Dynamic Features of Linux on System z

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August 10th, 2011
Session Number 9878

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Agenda

- Uses of Dynamic Resource Configuration
- Dynamically Adding Memory Resources to Linux
- Dynamically Adding Virtual CP Resources to Linux
- Automated Adjustment of CP and Memory Resources (CPU Hotplug)
- Linux on System z Suspend & Resume

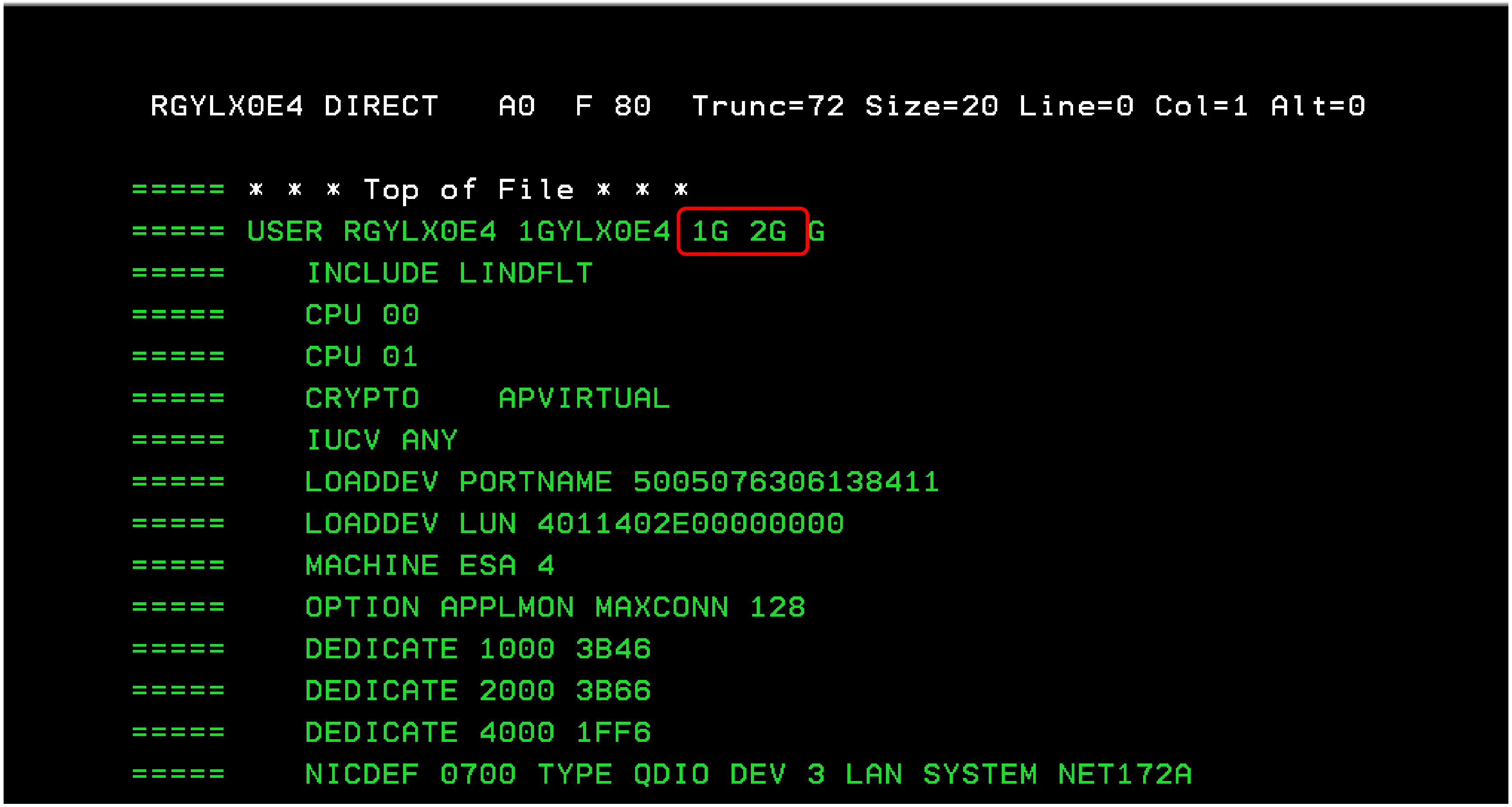
Uses of dynamic resource configuration

- Helps to avoid Linux guest restarts and potential outage/downtime resource allocation changes
- Accommodate unplanned increases in application workload demands
- It can allow for more efficient overall Hypervisor operation (reduced overhead)
- Automated policy based reconfiguration more responsive than manual adjustments.

“Hotplug Memory”

- You can dynamically increase/decrease the memory for your running Linux guest system.
- To make memory available as hotplug memory you must define it to your LPAR or z/VM.
- Hotplug memory is supported by z/VM 5.4 with the PTF for APAR VM64524 and by later z/VM versions.

Dynamically Adding Memory

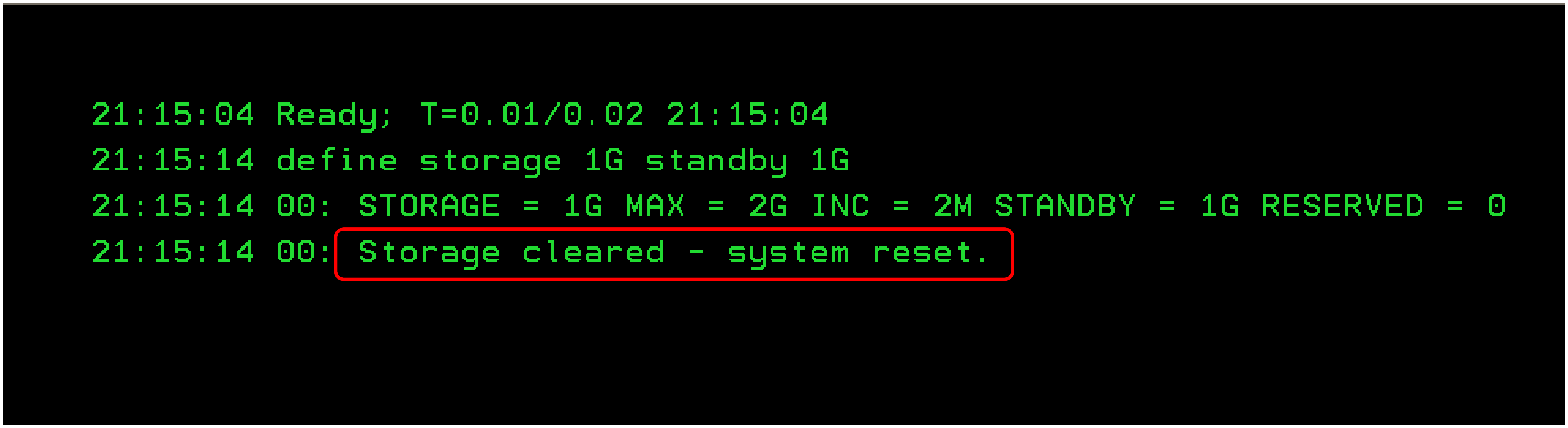


```
  RGYLX0E4 DIRECT   A0  F 80  Trunc=72 Size=20 Line=0 Col=1 Alt=0

===== * * * Top of File * * *
===== USER RGYLX0E4 1GYLX0E4 1G 2G G
=====    INCLUDE LINDFLT
=====    CPU 00
=====    CPU 01
=====    CRYPTO    APVIRTUAL
=====    IUCV ANY
=====    LOADDEV PORTNAME 5005076306138411
=====    LOADDEV LUN 4011402E00000000
=====    MACHINE ESA 4
=====    OPTION APPLMON MAXCONN 128
=====    DEDICATE 1000 3B46
=====    DEDICATE 2000 3B66
=====    DEDICATE 4000 1FF6
=====    NICDEF 0700 TYPE QDIO DEV 3 LAN SYSTEM NET172A
```

Dynamically Adding Memory

- This z/VM guest has a user directory entry with 1GB of initial memory and 2 GB of maximum memory
- In z/VM, changing the memory size or configuration of a guest causes a storage reset
- If you are running Linux natively in an LPAR without z/VM, you would use reserved storage in the LPAR definition to set aside potential additional memory
- In z/VM, define the memory to be dynamically enabled as “standby” storage

Dynamically Adding Memory



```
21:15:04 Ready; T=0.01/0.02 21:15:04
21:15:14 define storage 1G standby 1G
21:15:14 00: STORAGE = 1G MAX = 2G INC = 2M STANDBY = 1G RESERVED = 0
21:15:14 00: Storage cleared - system reset.
```

Dynamically Adding Memory

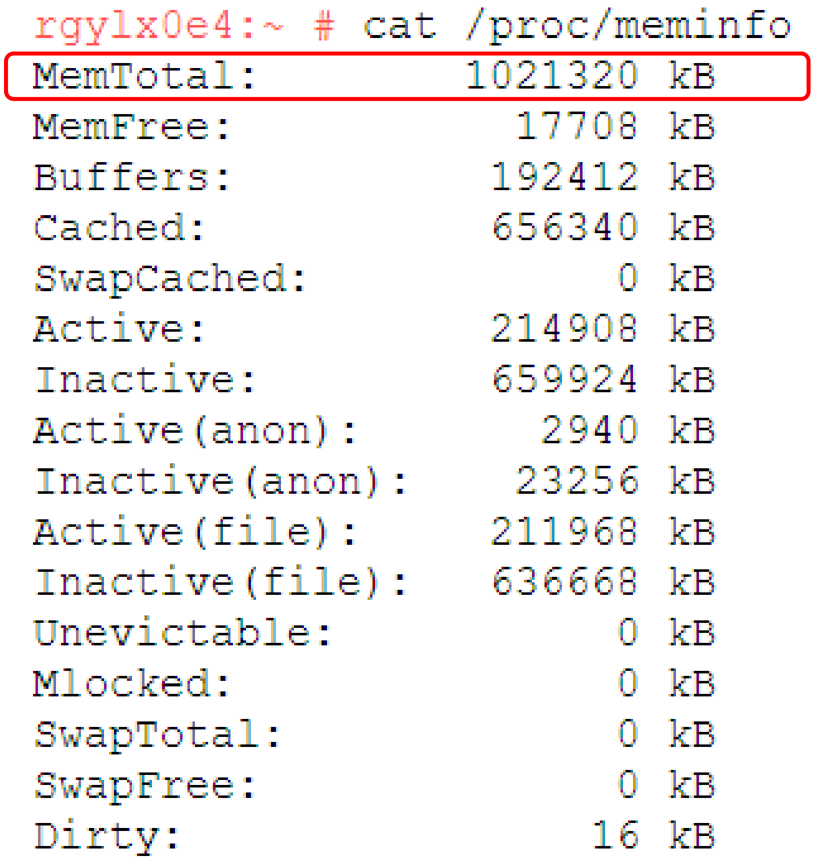
- “`DEFINE STORAGE 1G STANDBY 1G`” issued for this guest
- Issuing a DEFINE STORAGE command causes storage to be cleared
- Anything running at the time of the reset will be immediately terminated without running any shutdown procedures
- This means if you issued this command from a CMS EXEC, CMS is no longer running because storage has been cleared.

Dynamically Adding Memory

- Example of **IPL** and **define storage** commands in PROFILE EXEC:

```
IPLLNX:
   CALL DIAG 8,'DEFINE STORAGE 1G STANDBY  1G '
  '15'X,
        'IPL 200 ' '15'X
        'CP MSG * IPL 200'
   return
```

Dynamically Adding Memory

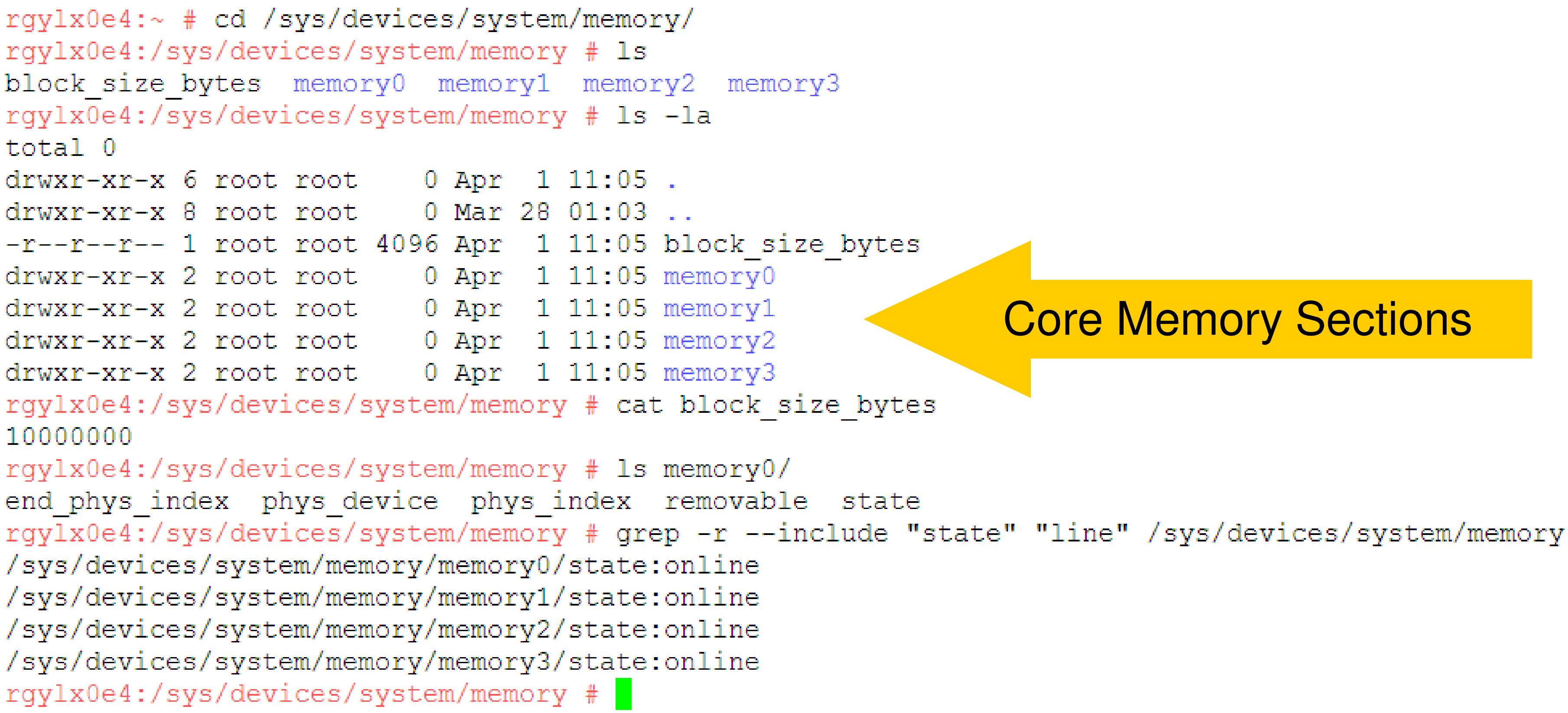


```
rgylx0e4:~ # cat /proc/meminfo
MemTotal:        1021320 kB
MemFree:           17708 kB
Buffers:          192412 kB
Cached:           656340 kB
SwapCached:            0 kB
Active:           214908 kB
Inactive:         659924 kB
Active(anon):       2940 kB
Inactive(anon):    23256 kB
Active(file):     211968 kB
Inactive(file):   636668 kB
Unevictable:           0 kB
Mlocked:               0 kB
SwapTotal:             0 kB
SwapFree:              0 kB
Dirty:                16 kB
```

Dynamically Adding Memory

- After IPLing Linux in this guest, observe via /proc/meminfo that approximately 1GB of memory is available
- The “standby” memory is not reported by /proc/meminfo
- The /sys file system however has an awareness of this “standby” or “hot plug” memory
- With current level of s390-tools, lsmem can be used to report this information and chmem to bring elements online or offline

Dynamically Adding Memory



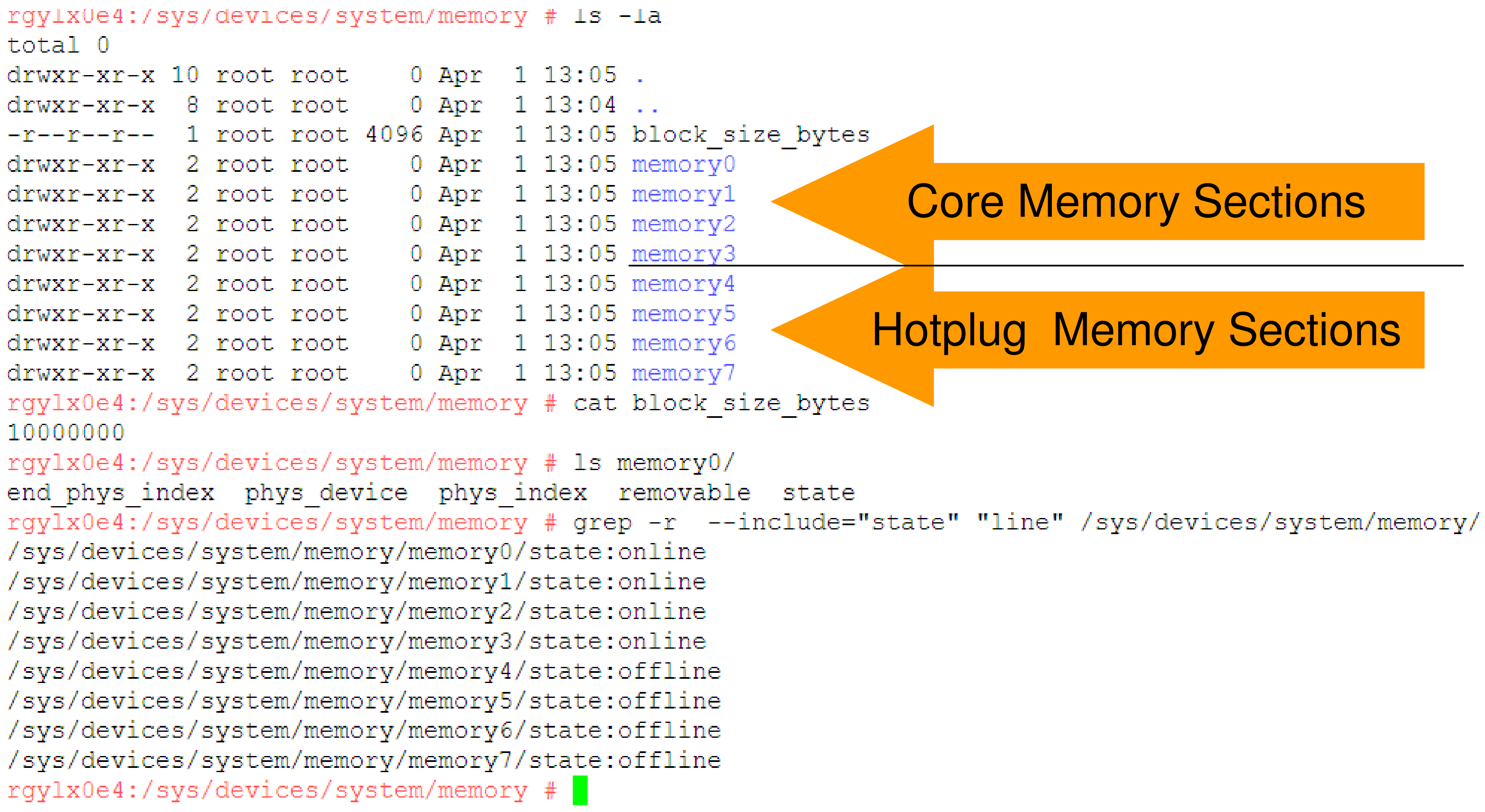
```
rgylx0e4:~ # cd /sys/devices/system/memory/
rgylx0e4:/sys/devices/system/memory # ls
block_size_bytes  memory0  memory1  memory2  memory3
rgylx0e4:/sys/devices/system/memory # ls -la
total 0
drwxr-xr-x 6 root root    0 Apr  1 11:05 .
drwxr-xr-x 8 root root    0 Mar 28 01:03 ..
-r--r--r-- 1 root root 4096 Apr  1 11:05 block_size_bytes
drwxr-xr-x 2 root root    0 Apr  1 11:05 memory0
drwxr-xr-x 2 root root    0 Apr  1 11:05 memory1
drwxr-xr-x 2 root root    0 Apr  1 11:05 memory2
drwxr-xr-x 2 root root    0 Apr  1 11:05 memory3
rgylx0e4:/sys/devices/system/memory # cat block_size_bytes
10000000
rgylx0e4:/sys/devices/system/memory # ls memory0/
end_phys_index  phys_device  phys_index  removable  state
rgylx0e4:/sys/devices/system/memory # grep -r --include "state" "line" /sys/devices/system/memory
/sys/devices/system/memory/memory0/state:online
/sys/devices/system/memory/memory1/state:online
/sys/devices/system/memory/memory2/state:online
/sys/devices/system/memory/memory3/state:online
rgylx0e4:/sys/devices/system/memory #
```

Core Memory Sections

Dynamically Adding Memory

- When no standby memory is defined, only the 4 “**core**” memory sections exist
- No hotplug memory sections currently exist
- The next slide will show an example of /sys/devices/system/memory with **hotplug** memory sections available.

Dynamically Adding Memory



```
rgylx0e4:/sys/devices/system/memory # ls -la
total 0
drwxr-xr-x 10 root root    0 Apr  1 13:05 .
drwxr-xr-x  8 root root    0 Apr  1 13:04 ..
-r--r--r--  1 root root 4096 Apr  1 13:05 block_size_bytes
drwxr-xr-x  2 root root    0 Apr  1 13:05 memory0
drwxr-xr-x  2 root root    0 Apr  1 13:05 memory1
drwxr-xr-x  2 root root    0 Apr  1 13:05 memory2
drwxr-xr-x  2 root root    0 Apr  1 13:05 memory3
drwxr-xr-x  2 root root    0 Apr  1 13:05 memory4
drwxr-xr-x  2 root root    0 Apr  1 13:05 memory5
drwxr-xr-x  2 root root    0 Apr  1 13:05 memory6
drwxr-xr-x  2 root root    0 Apr  1 13:05 memory7
rgylx0e4:/sys/devices/system/memory # cat block_size_bytes
10000000
rgylx0e4:/sys/devices/system/memory # ls memory0/
end_phys_index  phys_device  phys_index  removable  state
rgylx0e4:/sys/devices/system/memory # grep -r  --include="state" "line" /sys/devices/system/memory/
/sys/devices/system/memory/memory0/state:online
/sys/devices/system/memory/memory1/state:online
/sys/devices/system/memory/memory2/state:online
/sys/devices/system/memory/memory3/state:online
/sys/devices/system/memory/memory4/state:offline
/sys/devices/system/memory/memory5/state:offline
/sys/devices/system/memory/memory6/state:offline
/sys/devices/system/memory/memory7/state:offline
rgylx0e4:/sys/devices/system/memory # 
```

Core Memory Sections

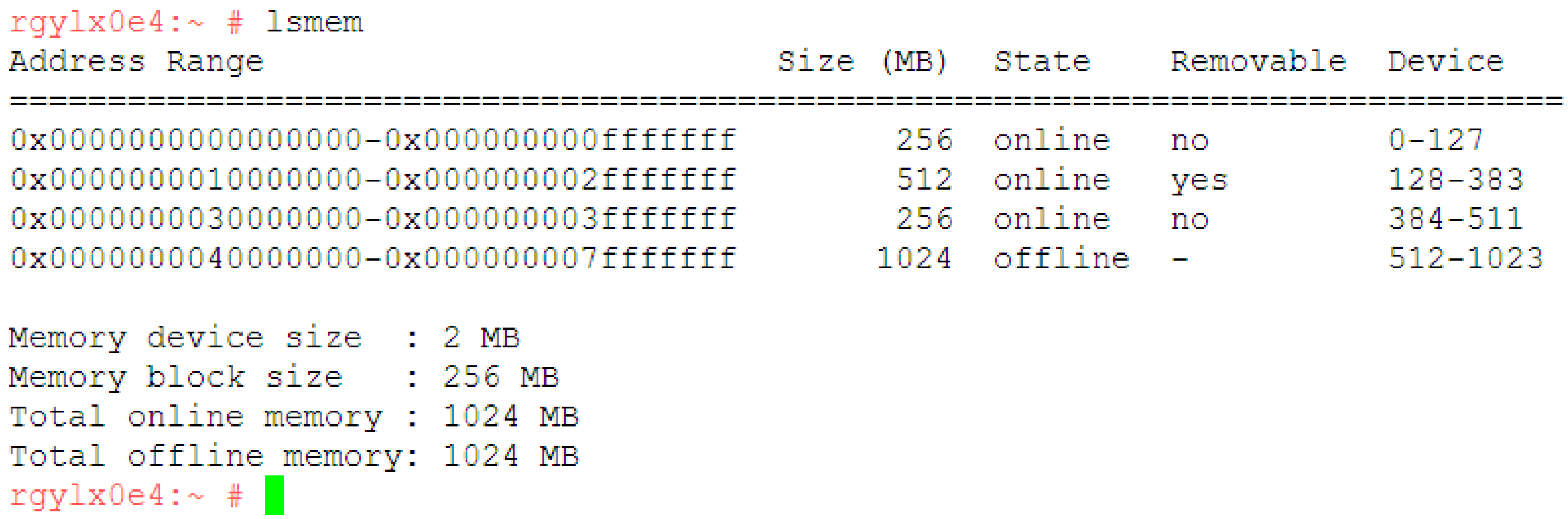
Hotplug Memory Sections

Dynamically Adding Memory

- /sys/devices/system/memory shows the eight “sections”.
- Linux allocates the initially allocated memory as “Core” memory. This is divided in to 4 sections
- The additional memory that can be added is “Hotplug” memory.   This is also divided in to 4 sections
- The state of each memory section can be queried or set
- The size of each section is documented in the “block_size_bytes” file

Dynamically Adding Memory

11.1

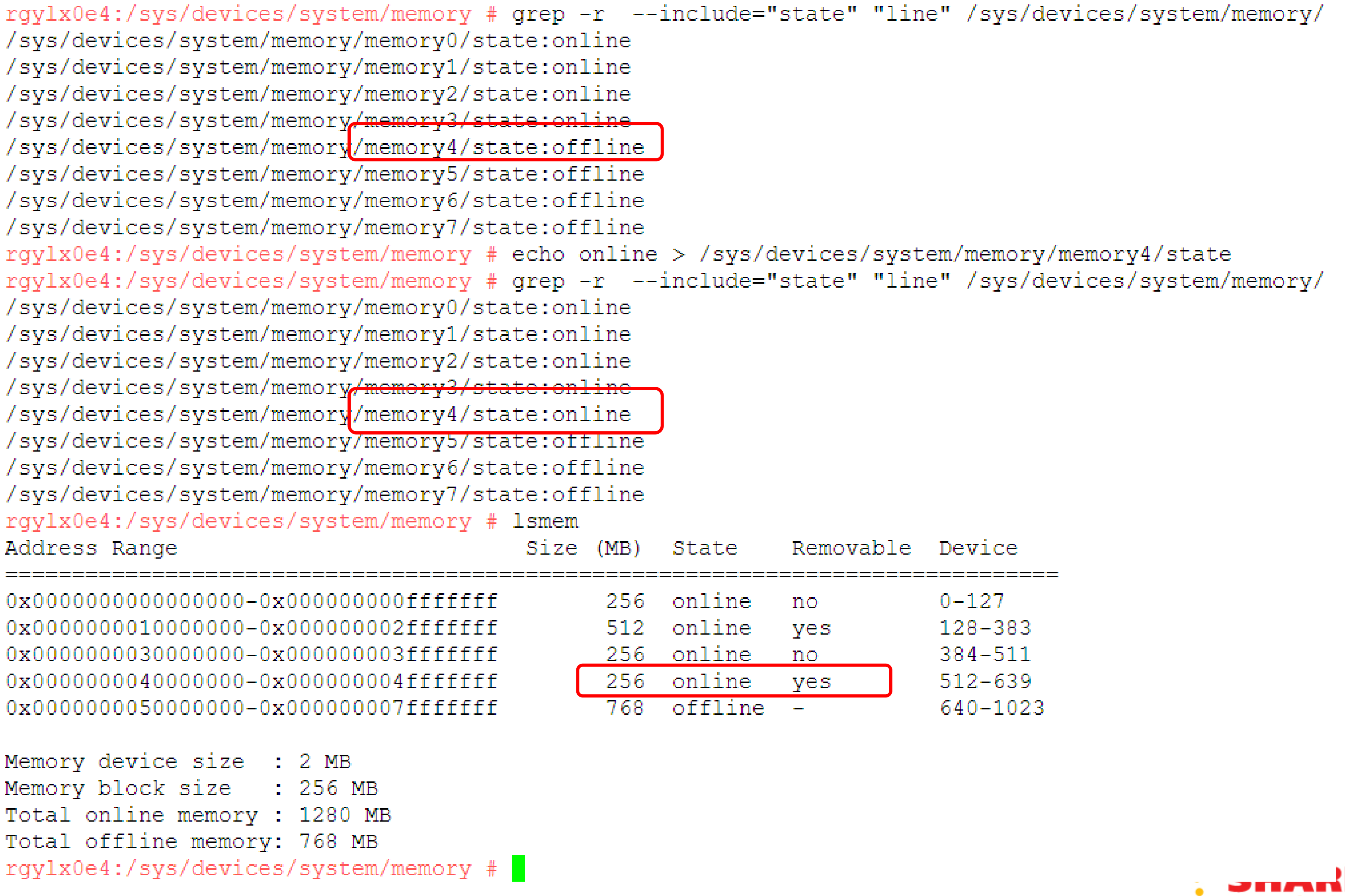


```
rgylx0e4:~ # lsmem
Address Range                                      Size (MB)  State    Removable  Device
===============================================================================
0x0000000000000000-0x000000000fffffff                  256  online   no         0-127
0x0000000010000000-0x000000002fffffff                  512  online   yes        128-383
0x0000000030000000-0x000000003fffffff                  256  online   no         384-511
0x0000000040000000-0x000000007fffffff                 1024  offline  -          512-1023

Memory device size  : 2 MB
Memory block size   : 256 MB
Total online memory : 1024 MB
Total offline memory: 1024 MB
rgylx0e4:~ #
```

Dynamically Adding Memory

- Recent versions of s390-tools include the **lsmem** command
- **lsmem** provides a quick easily readable view of the same information that is in /sys/devices/system/memory directory. It details:
    - Which memory ranges are online or offline
    - Which memory is removable
    - The size of each range
    - The total memory online & offline
    - The memory section block size

Dynamically Adding Memory

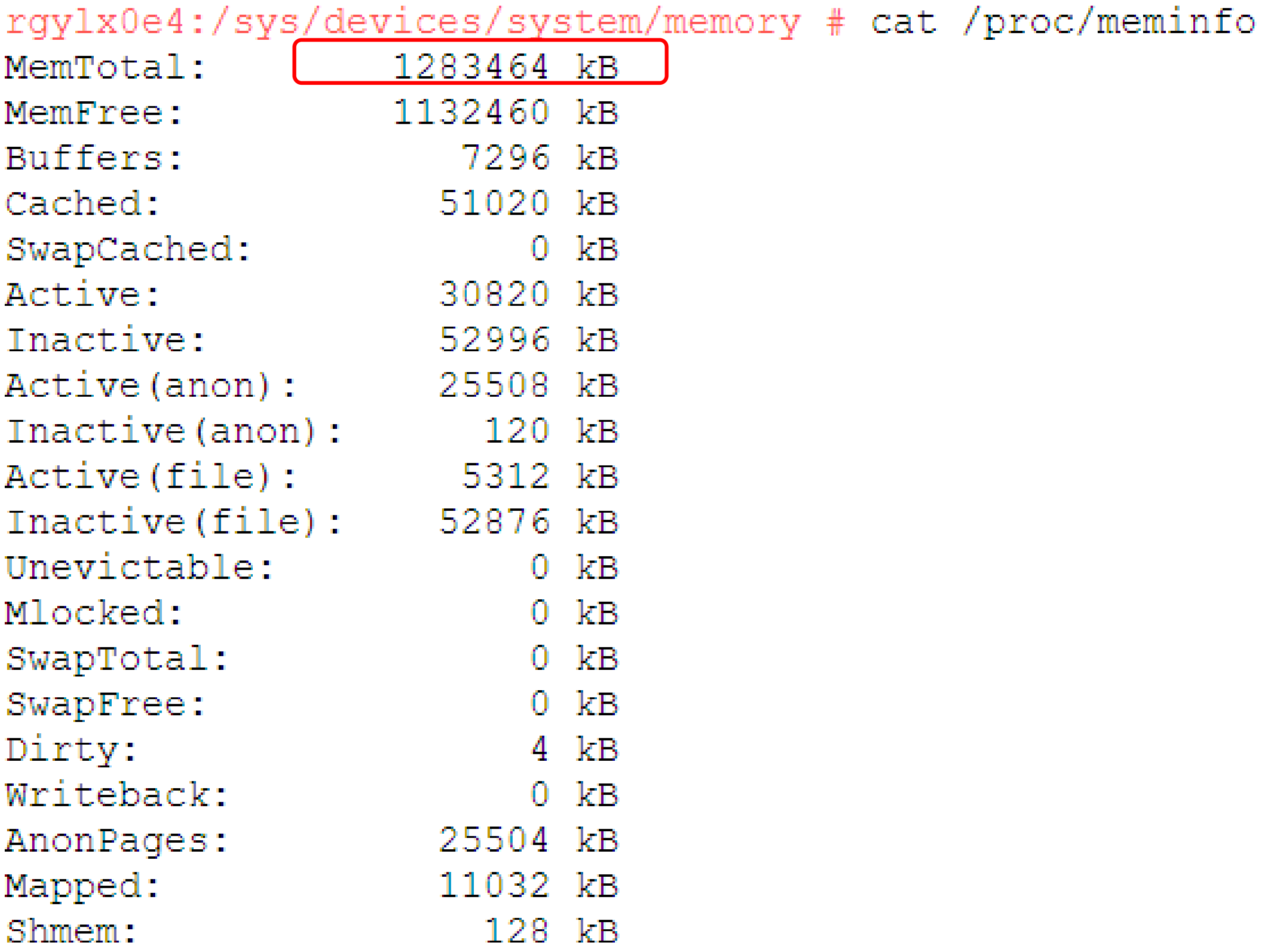


```
rgylx0e4:/sys/devices/system/memory # grep -r  --include="state" "line" /sys/devices/system/memory/
/sys/devices/system/memory/memory0/state:online
/sys/devices/system/memory/memory1/state:online
/sys/devices/system/memory/memory2/state:online
/sys/devices/system/memory/memory3/state:online
/sys/devices/system/memory/memory4/state:offline
/sys/devices/system/memory/memory5/state:offline
/sys/devices/system/memory/memory6/state:offline
/sys/devices/system/memory/memory7/state:offline
rgylx0e4:/sys/devices/system/memory # echo online > /sys/devices/system/memory/memory4/state
rgylx0e4:/sys/devices/system/memory # grep -r  --include="state" "line" /sys/devices/system/memory/
/sys/devices/system/memory/memory0/state:online
/sys/devices/system/memory/memory1/state:online
/sys/devices/system/memory/memory2/state:online
/sys/devices/system/memory/memory3/state:online
/sys/devices/system/memory/memory4/state:online
/sys/devices/system/memory/memory5/state:offline
/sys/devices/system/memory/memory6/state:offline
/sys/devices/system/memory/memory7/state:offline
rgylx0e4:/sys/devices/system/memory # lsmem
Address Range                          Size (MB)  State    Removable  Device
===============================================================================
0x0000000000000000-0x000000000fffffff        256  online   no         0-127
0x0000000010000000-0x000000002fffffff        512  online   yes        128-383
0x0000000030000000-0x000000003fffffff        256  online   no         384-511
0x0000000040000000-0x000000004fffffff        256  online   yes        512-639
0x0000000050000000-0x000000007fffffff        768  offline  -          640-1023

Memory device size  : 2 MB
Memory block size   : 256 MB
Total online memory : 1280 MB
Total offline memory: 768 MB
rgylx0e4:/sys/devices/system/memory #
```

Dynamically Adding Memory

- One of the four hotplug memory sections is enabled by echoing “online” in to the state file.
- lsmem shows 256 MB of hotplug memory enabled and 1280MB now online

Dynamically Adding Memory

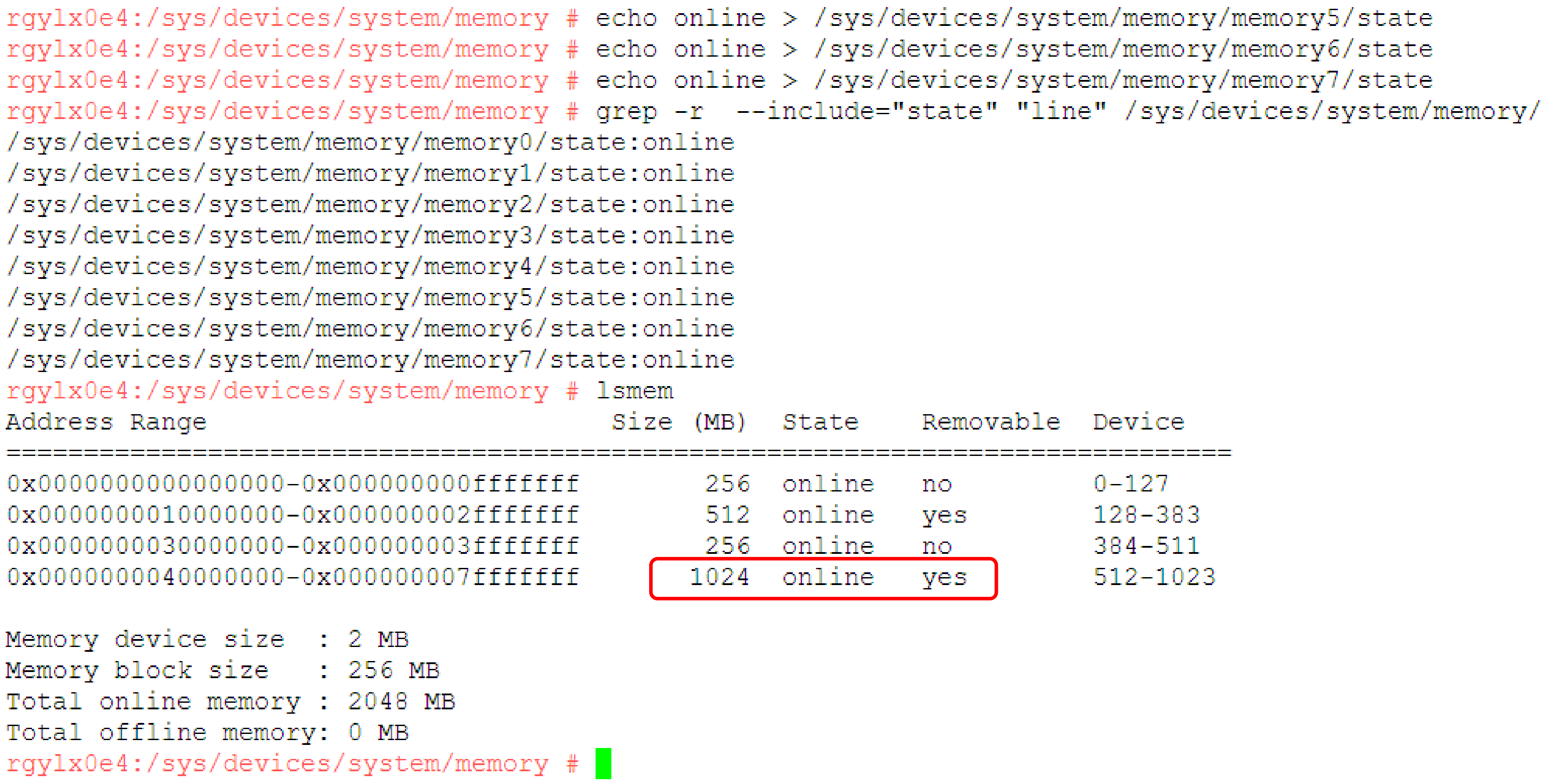


```
rgylx0e4:/sys/devices/system/memory # cat /proc/meminfo
MemTotal:        1283464 kB
MemFree:         1132460 kB
Buffers:            7296 kB
Cached:            51020 kB
SwapCached:            0 kB
Active:            30820 kB
Inactive:          52996 kB
Active(anon):      25508 kB
Inactive(anon):      120 kB
Active(file):       5312 kB
Inactive(file):    52876 kB
Unevictable:           0 kB
Mlocked:               0 kB
SwapTotal:             0 kB
SwapFree:              0 kB
Dirty:                 4 kB
Writeback:             0 kB
AnonPages:         25504 kB
Mapped:            11032 kB
Shmem:               128 kB
```

Dynamically Adding Memory

- After enabling one memory section /proc/meminfo shows an additional 250MB of memory
- This is 1/4th of our standby memory we defined with the DEFINE STORAGE command earlier
- Since we have 4 storage “sections” to represent the standby memory this amount is correct

Dynamically Adding Memory

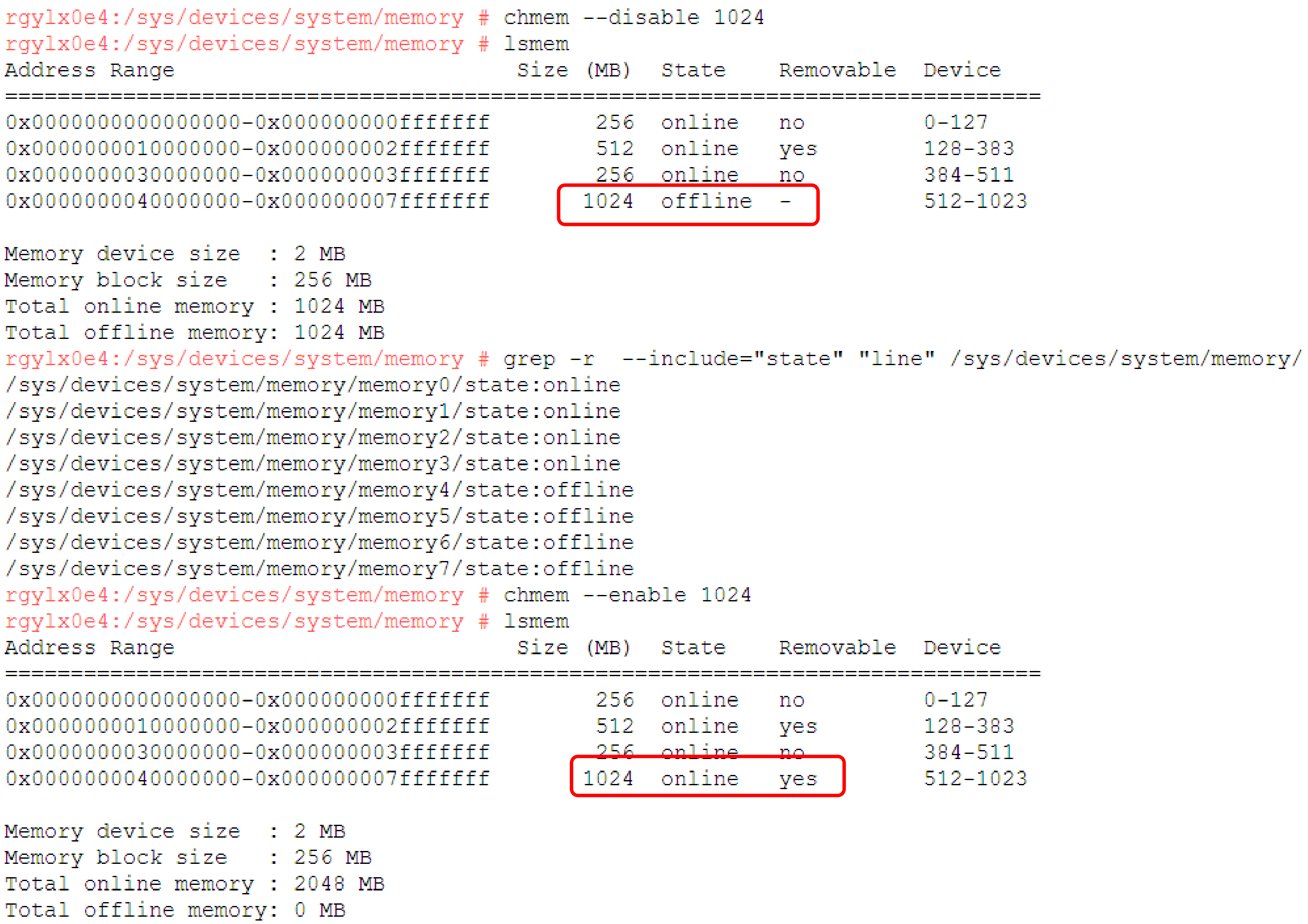


```
rgylx0e4:/sys/devices/system/memory # echo online > /sys/devices/system/memory/memory5/state
rgylx0e4:/sys/devices/system/memory # echo online > /sys/devices/system/memory/memory6/state
rgylx0e4:/sys/devices/system/memory # echo online > /sys/devices/system/memory/memory7/state
rgylx0e4:/sys/devices/system/memory # grep -r  --include="state" "line" /sys/devices/system/memory/
/sys/devices/system/memory/memory0/state:online
/sys/devices/system/memory/memory1/state:online
/sys/devices/system/memory/memory2/state:online
/sys/devices/system/memory/memory3/state:online
/sys/devices/system/memory/memory4/state:online
/sys/devices/system/memory/memory5/state:online
/sys/devices/system/memory/memory6/state:online
/sys/devices/system/memory/memory7/state:online
rgylx0e4:/sys/devices/system/memory # lsmem
Address Range                          Size (MB)  State    Removable  Device
===============================================================================
0x0000000000000000-0x000000000fffffff        256  online   no         0-127
0x0000000010000000-0x000000002fffffff        512  online   yes        128-383
0x0000000030000000-0x000000003fffffff        256  online   no         384-511
0x0000000040000000-0x000000007fffffff       1024  online   yes        512-1023

Memory device size  : 2 MB
Memory block size   : 256 MB
Total online memory : 2048 MB
Total offline memory: 0 MB
rgylx0e4:/sys/devices/system/memory # 
```

Dynamically Adding Memory

- echo online is issued for the remaining 3 storage elements
- After enabling all the hotplug memory sections we should see a full 2GB of memory reported
- The full 2GB of memory is now reported by /proc/meminfo

Dynamically Remove/Add Memory



```
rgylx0e4:/sys/devices/system/memory # chmem --disable 1024
rgylx0e4:/sys/devices/system/memory # lsmem
Address Range                          Size (MB)  State    Removable  Device
==============================================================================
0x0000000000000000-0x000000000fffffff        256  online   no         0-127
0x0000000010000000-0x000000002fffffff        512  online   yes        128-383
0x0000000030000000-0x000000003fffffff        256  online   no         384-511
0x0000000040000000-0x000000007fffffff       1024  offline  -          512-1023

Memory device size  : 2 MB
Memory block size   : 256 MB
Total online memory : 1024 MB
Total offline memory: 1024 MB
rgylx0e4:/sys/devices/system/memory # grep -r  --include="state" "line" /sys/devices/system/memory/
/sys/devices/system/memory/memory0/state:online
/sys/devices/system/memory/memory1/state:online
/sys/devices/system/memory/memory2/state:online
/sys/devices/system/memory/memory3/state:online
/sys/devices/system/memory/memory4/state:offline
/sys/devices/system/memory/memory5/state:offline
/sys/devices/system/memory/memory6/state:offline
/sys/devices/system/memory/memory7/state:offline
rgylx0e4:/sys/devices/system/memory # chmem --enable 1024
rgylx0e4:/sys/devices/system/memory # lsmem
Address Range                          Size (MB)  State    Removable  Device
==============================================================================
0x0000000000000000-0x000000000fffffff        256  online   no         0-127
0x0000000010000000-0x000000002fffffff        512  online   yes        128-383
0x0000000030000000-0x000000003fffffff        256  online   no         384-511
0x0000000040000000-0x000000007fffffff       1024  online   yes        512-1023

Memory device size  : 2 MB
Memory block size   : 256 MB
Total online memory : 2048 MB
Total offline memory: 0 MB
```

Dynamically Adding Memory

- The memory sections can be set online or offline via the chmem command instead of echoing in to the “state” file
- lsmem will reported the memory sections in an accumulated fashion when the attributes are the same
- Not all memory sections will be removable, and the removable state can change over time

Summary of Memory Hotplug

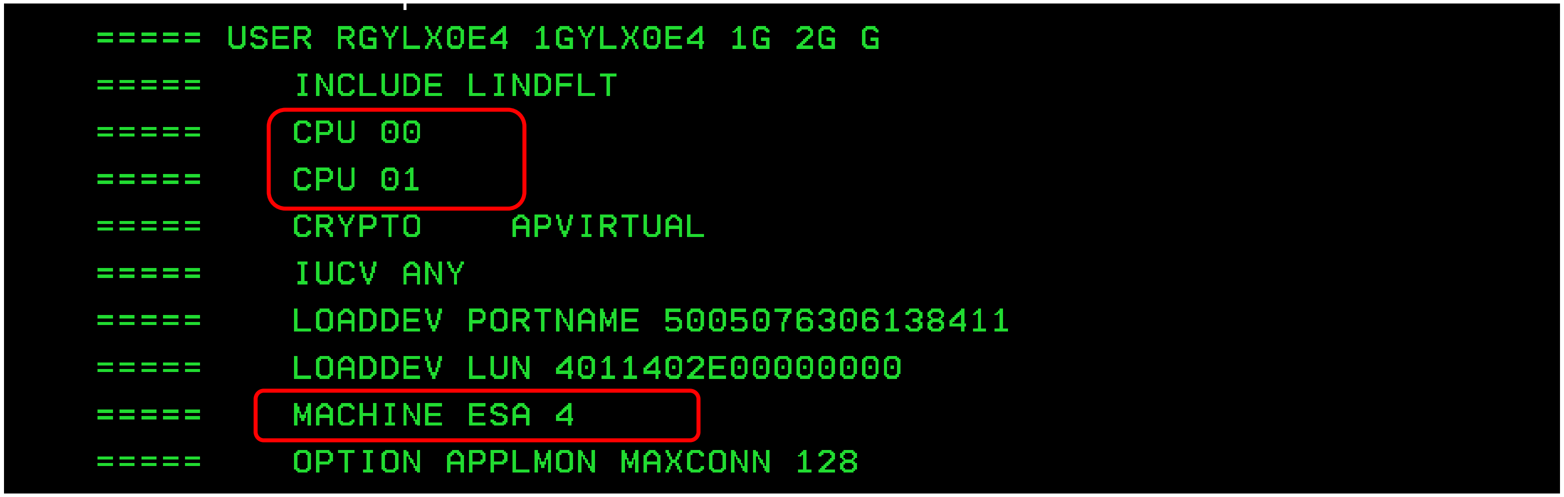
- Utilizing hotplug memory does require some advanced planning:
  - z/VM 5.4 with VM64524 or above
  - DEFINE STORAGE STANDBY issued before Linux is IPLed
  - For native LPAR, RESERVED STORAGE must be defined
  - SLES 11 / RHEL 6
- Suspend/Resume restriction: The Linux instance must not have used any hotplug memory since it was last booted.
- You may not be able to disable hotplug memory that has been enabled

Summary of Memory Hotplug

- Can be very helpful when exact future memory need is unknown, without over allocating online memory from the start.
- After a Linux reboot core memory is made available again and hotplug memory is freed

Dynamically Managing Virtual CPs from Linux

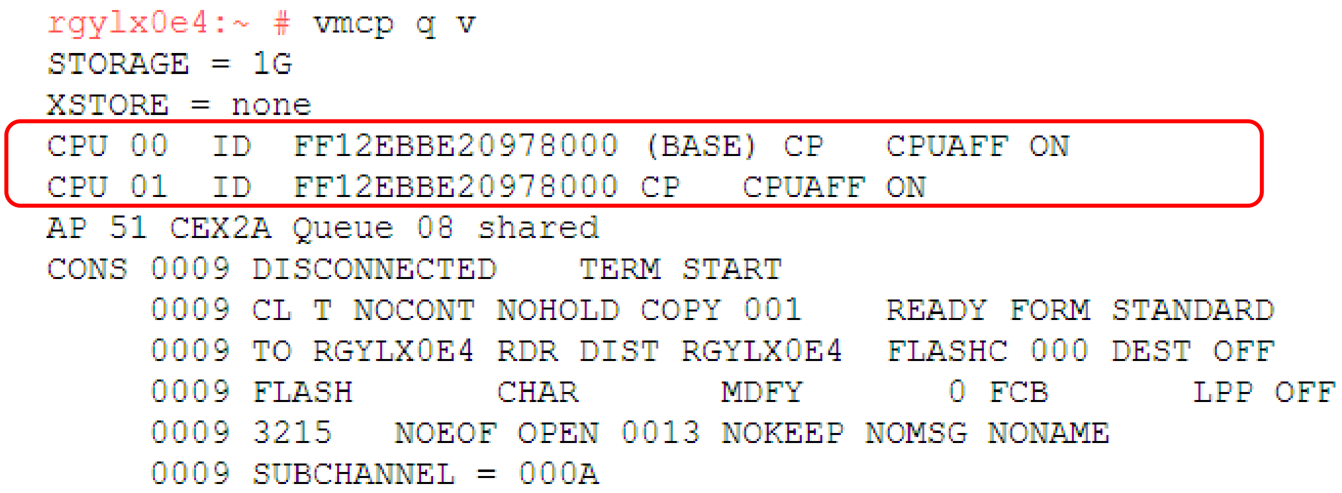
Dynamically Managing Virtual CPs



```
===== USER RGYLX0E4 1GYLX0E4 1G 2G G
=====    INCLUDE LINDFLT
=====    CPU 00
=====    CPU 01
=====    CRYPTO     APVIRTUAL
=====    IUCV ANY
=====    LOADDEV PORTNAME 5005076306138411
=====    LOADDEV LUN 4011402E00000000
=====    MACHINE ESA 4
=====    OPTION APPLMON MAXCONN 128
```

- The directory entry shows a guest with two initial virtual CPs
- The maximum potential virtual CPs shown is four
- z/VM does not make the additional potential virtual CPs available for Linux to enable on its own
- The additional potential virtual CPs must first be **defined** in the z/VM guest before dynamically enabling on Linux

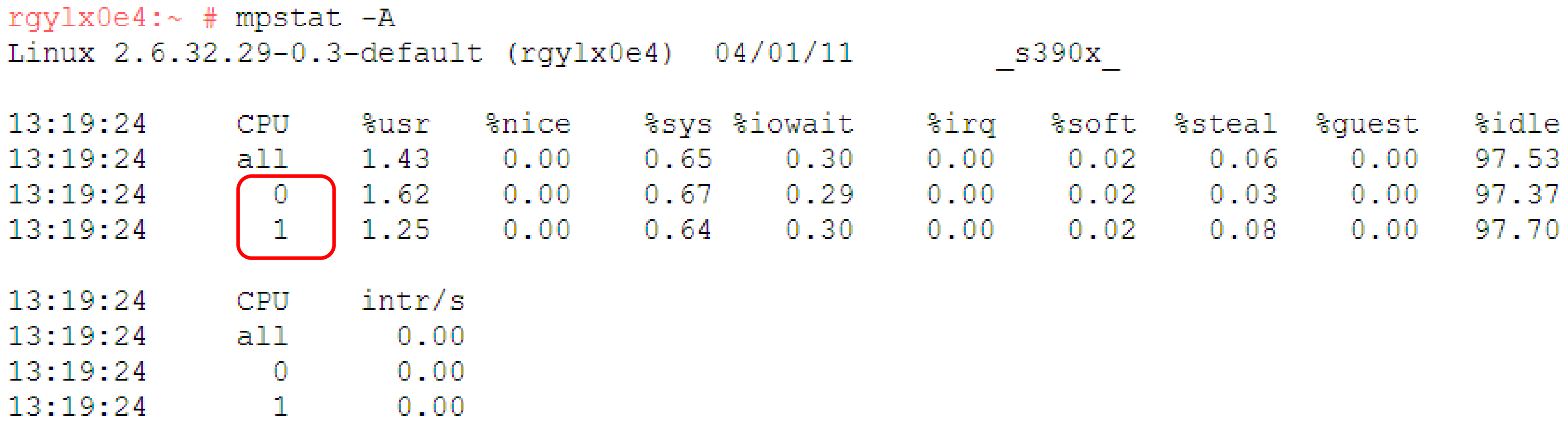
Dynamically Managing Virtual CPs



```
rgylx0e4:~ # vmcp q v
STORAGE = 1G
XSTORE = none
CPU 00  ID  FF12EBBE20978000 (BASE) CP   CPUAFF ON
CPU 01  ID  FF12EBBE20978000 CP   CPUAFF ON
AP 51 CEX2A Queue 08 shared
CONS 0009 DISCONNECTED    TERM START
     0009 CL T NOCONT NOHOLD COPY 001    READY FORM STANDARD
     0009 TO RGYLX0E4 RDR DIST RGYLX0E4  FLASHC 000 DEST OFF
     0009 FLASH       CHAR       MDFY        0 FCB      LPP OFF
     0009 3215   NOEOF OPEN 0013 NOKEEP NOMSG NONAME
     0009 SUBCHANNEL = 000A
```

- Here the current z/VM guests virtual resources are displayed from within Linux
- The two initial and active virtual CPs are shown
- Notice there is no information displayed about the potential additional virtual CPs

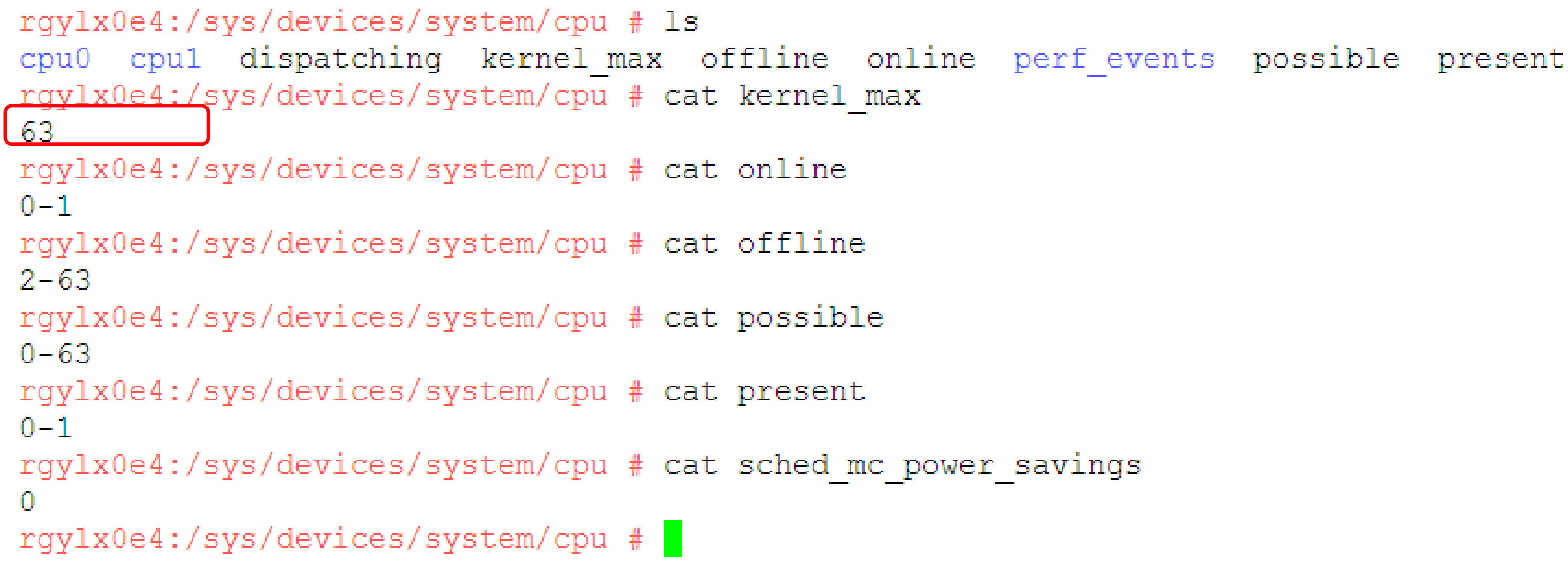
Dynamically Managing Virtual CPs



```
rgylx0e4:~ # mpstat -A
Linux 2.6.32.29-0.3-default (rgylx0e4)  04/01/11        _s390x_

13:19:24     CPU    %usr   %nice    %sys %iowait    %irq   %soft  %steal  %guest   %idle
13:19:24     all    1.43    0.00    0.65    0.30    0.00    0.02    0.06    0.00   97.53
13:19:24       0    1.62    0.00    0.67    0.29    0.00    0.02    0.03    0.00   97.37
13:19:24       1    1.25    0.00    0.64    0.30    0.00    0.02    0.08    0.00   97.70

13:19:24     CPU    intr/s
13:19:24     all      0.00
13:19:24       0      0.00
13:19:24       1      0.00
```

- Note the mpstat output from before defining the additional virtual CPs
- Observe the even distribution of idle time and usage

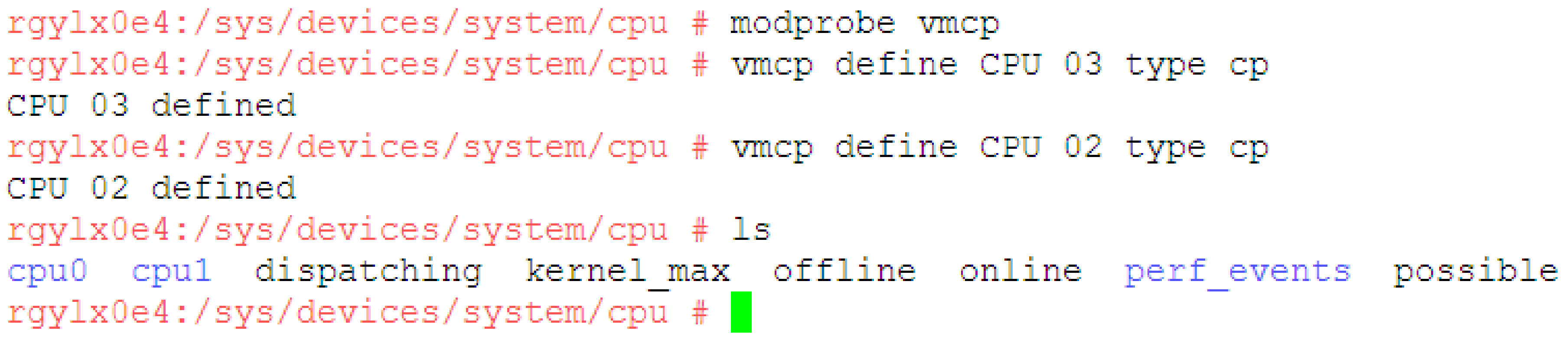
Dynamically Managing Virtual CPs



```
rgylx0e4:/sys/devices/system/cpu # ls
cpu0  cpu1  dispatching  kernel_max  offline  online  perf_events  possible  present
rgylx0e4:/sys/devices/system/cpu # cat kernel_max
63
rgylx0e4:/sys/devices/system/cpu # cat online
0-1
rgylx0e4:/sys/devices/system/cpu # cat offline
2-63
rgylx0e4:/sys/devices/system/cpu # cat possible
0-63
rgylx0e4:/sys/devices/system/cpu # cat present
0-1
rgylx0e4:/sys/devices/system/cpu # cat sched_mc_power_savings
0
rgylx0e4:/sys/devices/system/cpu # 
```

- The Linux sysfs file system can access information about the two active virtual CPs
- The kernel has a maximum potential of 64 processors
- No information about the two potential additional virtual CPs is shown yet

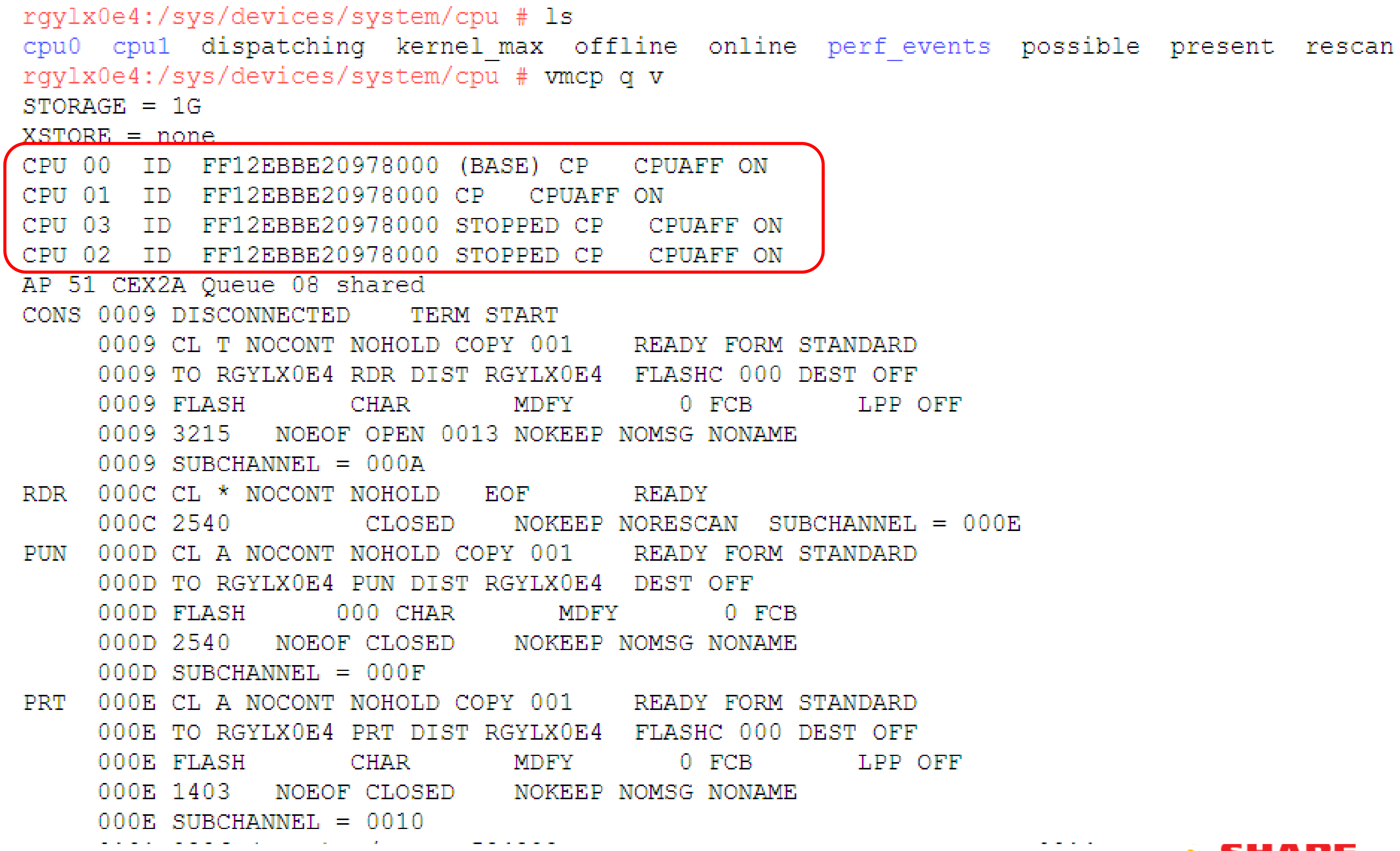
Dynamically Managing Virtual CPs



```
rgylx0e4:/sys/devices/system/cpu # modprobe vmcp
rgylx0e4:/sys/devices/system/cpu # vmcp define CPU 03 type cp
CPU 03 defined
rgylx0e4:/sys/devices/system/cpu # vmcp define CPU 02 type cp
CPU 02 defined
rgylx0e4:/sys/devices/system/cpu # ls
cpu0  cpu1  dispatching  kernel_max  offline  online  perf_events  possible
rgylx0e4:/sys/devices/system/cpu #
```

- Using the vmcp command we pass the zVM CP DEFINE CPU commands on to our z/VM guest.
- Remember this is a class G guest enabling the additional resources previously called out in the user directory
- After defining the additional virtual CPs in z/VM we still do not see them in the Linux /sysfs

Dynamically Managing Virtual CPs

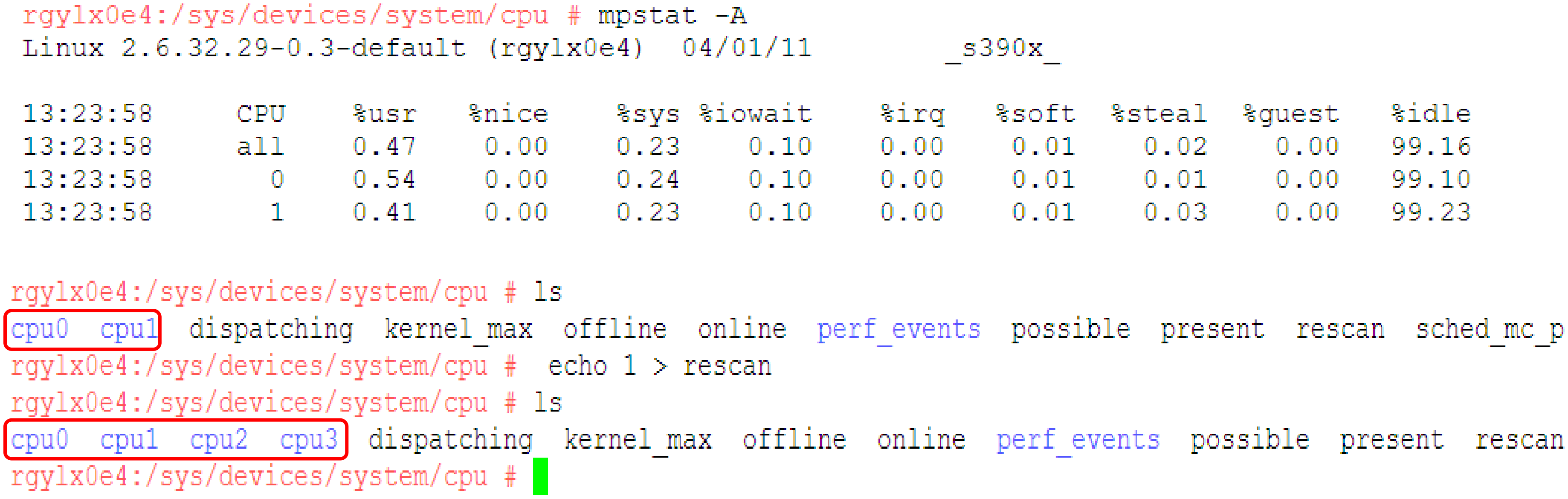


```
rgylx0e4:/sys/devices/system/cpu # ls
cpu0  cpu1  dispatching  kernel_max  offline  online  perf_events  possible  present  rescan
rgylx0e4:/sys/devices/system/cpu # vmcp q v
STORAGE = 1G
XSTORE = none
CPU 00  ID  FF12EBBE20978000 (BASE) CP   CPUAFF ON
CPU 01  ID  FF12EBBE20978000 CP   CPUAFF ON
CPU 03  ID  FF12EBBE20978000 STOPPED CP   CPUAFF ON
CPU 02  ID  FF12EBBE20978000 STOPPED CP   CPUAFF ON
AP 51 CEX2A Queue 08 shared
CONS 0009 DISCONNECTED    TERM START
     0009 CL T NOCONT NOHOLD COPY 001    READY FORM STANDARD
     0009 TO RGYLX0E4 RDR DIST RGYLX0E4  FLASHC 000 DEST OFF
     0009 FLASH       CHAR       MDFY       0 FCB       LPP OFF
     0009 3215   NOEOF OPEN 0013 NOKEEP NOMSG NONAME
     0009 SUBCHANNEL = 000A
RDR  000C CL * NOCONT NOHOLD   EOF       READY
     000C 2540         CLOSED    NOKEEP NORESCAN  SUBCHANNEL = 000E
PUN  000D CL A NOCONT NOHOLD COPY 001    READY FORM STANDARD
     000D TO RGYLX0E4 PUN DIST RGYLX0E4  DEST OFF
     000D FLASH      000 CHAR       MDFY       0 FCB
     000D 2540   NOEOF CLOSED    NOKEEP NOMSG NONAME
     000D SUBCHANNEL = 000F
PRT  000E CL A NOCONT NOHOLD COPY 001    READY FORM STANDARD
     000E TO RGYLX0E4 PRT DIST RGYLX0E4  FLASHC 000 DEST OFF
     000E FLASH       CHAR       MDFY       0 FCB       LPP OFF
     000E 1403   NOEOF CLOSED    NOKEEP NOMSG NONAME
     000E SUBCHANNEL = 0010
```

Dynamically Managing Virtual CPs

- By using the z/VM QUERY VIRTUAL command we can see the additional virtual CPs have been defined to the guest
- The new virtual CPs are in a “stopped” state

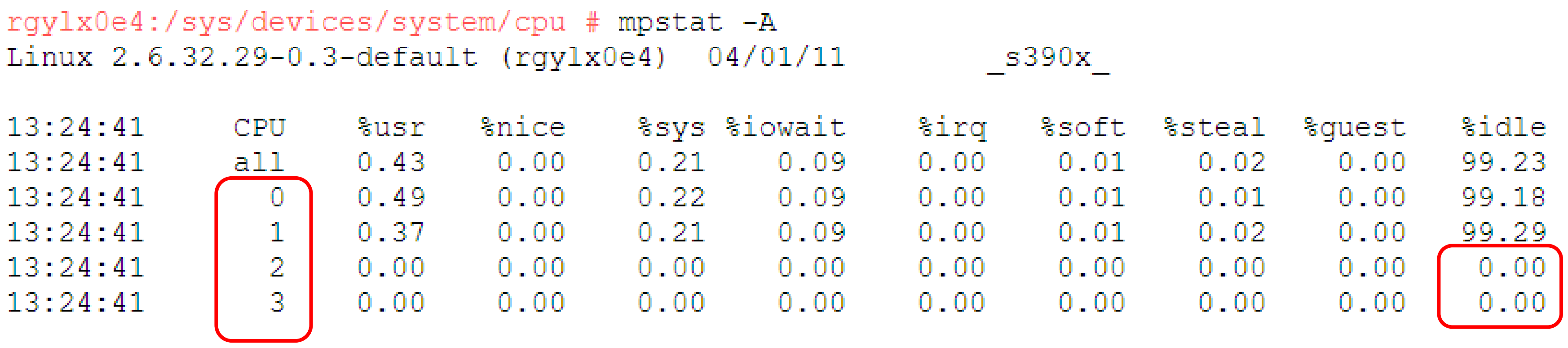
Dynamically Managing Virtual CPs



```
rgylx0e4:/sys/devices/system/cpu # mpstat -A
Linux 2.6.32.29-0.3-default (rgylx0e4)  04/01/11        _s390x_

13:23:58     CPU    %usr   %nice    %sys %iowait    %irq   %soft  %steal  %guest   %idle
13:23:58     all    0.47    0.00    0.23    0.10    0.00    0.01    0.02    0.00   99.16
13:23:58       0    0.54    0.00    0.24    0.10    0.00    0.01    0.01    0.00   99.10
13:23:58       1    0.41    0.00    0.23    0.10    0.00    0.01    0.03    0.00   99.23

rgylx0e4:/sys/devices/system/cpu # ls
cpu0  cpu1  dispatching  kernel_max  offline  online  perf_events  possible  present  rescan  sched_mc_p
rgylx0e4:/sys/devices/system/cpu #  echo 1 > rescan
rgylx0e4:/sys/devices/system/cpu # ls
cpu0  cpu1  cpu2  cpu3  dispatching  kernel_max  offline  online  perf_events  possible  present  rescan
rgylx0e4:/sys/devices/system/cpu # 
```

- mpstat is only reporting two CPUs
- The rescan operation is used to search for new available CPUs in the guest.
- After rescan, additional /sysfs entries exist

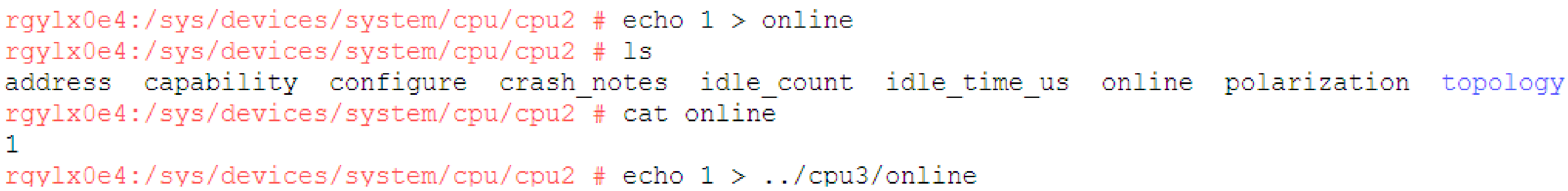
Dynamically Managing Virtual CPs



```
rgylx0e4:/sys/devices/system/cpu # mpstat -A
Linux 2.6.32.29-0.3-default (rgylx0e4)  04/01/11        _s390x_

13:24:41     CPU    %usr   %nice    %sys %iowait    %irq   %soft  %steal  %guest   %idle
13:24:41     all    0.43    0.00    0.21    0.09    0.00    0.01    0.02    0.00   99.23
13:24:41       0    0.49    0.00    0.22    0.09    0.00    0.01    0.01    0.00   99.18
13:24:41       1    0.37    0.00    0.21    0.09    0.00    0.01    0.02    0.00   99.29
13:24:41       2    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
13:24:41       3    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
```

- mpstat reports 0% use and 0% idle for the new CPUs. This is because they are stopped and offline
- The new CPUs must still be brought online to Linux

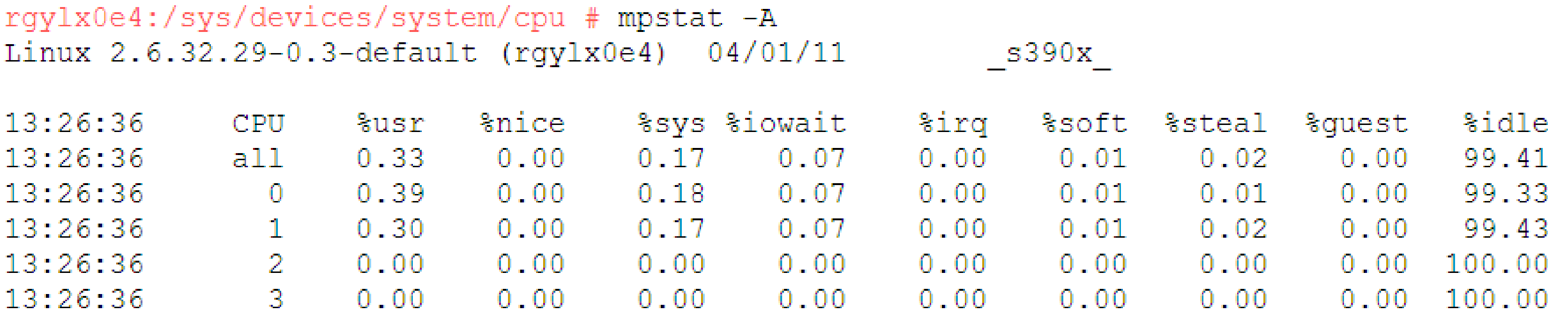
Dynamically Managing Virtual CPs



```
rgylx0e4:/sys/devices/system/cpu/cpu2 # echo 1 > online
rgylx0e4:/sys/devices/system/cpu/cpu2 # ls
address  capability  configure  crash_notes  idle_count  idle_time_us  online  polarization  topology
rgylx0e4:/sys/devices/system/cpu/cpu2 # cat online
1
rgylx0e4:/sys/devices/system/cpu/cpu2 # echo 1 > ../cpu3/online
```

- Bring the new CPUs online to Linux by echoing 1 in to the “online” file for the given CPU

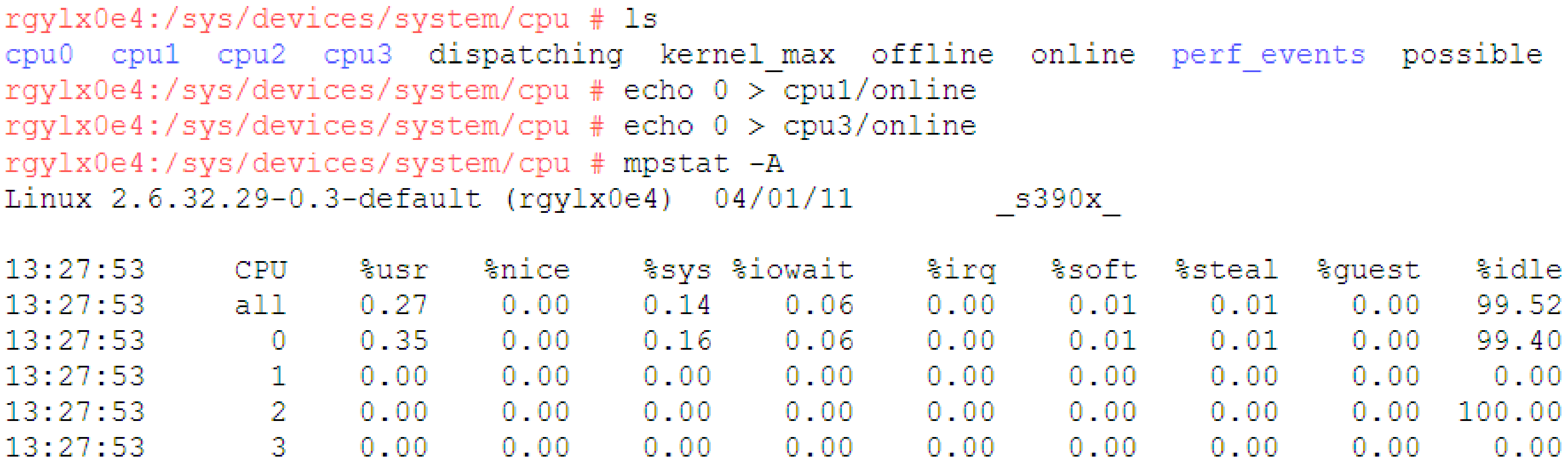
Dynamically Managing Virtual CPs



```
rgylx0e4:/sys/devices/system/cpu # mpstat -A
Linux 2.6.32.29-0.3-default (rgylx0e4)  04/01/11        _s390x_

13:26:36     CPU    %usr   %nice    %sys %iowait    %irq   %soft  %steal  %guest   %idle
13:26:36     all    0.33    0.00    0.17    0.07    0.00    0.01    0.02    0.00   99.41
13:26:36       0    0.39    0.00    0.18    0.07    0.00    0.01    0.01    0.00   99.33
13:26:36       1    0.30    0.00    0.17    0.07    0.00    0.01    0.02    0.00   99.43
13:26:36       2    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
13:26:36       3    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
```

- On a idle system, the new CPUs momentarily show 100% idle after being brought online
- Once a little bit of workload hits the system, this quickly changes

Dynamically Managing Virtual CPs



```
rgylx0e4:/sys/devices/system/cpu # ls
cpu0  cpu1  cpu2  cpu3  dispatching  kernel_max  offline  online  perf_events  possible
rgylx0e4:/sys/devices/system/cpu # echo 0 > cpu1/online
rgylx0e4:/sys/devices/system/cpu # echo 0 > cpu3/online
rgylx0e4:/sys/devices/system/cpu # mpstat -A
Linux 2.6.32.29-0.3-default (rgylx0e4)  04/01/11        _s390x_

13:27:53     CPU    %usr   %nice    %sys %iowait    %irq   %soft  %steal  %guest   %idle
13:27:53     all    0.27    0.00    0.14    0.06    0.00    0.01    0.01    0.00   99.52
13:27:53       0    0.35    0.00    0.16    0.06    0.00    0.01    0.01    0.00   99.40
13:27:53       1    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
13:27:53       2    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
13:27:53       3    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
```

Dynamically Managing Virtual CPs

- You can take offline CPUs that were initially online as well
- Some Considerations
  - Obviously multithreaded application or multiple applications in a single virtual server could potentially benefit from additional virtual CPs
  - Could impact monitor applications or middleware that might query the number of processors on startup (ie the Java Virtual Machine)
  - zVM “DEFINE CPU” is a Class G command
  - This does NOT add additional capacity to the LPAR, it simply makes resources available to the guest
  - (R.O.T.) Don’t add unnecessary virtual CPs or more virtual CPs than logical processors.

Automated Policy Based Adjustment of CPs and Memory
(The CPU Hotplug Daemon)

Automated Adjustment of CPs and Memory

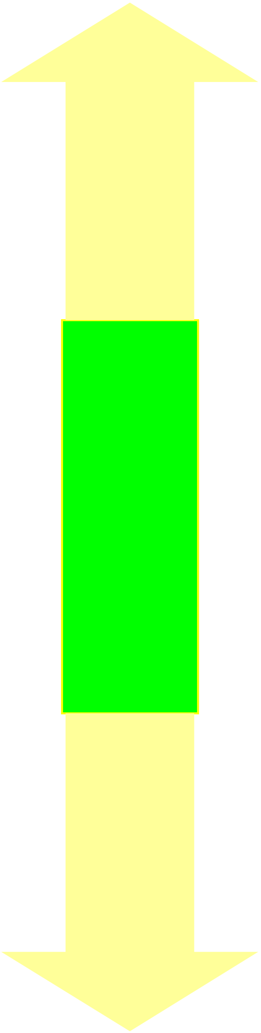
- The hot plug daemon (cpuplugd) can dynamically offline and re-online processors in Linux
- The hot plug daemon can also add and remove memory over time via CMM
- The cpuplug daemon checks the system at configurable intervals
- You must configure the plug and unplug rules for it to operate
- You must activate the cpuplug daemon to use it, by default it is inactive

Automated Adjustment of CPs and Memory

- The default rules are NOT recommendations
- You should customize the rules/configuration to fit your environment
- cpuplugd -V -f -c /etc/sysconfig/cpuplugd - This invokes cpuplugd in the foreground with verbose messaging to help you understand its operation
- It is highly recommended you customize its operation before enabling the cpuplug daemon
- It is important to understand what state you will be in after you execute a “plug” or “unplug” operation when writing the rules.

Automated Adjustment of CPs

More virtual CPs



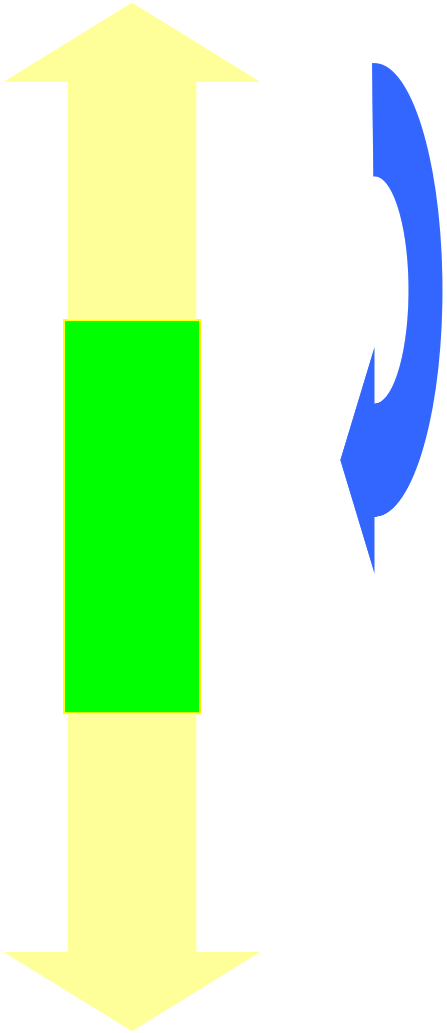
Excessive available CP capacity

Desired CP capacity

Inadequate available CP capacity

Less virtual CPs

Automated Adjustment of CPs



Excessive available CP capacity

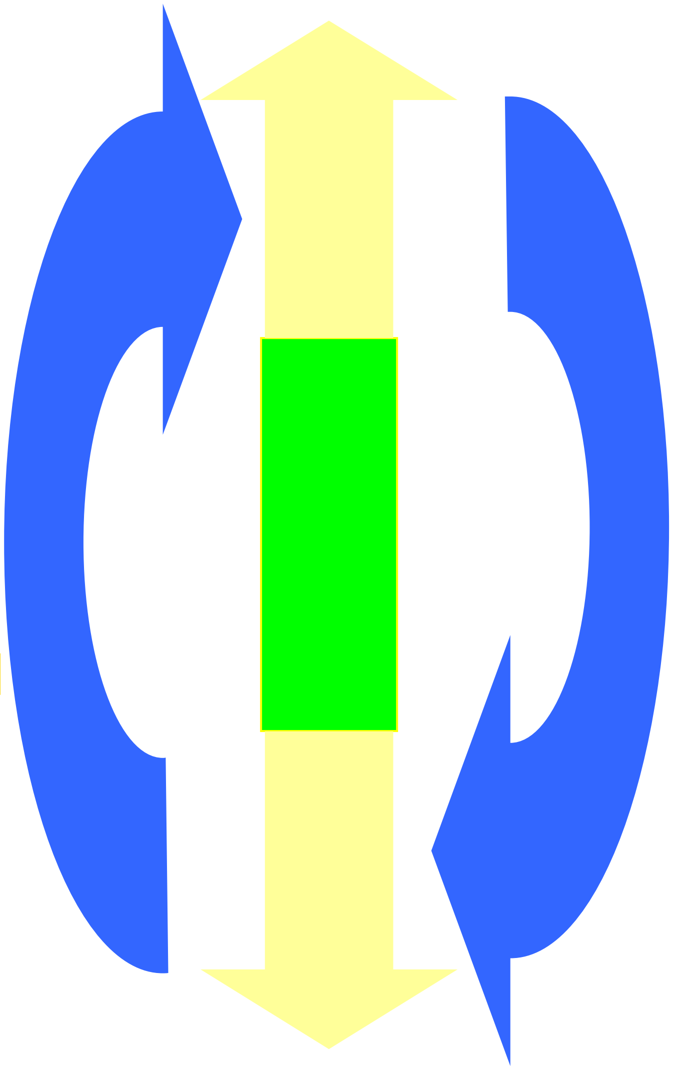
Desired CP capacity

Inadequate available CP capacity

Desired Action –

- Remove enough capacity so you are in the "green zone" after the plug rule triggers
- If resource demand is unchanged, subsequent intervals should not undo your action

Automated Adjustment of CPs



Excessive available CP capacity

Desired CP capacity

Inadequate available CP capacity

Step 2

Step 4

Step 6

Step N+1

Very likely NOT your optimal configuration

Step 1

Step3

Step 5

Step N

Automated Adjustment of CPs

- You can only add/remove a full virtual CP of capacity.
- This means at times you might have 1.25 or more virtual CPs of idle capacity as an acceptable state.
- Understand the range in which your rules are plugging and unplugging virtual CPs. It should be at least the size of one virtual CP, since that is the minimum granularity you can add or remove.

What happens if I run with the default rules?

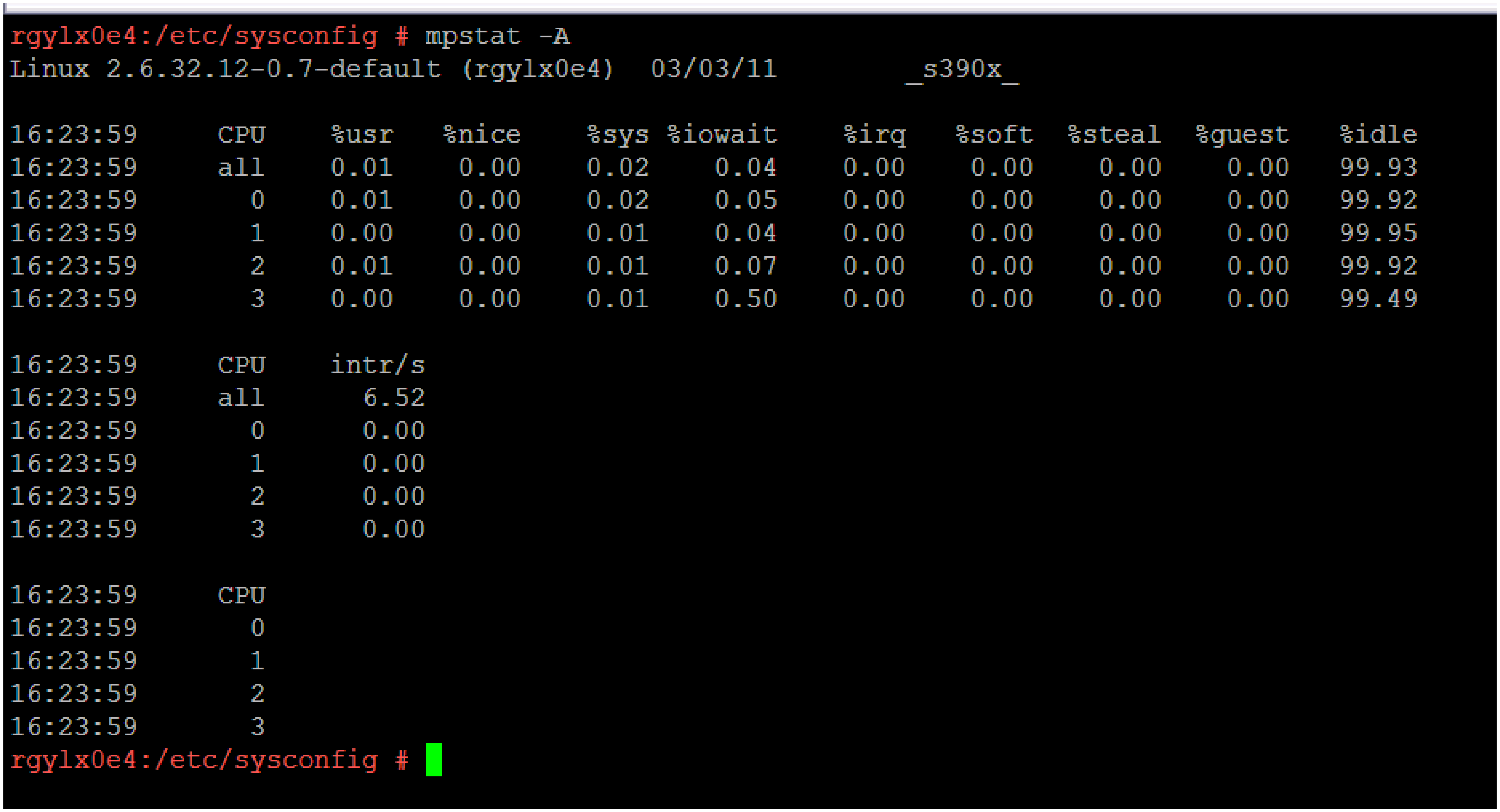
- CPU_MIN= 1
- CPU_MAX= 0 (maximum available)
- UPDATE= 10
- HOTPLUG="(loadavg > onumcpus + 0.75) & (idle < 10.0)“
- HOTUNPLUG="(loadavg < onumcpus - 0.25) | (idle > 50)“
- Defined As:
  - loadavg: The current loadaverage
  - onumcpus: The actual number of cpus which are online
  - runable_proc: The current amount of runable processes
  - idle: The current idle percentage

What happens if I run with the default rules?

- Where:
  - **loadavg:** the current load average – Comes from the first /proc/loadavg value. The average number of runnable process. Not average CPU utilization! One looping process on a system would cause this to approach 1.0 Five looping processes on a single CPU system would cause this to approach 5.0
  - **onumcpus:** the actual number of cpus which are online (Via: /sys/devices/system/cpu/cpu%d/online)
  - **runable_proc**: the current amount of runable processes (The 4th /proc/loadavg value)
  - **idle:** the current idle percentage – Where 1 idle processor = 100 and 4 idle processors = 400 (/proc/stat 4th value)

Specific cpuplugd examples for CPU

Automated Adjustment of CPs

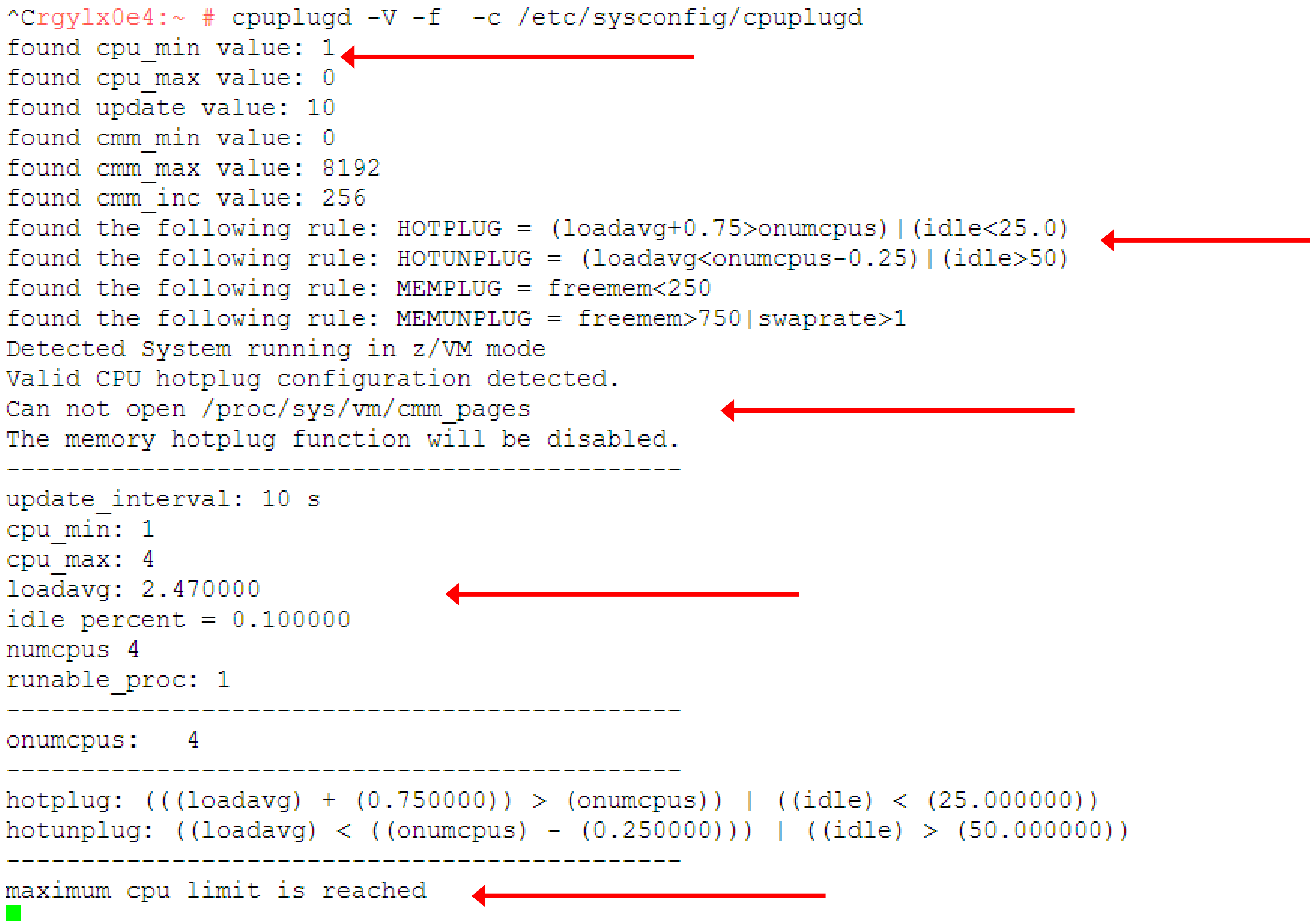


```
rgylx0e4:/etc/sysconfig # mpstat -A
Linux 2.6.32.12-0.7-default (rgylx0e4)  03/03/11        _s390x_

16:23:59     CPU    %usr   %nice    %sys %iowait    %irq   %soft  %steal  %guest   %idle
16:23:59     all    0.01    0.00    0.02    0.04    0.00    0.00    0.00    0.00   99.93
16:23:59       0    0.01    0.00    0.02    0.05    0.00    0.00    0.00    0.00   99.92
16:23:59       1    0.00    0.00    0.01    0.04    0.00    0.00    0.00    0.00   99.95
16:23:59       2    0.01    0.00    0.01    0.07    0.00    0.00    0.00    0.00   99.92
16:23:59       3    0.00    0.00    0.01    0.50    0.00    0.00    0.00    0.00   99.49

16:23:59     CPU    intr/s
16:23:59     all      6.52
16:23:59       0      0.00
16:23:59       1      0.00
16:23:59       2      0.00
16:23:59       3      0.00

16:23:59     CPU
16:23:59       0
16:23:59       1
16:23:59       2
16:23:59       3
rgylx0e4:/etc/sysconfig #
```

Automated Adjustment of CPs

- The initial state of the system is:
  - 4 virtual CPs
  - System is currently completely idle and has more processor capacity than it currently needs

Automated Adjustment of CPs

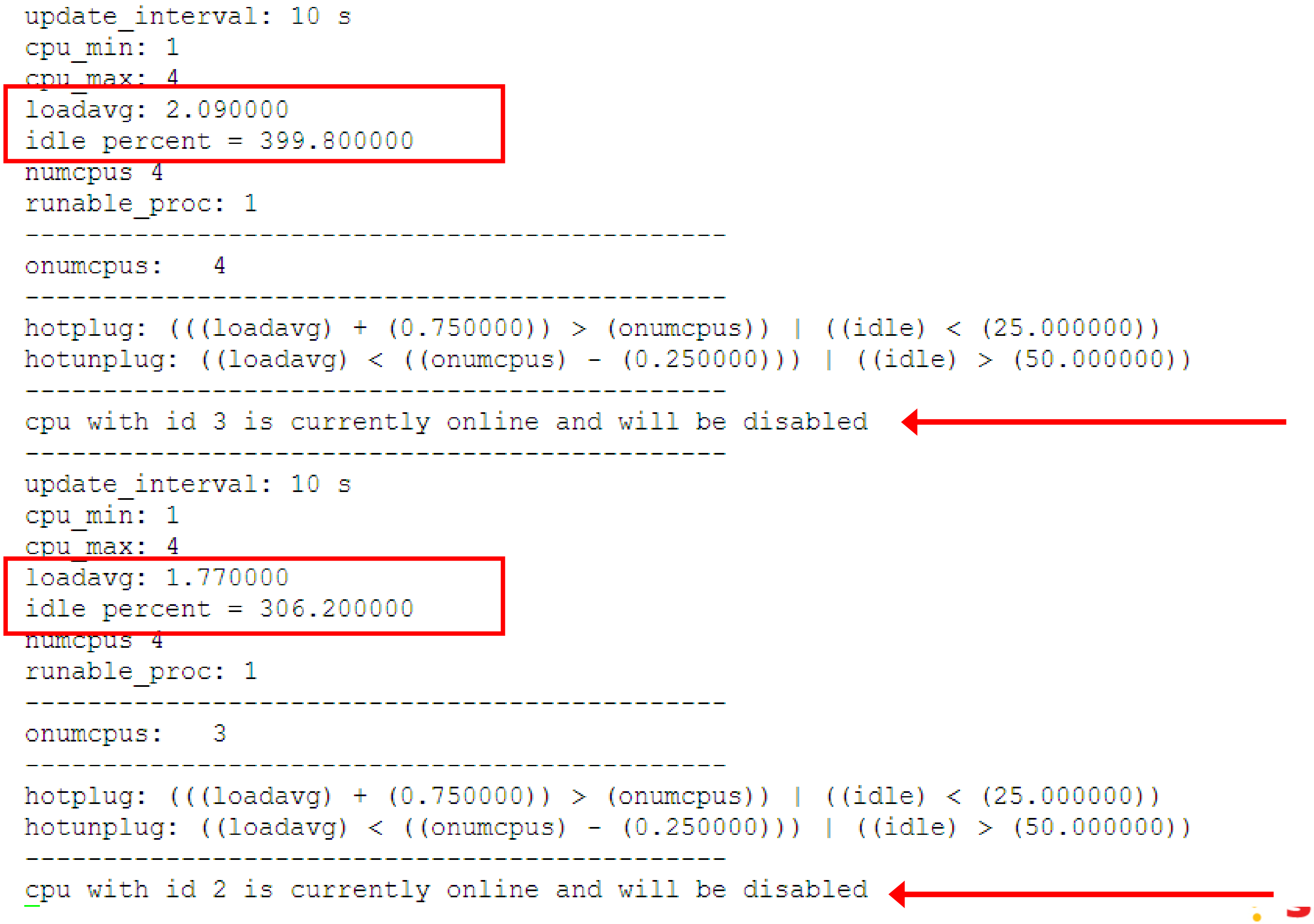


```
^Crgylx0e4:~ # cpuplugd -V -f  -c /etc/sysconfig/cpuplugd
found cpu_min value: 1
found cpu_max value: 0
found update value: 10
found cmm_min value: 0
found cmm_max value: 8192
found cmm_inc value: 256
found the following rule: HOTPLUG = (loadavg+0.75>onumcpus)|(idle<25.0)
found the following rule: HOTUNPLUG = (loadavg<onumcpus-0.25)|(idle>50)
found the following rule: MEMPLUG = freemem<250
found the following rule: MEMUNPLUG = freemem>750|swaprate>1
Detected System running in z/VM mode
Valid CPU hotplug configuration detected.
Can not open /proc/sys/vm/cmm_pages
The memory hotplug function will be disabled.
---------------------------------------------
update_interval: 10 s
cpu_min: 1
cpu_max: 4
loadavg: 2.470000
idle percent = 0.100000
numcpus 4
runable_proc: 1
---------------------------------------------
onumcpus:   4
---------------------------------------------
hotplug: (((loadavg) + (0.750000)) > (onumcpus)) | ((idle) < (25.000000))
hotunplug: ((loadavg) < ((onumcpus) - (0.250000))) | ((idle) > (50.000000))
---------------------------------------------
maximum cpu limit is reached
```

Automated Adjustment of CPs

- The cpu hotplug daemon is started in the foreground with cpuplugd –V –f –c /etc/sysconfig/cpuplugd
- Active rules echoed
  - HOTPLUG (loadavg+0.75>onumcpus)|(idle<25.0)
  - HOTUNPLUG=(loadavg<onumcpus-.25)|(idle>50)
- Memory hotplug currently disabled, no /proc/sys/vm/cmm_pages. This will be covered later
- First interval
  - loadavg = 2.47
  - Idle percent = 0.1
  - Max CPU limit reached (all 4 are active)

Automated Adjustment of CPs

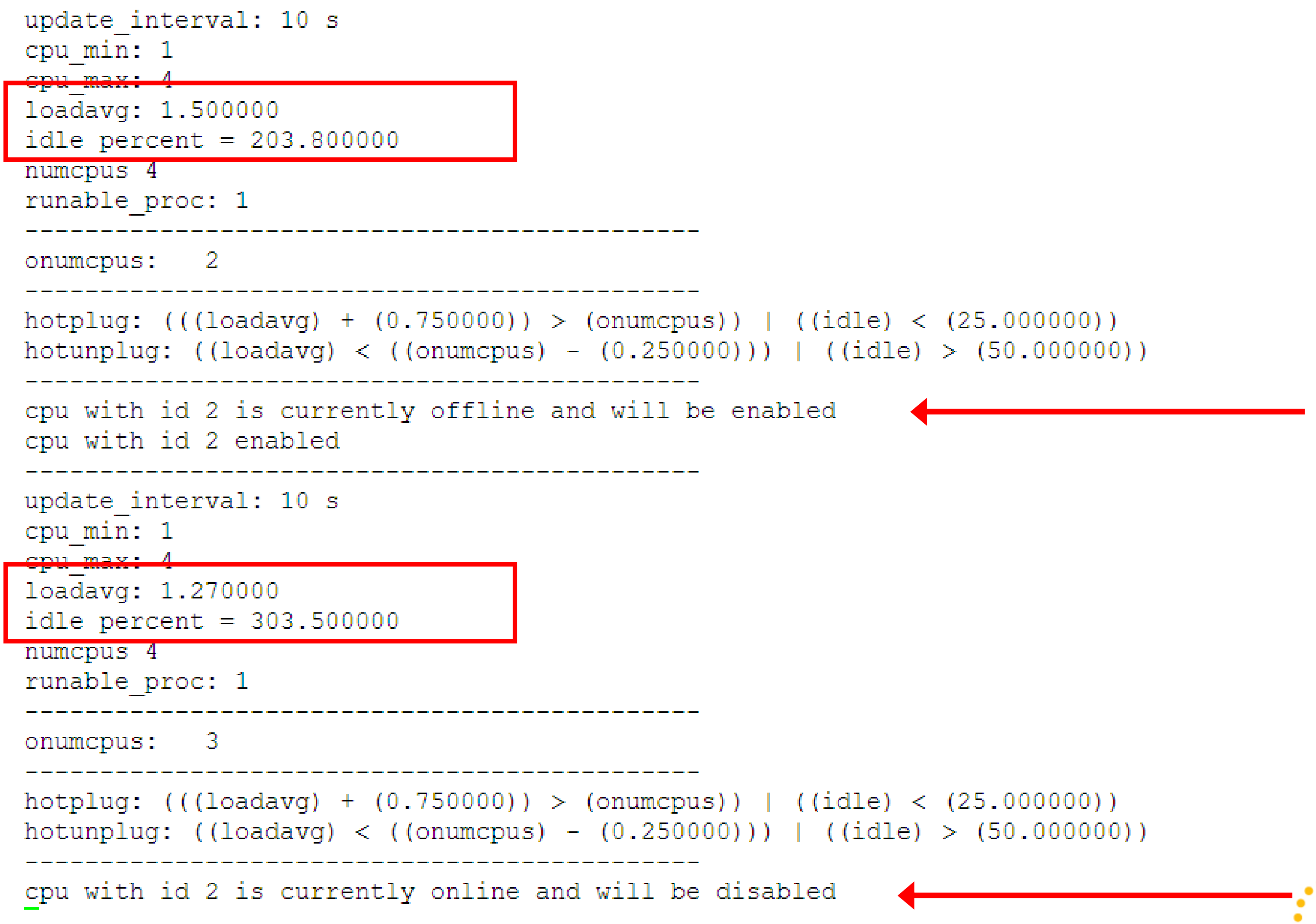


```
update_interval: 10 s
cpu_min: 1
cpu_max: 4
loadavg: 2.090000
idle percent = 399.800000
numcpus 4
runable_proc: 1
---------------------------------------------
onumcpus:   4
---------------------------------------------
hotplug: (((loadavg) + (0.750000)) > (onumcpus)) | ((idle) < (25.000000))
hotunplug: ((loadavg) < ((onumcpus) - (0.250000))) | ((idle) > (50.000000))
---------------------------------------------
cpu with id 3 is currently online and will be disabled
---------------------------------------------
update_interval: 10 s
cpu_min: 1
cpu_max: 4
loadavg: 1.770000
idle percent = 306.200000
numcpus 4
runable_proc: 1
---------------------------------------------
onumcpus:   3
---------------------------------------------
hotplug: (((loadavg) + (0.750000)) > (onumcpus)) | ((idle) < (25.000000))
hotunplug: ((loadavg) < ((onumcpus) - (0.250000))) | ((idle) > (50.000000))
---------------------------------------------
cpu with id 2 is currently online and will be disabled
```

Automated Adjustment of CPs

- 2nd Interval
  - Loadavg = 2
  - Idle = 399 (out of 4 online CPUs)
  - Action: CPU ID 3 disabled
- 3rd Interval
  - Loadavg = 1.77
  - Idle =306 (out of 3 online CPUs)
  - Action: CPU ID 2 disabled

Automated Adjustment of CPs

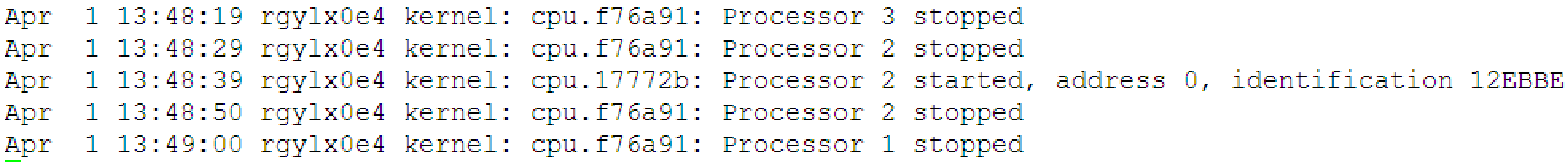


```
update_interval: 10 s
cpu_min: 1
cpu_max: 4
loadavg: 1.500000
idle percent = 203.800000
numcpus 4
runable_proc: 1
---------------------------------------------
onumcpus:   2
---------------------------------------------
hotplug: (((loadavg) + (0.750000)) > (onumcpus)) | ((idle) < (25.000000))
hotunplug: ((loadavg) < ((onumcpus) - (0.250000))) | ((idle) > (50.000000))
---------------------------------------------
cpu with id 2 is currently offline and will be enabled
cpu with id 2 enabled
---------------------------------------------
update_interval: 10 s
cpu_min: 1
cpu_max: 4
loadavg: 1.270000
idle percent = 303.500000
numcpus 4
runable_proc: 1
---------------------------------------------
onumcpus:   3
---------------------------------------------
hotplug: (((loadavg) + (0.750000)) > (onumcpus)) | ((idle) < (25.000000))
hotunplug: ((loadavg) < ((onumcpus) - (0.250000))) | ((idle) > (50.000000))
---------------------------------------------
cpu with id 2 is currently online and will be disabled
```

Automated Adjustment of CPs

- Interval 4
  - Loadavg = 1.5
  - Idle % = 203
  - Action = Enable CPU ID 2 (because of loadavg part of rule, not idle%)
- Interval 5
  - Loadavg = 1.27
  - Idle % = 303
  - Action = Disable CPU ID 2 (because of both parts of the unplug rule)
- Load has stayed the same thru all of the intervals, yet we are adding and removing the same CPU

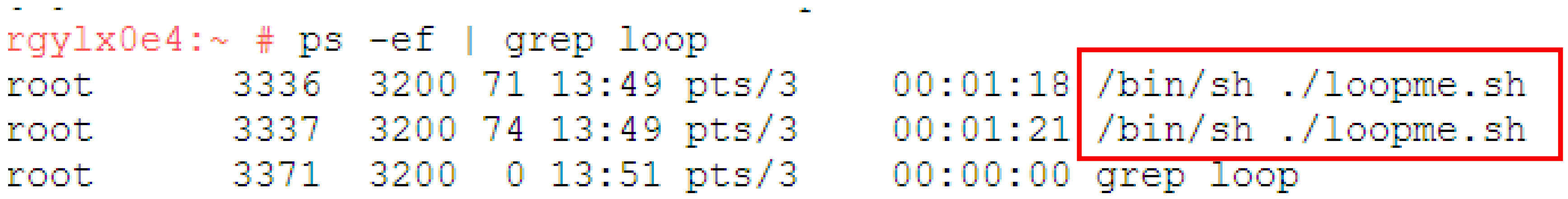
Automated Adjustment of CPs



```
Apr  1 13:48:19 rgylx0e4 kernel: cpu.f76a91: Processor 3 stopped
Apr  1 13:48:29 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:48:39 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 0, identification 12EBBE
Apr  1 13:48:50 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:49:00 rgylx0e4 kernel: cpu.f76a91: Processor 1 stopped
```

- Messages about processors being enabled or disabled by CPU hotplug will appear in /var/log/messages.
- In this example 3 of 4 virtual CPs were stopped
- This information could easily be captured for reporting or alerting

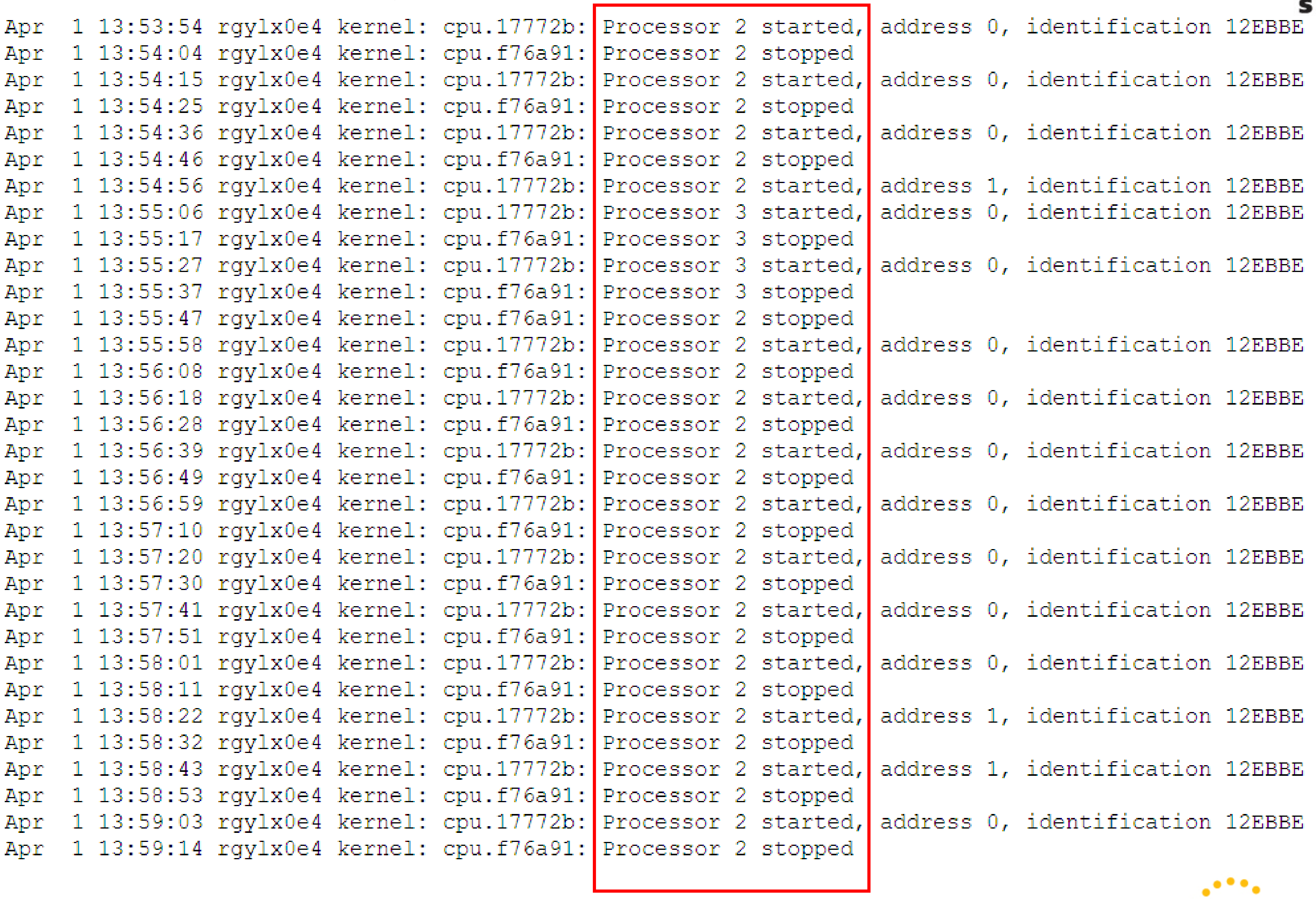
Automated Adjustment of CPs



```
rgylx0e4:~ # ps -ef | grep loop
root      3336  3200 71 13:49 pts/3    00:01:18 /bin/sh ./loopme.sh
root      3337  3200 74 13:49 pts/3    00:01:21 /bin/sh ./loopme.sh
root      3371  3200  0 13:51 pts/3    00:00:00 grep loop
```

- Two processes running in a CPU loop on a 4 way system
- Lets take a look at the impact to CPU Hotplug

Automated Adjustment of CPs



```
Apr  1 13:53:54 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 0, identification 12EBBE
Apr  1 13:54:04 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:54:15 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 0, identification 12EBBE
Apr  1 13:54:25 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:54:36 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 0, identification 12EBBE
Apr  1 13:54:46 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:54:56 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 1, identification 12EBBE
Apr  1 13:55:06 rgylx0e4 kernel: cpu.17772b: Processor 3 started, address 0, identification 12EBBE
Apr  1 13:55:17 rgylx0e4 kernel: cpu.f76a91: Processor 3 stopped
Apr  1 13:55:27 rgylx0e4 kernel: cpu.17772b: Processor 3 started, address 0, identification 12EBBE
Apr  1 13:55:37 rgylx0e4 kernel: cpu.f76a91: Processor 3 stopped
Apr  1 13:55:47 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:55:58 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 0, identification 12EBBE
Apr  1 13:56:08 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:56:18 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 0, identification 12EBBE
Apr  1 13:56:28 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:56:39 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 0, identification 12EBBE
Apr  1 13:56:49 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:56:59 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 0, identification 12EBBE
Apr  1 13:57:10 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:57:20 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 0, identification 12EBBE
Apr  1 13:57:30 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:57:41 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 0, identification 12EBBE
Apr  1 13:57:51 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:58:01 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 0, identification 12EBBE
Apr  1 13:58:11 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:58:22 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 1, identification 12EBBE
Apr  1 13:58:32 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:58:43 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 1, identification 12EBBE
Apr  1 13:58:53 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
Apr  1 13:59:03 rgylx0e4 kernel: cpu.17772b: Processor 2 started, address 0, identification 12EBBE
Apr  1 13:59:14 rgylx0e4 kernel: cpu.f76a91: Processor 2 stopped
```

Automated Adjustment of CPs

- **Summary of our little experiment**
  - Under a steady load to 2 CPU bound processes, CPs zero and one stay online.
  - CP two oscillates between online and offline
  - CP three stays offline
  - Suggests the plug/unplug rules should be refined, since you are unable to add a virtual CP without removing it on the next interval.

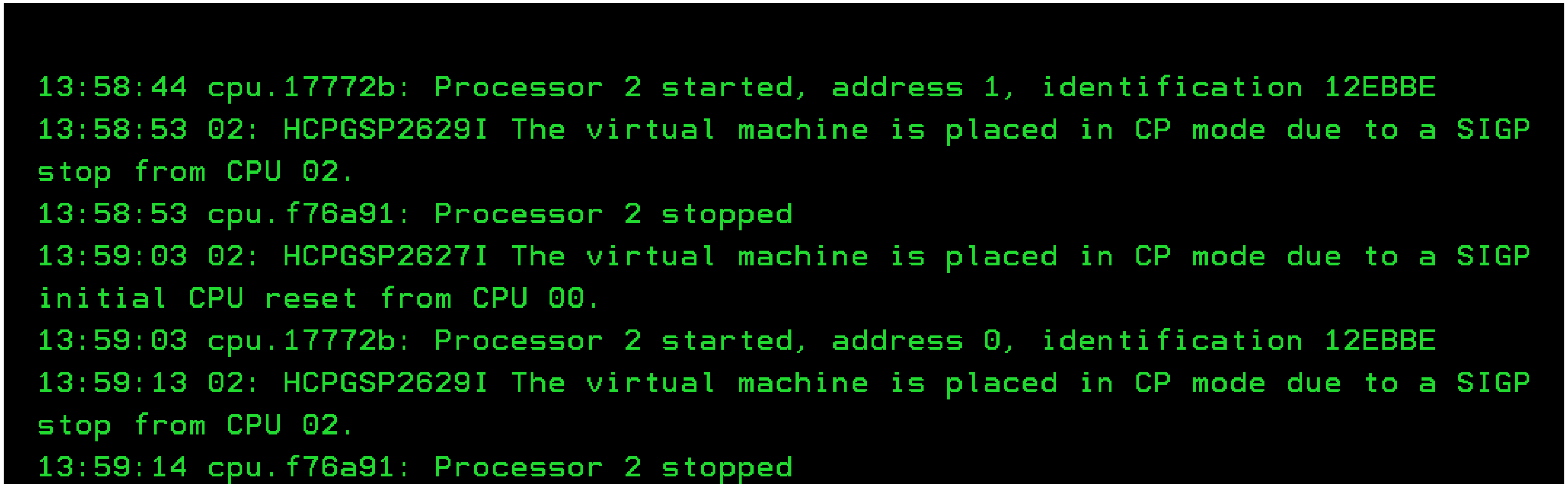
Automated Adjustment of CPs

- Given:

```
HOTPLUG (loadavg+0.75>onumcpus)|(idle<25.0)
HOTUNPLUG=(loadavg<onumcpus-.25)|(idle>50)
```

  - The idle part of the rules requires the system be between 25 and 50% idle not to take action. However adding or removing any CP will change this by a value of 100. This is not likely what you want.
  - Unplugging a CPU when it is 51% idle could impact your application. What handles the 49% of the CP that was not idle?

Automated Adjustment of CPs



```
13:58:44 cpu.17772b: Processor 2 started, address 1, identification 12EBBE
13:58:53 02: HCPGSP2629I The virtual machine is placed in CP mode due to a SIGP
stop from CPU 02.
13:58:53 cpu.f76a91: Processor 2 stopped
13:59:03 02: HCPGSP2627I The virtual machine is placed in CP mode due to a SIGP
initial CPU reset from CPU 00.
13:59:03 cpu.17772b: Processor 2 started, address 0, identification 12EBBE
13:59:13 02: HCPGSP2629I The virtual machine is placed in CP mode due to a SIGP
stop from CPU 02.
13:59:14 cpu.f76a91: Processor 2 stopped
```

- Processor status change messages appear on the Linux console
- z/VM also issues HCPGSP2629I

Next lets look at the memory management features

Automated Adjustment of Memory

- cpuplugd memory management utilizes CMM (CMM1)
- The cpuplug daemon determines how much memory to add or remove based upon the rules you put in place
- It is based upon a configurable interval you set
- The memory increment added or removed is also configurable
- Separate plug and unplug rules are used for memory
- There are NO default memory plug and unplug rules
- If you start cpuplugd without any configuration changes it will manage CPUs but NOT memory.

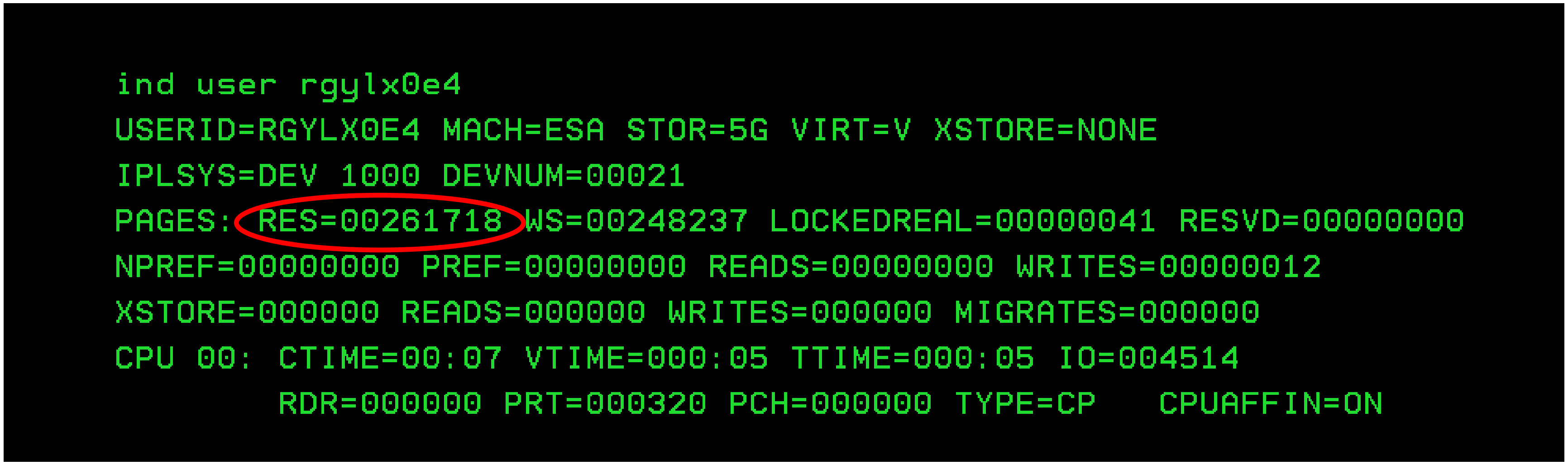
Automated Adjustment of Memory

- Writing memory plug and unplug rules
  - **apcr:** the amount of page cache reads as listed in vmstat bi/bo
  - **freemem** the amount of free memory (in megabyte)
  - **swaprate** the number of swapin and swapout operations
- CMM pool size and increment
  - **CMM_MIN** min size of the static page pool (default 0)
  - **CMM_MAX** max size of the static page pool (default 8192 pages)
  - **CMM_INC** amount added/removed (default 256 pages or 1MB)
- apcr can be used to gauge the IO load on Linux system. With heavier IO rates you may want to allow the system to utilize more memory to help improve performance. This memory would get utilized by pagecache.

Automated Adjustment of Memory

- Cpuplugd and CMM1 currently will NOT release pagecache memory
- With the default interval of 10 seconds, in a memory constrained situation you will only add 6MB/min or 360MB/hr
- With instantaneous allocations in GB by some application environments this has the potential to impact application performance, unless increased
- Lets take a brief look at an example

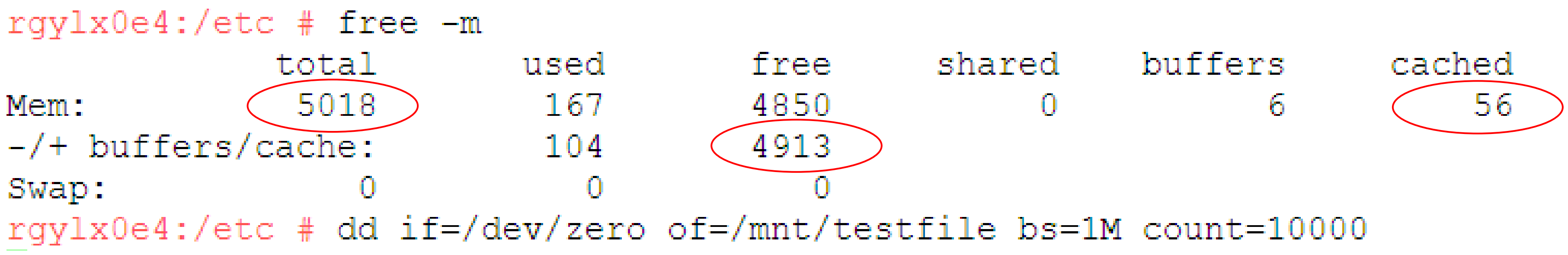
Automated Adjustment of Memory



```
ind user rgylx0e4
USERID=RGYLX0E4 MACH=ESA STOR=5G VIRT=V XSTORE=NONE
IPLSYS=DEV 1000 DEVNUM=00021
PAGES: RES=00261718 WS=00248237 LOCKEDREAL=00000041 RESVD=00000000
NPREF=00000000 PREF=00000000 READS=00000000 WRITES=00000012
XSTORE=000000 READS=000000 WRITES=000000 MIGRATES=000000
CPU 00: CTIME=00:07 VTIME=000:05 TTIME=000:05 IO=004514
        RDR=000000 PRT=000320 PCH=000000 TYPE=CP   CPUAFFIN=ON
```

- This guest currently only has a small amount of memory resident
- In order to see the impact of CPU hotplug we will make more memory resident

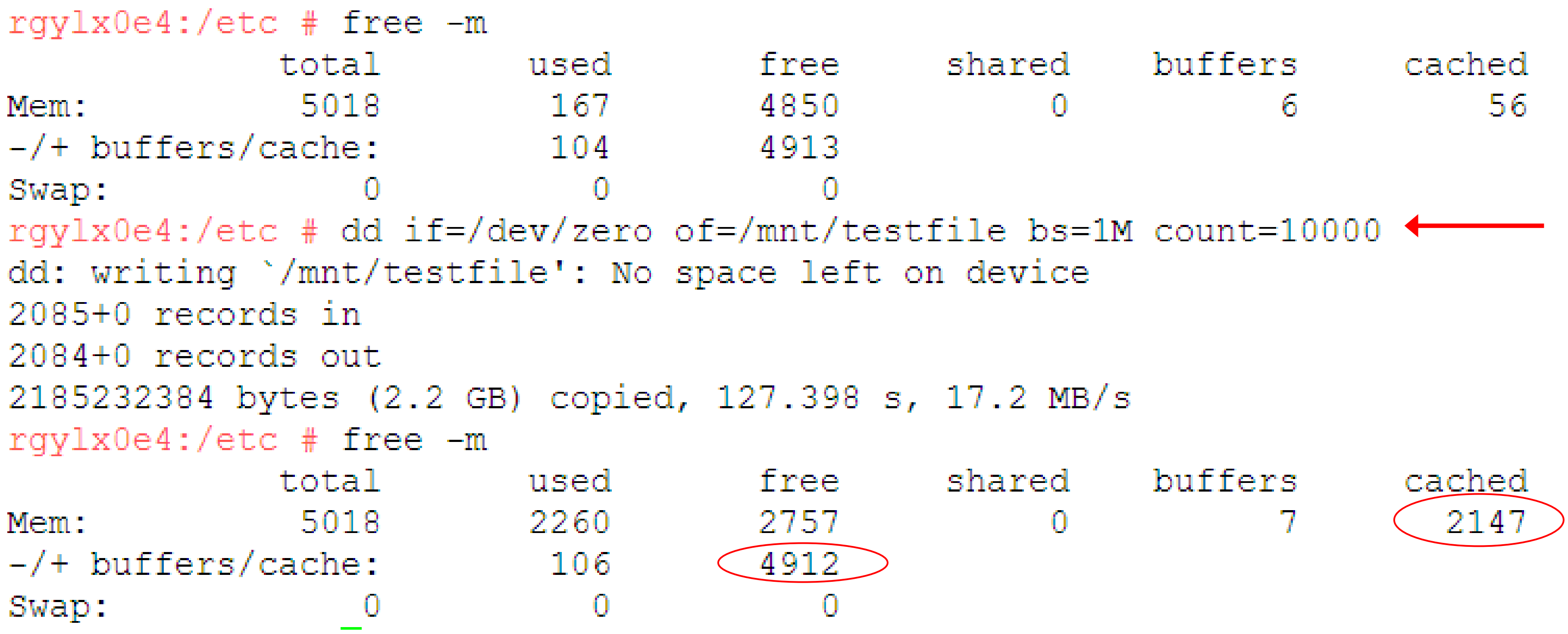
Automated Adjustment of Memory



```
rgylx0e4:/etc # free -m
             total       used       free     shared    buffers     cached
Mem:          5018        167       4850          0          6         56
-/+ buffers/cache:        104       4913
Swap:            0          0          0
rgylx0e4:/etc # dd if=/dev/zero of=/mnt/testfile bs=1M count=10000
```

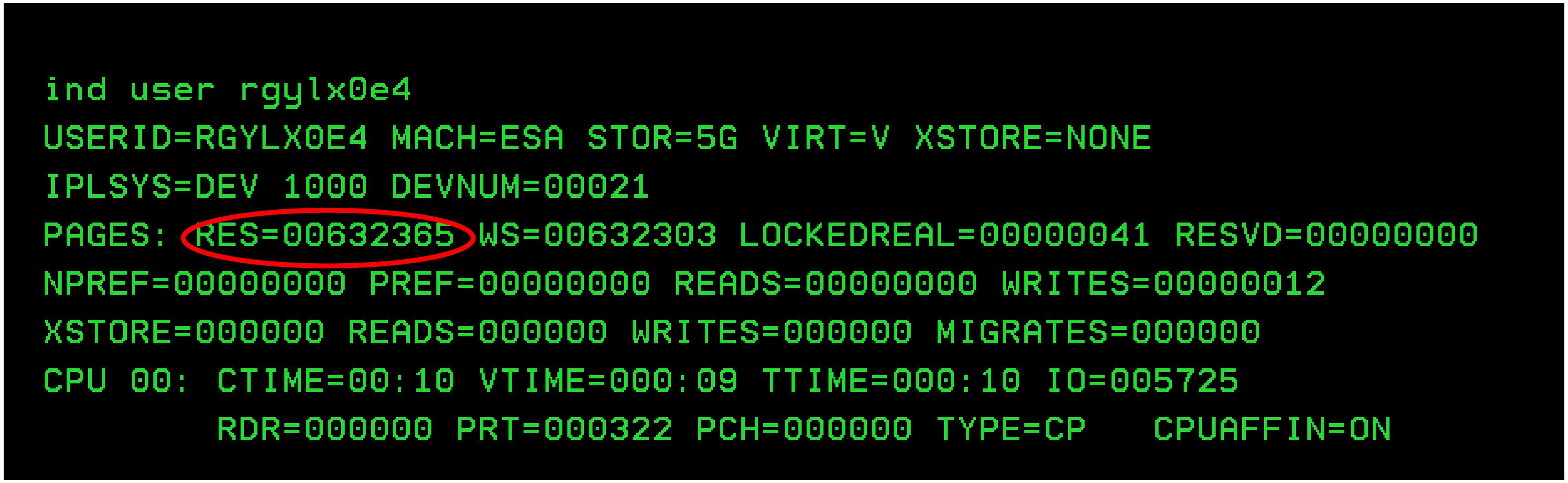
- The entire 5GB of memory is almost all free
- Only 5MB used as cache
- The “dd” command is used in this example to populate page cache and consume memory

Automated Adjustment of Memory



```
rgylx0e4:/etc # free -m
             total       used       free     shared    buffers     cached
Mem:          5018        167       4850          0          6         56
-/+ buffers/cache:        104       4913
Swap:            0          0          0
rgylx0e4:/etc # dd if=/dev/zero of=/mnt/testfile bs=1M count=10000
dd: writing `/mnt/testfile': No space left on device
2085+0 records in
2084+0 records out
2185232384 bytes (2.2 GB) copied, 127.398 s, 17.2 MB/s
rgylx0e4:/etc # free -m
             total       used       free     shared    buffers     cached
Mem:          5018       2260       2757          0          7       2147
-/+ buffers/cache:        106       4912
Swap:            0          0          0
```

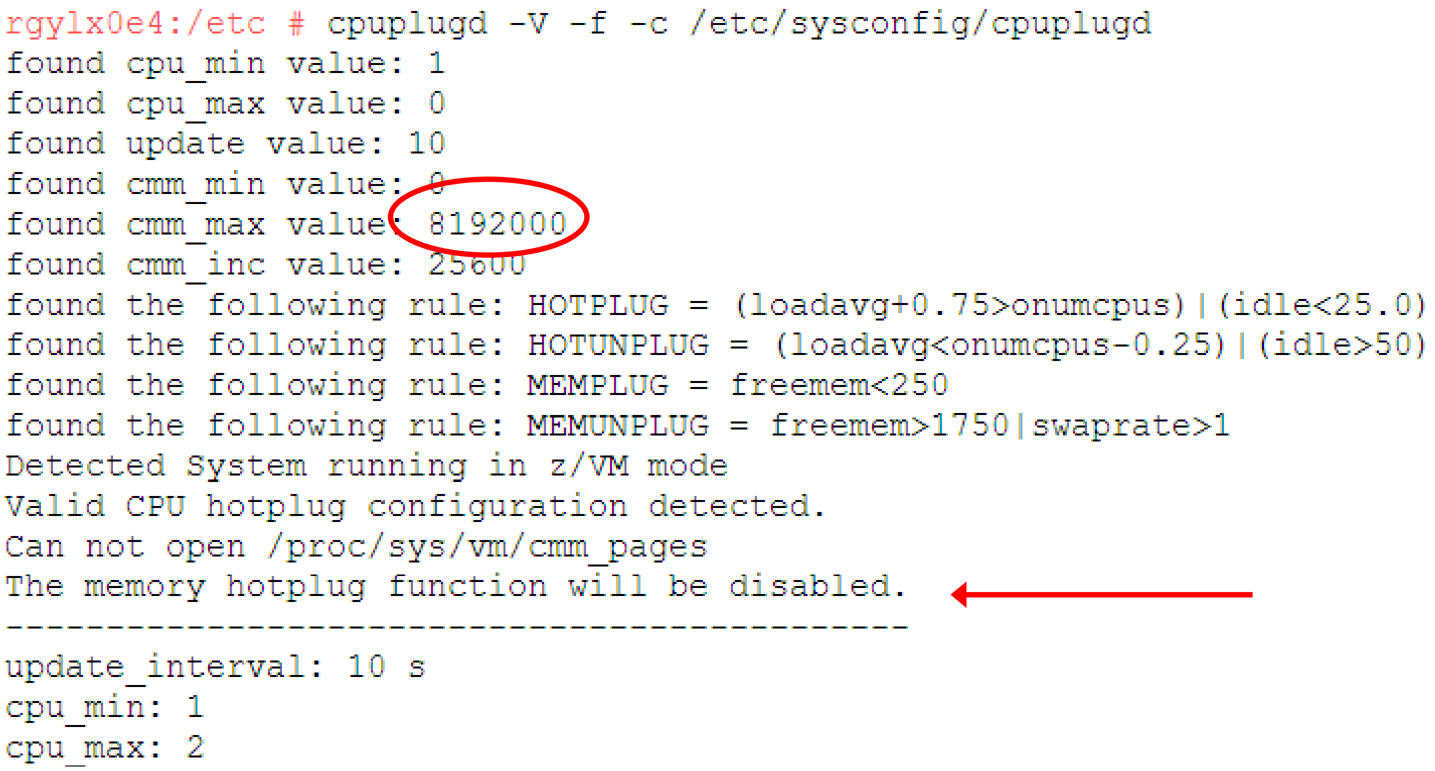
Automated Adjustment of Memory



```
ind user rgylx0e4
USERID=RGYLX0E4 MACH=ESA STOR=5G VIRT=V XSTORE=NONE
IPLSYS=DEV 1000 DEVNUM=00021
PAGES: RES=00632365 WS=00632303 LOCKEDREAL=00000041 RESVD=00000000
NPREF=00000000 PREF=00000000 READS=00000000 WRITES=00000012
XSTORE=000000 READS=000000 WRITES=000000 MIGRATES=000000
CPU 00: CTIME=00:10 VTIME=000:09 TTIME=000:10 IO=005725
        RDR=000000 PRT=000322 PCH=000000 TYPE=CP   CPUAFFIN=ON
```

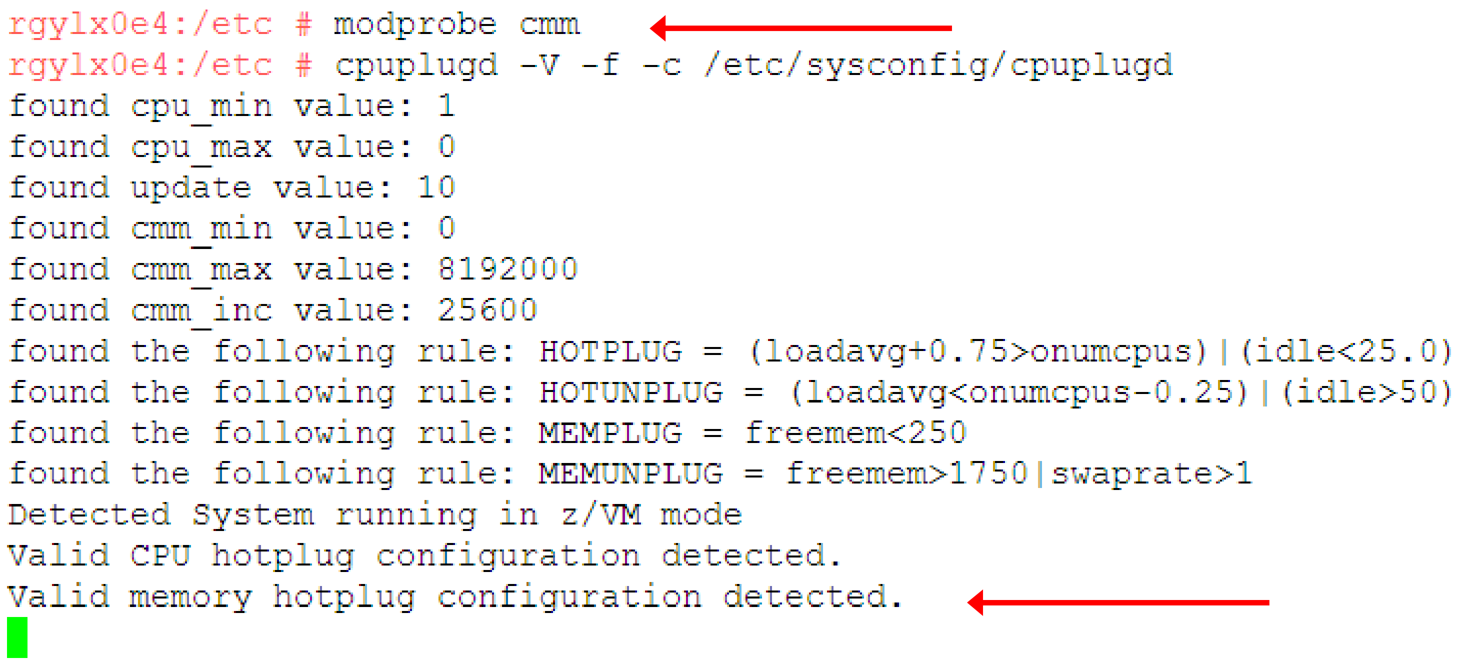
- The memory consumption has more than doubled.

Automated Adjustment of Memory



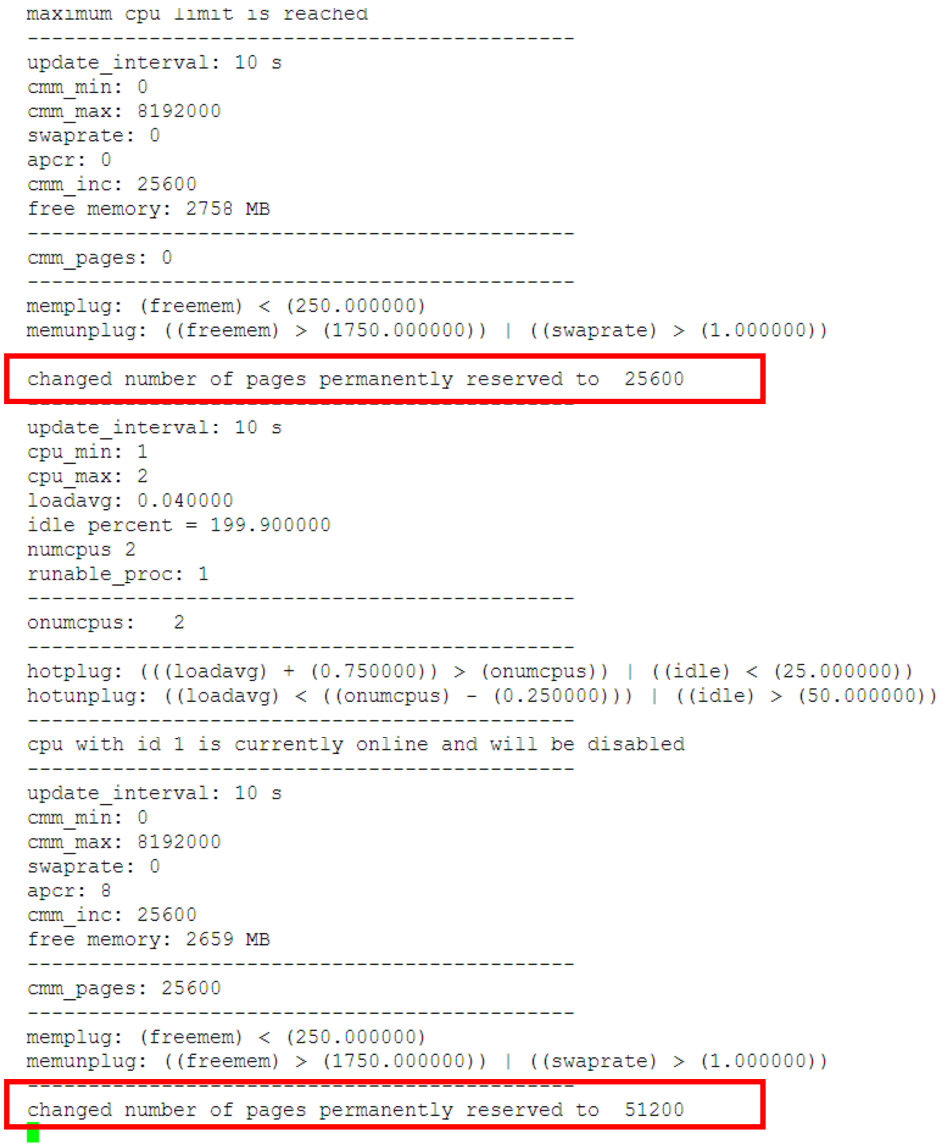
```
rgylx0e4:/etc # cpuplugd -V -f -c /etc/sysconfig/cpuplugd
found cpu_min value: 1
found cpu_max value: 0
found update value: 10
found cmm_min value: 0
found cmm_max value: 8192000
found cmm_inc value: 25600
found the following rule: HOTPLUG = (loadavg+0.75>onumcpus)|(idle<25.0)
found the following rule: HOTUNPLUG = (loadavg<onumcpus-0.25)|(idle>50)
found the following rule: MEMPLUG = freemem<250
found the following rule: MEMUNPLUG = freemem>1750|swaprate>1
Detected System running in z/VM mode
Valid CPU hotplug configuration detected.
Can not open /proc/sys/vm/cmm_pages
The memory hotplug function will be disabled.
---------------------------------------------
update_interval: 10 s
cpu_min: 1
cpu_max: 2
```

Automated Adjustment of Memory



```
rgylx0e4:/etc # modprobe cmm
rgylx0e4:/etc # cpuplugd -V -f -c /etc/sysconfig/cpuplugd
found cpu_min value: 1
found cpu_max value: 0
found update value: 10
found cmm_min value: 0
found cmm_max value: 8192000
found cmm_inc value: 25600
found the following rule: HOTPLUG = (loadavg+0.75>onumcpus)|(idle<25.0)
found the following rule: HOTUNPLUG = (loadavg<onumcpus-0.25)|(idle>50)
found the following rule: MEMPLUG = freemem<250
found the following rule: MEMUNPLUG = freemem>1750|swaprate>1
Detected System running in z/VM mode
Valid CPU hotplug configuration detected.
Valid memory hotplug configuration detected.
```

Automated Adjustment of Memory

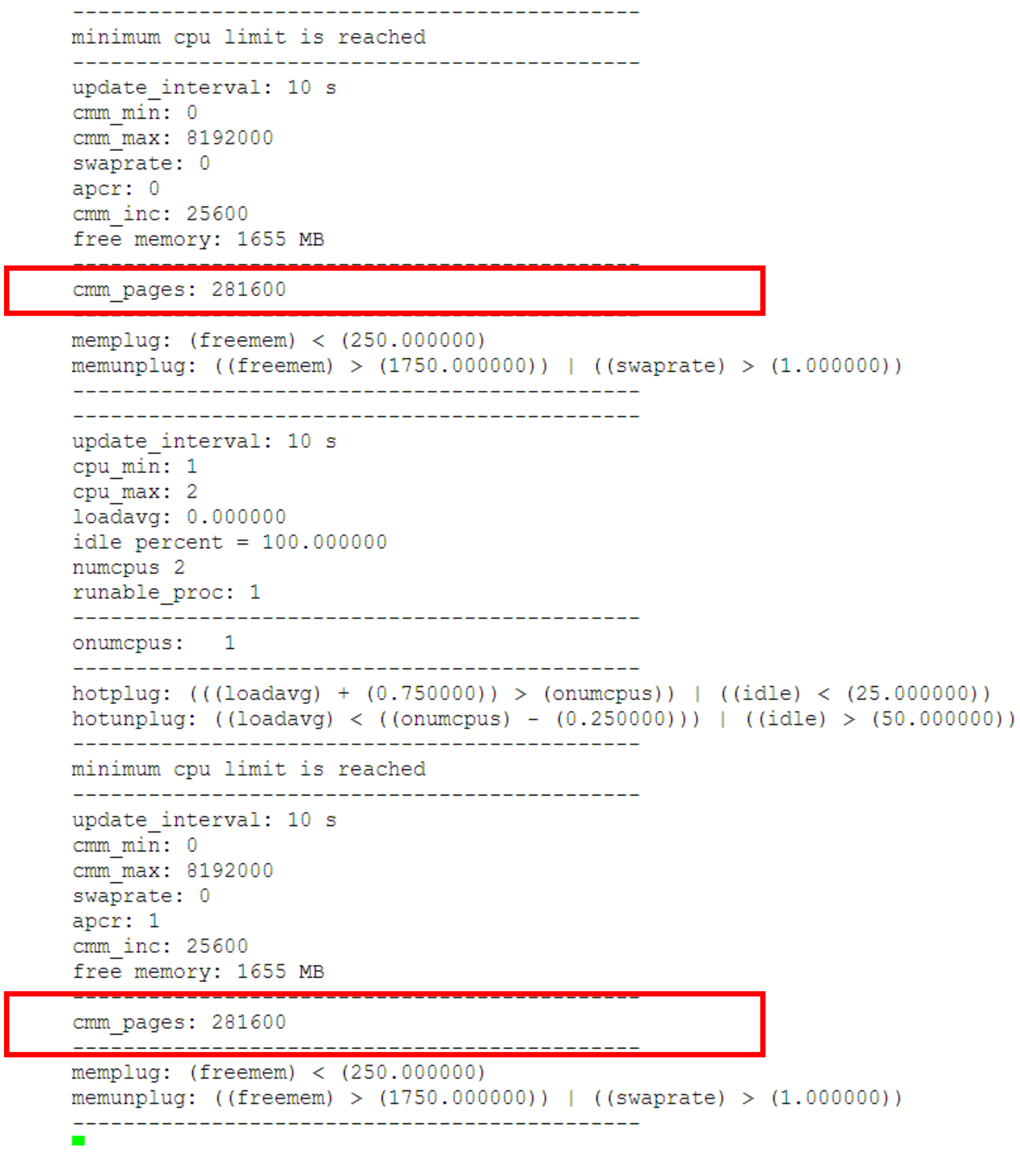


```
maximum cpu limit is reached
----------------------------------------------
update_interval: 10 s
cmm_min: 0
cmm_max: 8192000
swaprate: 0
apcr: 0
cmm_inc: 25600
free memory: 2758 MB
----------------------------------------------
cmm_pages: 0
----------------------------------------------
memplug: (freemem) < (250.000000)
memunplug: ((freemem) > (1750.000000)) | ((swaprate) > (1.000000))

changed number of pages permanently reserved to  25600
----------------------------------------------
update_interval: 10 s
cpu_min: 1
cpu_max: 2
loadavg: 0.040000
idle percent = 199.900000
numcpus 2
runable_proc: 1
----------------------------------------------
onumcpus:   2
----------------------------------------------
hotplug: (((loadavg) + (0.750000)) > (onumcpus)) | ((idle) < (25.000000))
hotunplug: ((loadavg) < ((onumcpus) - (0.250000))) | ((idle) > (50.000000))
----------------------------------------------
cpu with id 1 is currently online and will be disabled
----------------------------------------------
update_interval: 10 s
cmm_min: 0
cmm_max: 8192000
swaprate: 0
apcr: 8
cmm_inc: 25600
free memory: 2659 MB
----------------------------------------------
cmm_pages: 25600
----------------------------------------------
memplug: (freemem) < (250.000000)
memunplug: ((freemem) > (1750.000000)) | ((swaprate) > (1.000000))
----------------------------------------------
changed number of pages permanently reserved to  51200
```

~ 100MB reserved

~ 200MB reserved

Automated Adjustment of Memory



```
---------------------------------------------
minimum cpu limit is reached
---------------------------------------------
update_interval: 10 s
cmm_min: 0
cmm_max: 8192000
swaprate: 0
apcr: 0
cmm_inc: 25600
free memory: 1655 MB
---------------------------------------------
cmm_pages: 281600
---------------------------------------------
memplug: (freemem) < (250.000000)
memunplug: ((freemem) > (1750.000000)) | ((swaprate) > (1.000000))
---------------------------------------------
---------------------------------------------
update_interval: 10 s
cpu_min: 1
cpu_max: 2
loadavg: 0.000000
idle percent = 100.000000
numcpus 2
runable_proc: 1
---------------------------------------------
onumcpus:   1
---------------------------------------------
hotplug: (((loadavg) + (0.750000)) > (onumcpus)) | ((idle) < (25.000000))
hotunplug: ((loadavg) < ((onumcpus) - (0.250000))) | ((idle) > (50.000000))
---------------------------------------------
minimum cpu limit is reached
---------------------------------------------
update_interval: 10 s
cmm_min: 0
cmm_max: 8192000
swaprate: 0
apcr: 1
cmm_inc: 25600
free memory: 1655 MB
---------------------------------------------
cmm_pages: 281600
---------------------------------------------
memplug: (freemem) < (250.000000)
memunplug: ((freemem) > (1750.000000)) | ((swaprate) > (1.000000))
---------------------------------------------
```

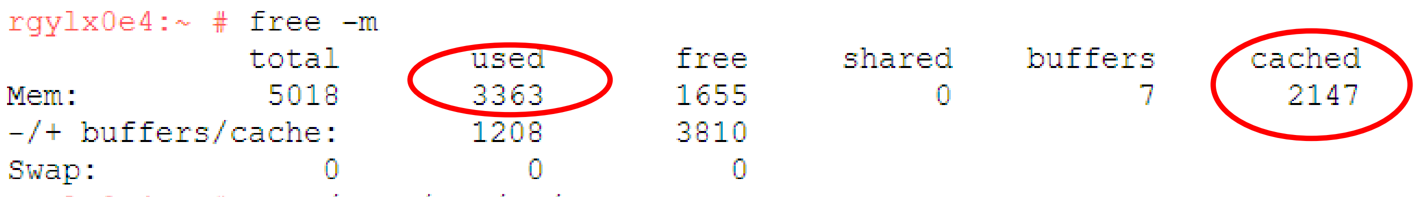
~ 1.1GB reserved

Page reservation stabilized

Automated Adjustment of Memory

- Stabilized 281600 page of memory
- Rules say to unplug memory while freemem > 1750 MB
- The trace shows it is down to 1655 MB

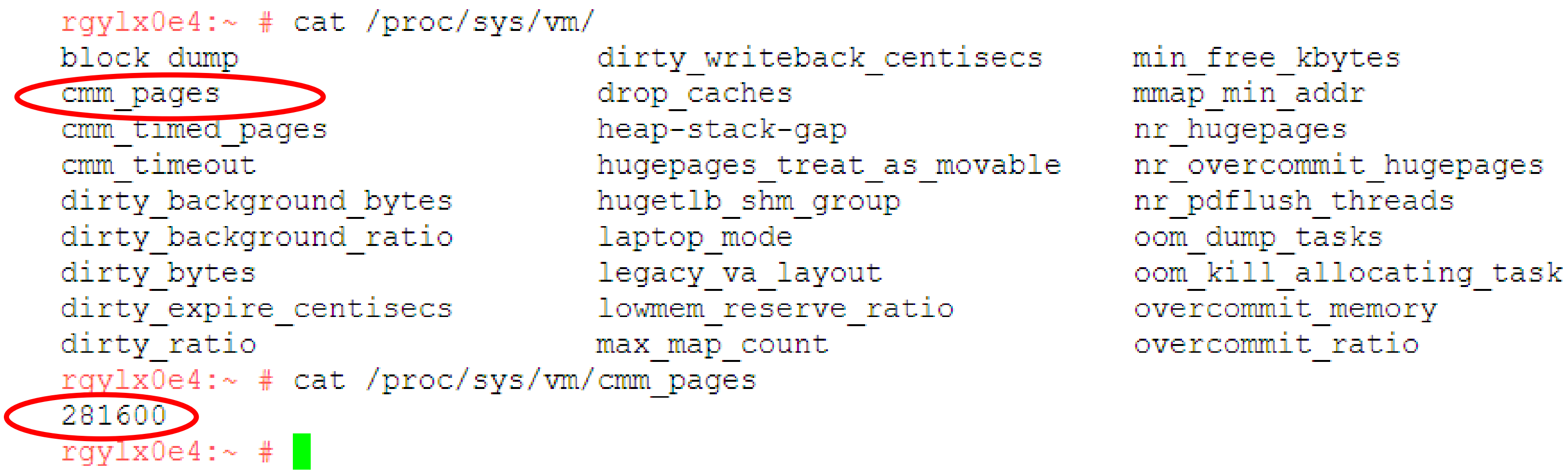
Automated Adjustment of Memory



```
rgylx0e4:~ # free -m
             total       used       free     shared    buffers     cached
Mem:          5018       3363       1655          0          7       2147
-/+ buffers/cache:       1208       3810
Swap:            0          0          0
```

- Note that the “cached” memory is still 2147. cpuplugd does not current act upon “cached” memory
- “used” memory has increased. The pages we reserved with CMM are considered “used”.

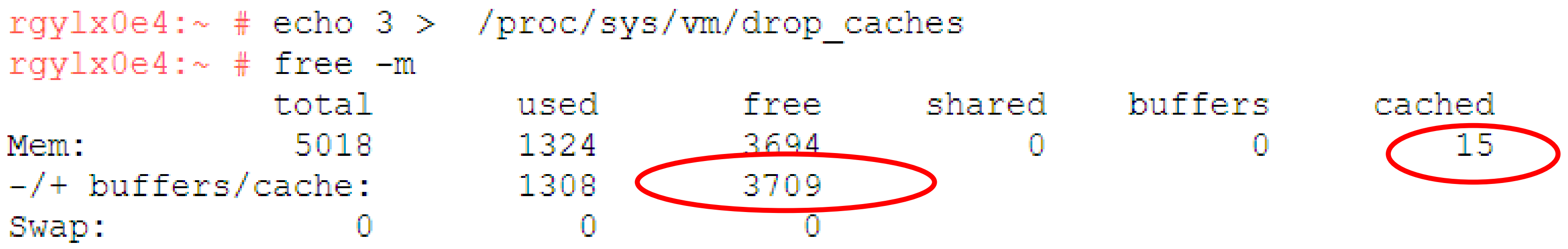
Automated Adjustment of Memory



```
rgylx0e4:~ # cat /proc/sys/vm/
block dump                    dirty_writeback_centisecs     min_free_kbytes
cmm_pages                     drop_caches                   mmap_min_addr
cmm_timed_pages               heap-stack-gap                nr_hugepages
cmm_timeout                   hugepages_treat_as_movable    nr_overcommit_hugepages
dirty_background_bytes        hugetlb_shm_group             nr_pdflush_threads
dirty_background_ratio        laptop_mode                   oom_dump_tasks
dirty_bytes                   legacy_va_layout              oom_kill_allocating_task
dirty_expire_centisecs        lowmem_reserve_ratio          overcommit_memory
dirty_ratio                   max_map_count                 overcommit_ratio
rgylx0e4:~ # cat /proc/sys/vm/cmm_pages
281600
rgylx0e4:~ #
```

- The size of the memory reserved from CMM can be queried by reading /proc/sys/vm/cmm_pages
- A trace is not required to obtain that point in time value

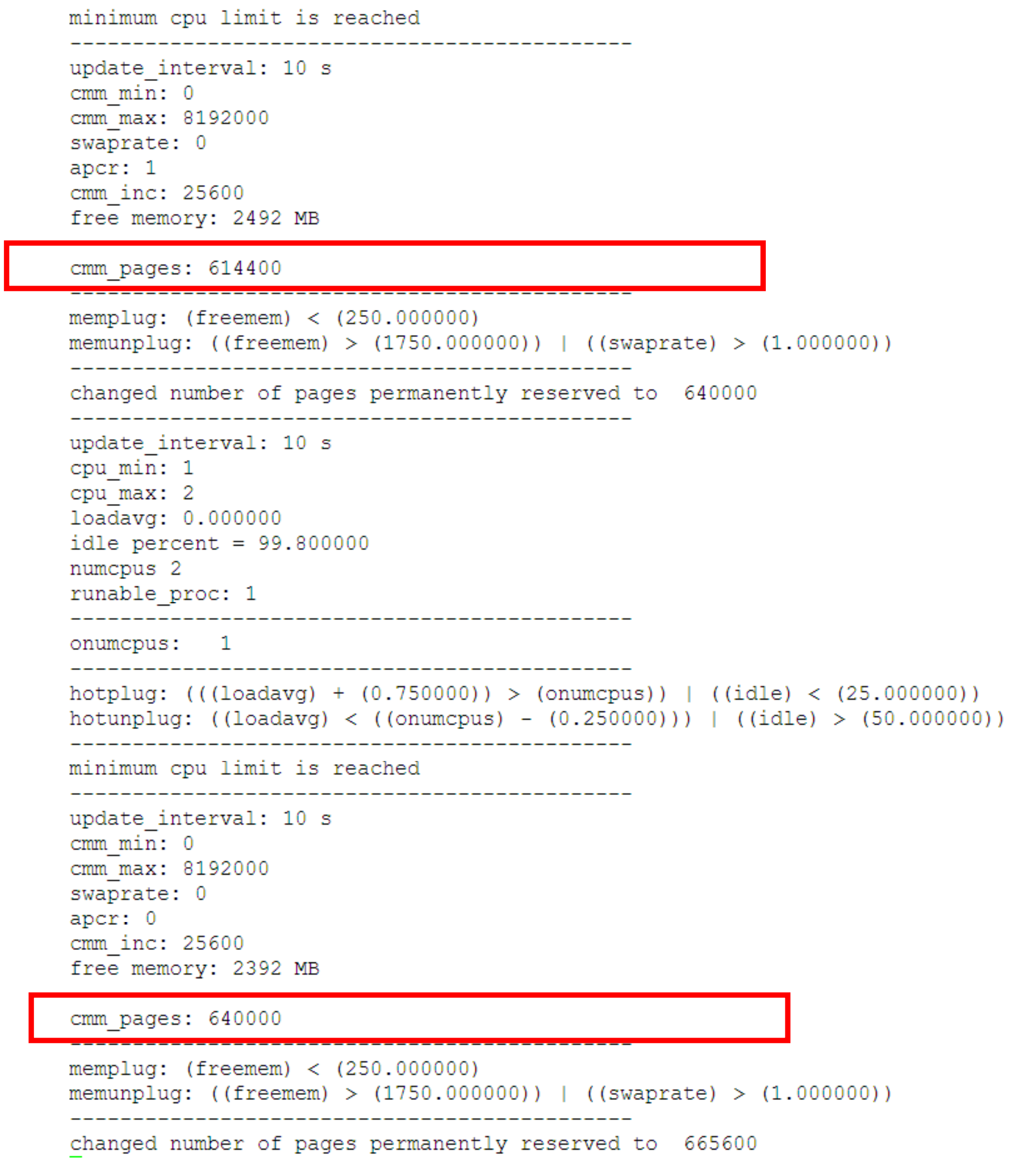
Automated Adjustment of Memory



```
rgylx0e4:~ # echo 3 >  /proc/sys/vm/drop_caches
rgylx0e4:~ # free -m
             total       used       free     shared    buffers     cached
Mem:          5018       1324       3694          0          0         15
-/+ buffers/cache:       1308       3709
Swap:            0          0          0
```

- A 3 is echoed into drop_caches to cause the current page_cache to be dropped
- This decreased the “used” total and increases the free memory total
- Since our cpuplugd memory rule is a function of “freemem” we can now return even more real memory to the hypervisor

Automated Adjustment of Memory

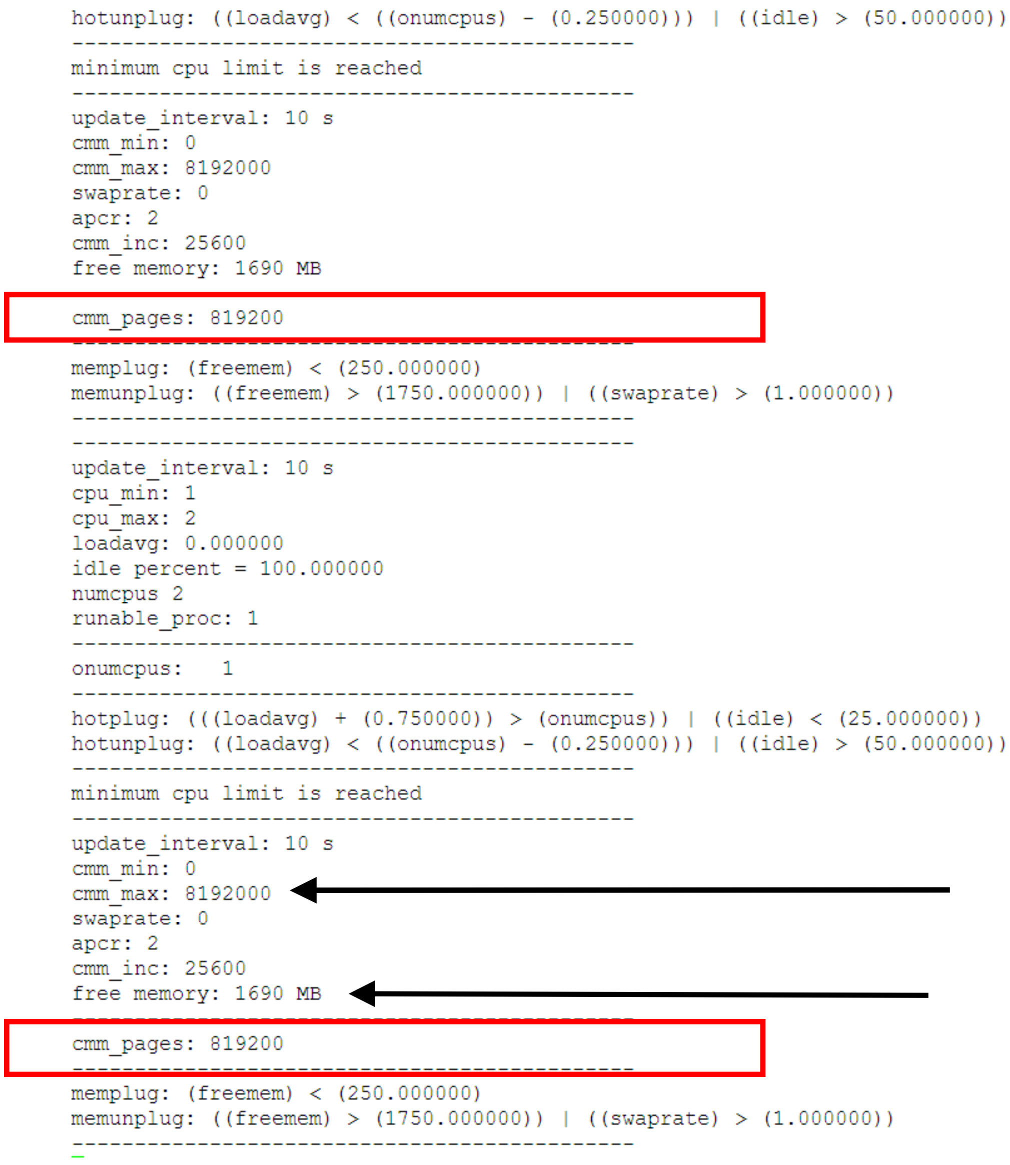


```
minimum cpu limit is reached
---------------------------------------------
update_interval: 10 s
cmm_min: 0
cmm_max: 8192000
swaprate: 0
apcr: 1
cmm_inc: 25600
free memory: 2492 MB
cmm_pages: 614400
---------------------------------------------
memplug: (freemem) < (250.000000)
memunplug: ((freemem) > (1750.000000)) | ((swaprate) > (1.000000))
---------------------------------------------
changed number of pages permanently reserved to  640000
---------------------------------------------
update_interval: 10 s
cpu_min: 1
cpu_max: 2
loadavg: 0.000000
idle percent = 99.800000
numcpus 2
runable_proc: 1
---------------------------------------------
onumcpus:   1
---------------------------------------------
hotplug: (((loadavg) + (0.750000)) > (onumcpus)) | ((idle) < (25.000000))
hotunplug: ((loadavg) < ((onumcpus) - (0.250000))) | ((idle) > (50.000000))
---------------------------------------------
minimum cpu limit is reached
---------------------------------------------
update_interval: 10 s
cmm_min: 0
cmm_max: 8192000
swaprate: 0
apcr: 0
cmm_inc: 25600
free memory: 2392 MB
cmm_pages: 640000
---------------------------------------------
memplug: (freemem) < (250.000000)
memunplug: ((freemem) > (1750.000000)) | ((swaprate) > (1.000000))
---------------------------------------------
changed number of pages permanently reserved to  665600
```

~ 2.5 GB reserved

~ 2.6 GB reserved

Automated Adjustment of Memory



```
hotunplug: ((loadavg) < ((onumcpus) - (0.250000))) | ((idle) > (50.000000))
---------------------------------------------
minimum cpu limit is reached
---------------------------------------------
update_interval: 10 s
cmm_min: 0
cmm_max: 8192000
swaprate: 0
apcr: 2
cmm_inc: 25600
free memory: 1690 MB
cmm_pages: 819200
---------------------------------------------
memplug: (freemem) < (250.000000)
memunplug: ((freemem) > (1750.000000)) | ((swaprate) > (1.000000))
---------------------------------------------
---------------------------------------------
update_interval: 10 s
cpu_min: 1
cpu_max: 2
loadavg: 0.000000
idle percent = 100.000000
numcpus 2
runable_proc: 1
---------------------------------------------
onumcpus:   1
---------------------------------------------
hotplug: (((loadavg) + (0.750000)) > (onumcpus)) | ((idle) < (25.000000))
hotunplug: ((loadavg) < ((onumcpus) - (0.250000))) | ((idle) > (50.000000))
---------------------------------------------
minimum cpu limit is reached
---------------------------------------------
update_interval: 10 s
cmm_min: 0
cmm_max: 8192000
swaprate: 0
apcr: 2
cmm_inc: 25600
free memory: 1690 MB
---------------------------------------------
cmm_pages: 819200
---------------------------------------------
memplug: (freemem) < (250.000000)
memunplug: ((freemem) > (1750.000000)) | ((swaprate) > (1.000000))
---------------------------------------------
_
```

~ 3.3 GB reserved

Reserved page count stabilized

CPU Hotplug Summary

- CPU Hotplug memory management will NOT release page cache memory on its own
- In our example, the CMM module had to be loaded before starting cpuplugd
- Understand how much memory you want to allow CMM to claim and the rate at which you will return memory to the system for use. The last thing you want is a failing memory allocation, or adverse performance impact.

CPU Hotplug Summary

- Under heavier IO load you might want to make more free memory available to Linux
- The goal is to allow the Linux to dynamically return pages of memory to z/VM when they are not in use, and to allow the entire system to operate more efficiently
- The amount of memory required an application to run is a function of the application program code, the workload volume, and any other software added to monitor or manage the environment.

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Linux on System z Suspend and Resume

SHARE in Orlando 2011

Suspend and Resume - Uses

- Possible Uses:
  - Linux instance with middleware that has long startup or initialization time.
  - Instances with long idle periods during the day where the server is not used. Use to free memory and processor resources while suspended
  - Resume a guest to central storage, moments before it is needed. (Assuming you know when it will be needed again)
  - Provide consistency? Suspend, FlashCopy, and Resume ?

Suspend and Resume - Planning

- Planning for Suspend and Resume
  - Kernel 2.6.31 or higher
  - RHEL 6 / SLES 11 or higher
  - Suspended Linux is written to the designed swap disk
  - Must be large enough to hold the memory foot print of the Linux server
- Restrictions
  - No hotplug memory since the last boot
  - No CLAW Device Driver
  - All tape devices closed and unloaded
  - No DCSS with exclusive writable access

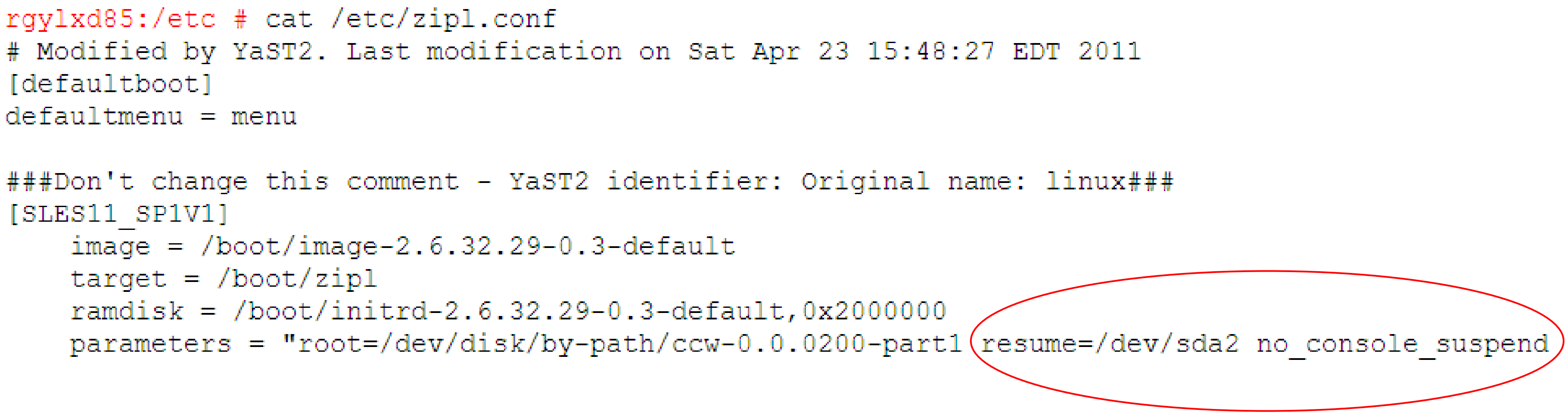
Suspend and Resume – Planning

- While suspended:
  - Don’t alter the data on the swap device with the suspend Linux
  - DCSSs and NSSs used must remain unchanged
  - Avoid real and virtual hardware configuration changes
- For all the restrictions and configuration information see:
  - Linux on System z Device Drivers, Features, and Commands SC33-8411-x

Suspend and Resume - Planning

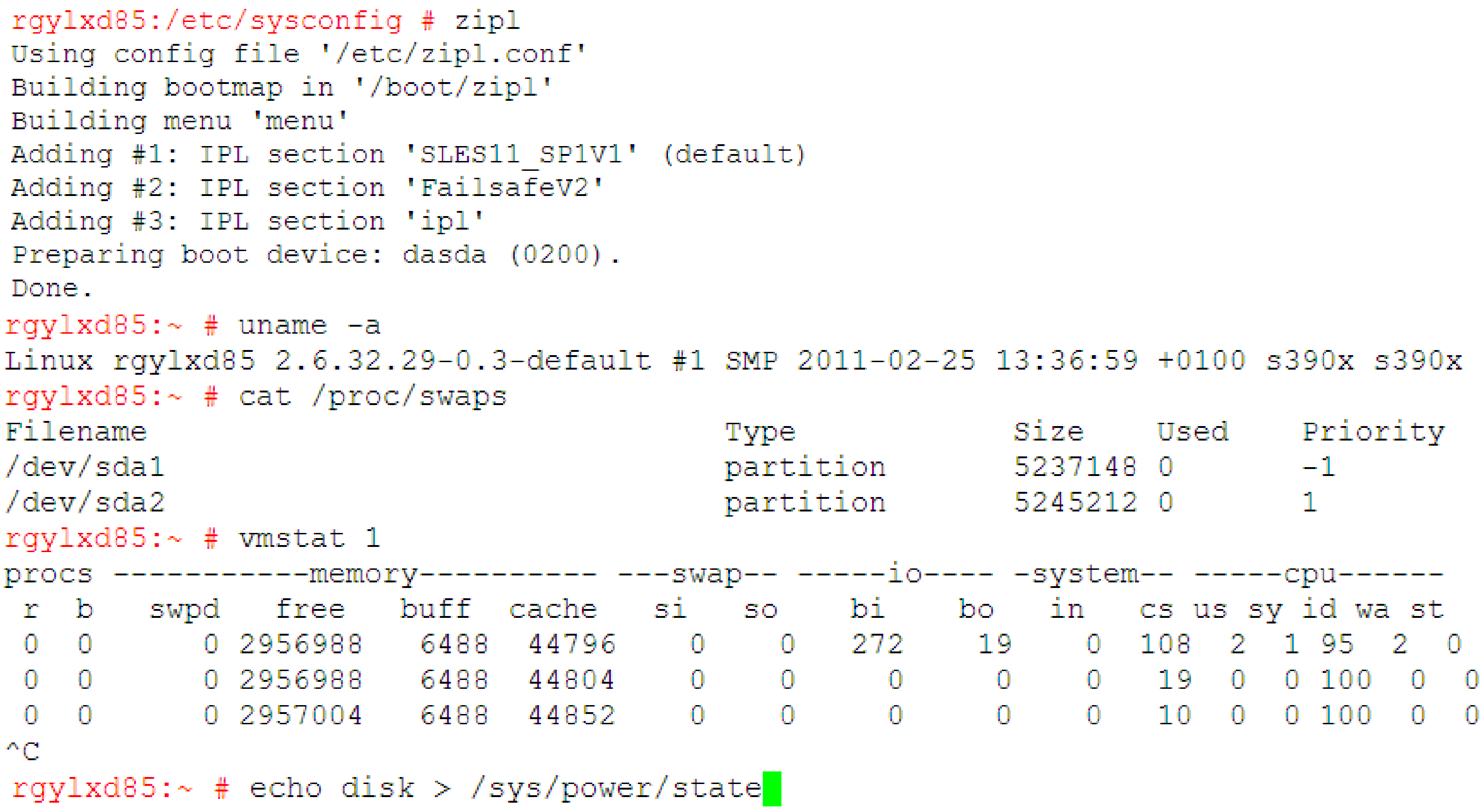
- Kernel Parameters
  - resume=<device node for swap partition>
  - no_console_suspend - Allows you to see console messages longer in to the suspend process
  - noresume -Skip resume of previously suspended system
- Consider swap file priorities
  - You might want to make swap partition for suspend the lowest priority
- Utilize echo disk > /sys/power/state
- Utilize SIGNAL SHUTDOWN and /etc/inittab CTRL-ALT-DELETE to suspend your system

Suspend and Resume - Preparing



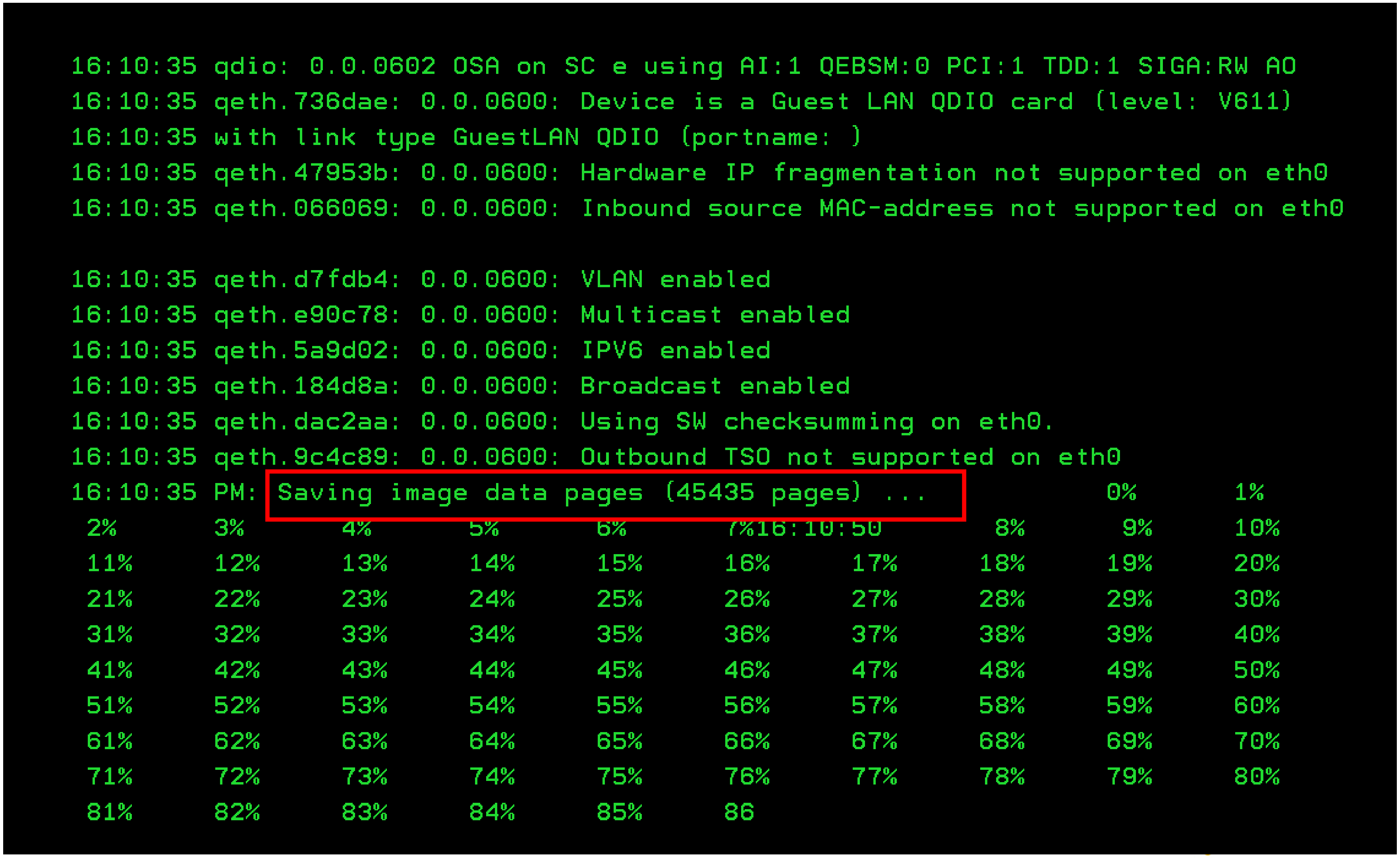
```
rgylxd85:/etc # cat /etc/zipl.conf
# Modified by YaST2. Last modification on Sat Apr 23 15:48:27 EDT 2011
[defaultboot]
defaultmenu = menu

###Don't change this comment - YaST2 identifier: Original name: linux###
[SLES11_SP1V1]
    image = /boot/image-2.6.32.29-0.3-default
    target = /boot/zipl
    ramdisk = /boot/initrd-2.6.32.29-0.3-default,0x2000000
    parameters = "root=/dev/disk/by-path/ccw-0.0.0200-part1 resume=/dev/sda2 no_console_suspend
```

Suspend and Resume - Preparing



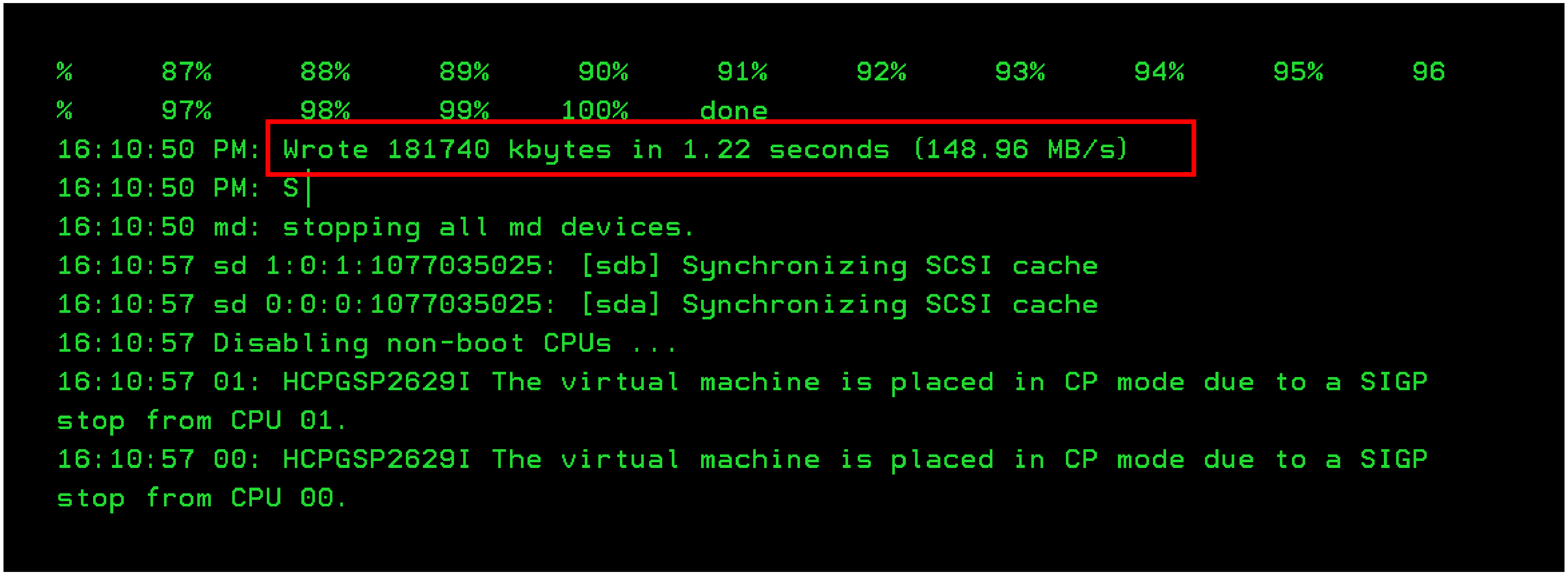
```
rgylxd85:/etc/sysconfig # zipl
Using config file '/etc/zipl.conf'
Building bootmap in '/boot/zipl'
Building menu 'menu'
Adding #1: IPL section 'SLES11_SP1V1' (default)
Adding #2: IPL section 'FailsafeV2'
Adding #3: IPL section 'ipl'
Preparing boot device: dasda (0200).
Done.
rgylxd85:~ # uname -a
Linux rgylxd85 2.6.32.29-0.3-default #1 SMP 2011-02-25 13:36:59 +0100 s390x s390x
rgylxd85:~ # cat /proc/swaps
Filename                                Type            Size    Used    Priority
/dev/sda1                               partition       5237148 0       -1
/dev/sda2                               partition       5245212 0       1
rgylxd85:~ # vmstat 1
procs -----------memory---------- ---swap-- -----io---- -system-- -----cpu------
 r  b   swpd   free   buff  cache   si   so    bi    bo   in   cs us sy id wa st
 0  0      0 2956988   6488  44796    0    0   272    19    0  108  2  1 95  2  0
 0  0      0 2956988   6488  44804    0    0     0     0    0   19  0  0 100  0  0
 0  0      0 2957004   6488  44852    0    0     0     0    0   10  0  0 100  0  0
^C
rgylxd85:~ # echo disk > /sys/power/state
```

Suspend and Resume - Suspending



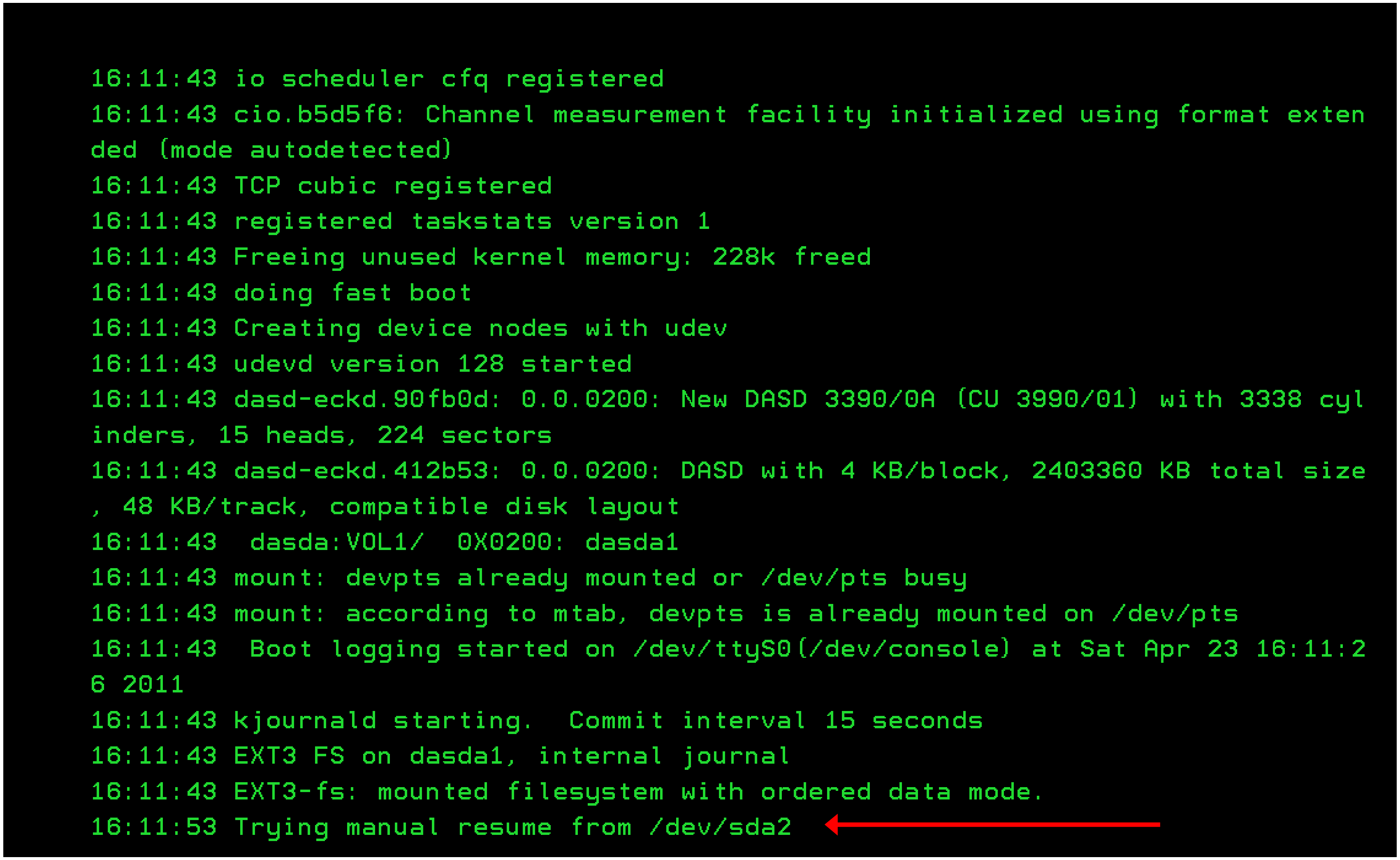
```
16:10:35 qdio: 0.0.0602 OSA on SC e using AI:1 QEBSM:0 PCI:1 TDD:1 SIGA:RW AO
16:10:35 qeth.736dae: 0.0.0600: Device is a Guest LAN QDIO card (level: V611)
16:10:35 with link type GuestLAN QDIO (portname: )
16:10:35 qeth.47953b: 0.0.0600: Hardware IP fragmentation not supported on eth0
16:10:35 qeth.066069: 0.0.0600: Inbound source MAC-address not supported on eth0

16:10:35 qeth.d7fdb4: 0.0.0600: VLAN enabled
16:10:35 qeth.e90c78: 0.0.0600: Multicast enabled
16:10:35 qeth.5a9d02: 0.0.0600: IPV6 enabled
16:10:35 qeth.184d8a: 0.0.0600: Broadcast enabled
16:10:35 qeth.dac2aa: 0.0.0600: Using SW checksumming on eth0.
16:10:35 qeth.9c4c89: 0.0.0600: Outbound TSO not supported on eth0
16:10:35 PM: Saving image data pages (45435 pages) ...           0%      1%
 2%      3%      4%      5%      6%      7%16:10:50       8%       9%     10%
 11%     12%     13%     14%     15%     16%     17%     18%     19%     20%
 21%     22%     23%     24%     25%     26%     27%     28%     29%     30%
 31%     32%     33%     34%     35%     36%     37%     38%     39%     40%
 41%     42%     43%     44%     45%     46%     47%     48%     49%     50%
 51%     52%     53%     54%     55%     56%     57%     58%     59%     60%
 61%     62%     63%     64%     65%     66%     67%     68%     69%     70%
 71%     72%     73%     74%     75%     76%     77%     78%     79%     80%
 81%     82%     83%     84%     85%     86
```

Suspend and Resume - Suspending



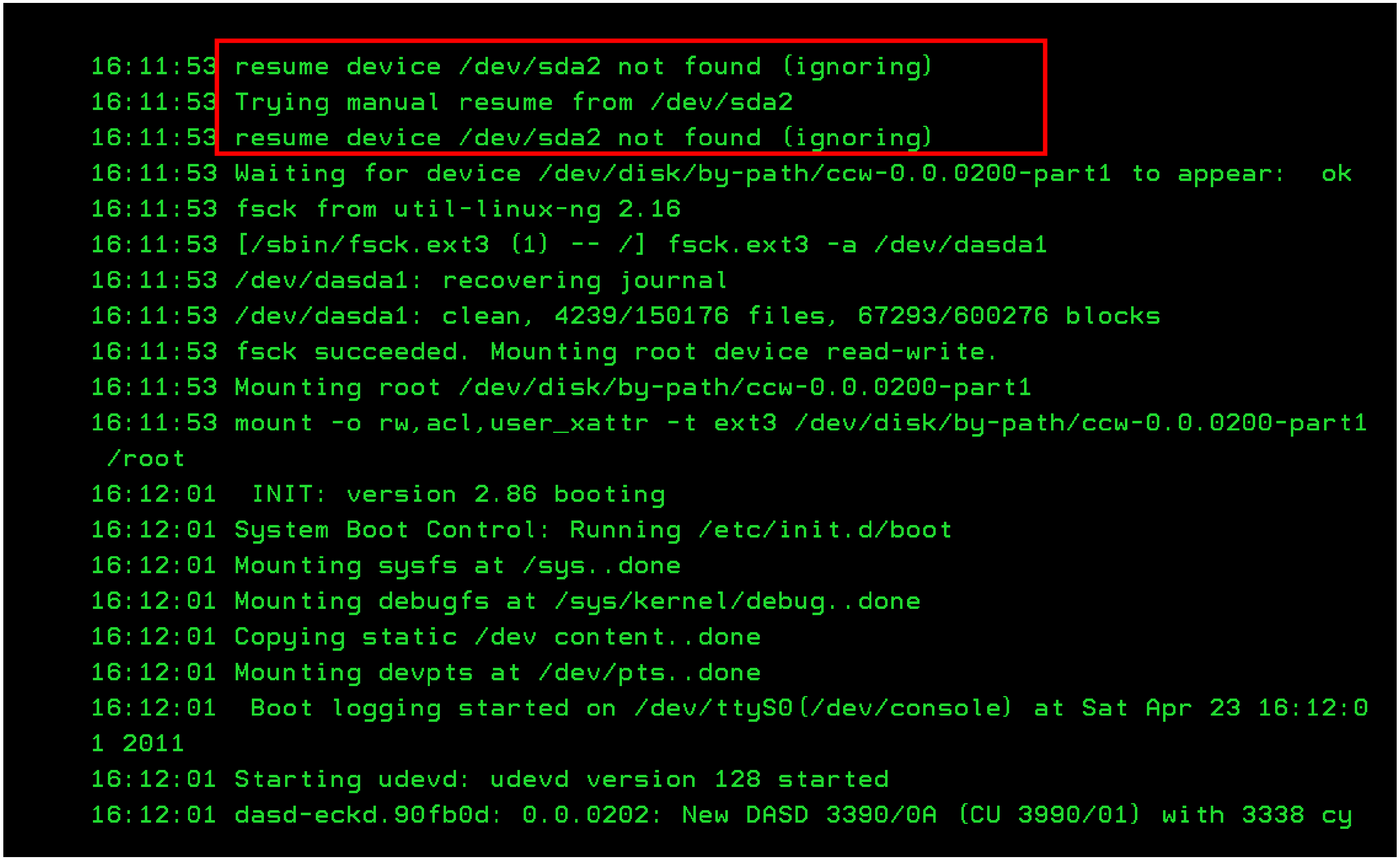
```
%      87%      88%      89%      90%      91%      92%      93%      94%      95%      96
%      97%      98%      99%     100%     done
16:10:50 PM: Wrote 181740 kbytes in 1.22 seconds (148.96 MB/s)
16:10:50 PM: S
16:10:50 md: stopping all md devices.
16:10:57 sd 1:0:1:1077035025: [sdb] Synchronizing SCSI cache
16:10:57 sd 0:0:0:1077035025: [sda] Synchronizing SCSI cache
16:10:57 Disabling non-boot CPUs ...
16:10:57 01: HCPGSP2629I The virtual machine is placed in CP mode due to a SIGP
stop from CPU 01.
16:10:57 00: HCPGSP2629I The virtual machine is placed in CP mode due to a SIGP
stop from CPU 00.
```

Suspend and Resume – Resume Attempt



```
16:11:43 io scheduler cfq registered
16:11:43 cio.b5d5f6: Channel measurement facility initialized using format exten
ded (mode autodetected)
16:11:43 TCP cubic registered
16:11:43 registered taskstats version 1
16:11:43 Freeing unused kernel memory: 228k freed
16:11:43 doing fast boot
16:11:43 Creating device nodes with udev
16:11:43 udevd version 128 started
16:11:43 dasd-eckd.90fb0d: 0.0.0200: New DASD 3390/0A (CU 3990/01) with 3338 cyl
inders, 15 heads, 224 sectors
16:11:43 dasd-eckd.412b53: 0.0.0200: DASD with 4 KB/block, 2403360 KB total size
, 48 KB/track, compatible disk layout
16:11:43  dasda:VOL1/  0X0200: dasda1
16:11:43 mount: devpts already mounted or /dev/pts busy
16:11:43 mount: according to mtab, devpts is already mounted on /dev/pts
16:11:43  Boot logging started on /dev/ttyS0(/dev/console) at Sat Apr 23 16:11:2
6 2011
16:11:43 kjournald starting.  Commit interval 15 seconds
16:11:43 EXT3 FS on dasda1, internal journal
16:11:43 EXT3-fs: mounted filesystem with ordered data mode.
16:11:53 Trying manual resume from /dev/sda2
```

Suspend and Resume – Resume Attempt

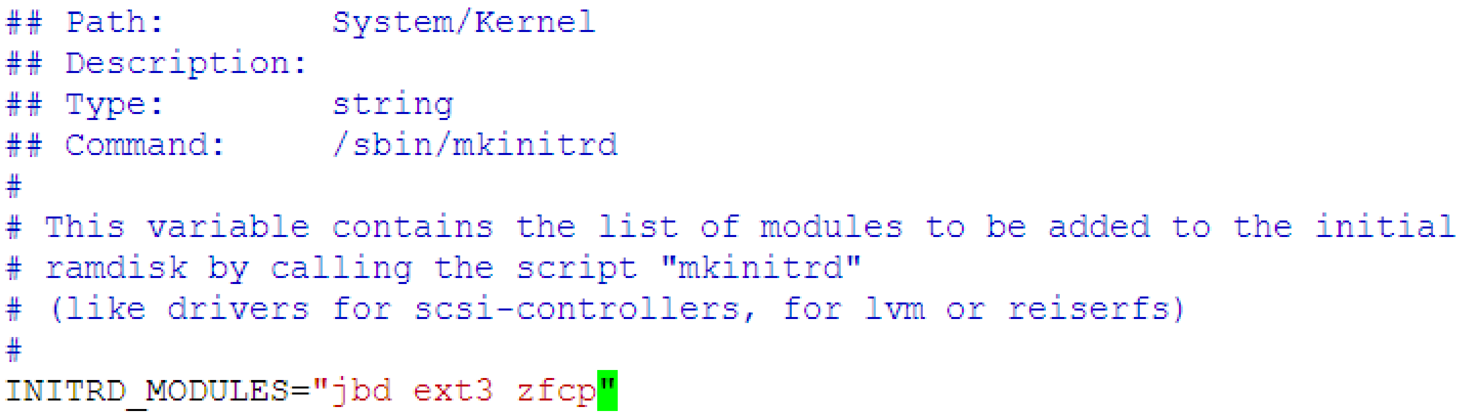


```
16:11:53 resume device /dev/sda2 not found (ignoring)
16:11:53 Trying manual resume from /dev/sda2
16:11:53 resume device /dev/sda2 not found (ignoring)
16:11:53 Waiting for device /dev/disk/by-path/ccw-0.0.0200-part1 to appear:  ok
16:11:53 fsck from util-linux-ng 2.16
16:11:53 [/sbin/fsck.ext3 (1) -- /] fsck.ext3 -a /dev/dasda1
16:11:53 /dev/dasda1: recovering journal
16:11:53 /dev/dasda1: clean, 4239/150176 files, 67293/600276 blocks
16:11:53 fsck succeeded. Mounting root device read-write.
16:11:53 Mounting root /dev/disk/by-path/ccw-0.0.0200-part1
16:11:53 mount -o rw,acl,user_xattr -t ext3 /dev/disk/by-path/ccw-0.0.0200-part1
 /root
16:12:01  INIT: version 2.86 booting
16:12:01 System Boot Control: Running /etc/init.d/boot
16:12:01 Mounting sysfs at /sys..done
16:12:01 Mounting debugfs at /sys/kernel/debug..done
16:12:01 Copying static /dev content..done
16:12:01 Mounting devpts at /dev/pts..done
16:12:01  Boot logging started on /dev/ttyS0(/dev/console) at Sat Apr 23 16:12:0
1 2011
16:12:01 Starting udevd: udevd version 128 started
16:12:01 dasd-eckd.90fb0d: 0.0.0202: New DASD 3390/0A (CU 3990/01) with 3338 cy
```

Suspend and Resume – Attempt Summary

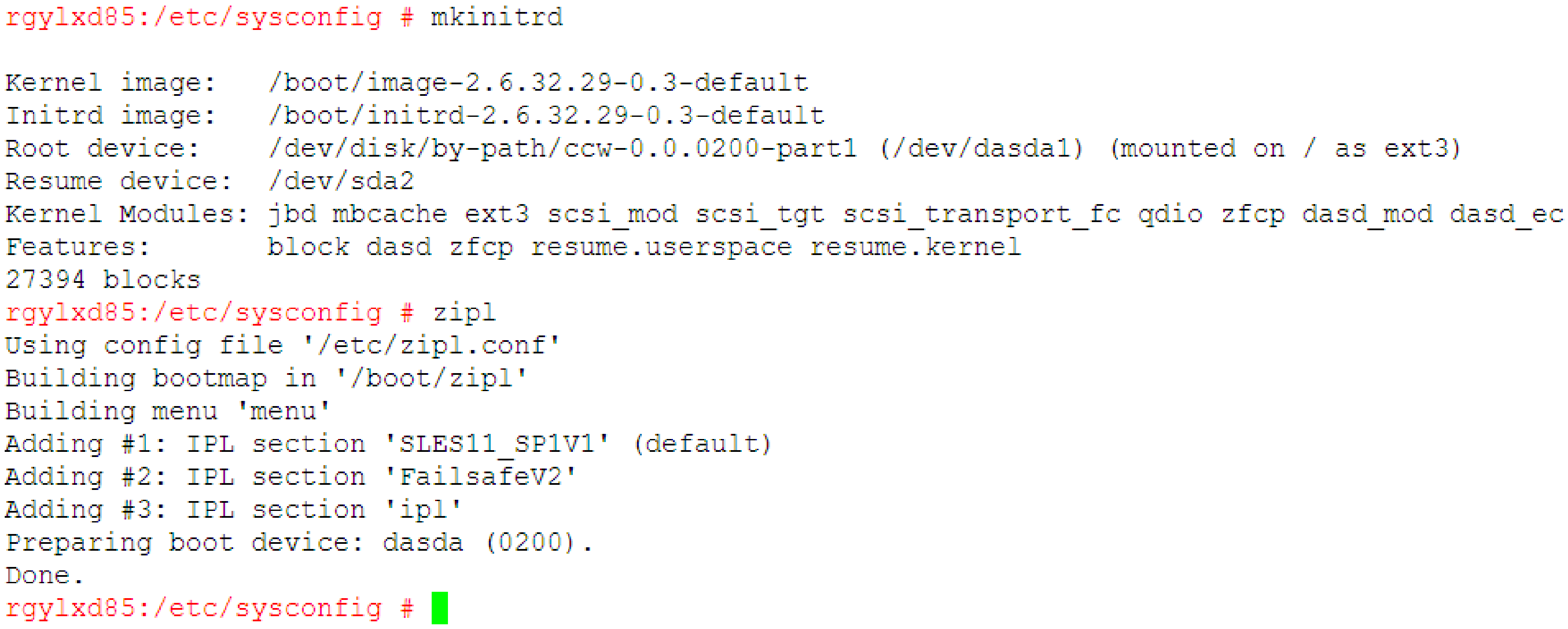
- The resume on the previous page failed
- The initial ram disk did not include zfcp, however the swap file on the SCSI device is required for the resume operation
- This example only had 3390 model 3 volumes available and needed to be able to suspend guests larger than 2.2 GB
- This issue is easily resolved by adding zfcp to the initrd

Suspend and Resume – Preparing zfcp



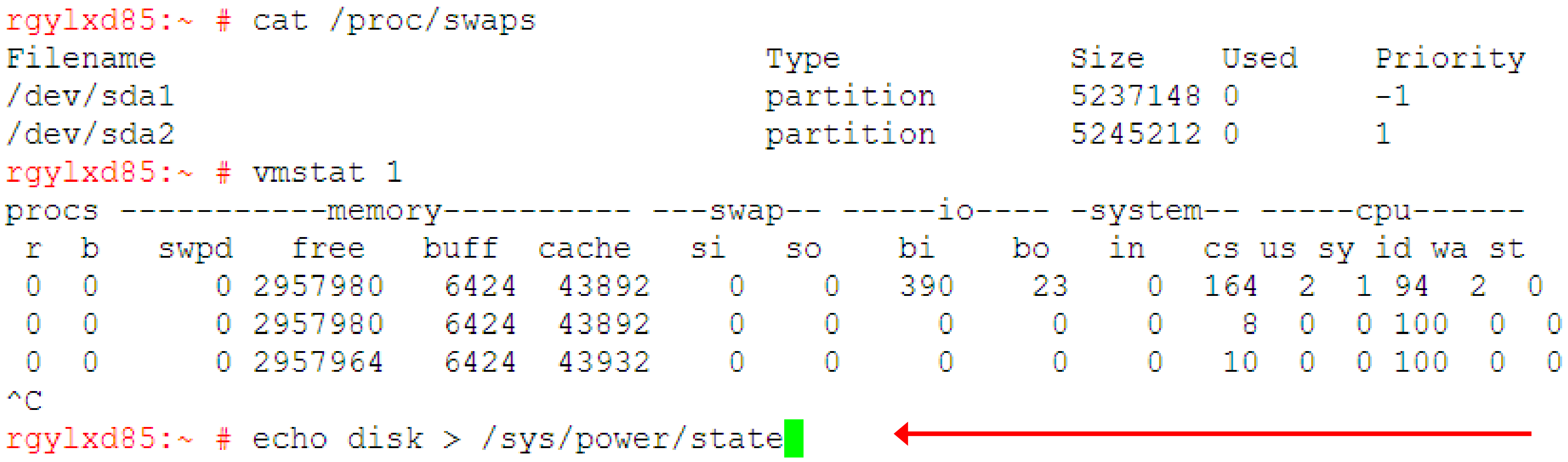
```
## Path:         System/Kernel
## Description:
## Type:         string
## Command:      /sbin/mkinitrd
#
# This variable contains the list of modules to be added to the initial
# ramdisk by calling the script "mkinitrd"
# (like drivers for scsi-controllers, for lvm or reiserfs)
#
INITRD_MODULES="jbd ext3 zfcp"
```

Suspend and Resume - Preparing



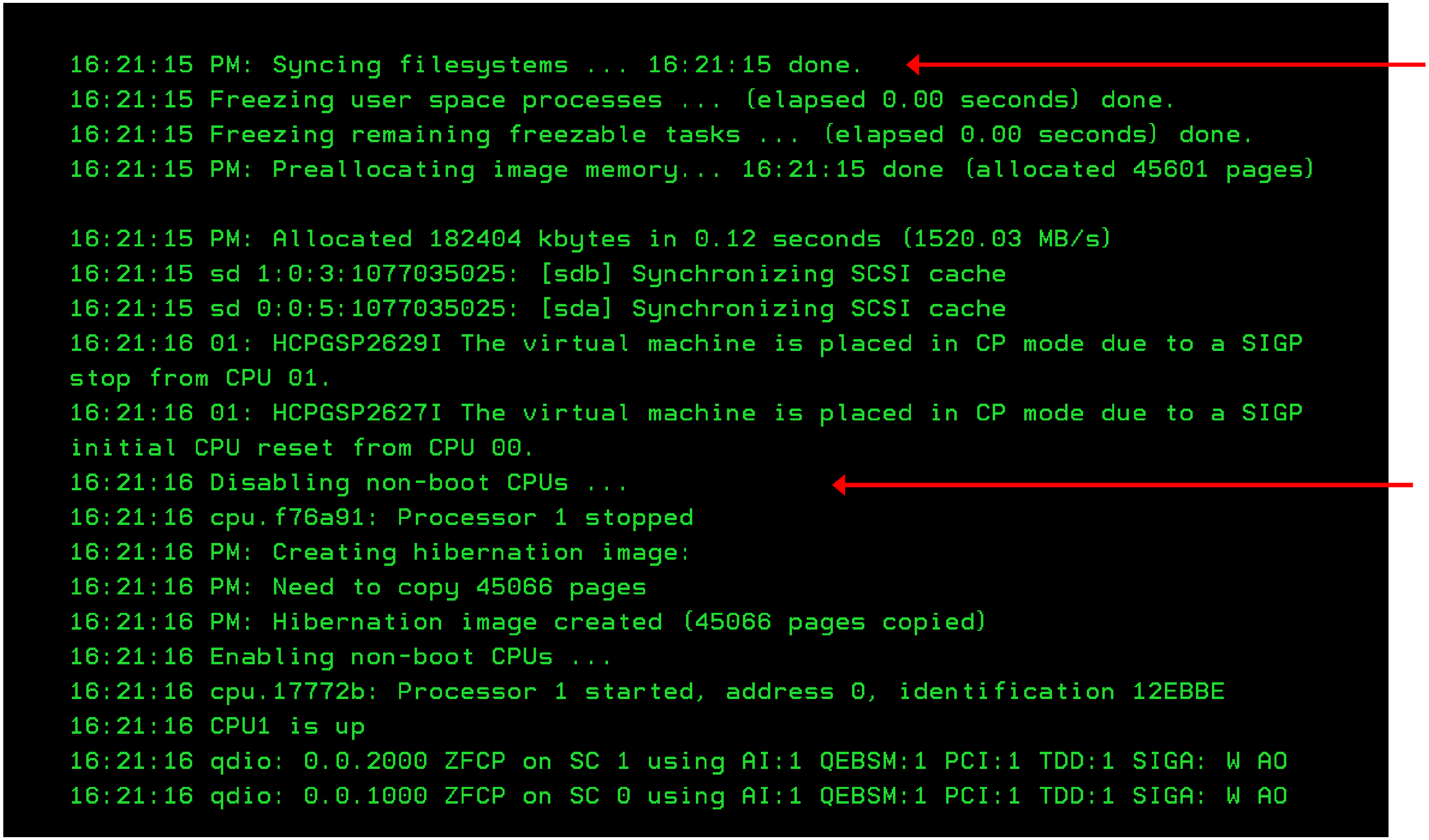
```
rgylxd85:/etc/sysconfig # mkinitrd

Kernel image:   /boot/image-2.6.32.29-0.3-default
Initrd image:   /boot/initrd-2.6.32.29-0.3-default
Root device:    /dev/disk/by-path/ccw-0.0.0200-part1 (/dev/dasda1) (mounted on / as ext3)
Resume device:  /dev/sda2
Kernel Modules: jbd mbcache ext3 scsi_mod scsi_tgt scsi_transport_fc qdio zfcp dasd_mod dasd_ec
Features:       block dasd zfcp resume.userspace resume.kernel
27394 blocks
rgylxd85:/etc/sysconfig # zipl
Using config file '/etc/zipl.conf'
Building bootmap in '/boot/zipl'
Building menu 'menu'
Adding #1: IPL section 'SLES11_SP1V1' (default)
Adding #2: IPL section 'FailsafeV2'
Adding #3: IPL section 'ipl'
Preparing boot device: dasda (0200).
Done.
rgylxd85:/etc/sysconfig #
```

Suspend and Resume - Suspending



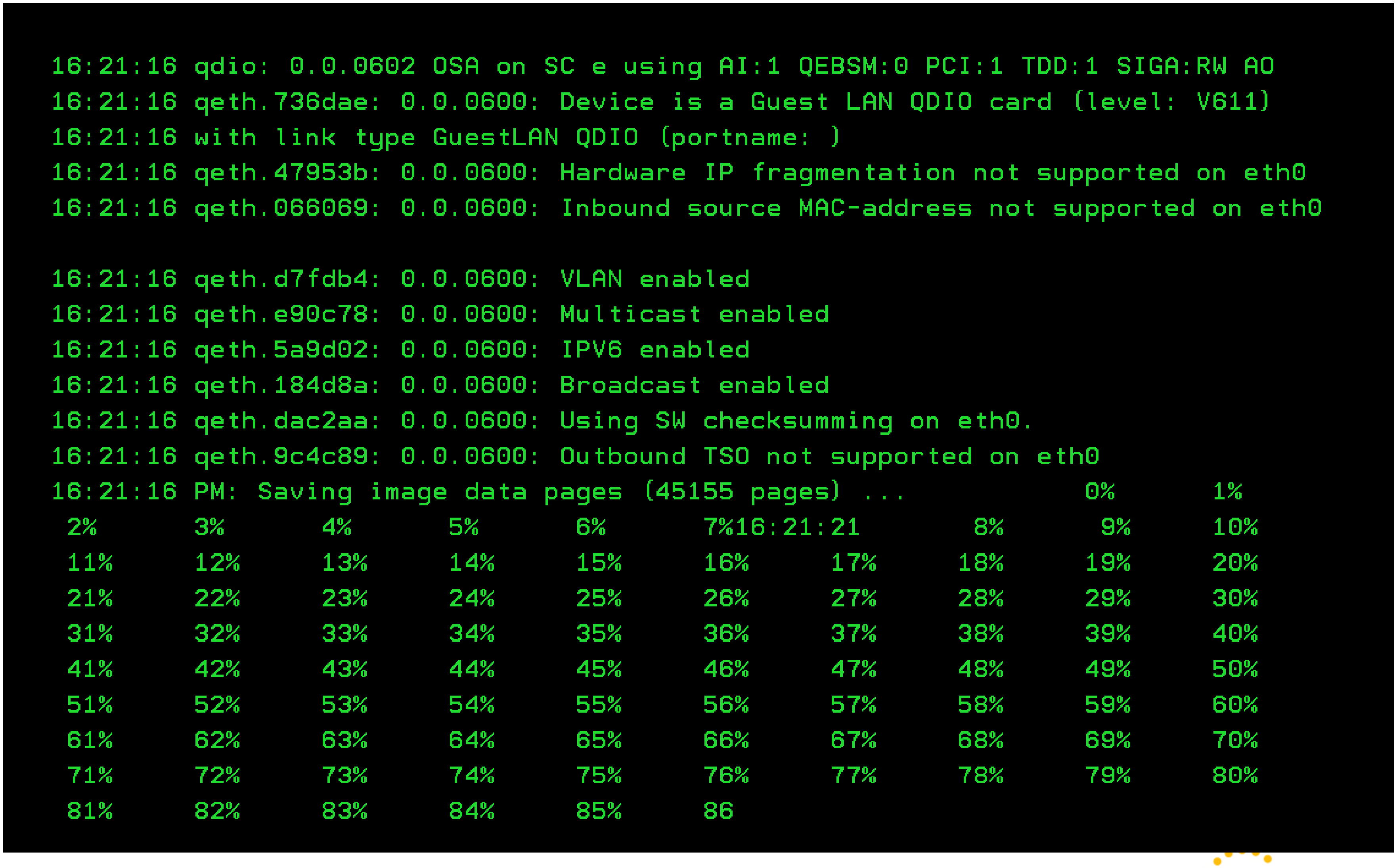
```
rgylxd85:~ # cat /proc/swaps
Filename                                Type            Size    Used    Priority
/dev/sda1                               partition       5237148 0       -1
/dev/sda2                               partition       5245212 0       1
rgylxd85:~ # vmstat 1
procs -----------memory---------- ---swap-- -----io---- -system-- -----cpu------
 r  b   swpd   free   buff  cache   si   so    bi    bo   in   cs us sy id wa st
 0  0      0 2957980   6424  43892    0    0   390    23    0  164  2  1 94  2  0
 0  0      0 2957980   6424  43892    0    0     0     0    0    8  0  0 100  0  0
 0  0      0 2957964   6424  43932    0    0     0     0    0   10  0  0 100  0  0
^C
rgylxd85:~ # echo disk > /sys/power/state
```

Suspend and Resume - Suspending



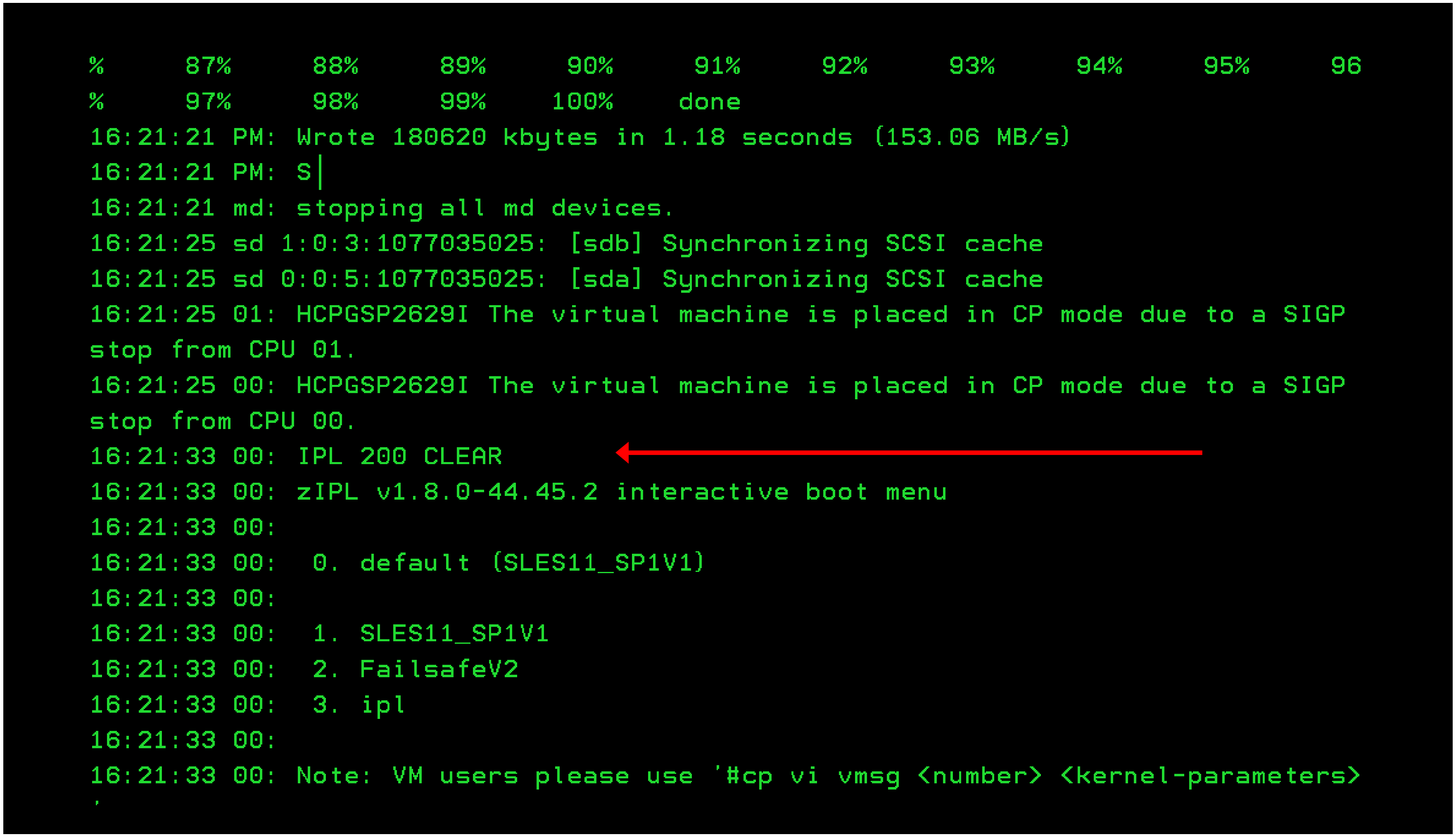
```
16:21:15 PM: Syncing filesystems ... 16:21:15 done.
16:21:15 Freezing user space processes ... (elapsed 0.00 seconds) done.
16:21:15 Freezing remaining freezable tasks ... (elapsed 0.00 seconds) done.
16:21:15 PM: Preallocating image memory... 16:21:15 done (allocated 45601 pages)

16:21:15 PM: Allocated 182404 kbytes in 0.12 seconds (1520.03 MB/s)
16:21:15 sd 1:0:3:1077035025: [sdb] Synchronizing SCSI cache
16:21:15 sd 0:0:5:1077035025: [sda] Synchronizing SCSI cache
16:21:16 01: HCPGSP2629I The virtual machine is placed in CP mode due to a SIGP
stop from CPU 01.
16:21:16 01: HCPGSP2627I The virtual machine is placed in CP mode due to a SIGP
initial CPU reset from CPU 00.
16:21:16 Disabling non-boot CPUs ...
16:21:16 cpu.f76a91: Processor 1 stopped
16:21:16 PM: Creating hibernation image:
16:21:16 PM: Need to copy 45066 pages
16:21:16 PM: Hibernation image created (45066 pages copied)
16:21:16 Enabling non-boot CPUs ...
16:21:16 cpu.17772b: Processor 1 started, address 0, identification 12EBBE
16:21:16 CPU1 is up
16:21:16 qdio: 0.0.2000 ZFCP on SC 1 using AI:1 QEBSM:1 PCI:1 TDD:1 SIGA: W AO
16:21:16 qdio: 0.0.1000 ZFCP on SC 0 using AI:1 QEBSM:1 PCI:1 TDD:1 SIGA: W AO
```

Suspend and Resume - Suspending



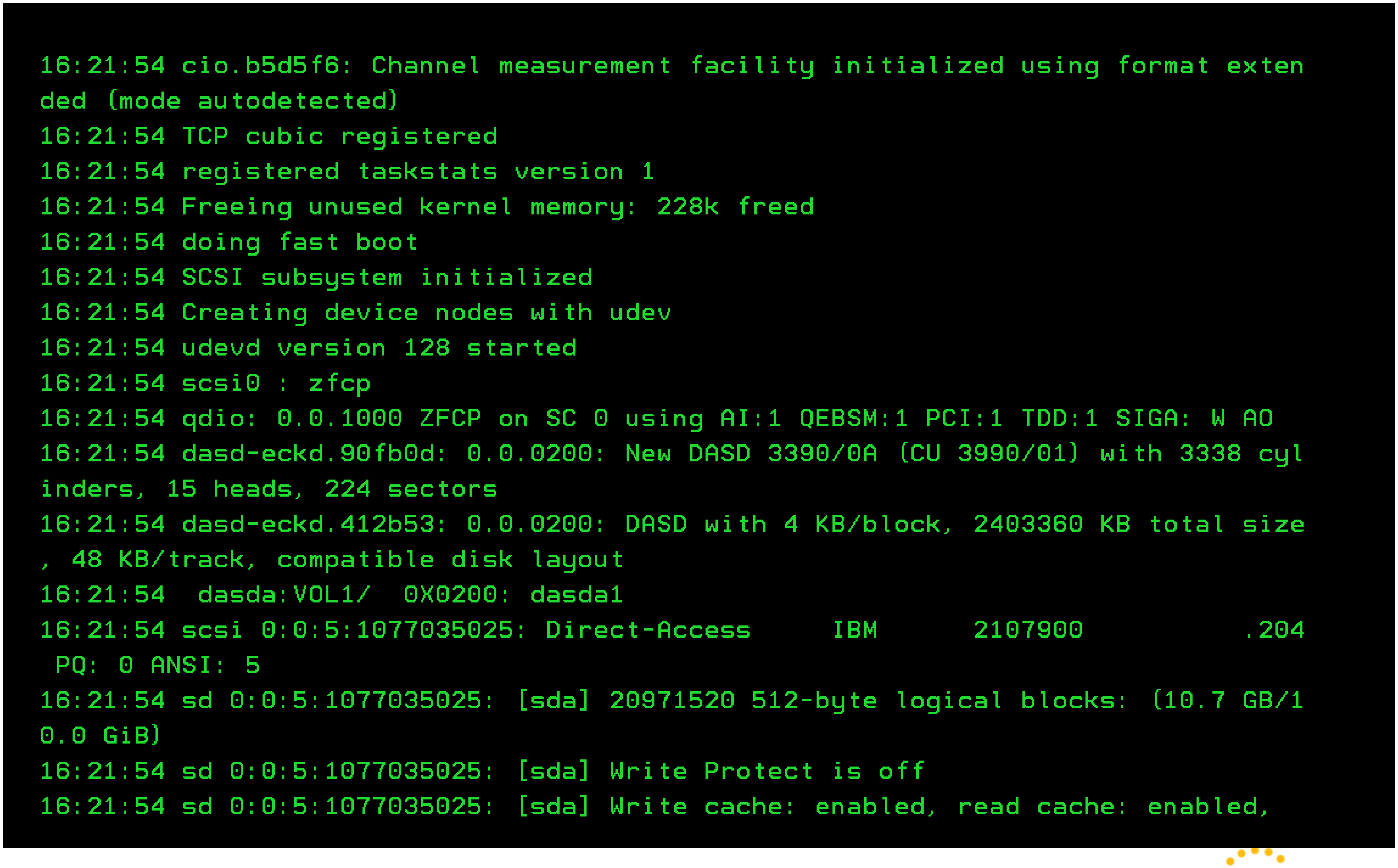
```
16:21:16 qdio: 0.0.0602 OSA on SC e using AI:1 QEBSM:0 PCI:1 TDD:1 SIGA:RW AO
16:21:16 qeth.736dae: 0.0.0600: Device is a Guest LAN QDIO card (level: V611)
16:21:16 with link type GuestLAN QDIO (portname: )
16:21:16 qeth.47953b: 0.0.0600: Hardware IP fragmentation not supported on eth0
16:21:16 qeth.066069: 0.0.0600: Inbound source MAC-address not supported on eth0

16:21:16 qeth.d7fdb4: 0.0.0600: VLAN enabled
16:21:16 qeth.e90c78: 0.0.0600: Multicast enabled
16:21:16 qeth.5a9d02: 0.0.0600: IPV6 enabled
16:21:16 qeth.184d8a: 0.0.0600: Broadcast enabled
16:21:16 qeth.dac2aa: 0.0.0600: Using SW checksumming on eth0.
16:21:16 qeth.9c4c89: 0.0.0600: Outbound TSO not supported on eth0
16:21:16 PM: Saving image data pages (45155 pages) ...           0%      1%
 2%      3%      4%      5%      6%      7%16:21:21       8%      9%     10%
 11%     12%     13%     14%     15%     16%     17%     18%     19%     20%
 21%     22%     23%     24%     25%     26%     27%     28%     29%     30%
 31%     32%     33%     34%     35%     36%     37%     38%     39%     40%
 41%     42%     43%     44%     45%     46%     47%     48%     49%     50%
 51%     52%     53%     54%     55%     56%     57%     58%     59%     60%
 61%     62%     63%     64%     65%     66%     67%     68%     69%     70%
 71%     72%     73%     74%     75%     76%     77%     78%     79%     80%
 81%     82%     83%     84%     85%     86
```

Suspend and Resume – Suspended/Resume



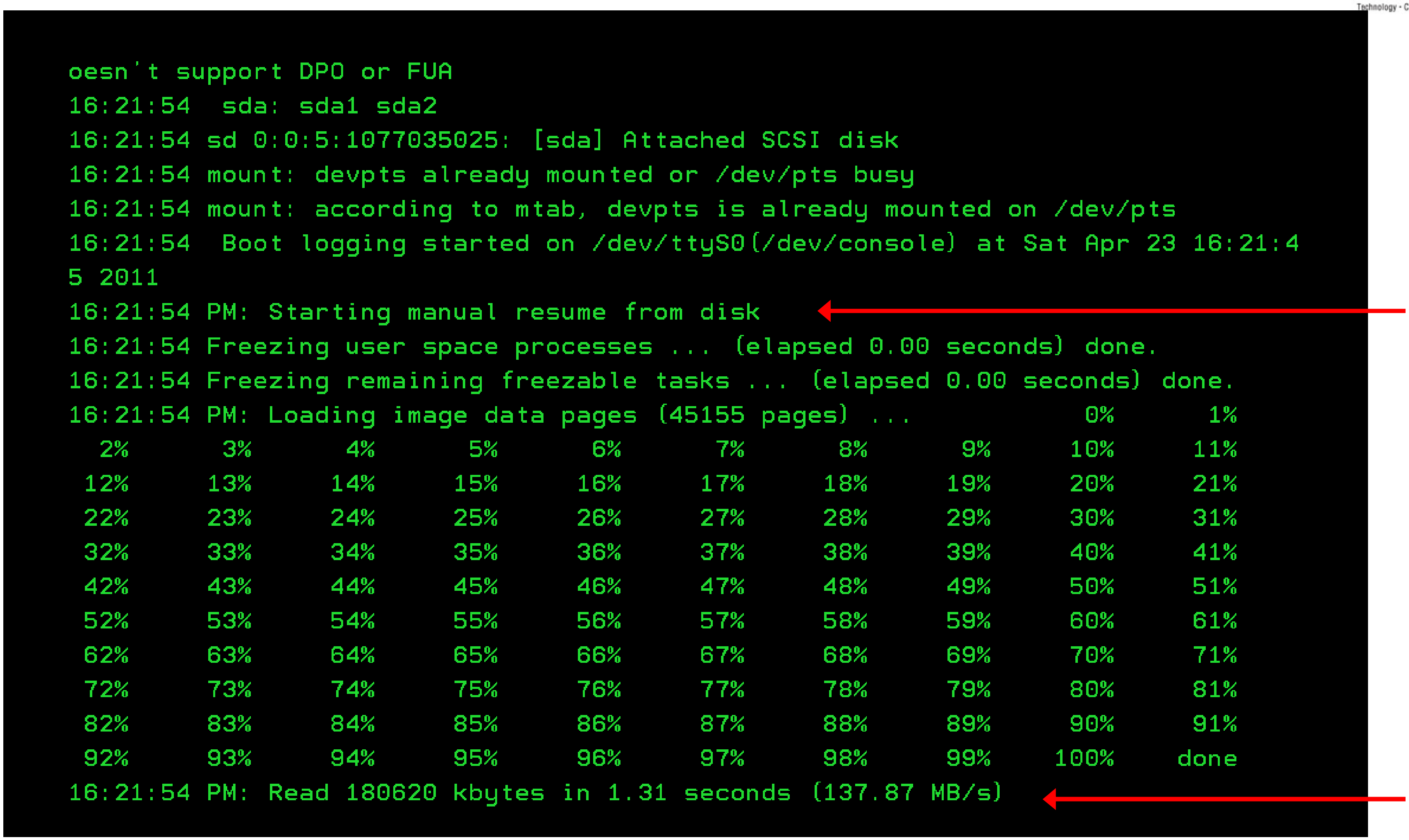
```
%      87%     88%     89%     90%     91%     92%     93%     94%     95%     96
%      97%     98%     99%    100%    done
16:21:21 PM: Wrote 180620 kbytes in 1.18 seconds (153.06 MB/s)
16:21:21 PM: S
16:21:21 md: stopping all md devices.
16:21:25 sd 1:0:3:1077035025: [sdb] Synchronizing SCSI cache
16:21:25 sd 0:0:5:1077035025: [sda] Synchronizing SCSI cache
16:21:25 01: HCPGSP2629I The virtual machine is placed in CP mode due to a SIGP
stop from CPU 01.
16:21:25 00: HCPGSP2629I The virtual machine is placed in CP mode due to a SIGP
stop from CPU 00.
16:21:33 00: IPL 200 CLEAR
16:21:33 00: zIPL v1.8.0-44.45.2 interactive boot menu
16:21:33 00:
16:21:33 00:  0. default (SLES11_SP1V1)
16:21:33 00:
16:21:33 00:  1. SLES11_SP1V1
16:21:33 00:  2. FailsafeV2
16:21:33 00:  3. ipl
16:21:33 00:
16:21:33 00: Note: VM users please use '#cp vi vmsg <number> <kernel-parameters>
'
```

Suspend and Resume - Resuming



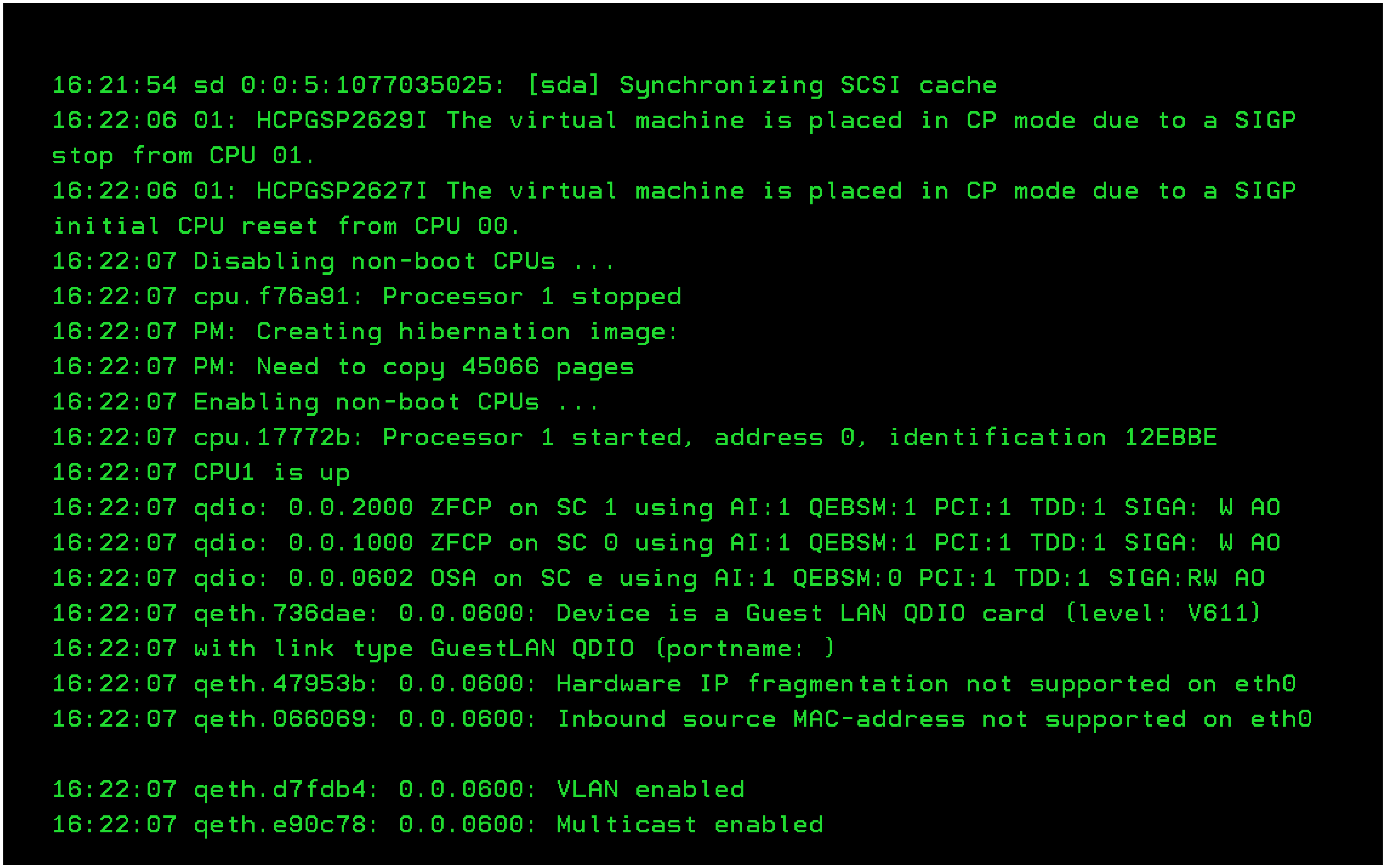
```
16:21:54 cio.b5d5f6: Channel measurement facility initialized using format exten
ded (mode autodetected)
16:21:54 TCP cubic registered
16:21:54 registered taskstats version 1
16:21:54 Freeing unused kernel memory: 228k freed
16:21:54 doing fast boot
16:21:54 SCSI subsystem initialized
16:21:54 Creating device nodes with udev
16:21:54 udevd version 128 started
16:21:54 scsi0 : zfcp
16:21:54 qdio: 0.0.1000 ZFCP on SC 0 using AI:1 QEBSM:1 PCI:1 TDD:1 SIGA: W AO
16:21:54 dasd-eckd.90fb0d: 0.0.0200: New DASD 3390/0A (CU 3990/01) with 3338 cyl
inders, 15 heads, 224 sectors
16:21:54 dasd-eckd.412b53: 0.0.0200: DASD with 4 KB/block, 2403360 KB total size
, 48 KB/track, compatible disk layout
16:21:54  dasda:VOL1/  0X0200: dasda1
16:21:54 scsi 0:0:5:1077035025: Direct-Access     IBM      2107900          .204
 PQ: 0 ANSI: 5
16:21:54 sd 0:0:5:1077035025: [sda] 20971520 512-byte logical blocks: (10.7 GB/1
0.0 GiB)
16:21:54 sd 0:0:5:1077035025: [sda] Write Protect is off
16:21:54 sd 0:0:5:1077035025: [sda] Write cache: enabled, read cache: enabled,
```

Suspend and Resume - Resuming



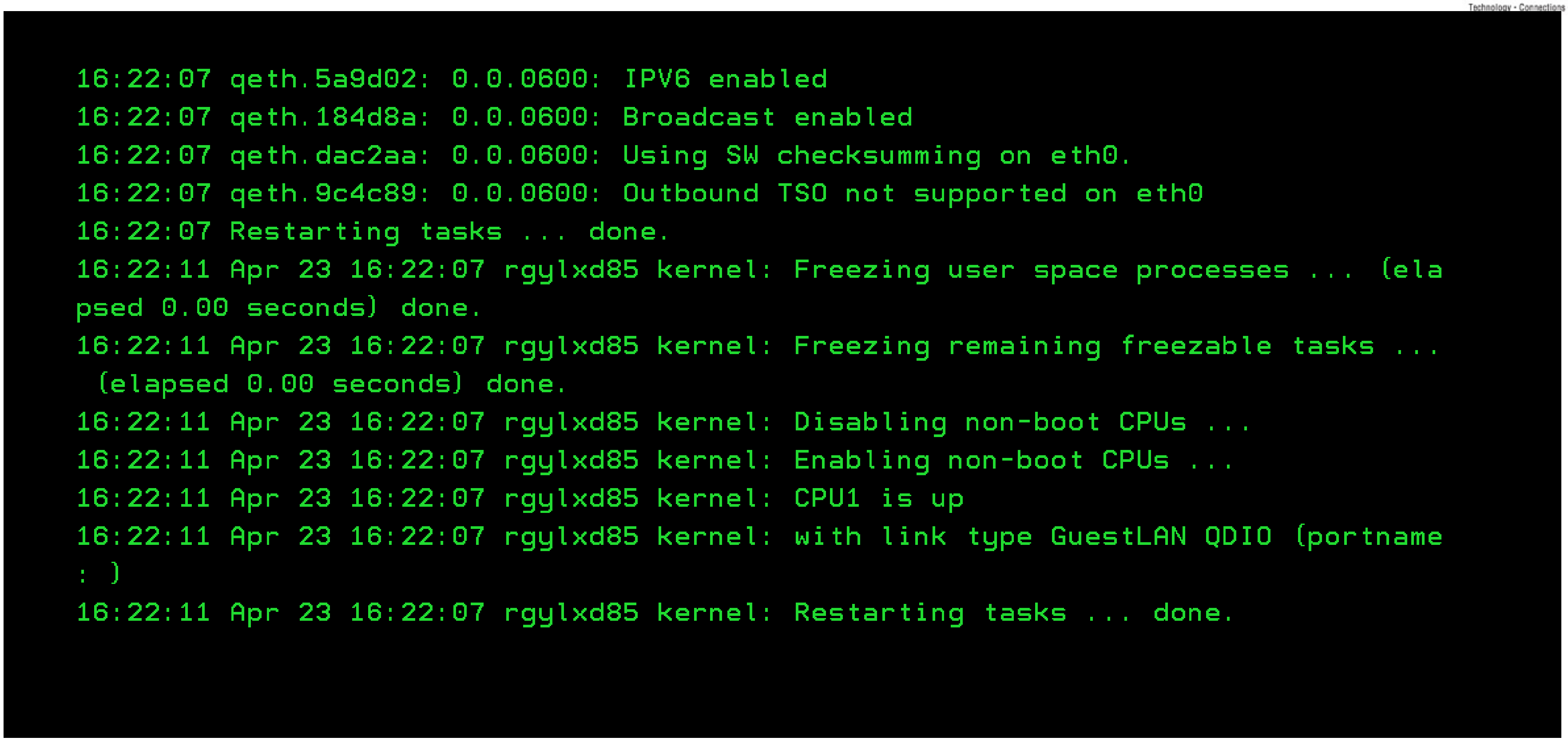
```
oesn't support DPO or FUA
16:21:54  sda: sda1 sda2
16:21:54 sd 0:0:5:1077035025: [sda] Attached SCSI disk
16:21:54 mount: devpts already mounted or /dev/pts busy
16:21:54 mount: according to mtab, devpts is already mounted on /dev/pts
16:21:54  Boot logging started on /dev/ttyS0(/dev/console) at Sat Apr 23 16:21:4
5 2011
16:21:54 PM: Starting manual resume from disk
16:21:54 Freezing user space processes ... (elapsed 0.00 seconds) done.
16:21:54 Freezing remaining freezable tasks ... (elapsed 0.00 seconds) done.
16:21:54 PM: Loading image data pages (45155 pages) ...           0%      1%
  2%      3%      4%      5%      6%      7%      8%      9%     10%     11%
 12%     13%     14%     15%     16%     17%     18%     19%     20%     21%
 22%     23%     24%     25%     26%     27%     28%     29%     30%     31%
 32%     33%     34%     35%     36%     37%     38%     39%     40%     41%
 42%     43%     44%     45%     46%     47%     48%     49%     50%     51%
 52%     53%     54%     55%     56%     57%     58%     59%     60%     61%
 62%     63%     64%     65%     66%     67%     68%     69%     70%     71%
 72%     73%     74%     75%     76%     77%     78%     79%     80%     81%
 82%     83%     84%     85%     86%     87%     88%     89%     90%     91%
 92%     93%     94%     95%     96%     97%     98%     99%    100%    done
16:21:54 PM: Read 180620 kbytes in 1.31 seconds (137.87 MB/s)
```

Suspend and Resume - Resuming



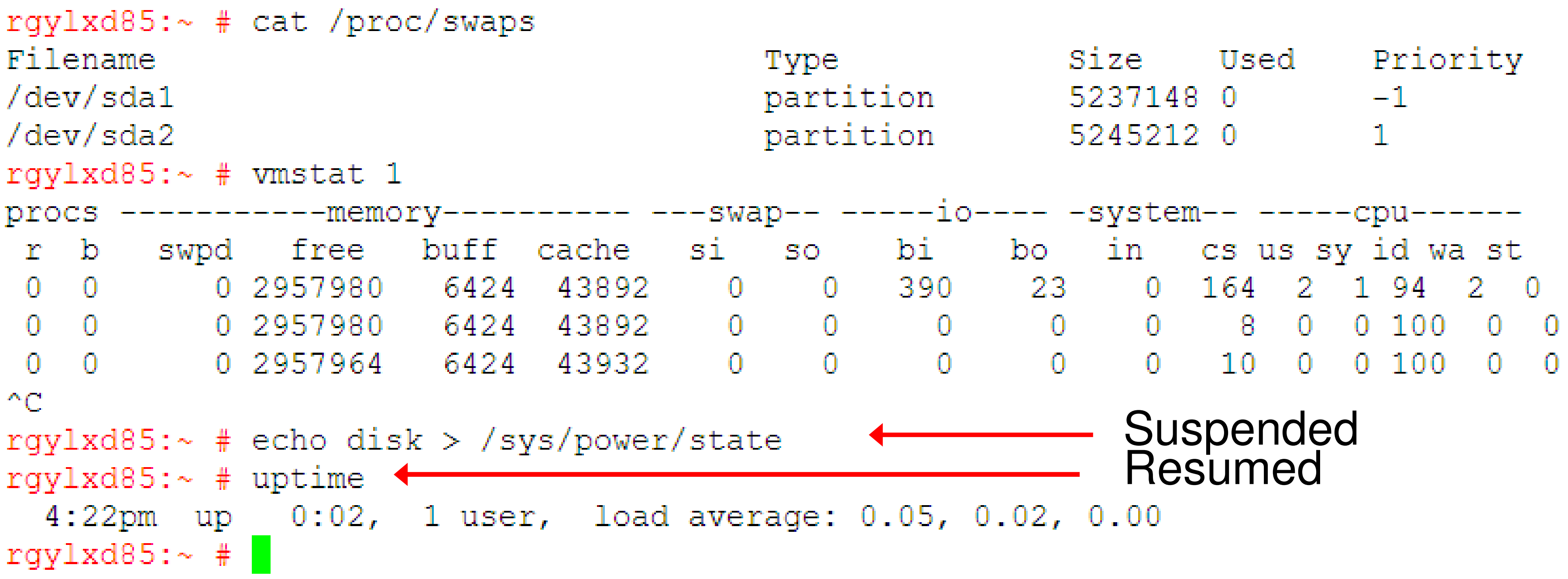
```
16:21:54 sd 0:0:5:1077035025: [sda] Synchronizing SCSI cache
16:22:06 01: HCPGSP2629I The virtual machine is placed in CP mode due to a SIGP
stop from CPU 01.
16:22:06 01: HCPGSP2627I The virtual machine is placed in CP mode due to a SIGP
initial CPU reset from CPU 00.
16:22:07 Disabling non-boot CPUs ...
16:22:07 cpu.f76a91: Processor 1 stopped
16:22:07 PM: Creating hibernation image:
16:22:07 PM: Need to copy 45066 pages
16:22:07 Enabling non-boot CPUs ...
16:22:07 cpu.17772b: Processor 1 started, address 0, identification 12EBBE
16:22:07 CPU1 is up
16:22:07 qdio: 0.0.2000 ZFCP on SC 1 using AI:1 QEBSM:1 PCI:1 TDD:1 SIGA: W AO
16:22:07 qdio: 0.0.1000 ZFCP on SC 0 using AI:1 QEBSM:1 PCI:1 TDD:1 SIGA: W AO
16:22:07 qdio: 0.0.0602 OSA on SC e using AI:1 QEBSM:0 PCI:1 TDD:1 SIGA:RW AO
16:22:07 qeth.736dae: 0.0.0600: Device is a Guest LAN QDIO card (level: V611)
16:22:07 with link type GuestLAN QDIO (portname: )
16:22:07 qeth.47953b: 0.0.0600: Hardware IP fragmentation not supported on eth0
16:22:07 qeth.066069: 0.0.0600: Inbound source MAC-address not supported on eth0

16:22:07 qeth.d7fdb4: 0.0.0600: VLAN enabled
16:22:07 qeth.e90c78: 0.0.0600: Multicast enabled
```

Suspend and Resume - Resuming



```
16:22:07 qeth.5a9d02: 0.0.0600: IPV6 enabled
16:22:07 qeth.184d8a: 0.0.0600: Broadcast enabled
16:22:07 qeth.dac2aa: 0.0.0600: Using SW checksumming on eth0.
16:22:07 qeth.9c4c89: 0.0.0600: Outbound TSO not supported on eth0
16:22:07 Restarting tasks ... done.
16:22:11 Apr 23 16:22:07 rgylxd85 kernel: Freezing user space processes ... (ela
psed 0.00 seconds) done.
16:22:11 Apr 23 16:22:07 rgylxd85 kernel: Freezing remaining freezable tasks ...
 (elapsed 0.00 seconds) done.
16:22:11 Apr 23 16:22:07 rgylxd85 kernel: Disabling non-boot CPUs ...
16:22:11 Apr 23 16:22:07 rgylxd85 kernel: Enabling non-boot CPUs ...
16:22:11 Apr 23 16:22:07 rgylxd85 kernel: CPU1 is up
16:22:11 Apr 23 16:22:07 rgylxd85 kernel: with link type GuestLAN QDIO (portname
: )
16:22:11 Apr 23 16:22:07 rgylxd85 kernel: Restarting tasks ... done.
```

Suspend and Resume



```
rgylxd85:~ # cat /proc/swaps
Filename                                Type            Size    Used    Priority
/dev/sda1                               partition       5237148 0       -1
/dev/sda2                               partition       5245212 0       1
rgylxd85:~ # vmstat 1
procs -----------memory---------- ---swap-- -----io---- -system-- -----cpu------
 r  b   swpd   free   buff  cache   si   so    bi    bo   in   cs us sy id wa st
 0  0      0 2957980   6424  43892    0    0   390    23    0  164  2  1 94  2  0
 0  0      0 2957980   6424  43892    0    0     0     0    0    8  0  0 100  0  0
 0  0      0 2957964   6424  43932    0    0     0     0    0   10  0  0 100  0  0
^C
rgylxd85:~ # echo disk > /sys/power/state
rgylxd85:~ # uptime
  4:22pm  up   0:02,  1 user,  load average: 0.05, 0.02, 0.00
rgylxd85:~ # 
```

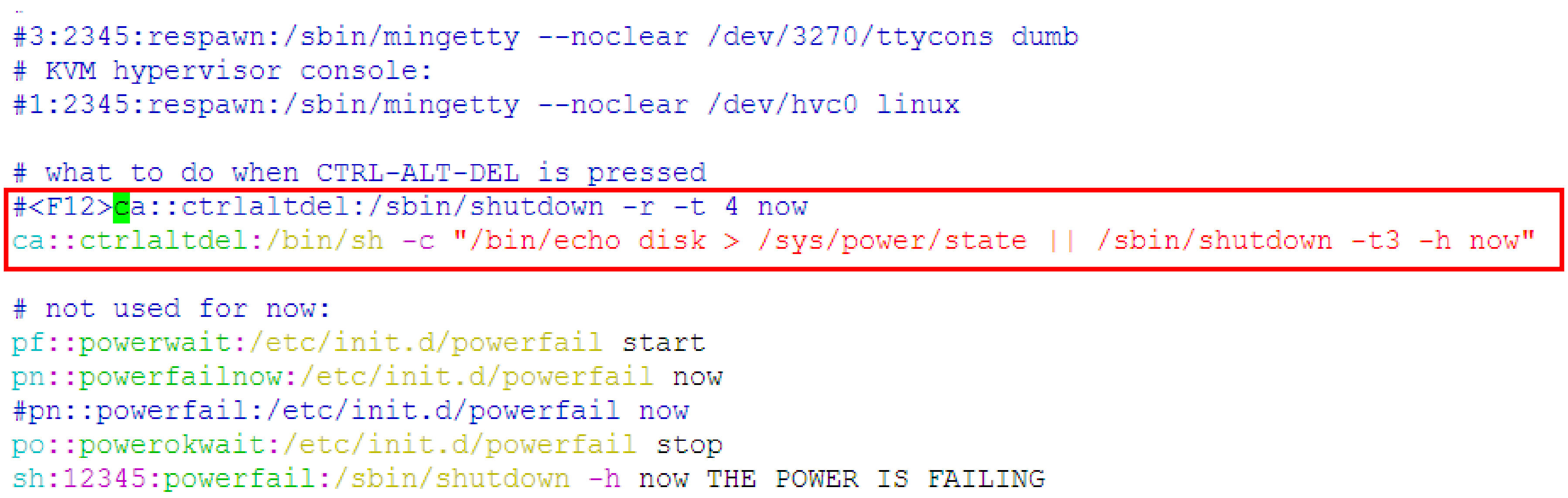
Suspended

Resumed

If the suspend and resume are completed fast enough your TCP connections may not even drop. The above ssh session is an example of that.

Using SIGNAL SHUTDOWN to trigger a suspend

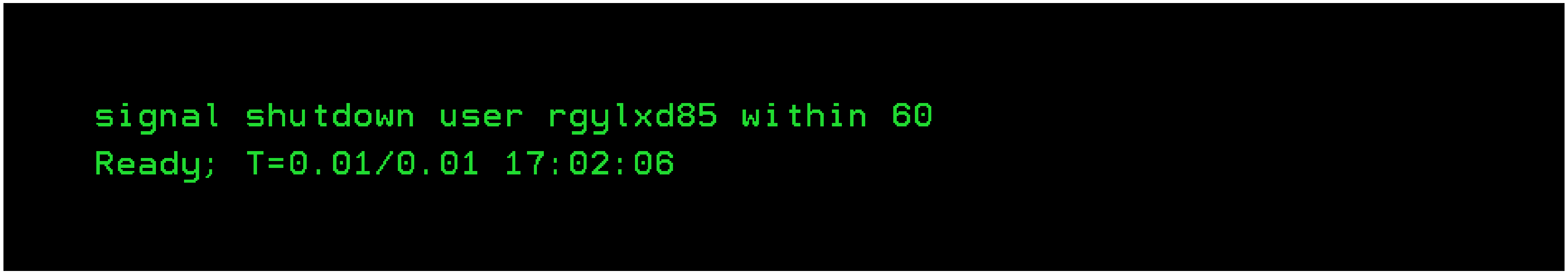
Suspend and Resume - /etc/inittab



```
#3:2345:respawn:/sbin/mingetty --noclear /dev/3270/ttycons dumb
# KVM hypervisor console:
#1:2345:respawn:/sbin/mingetty --noclear /dev/hvc0 linux

# what to do when CTRL-ALT-DEL is pressed
#<F12>ca::ctrlaltdel:/sbin/shutdown -r -t 4 now
ca::ctrlaltdel:/bin/sh -c "/bin/echo disk > /sys/power/state || /sbin/shutdown -t3 -h now"

# not used for now:
pf::powerwait:/etc/init.d/powerfail start
pn::powerfailnow:/etc/init.d/powerfail now
#pn::powerfail:/etc/init.d/powerfail now
po::powerokwait:/etc/init.d/powerfail stop
sh:12345:powerfail:/sbin/shutdown -h now THE POWER IS FAILING
```

- By adding the modified ctrlaltdel entry to /etc/inittab you can suspend your Linux guest to a swap file when it receive a “Signal shutdown”.
- In the event the suspend fails, a “regular” shutdown would occur.

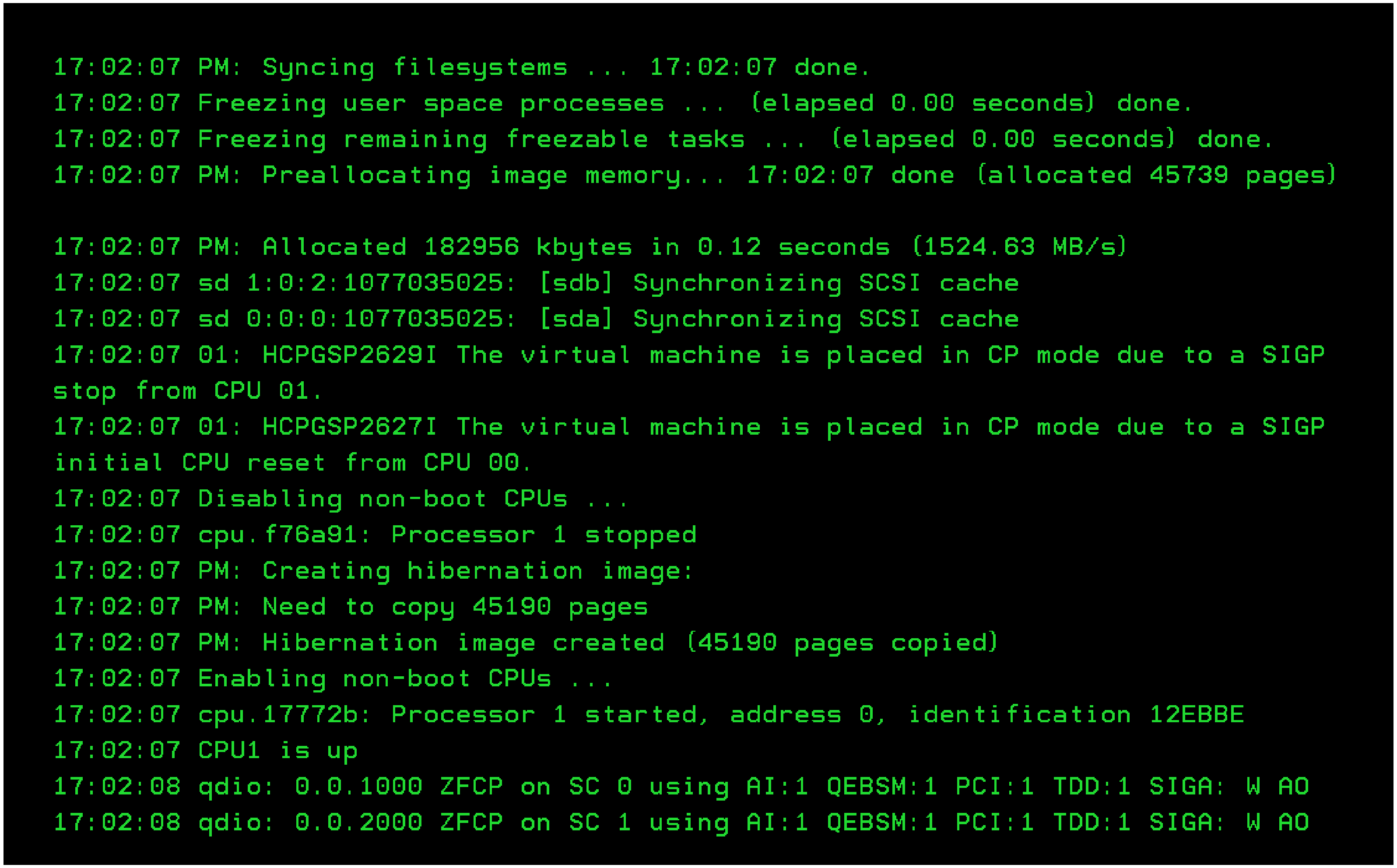
Suspend and Resume - signal



```
signal shutdown user rgylxd85 within 60
Ready; T=0.01/0.01 17:02:06
```

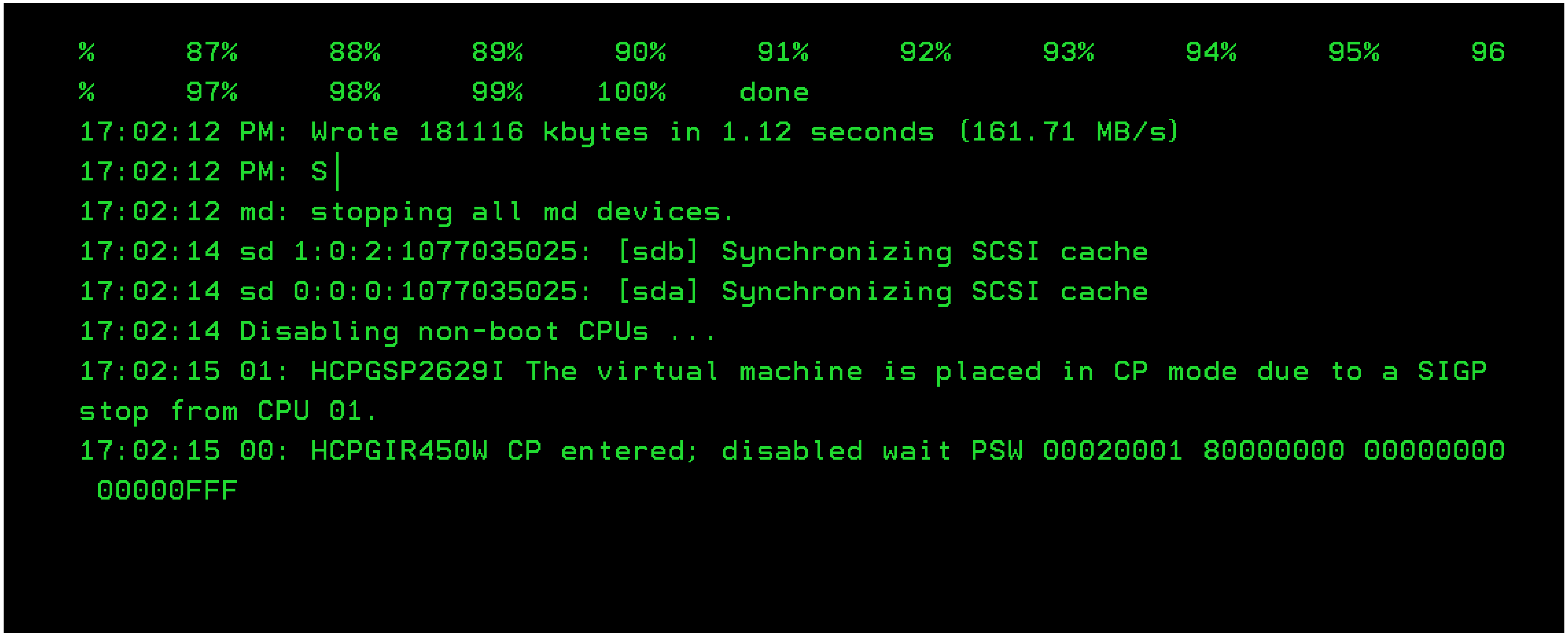
- Trigging a suspend from z/VM is easy once the Linux inittab update is in place.
- The standard signal shutdown command should very quickly suspend the guest

Suspend and Resume - Suspending



```
17:02:07 PM: Syncing filesystems ... 17:02:07 done.
17:02:07 Freezing user space processes ... (elapsed 0.00 seconds) done.
17:02:07 Freezing remaining freezable tasks ... (elapsed 0.00 seconds) done.
17:02:07 PM: Preallocating image memory... 17:02:07 done (allocated 45739 pages)

17:02:07 PM: Allocated 182956 kbytes in 0.12 seconds (1524.63 MB/s)
17:02:07 sd 1:0:2:1077035025: [sdb] Synchronizing SCSI cache
17:02:07 sd 0:0:0:1077035025: [sda] Synchronizing SCSI cache
17:02:07 01: HCPGSP2629I The virtual machine is placed in CP mode due to a SIGP
stop from CPU 01.
17:02:07 01: HCPGSP2627I The virtual machine is placed in CP mode due to a SIGP
initial CPU reset from CPU 00.
17:02:07 Disabling non-boot CPUs ...
17:02:07 cpu.f76a91: Processor 1 stopped
17:02:07 PM: Creating hibernation image:
17:02:07 PM: Need to copy 45190 pages
17:02:07 PM: Hibernation image created (45190 pages copied)
17:02:07 Enabling non-boot CPUs ...
17:02:07 cpu.17772b: Processor 1 started, address 0, identification 12EBBE
17:02:07 CPU1 is up
17:02:08 qdio: 0.0.1000 ZFCP on SC 0 using AI:1 QEBSM:1 PCI:1 TDD:1 SIGA: W AO
17:02:08 qdio: 0.0.2000 ZFCP on SC 1 using AI:1 QEBSM:1 PCI:1 TDD:1 SIGA: W AO
```

Suspend and Resume - Suspended



```
%     87%     88%     89%     90%     91%     92%     93%     94%     95%     96
%     97%     98%     99%    100%    done
17:02:12 PM: Wrote 181116 kbytes in 1.12 seconds (161.71 MB/s)
17:02:12 PM: S|
17:02:12 md: stopping all md devices.
17:02:14 sd 1:0:2:1077035025: [sdb] Synchronizing SCSI cache
17:02:14 sd 0:0:0:1077035025: [sda] Synchronizing SCSI cache
17:02:14 Disabling non-boot CPUs ...
17:02:15 01: HCPGSP2629I The virtual machine is placed in CP mode due to a SIGP
stop from CPU 01.
17:02:15 00: HCPGIR450W CP entered; disabled wait PSW 00020001 80000000 00000000
 00000FFF
```

Suspend and Resume

- After the signal is received by the Linux guest we see that a sync is issued for the file systems.
- User space and other freezable tasks are then frozen
- The hibernation image is created
- The image is written to the swap partition
- The CPUs and devices are stopped

Suspend and Resume - Summary

- Great option for middleware with long startup times
- Linux hotplug memory should currently be avoided with suspend / resume
- Ensure your initial ramdisk has all the device drivers you need to access the swap file and /boot partition for resume
- Ensure your swap file has adequate space to store the Linux instance
- If the resume fails, a normal IPL will occur

References

- Linux on System z Device Drivers, Features, and Commands
    - SC33-8411-09
- z/VM CP Commands and Utilities Reference
    - SC24-6175-01
- z/VM Directory Maintenance Facility Commands Reference
    - SC24-6188-01

धन्यवाद

Hindi

多謝

Traditional Chinese

감사합니다

Korean

Спасибо

Russian

Gracias

Spanish

شكرا

Arabic

Thank You

English

Obrigado

Brazilian Portuguese

Danke

German

Grazie

Italian

多谢

Simplified Chinese

Merci

French

நன்றி

Tamil

ありがとうございました

Japanese

ขอบคุณ

Thai

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