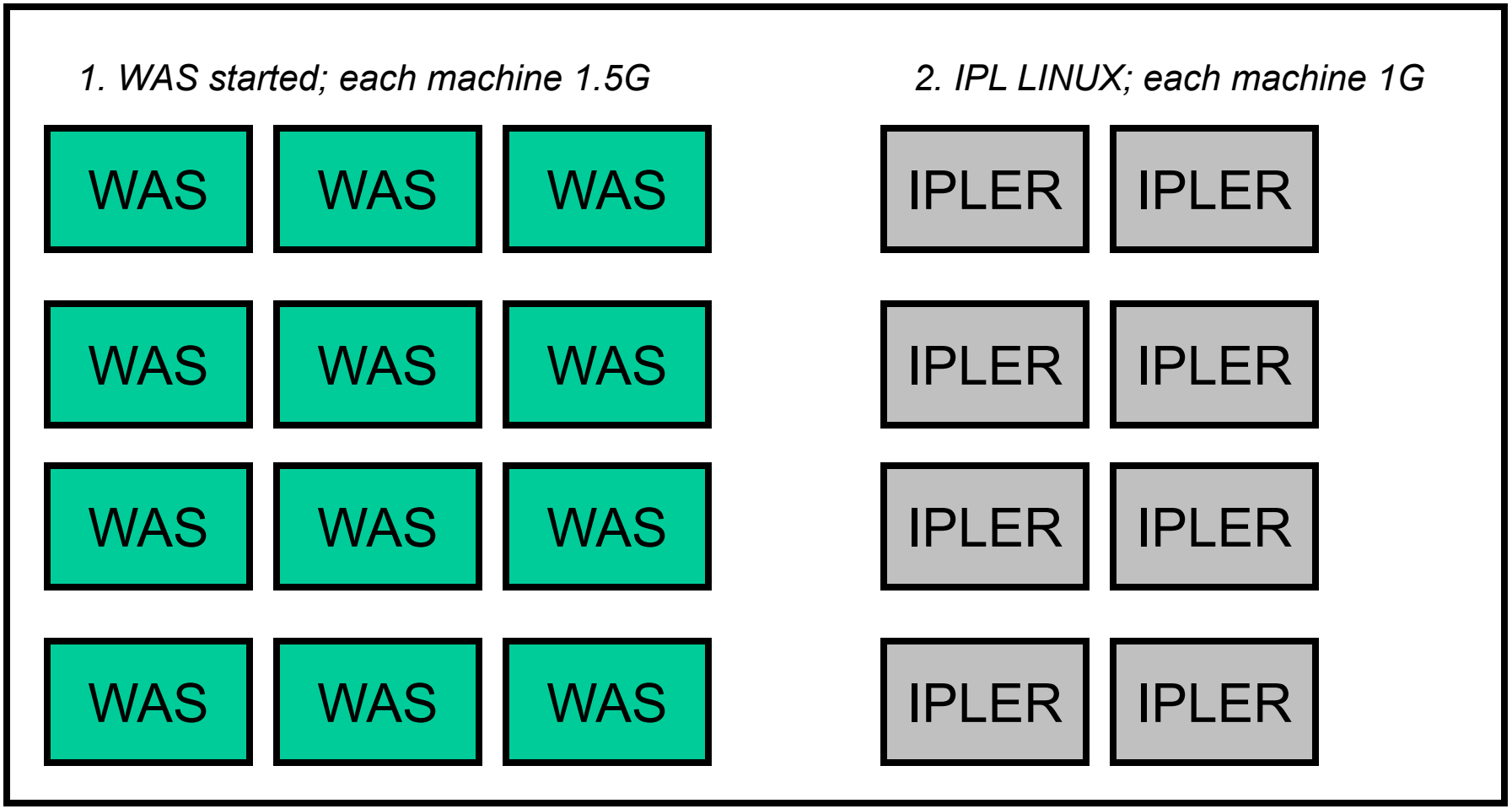
Production System Queue Reports 15:15 – 15:30

Velocity Software report ESAUSRQ

```
1Report: ESAUSRQ      User Queue and Load Analysis                  Velocity
 Monitor initialized: 02/25/09 at 15:00:00 on 2094 serial ABCDE     First re
 ------------------------------------------------------------------------

          <-----------User Load------------>      <-----------Average Number
 UserID   Logged  Non-          Disc- Total  Tran <-------Dispatch List-----
 /Class       on  Idle  Active  conn  InQue  /min    Q0    Q1    Q2    Q3  L
 -------- ------ ----- ------- ------ -----  ---- ----- ----- ----- ----- --
 15:30:00   87.0     .    70.3      .  56.0   725     0  10.7   5.3  40.0
 Hi-Freq:   87.1    70    70.3     84  55.6   725   0.4   9.5   5.7  39.9
0 ***Key User Analysis ***
```

Same results at 3 a.m. … … as at 3 p.m.

CP Storage: 2.5G with XSTORE .5G z9 with two IFLs uncapped LPAR



Tried this approach

- Over commitment of 10:1 and higher
  - Inquiring minds want to know!
    - Done in a test LPAR
- Results were just not good
- Certain runs:
  - Caused thrashing
    - Exceptionally high CP overhead – CP tries to keep all vm's happy ends up punishing all!
  - Elist formation
    - Severe memory resource shortage

Trying for the sweet spot: CP Storage: 2.5G with XSTORE .5G z9 with two IFLs uncapped LPAR

1. WAS started; each machine 640M

WAS WAS WAS

WAS WAS WAS

2. IPL LINUX; each machine 512M

IPLER IPLER

IPLER IPLER

Results

- Caveat: results are mine only based on limited circumstance testing.
- Caused extreme memory stress during most tests.
- Overcommitment of 10:1 didn't work so well.
  - So what's the right number: between 1 and 10…
    - Around 3 – 4? 5? … 6?
  - And cmm and cmma can help with overall storage management with careful management
- By no means formal tests.
- Will continue to evaluate

Comments

- **The VMRMSVM "kick in" determined by "black box" internal values; no control.**
- **Maybe it was the nature of the tests but…**
  - **External setting of low, medium or high relpage processing would be nice.**
  - **Follow suggestions for using CMM with non-production workloads.**
  - **CMM-1 and CMMA are not "set it and forget it"**
  - **Requires a performance monitor!**
    - **Used Velocity products, CP, and linux commands.**
- **Nonetheless CMM-1 and CMMA are reasonable tools in the right hands.**

Perceptions

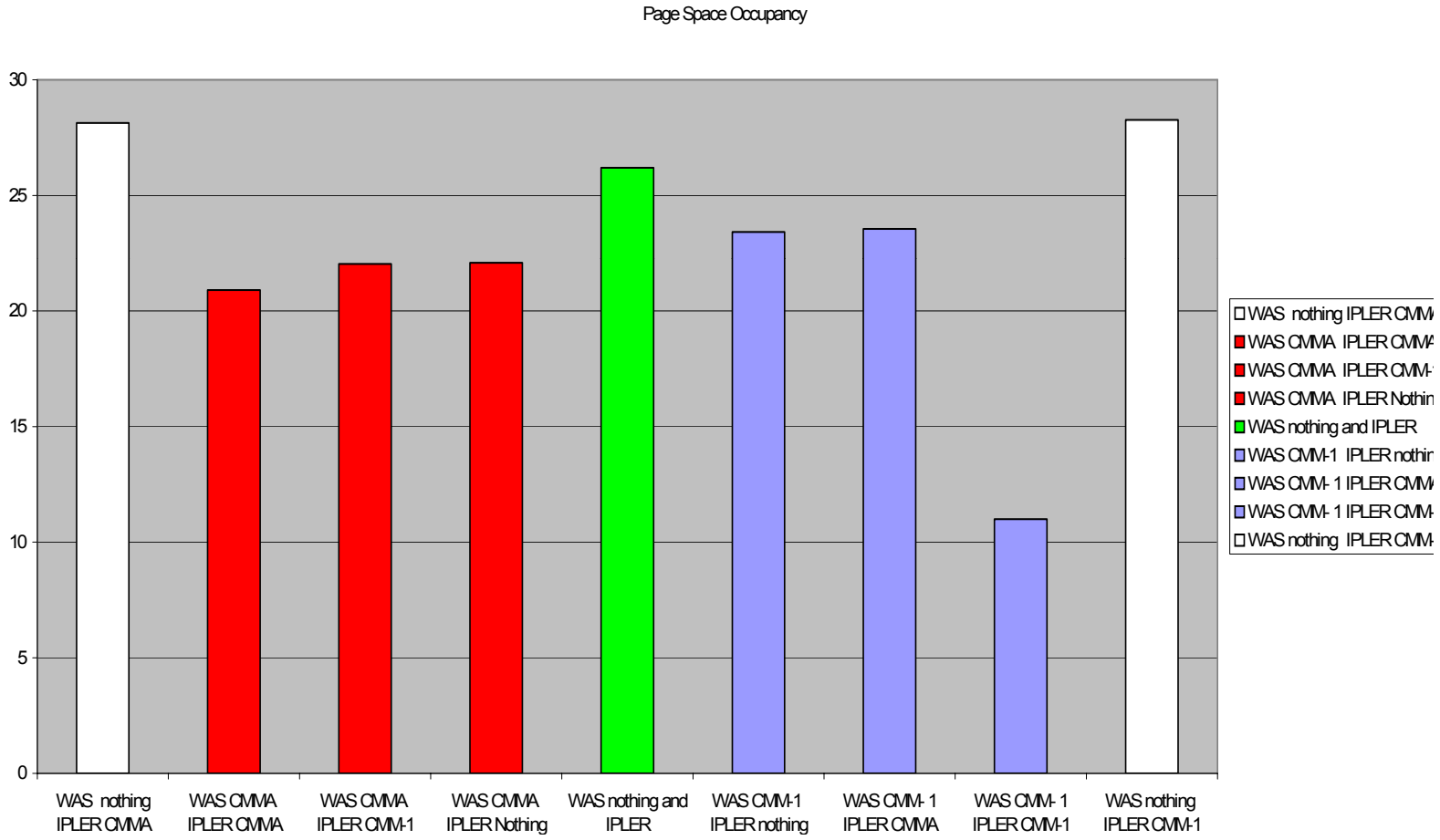
- After the VMRMSVM has instructed servers to give up a lot of pages:
  - Simple tasks in those machines had elongated response times
    - Attempts to ssh
- Machines not in the VMRMSVM hit list continue to do well
  - *Keep cmm-1 away from production?*

Test suites:
6 was at 640M 4 IPLERS at 512M

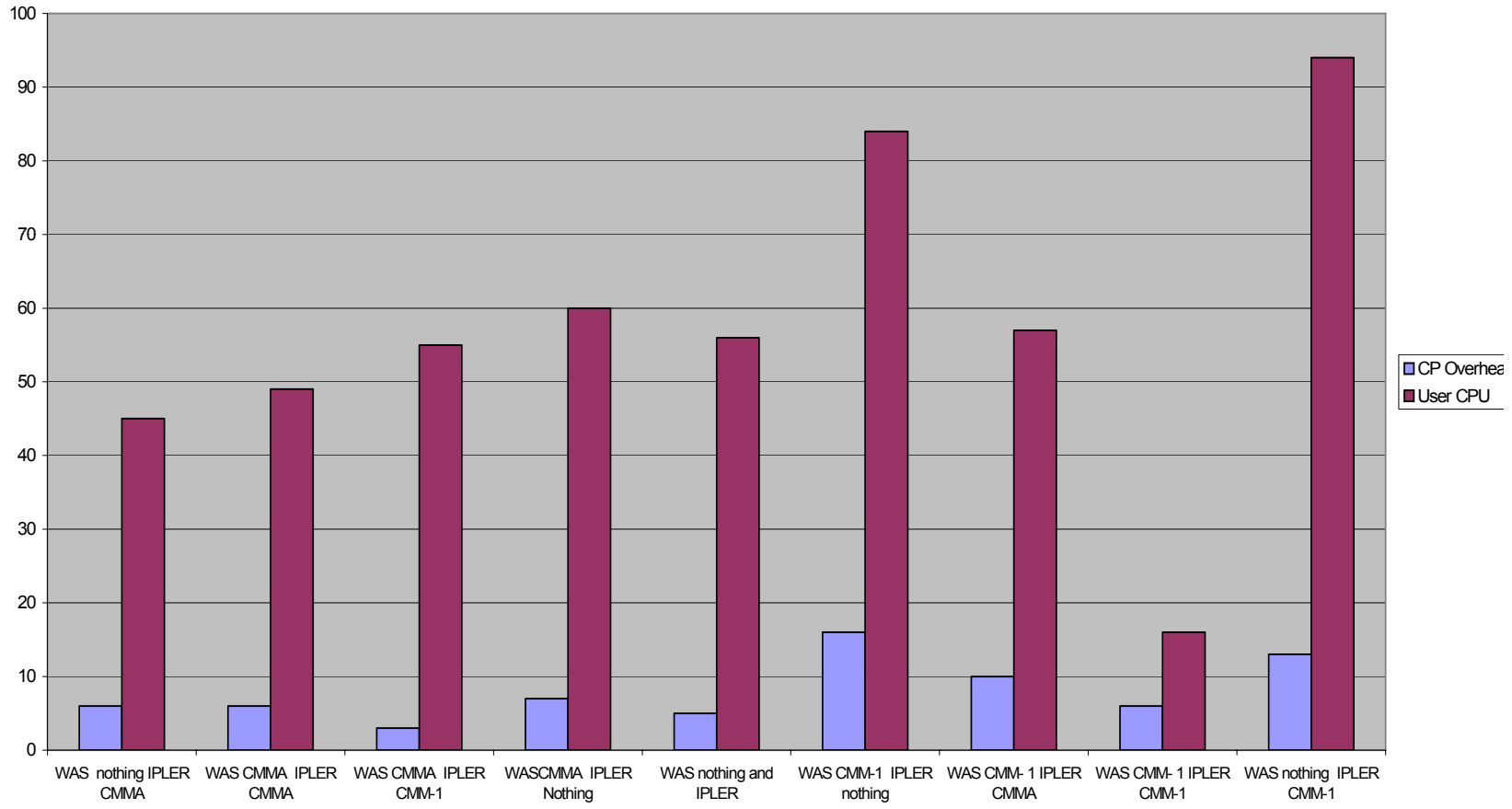
9 tests performed

WAS CMM	WAS CMMA	IPLER CMM	IPLER CMMA

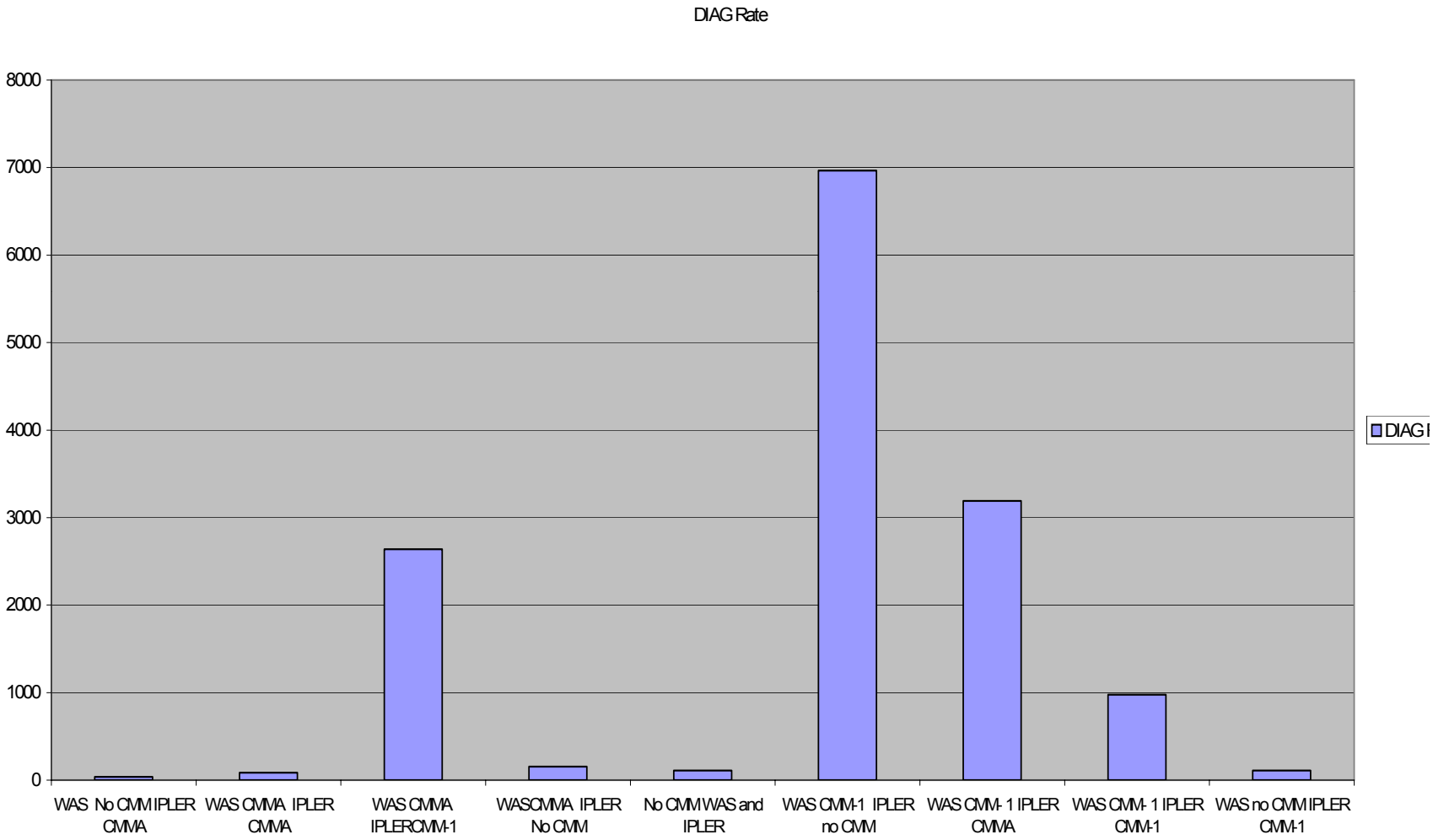
Paging Disk Occupancy



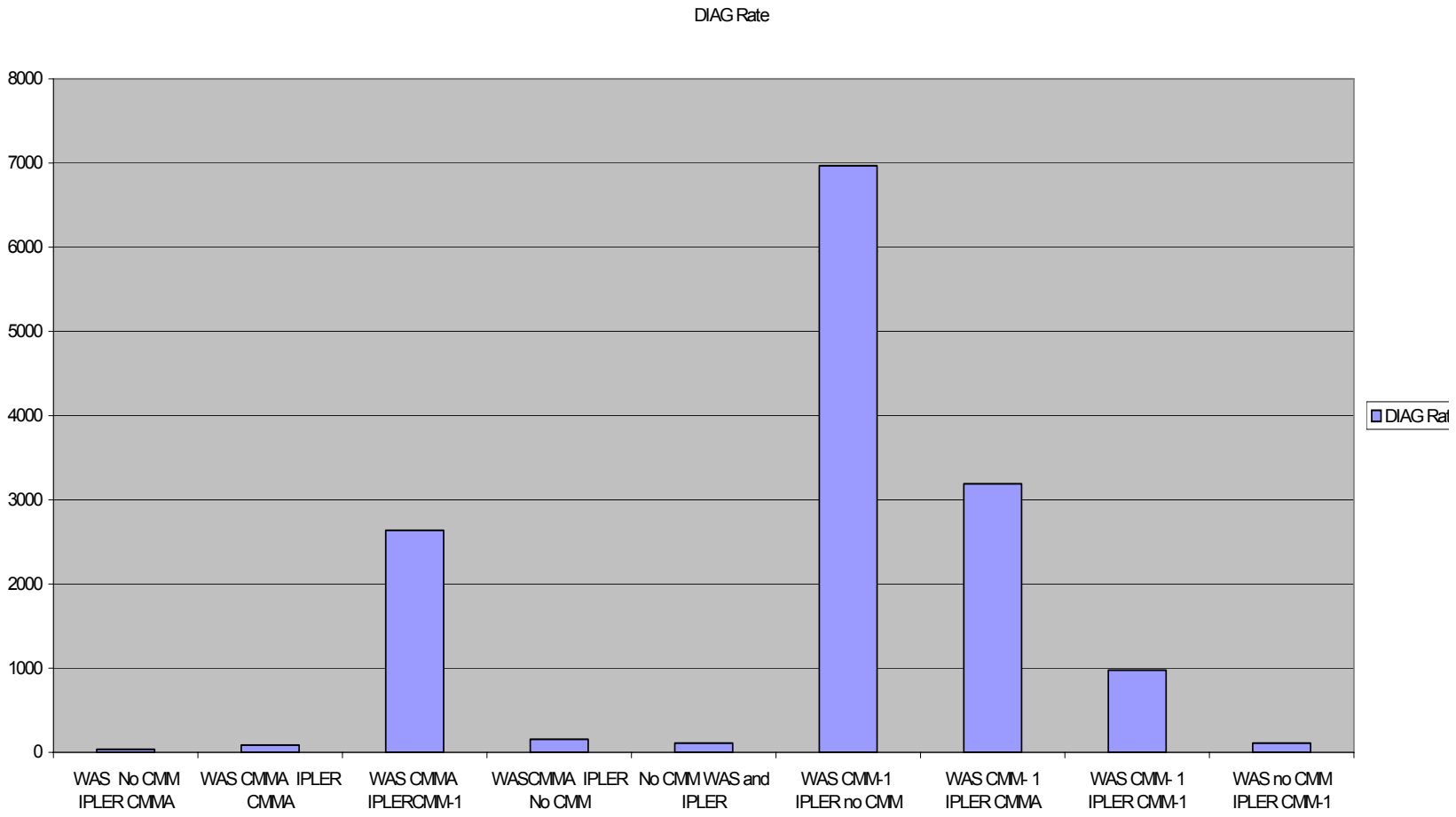
User CPU and CP Overhead



Working Set Sizes



DIAG Rate


DIAG Rate
8000
7000
6000
5000
4000
3000
2000
1000
0
WAS No CMM IPLER CMMA
WAS CMMA IPLER CMMA
WAS CMMA IPLERCMM-1
WASCMMA IPLER No CMM
No CMM WAS and IPLER
WAS CMM-1 IPLER no CMM
WAS CMM- 1 IPLER CMMA
WAS CMM- 1 IPLER CMM-1
WAS no CMM IPLER CMM-1
DIAG Rat

Test	Page read sec	Page Write sec
WAS No CMM IPLER CMMA	788	1217
WAS CMMA IPLER CMMA	421	1717
WAS CMMA IPLERCMM-1	42	208
WASCMMA IPLER No CMM	782	1927
No CMM WAS and IPLER	242	1038
WAS CMM-1 IPLER no CMM	2989	3220
WAS CMM- 1 IPLER CMMA	1847	2172
WAS CMM- 1 IPLER CMMA	2004	1234
WAS no CMM IPLER CMM-1	3004	5112

Thank you's

- Barton Robinson
- Dave Jones
- Dominic Coulombe

16:33:00	63	34	17.0	2.6	0.47	2	51.5	9.7
16:32:00	63	33	18.0	2.9	0.36	2	50.4	9.9
16:31:00	63	31	17.0	2.6	0.50	2	73.5	12.0
16:30:00	63	30	21.0	2.9	0.28	2	52.1	9.1
16:29:00	63	31	18.0	3.0	0.35	2	63.5	9.6
16:28:00	63	35	16.0	2.6	0.54	2	46.0	8.2
16:27:00	64	36	19.0	2.9	1.36	2	69.7	10.5
16:26:00	63	33	20.0	2.8	1.06	2	57.1	12.5
16:25:00	63	34	21.0	3.7	0.46	2	46.5	11.3
16:24:00	63	41	20.0	8.1	0.51	2	56.1	24.4
16:23:00	63	41	23.0	11.8	0.45	2	131.1	116.8
16:22:00	63	43	25.0	8.1	0.81	2	144.3	102.0

thrashing

```
 <---Users----> Transact. <-Paging--> <-----I/O----->
         <-avg number->  per Avg. <pages/sec> <-DASD--> Actv In Q Sec.
Time XStore DASD Rate Resp  Rate  Rate %Hit  Rate


16:33:00   63   34 17.0  2.6 0.47    2  51.5   9.7
 16:33:00   63   34 17.0  2.6 0.47  19043  16K 4773
16:32:00   63   33 18.0  2.9 0.36  13692  17K 4988
16:31:00   63   31 17.0  2.6 0.50  35853  13K 3692
16:30:00   63   30 21.0  2.9 0.28  24361  15K 4721
16:29:00   63   31 18.0  3.0 0.35  32031  14K 4144
16:28:00   63   35 16.0  2.6 0.54  11605  14K 4052
16:27:00   64   36 19.0  2.9 1.36  35700  12K 3198
16:26:00   63   33 20.0  2.8 1.06  21455  12K 3352
16:25:00   63   34 21.0  3.7 0.46  11526  13K 3322
16:24:00   63   41 20.0  8.1 0.51  18418 8547 2389
```

thrashing