Help! My (Virtual) Penguin Is Sick!

Or

Aptenodytes Patagonicus*

Problems on z/VM

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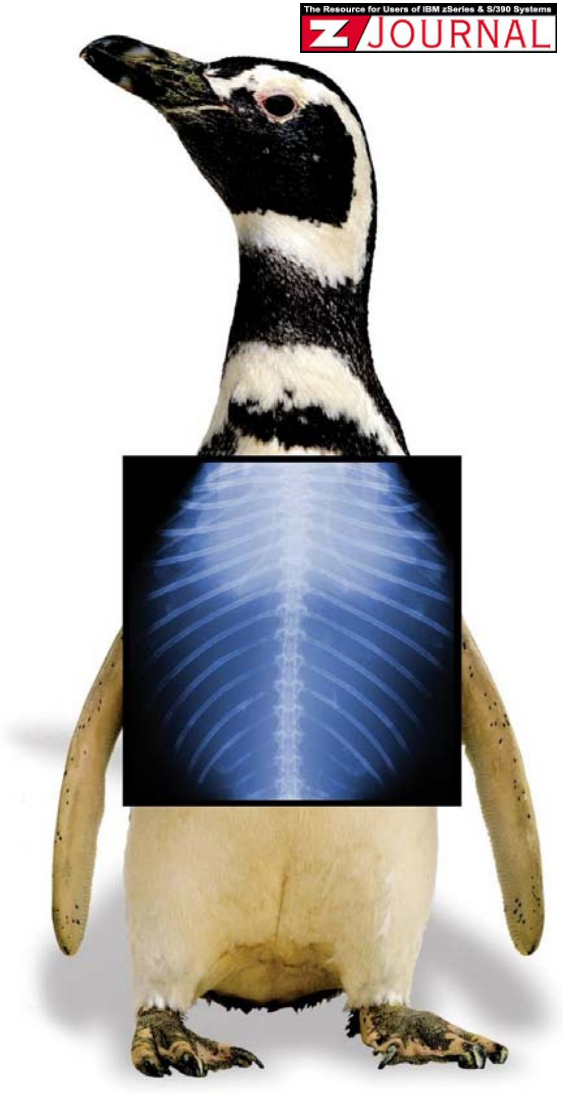

*** King Penguin, of course!**

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Why We're Here

The difference between
applications **people and** systems **people:**

Applications people worry about how it will work.

Systems people worry about how it will fail.

- If you support production, you're a systems person!

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Agenda

We'll cover:

- Ways Linux can get sick
- Techniques to decide what's wrong
- Debugging information you can gather

We won't cover:

- Detailed use of debugging tools (gdb, et al.)
- Dump (core) analysis

Paramedic / First Responder functionality, not ER surgery or pathology lab forensic reports!

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Penguins and Bears, Oh My!

Penguin Diseases 101

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The Modal Penguin Ailment

"Why isn't my Linux guest responding?" AKA:

- Can I get from here to there?
- If I can get there, is there a "there" there?
- If there is a "there" there, is it open?

These problems correspond to:

- Networking problems
- Linux issues
- VM troubles

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A Baseline is Useful!

Linux guests vary widely

- Networking configuration
- Performance profile
- Services provided

Keep written (and online) notes about your guests

- IP addresses, network interfaces, routing, etc.
- Typical/observed performance characteristics
- Disk space usage

In a crisis, you need to know how things ***should*** look!

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Network Issues

Is it a network issue:

- Between the user and VM?
- Between the VM stack and the Linux virtual machine?
- Within the Linux virtual machine?

If you can't get to the machine, it sure won't respond!

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VM Troubles

Is the Linux virtual machine even logged on?

- Someone might have logged it off, FORCEd it, etc.

Is the virtual machine in a stopped state?

- Users may disconnect from machines carelessly, leaving them stopped

Is VM broken?

- If VM is sick, Linux sure won't run!

Is VM letting the virtual machine run?

- CP might not be giving it resource

Linux Issues

Is it a kernel problem within the Linux guest?

- Even Linux can have problems — OOMs (Out-Of-Memory errors), loops, or Oopses (kernel errors)

Is a specific service (ssh, ftp, etc.) broken?

- If target service is down, Linux will appear to be down

Is it resource exhaustion within Linux?

- Insufficient disk space, or suffering from OOMs can cause some/all Linux services to wait
- Is an application or service hogging resources within the Linux virtual machine?

Penguin Problem Identification

Taking Your Penguin's Temperature and Pulse

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Linux Diagnostic Tools

Use Linux commands for diagnosis:

- **`ps`** (Process Status)
- **`df`** (Display Filesystems)
- **`free`** (memory usage display)
- etc…

Many of these just display **`/proc`** files

- **`/proc`** is a pseudo-filesystem whose files contain various system settings, counters, etc.
- Better than running control blocks in memory!
- Access files like any other file: **`cat`**, etc.
- Write to **`/proc`** to change system settings on-the-fly

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Diagnosing Network Issues

Try to **`ping`** Linux from user's machine

- Success means network OK between user & Linux
- Helps if you know the Linux hostname/IP address
- Also good to know whether Linux guest normally responds (some don't; some firewalls block ICMP)

Try **`traceroute`** to Linux from user's machine

- **`traceroute`** failure at last hop before Linux implicates Linux networking
- Must know normal routing and thus normal "last hop"!
- Linux, Windows, VM all have **`traceroute`**, spelled varying ways

Diagnosing Network Issues

If Linux networking appears broken:

- Log onto guest virtual machine directly
- Then log into Linux as **`root`**
- May not be possible if local root login disabled (may be able to login as another user and **`su`** to **`root`**)

Use **`ifconfig`** and/or **`netstat -i`** to examine network configuration and status

- Bouncing connection sometimes helps (**`ifconfig down`** followed by **`ifconfig up`**)

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Diagnosing Network Issues (continued)

Useful CP commands:

- **`#CP QUERY VIRTUAL NIC`** shows whether virtual NICs on Guest LANs are connected
- **`#CP QUERY LAN DETAILS`** shows what Guest LANs look like, including IP addresses assigned
  - Use **`#CP QUERY LAN DETAILS`** ***`lanname`*** if many LANs

Try `cat /proc/net/arp`

- Shows cached hardware addresses
- If none, that ***may*** tell you network isn't very happy
- Recommendation is to disable ARP caching anyway if using VSWITCH, so of limited usefulness

Diagnosing Network Issues (continued)

If QDIO network, **`ping`** broadcast (**`Bcast`**) address shown by **`ifconfig`**:

```
ping -b -c 1 10.3.2.255
WARNING: pinging broadcast address
PING 10.3.2.255 from 10.3.2.2 : 56(84) bytes of data.
64 bytes from 10.3.2.2: icmp_seq=0 ttl=64 time=41 usec
```

- On 3270, use **`ping -c 1`**, or **`ping`** will run forever
  - No **`<Cntrl>C`** on 3270; some distros support **`^C`**
- More than one response from an IP address means duplicate IP!

Learn to use tcpdump (or equivalent tool)

- Beyond scope of this presentation, but very powerful!

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Diagnosing VM Troubles

Is VM broken?

- Try to log onto another VM userid
- If that doesn't work, head for the machine room!

Is network to/from VM healthy?

- Try to **`ping`** and **`traceroute`** VM from your PC
- Try to **`ping`** external host from VM
- If you can get out but not back in, look for routing problem external to VM

Is the Linux virtual machine even logged on?

- Log onto a VM userid and issue
  `#CP QUERY USER` ***`linuxid`***
- Response ***`linuxid`*** **`NOT LOGGED ON`** is a problem!

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(Digression) VM SPOOLed Consoles

- VM lets you keep a copy of all console activity for a virtual machine
  - Conceptually similar to having **`root`** logged on using a hardcopy terminal
- Files are saved in VM system SPOOL space
- Closed on demand or automatically at system shutdown or user logoff
- *Invaluable* resource for determining abnormal virtual machine events
  - A bit less useful for Linux, since most services do not log to console
  - Oopses, OOMs, some segfaults *are* logged to console

How To SPOOL the Console

CP SPOOL command turns on SPOOLing:

```
CP SPOOL CONSOLE START
```

CP TERMINAL TIMESTMP ON useful:

- Timestamps all output

Various options control default destination userid, class, filename/filetype

Useful to indicate date/time SPOOL started:

```
CP SPOOL CONSOLE START NAME yyyymmdd hh:mm:ss
```

- Once file is closed, file timestamp will be ***close*** time, so this adds useful info

May want to centralize console collection:

```
CP SPOOL CONSOLE START TO CONSAVER
```

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Finding (Open) SPOOLed Consoles

To determine if a running virtual machine has its console SPOOLed:

#CP QUERY PRT ALL *linuxid*

- Look for open CON file:

```
ORIGINID FILE CLASS RECORDS  CPY HOLD DATE  TIME NAME TYPE
linuxid  6216 T CON nnnnnnn 001 NONE OPEN- 0009 name type
```

- Mere *existence* of file is useful data point

To close the console and send it to yourself:

#CP SEND CP *linuxid* CLOSE CONSOLE *yourid*

(where ***yourid*** is your userid)

- CP **SEND** requires privilege class C

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Processing VM SPOOLed Consoles

Result of previous command is message:

RDR FILE *nnnn* SENT FROM *linuxid* CON WAS *mmmm* RECS *rr* …

Note the "***nnnn***" value — that's the SPOOL file number in your virtual reader

Issue CMS **PEEK** command to view the file:

PEEK *nnnn* (FOR *

- Places you in XEDIT session, viewing file contents
- Large files require time, virtual storage to read
- Note: files may span days; **HCPMID6001I** appears each midnight

CMS **RECEIVE** command reads file to disk

- PF9 in **PEEK**, or:

RECEIVE *nnnn fn ft fm*

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Finding (Closed) Console Files

To find SPOOLed consoles for non-running virtual machines (or from previous logons):

#CP QUERY RDR ALL *linuxid*

#CP QUERY PRT ALL *linuxid*

- Shows files in ***linuxid*** 's virtual reader or printer

#CP QUERY RDR ALL XFER ALL *linuxid*

- Shows files sent/transferred to other virtual machines

Use CP **TRANSFER** to move files to your reader:

TRANSFER ownerid RDR nnnn *

- Then use **PEEK**, **RECEIVE**, et al.

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Notes About SPOOLed Consoles

Consoles can become very large

- For guests with significant console activity, consider closing periodically to keep files manageable
- E.g., close at midnight via WAKEUP-based machine
- EOF option closes automatically every 50,000 records (desirability depends on how you manage the files)

Naming consoles rationally helps a lot

- Use **`NAME`** option when SPOOLing
- **`RECEIVE`** them as "***`userid yyyymmdd`***", perhaps

Vendor console management products exist

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When/Why Was Linux Logged Off?

Examine operator's console to see when/ why guest logged off:

User *linuxid* LOGOFF AS *linuxid* USERS= *n*

- Logged off "normally", either by a user command or by Linux itself after shutdown

User *linuxid* LOGOFF AS *linuxid* USERS= *n* FORCED BY *vmid*

- Logged off by CP FORCE command issued by ***vmid***

User *linuxid* LOGOFF AS *linuxid* USERS= *n* FORCED BY SYSTEM

- Logged off due to CP "timebomb" logoff, after being in a read for (usually) 15 minutes while disconnected

- Look for more nuggets at bottom of guest console

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Diagnosing VM Troubles

Is Linux virtual machine stopped in **CP READ**?

- Issue **CP SEND CP *linuxid* BEGIN** to start it
  - Harmless at worst
- Use **RUNNABLE EXEC** (see *Resources*) to check

How did it get there?

- Force disconnected with **RUN OFF**
  - by system or because user closed emulator while connected
- Reconnected and left in **CP READ** (with **RUN OFF**)
- **CP STOP** or **CP CPU ALL STOP** issued on guest

Lesson:

Run Linux guests with CP SET RUN ON!!!

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Diagnosing VM Troubles

Is VM giving the virtual machine any service?

- CP might not be giving it resource
- Likely if Linux virtual machine reconnect shows **`RUNNING`** with no keyboard response
- If it seems normal at reconnect, hit ENTER a couple of times, look for **`VM READ`**, Linux **`login:`** prompt
- If no read, or significant delay before login prompt, VM may not be running the virtual machine

Basic understanding of scheduling and dispatching is important

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Scheduler and Dispatcher 101

Some critical concepts

- Guests must be ***runnable*** to do work
- CP must be willing to schedule the guest
- CP must be willing to dispatch the guest

A guest is always in one of ~~three~~ 3.5 lists:

1) **Dormant** list: guest has no work to do
2) **Dispatch** list: guest active, CP is allowing it to run
3) **Eligible** list: guest active, CP is not allowing it to run

3.5) Limit list: CPU-limited by **SET SHARE LIMITHARD**

(Can also be **running**…special case of Dispatch list!)

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Scheduler and Dispatcher 101

CP **scheduler** analyzes resources, decides whether enough to give guest service

- Entirely storage-related (memory)
- If not enough available, guest does not get scheduled

CP **dispatcher** gives guests access to CPUs

- If multiple guests are active, they take turns
- VM is very good at this — supports tens of thousands of active users with excellent response time

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Dispatch Classes – Class 1

When first dispatched, guest is Class 1 (“Q1”)

- CP waits one Class 1 Elapsed Timeslice (C1ETS) to see if it goes idle voluntarily
- Guests that do not go idle within that timeslice are preemptively stopped from execution— sent back to the scheduler
- C1ETS is dynamically calculated to keep a fixed % of guests in class 1
- C1ETS should be enough for short, interactive transactions (minor CMS commands)

Dispatch Classes – Class 2

If guest does not go idle in one C1ETS, it enters Class 2 (“Q2”)

- Next time CP runs it, given 8x C1ETS
- Guests that do not go idle within that amount of time are rescheduled
- Such guests are presumed to be running a command, but not necessarily doing something “major”

Dispatch Classes – Class 3

If guest does not go idle within class 2 C1ETS multiple, it enters Class 3 (“Q3”)

- Next time CP runs it, given 6x Class 2 = 48x C1ETS
- Guests that do not go idle within that amount of time are rescheduled
- Such users are presumed to be running a long-running command

Dispatch Classes – Class 0

QUICKDSP ON bypasses some rules

- Still get rescheduled, but never held in eligible list

Interactive guests (on terminals, hitting keys) also get Q0 stays ("hotshot" stays)

- Still get rescheduled, but "go to head of line" briefly
- Return to their previous queue level after Q0 stay

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Leaving the Dispatch List

Guests leave dispatch list because they:

- Go idle voluntarily (load a wait PSW)
- Wait on a CP resource (paging, DIAGNOSE I/O)
- Leave SIE due to execution of a privileged instruction

300ms **queue drop test timer** set on dispatch list exit

- Guest resuming activity within that period are reinserted into previous place in queue
- Guests that don't go idle never get queue dropped!

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How This Plays Out…

CP scheduling is based on storage analysis

- If not enough, guests are held in **Eligible list** (**E-list**)
- Assumption: other guests will go idle, storage will become available soon
- If not, E-listed guests never get scheduled

Note: There's also an L-list

- Users who are limited by their SHARE LIMITHARD setting
- ***Not*** the same thing, but such users also don't run!
- Other storage issues abound

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Why This Goes Wrong

Linux machines tend to:

- Be quite large (virtual storage size)
- Have working set close to virtual storage size
- Stay active (rarely/never go idle)

Linux real storage requirements are thus much higher than the average CMS guest

If enough Linux guests are logged on, CP notices it will overcommit real storage

- One or more such guests “lose”, are E-listed — and stay there!

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How Does This Manifest?

System is running along fine

- One guest too many is started
- Things “just stop”!

Dispatched guests “should” go idle

- Linux guests typically don’t, stay runnable all the time

Historically, guests doing I/O were “active”

- Recent releases have mostly eliminated this

Remember the queue drop timer

- Guests never go truly idle
- Never get scheduled properly, so E-listing permanent!

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The Bitner CPU Buffet

Detection

CP INDICATE QUEUES EXPANDED shows:

```
LINUX902        Q3 PS  00013577/00013567 .... -232.0 A00
LINUX901        Q3 PS  00030109/00030099 .... -231.7 A00
VSCS            Q1 R   00000128/00000106 .I.. -208.7 A00
VMLINUX3        Q3 IO  00052962/00051162 .... -.9398 A00
VMLINUX3 MP01   Q3 PS  00000000/00000000 ....  .0612 A00
LINUX123        E3 R   00177823/00196608 ....  5255. A00
```

- **HELP INDICATE QUEUES** shows meaning of output
- CP privilege class E required
- **Note:** “deadline time” (sixth column) indicates when CP thinks the guest will run
- Guest **LINUX123** is not running any time soon…

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Remediation

Buy lots more storage ($<6K/GB — cheap!)

Tune applications so guests do queue drop

- Obviously only meaningful if guests are nominally idle
- Remember **cron** et al. may wake them anyway

Log off some guests

- You didn't need that WAS application, did you?

Tune guest storage sizes

- Linux uses "extra" storage for file buffers
- Smaller guests may actually perform ***better***
- Define smaller guest virtual storage sizes, or use Collaborative Memory Management (CMM)

Diagnosing Kernel Problems

Log onto Linux guest to see if it's even alive:

- Hit ENTER, look for **`VM READ`**, **`login:`** prompt
- No **`VM READ`** means Linux is "hung" (looping, E-listed, or somehow busted)
- No login prompt could just mean **`login`** isn't running
  - Again, it helps to know what normal behavior is!
- Look at SPOOLed console for Oops messages

"What's an Oops?"

- A system ABEND, in VM terms: a kernel failure
- Like VM, may leave system in unusable state
- Doesn't necessarily indicate code bug — faulty hardware can cause an Oops (unlikely on VM)

Basic Oops Analysis

Utility **ksymoops** maps addresses in Oops output to kernel modules

- Uses system map file, usually found in **/boot**

Oops output used by **ksymoops** is in a file

- Usually found in **/var/log/messages**
- If **syslogd** not running, extract with **dmesg** utility (**dmesg > oops.log**)
- If Linux not even that alive, cut&paste from console log, or type it back in!

➢ **If cascading Oopses, only first usually relevant**

Diagnosing Kernel Loops

Use **#CP INDICATE USER *linuxid* EXPANDED** to watch guest CPU time

- If increasing rapidly, guest may be looping (could just be busy, though)
- Also note I/O counts, look for massive I/O load

If loop suspected, log onto guest, use **CP TRACE**:

- **#CP TRACE INST RUN NOTERM PRINT**
- Run a while; monitor with **#CP QUERY PRT * ALL**
- Then issue **#CP TRACE END**, **#CP CLOSE PRT ***, and **RECEIVE** the file
- Analyze for repeated hits/patterns (or ask vendor to)

Diagnosing Broken Linux Services

Use **`ps aux`** to show what services are running, pipe through **`grep`** to find target:

```
# ps aux | grep ssh
```

- Finds any processes that mention "**`ssh`**" (may find the **`grep`** itself, too)

Restart service that's not up and should be

- Perhaps restart it anyway if it claims to be up but isn't responding!

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Diagnosing Broken Linux Services

Look at system log files

- **`/var/log/messages`** often interesting

`dmesg` also shows recent kernel messages

- Looks at “kernel ring buffer”
  - Sort of like CP trace table, but just messages

Look at logs for service in question

- Location not predictable, alas
  - Prescribed by Linux Filesystem Hierarchy Standard, but...
  - Try **`/var/log/servicename`**, application directories
- Note: Linux & VM times may differ (timezone, drift)
- Default logging levels often omit useful information
  - May need to change, wait for reoccurrence

Diagnosing Resource Exhaustion

If Linux runs short on a resource, results “may be unpredictable”

- Well-behaved applications will fail in graceful ways
- Severe/rapid resource depletion may prevent this

Nothing unique about Linux resources:

- Disk space
- Memory
- Page (swap) space
- CPU
- Any and all can run short!

Diagnosing Disk Space Exhaustion

Use "**df**" (Display Filesystems):

```
# df -a –h
Filesystem             Size  Used Avail Use% Mounted on
none                   592M   94M  464M  17% /
none                      0     0     0   -  /proc
none                      0     0     0   -  /dev/pts
/dev/dasd/0000/part1   485M   17M  468M   4% /tmp
```

Most interesting part is "**Use%**"

- Filesystems above 90% are suspect
  - May be full due to temporary file usage
- Again, useful to know "normal" usage levels

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Diagnosing Memory Exhaustion

Linux may take OOM errors when insufficient "real" (virtual) memory is available

- Applications can get OOMs; kernel too (game over!)

OOMs are reported on Linux console:

`Out of Memory: Killed process (`*`processname`*`)`
(application OOM)

`Out of memory and no killable processes`
(kernel OOM)

`processname` same as **`ps`** would show

- May or may not be actual problem process

OOM killer configurable as of kernel level 2.4.23

- Now applications may get individual memory allocation failures, must handle

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Diagnosing Memory Exhaustion

`free` command displays system memory use:

```
# free -t
             total       used       free shared buffers cached
Mem:        191092     185160       5932      0   13032  80548
-/+ buffers/cache:      91580      99512
Swap:       197176       2920     194256
Total:      388268     188092     200176
```

"`-/+ buffers/cache`" line most interesting

- Shows usage without file buffers and cache
- Those pages reclaimable for system use (DPA, in VM terms)
- If Swap space mostly/entirely in use, expect OOMs!

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Diagnosing CPU Exhaustion

As in most environments, a single application can grab enough CPU to slow Linux

- Control mechanisms exist, but are not enabled by default

`top` command is "performance monitor" tool

- **`sar`** is a popular free alternative (see Resources)
- Vendor tools exist (RMF PM, Velocity, Perfman — see Resources)

`uptime` shows 1-, 5-, 15-minute CPU averages

- Look for rising trend to show recent problem
- Values above 1 mean CPU fully loaded (work waiting)
- Rising values may not mean Linux is using more CPU
  - Could mean higher fraction of less available CPU

Output from top Command

```
 4:26pm  up 5 days,  7:10,  2 users,  load average: 1.00, 1.00, 1.00
82 processes: 80 sleeping, 2 running, 0 zombie, 0 stopped
CPU states:  0.8% user, 14.0% system,  0.0% nice, 85.1% idle
Mem:  191092K av, 185808K used,   5284K free,      0K shrd, 12976K buff
Swap: 197176K av,   2920K used, 194256K free                80288K cached
  PID USER  PRI  NI  SIZE  RSS SHARE STAT %CPU %MEM   TIME COMMAND
 6250 root   17   0  1060 1060   844 R     5.9  0.5   0:01 top
 6142 root    9   0  2320 2320  1828 S     0.3  1.2   0:02 sshd
    1 root    9   0   556  540   492 S     0.0  0.2   0:02 init
    2 root    9   0     0    0     0 SW    0.0  0.0   0:00 kmcheck
    3 root    9   0     0    0     0 SW    0.0  0.0   0:00 keventd
```

etc…

Note that the top command is **`top`** itself!

- Look at other candidates, note “heavy hitters”
- “**`top d 5`**” auto-refreshes every 5 seconds, shows some trends

See man page to interpret, especially **`STAT`** value

- Note “**`0.0% nice`**”
- Negative value would mean some tasks have priority

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Other Performance Measurements

Look at **`/proc/loadavg`**

- 4th value: #processors/#processes running ("**`2/81`**")
- 5th value: # of processes started since system boot
- Rapidly changing 5th value = something going on!

SNMP can provide data, depending on settings

- Must be enabled, and SNMP collector operating somewhere!
- Do *not* leave default passwords (public/private strings) in place (obvious, but far too many folks do)

Linux I/O statistics may be useful

- Enable by **`echo set on > /proc/dasd/statistics`**
- Must be enabled ***before*** problem to be useful!
- Data saved in **`/proc/dasd/statistics`**

Other Performance Measurements

`/proc/chandev` shows state of devices

- Useful if other evidence suggests a device problem

Learn useful CP commands:

- **`QUERY VIRTUAL ALL`** (lots of output!)
- **`QUERY VIRTUAL DASD`** (show all virtual DASD)
- **`QUERY VIRTUAL xxxx`** (show a specific device)
- **`QUERY MDISK`** (show virtual DASD ownership)

VM performance tools provide external performance measurement

- Can profile usage; most don't show activity inside Linux

`iostat` (partner to **`sar`**) also does I/O monitoring

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VM Monitor Data

z/VM generates monitor data on demand

- Highly granular, very efficient mechanism

Linux for System z can, too

- Data generated believed to be suspect
- Must correlate with z/VM data to be meaningful
- Stay tuned…

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Penguin Forensics

Recording Evidence
Before Burying the Body

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First Failure Data Capture

IBM promotes First Failure Data Capture:

- Collecting useful debugging information when a problem first occurs
- “Try a reboot” is not FFDC!
- VM, MVS, AIX, DB2, even Tivoli push FFDC
- Windows XP Error Reporting is (sort of) FFDC

As Linux matures, FFDC concepts seep in

- Logging, trace tables, memory leak/overlay traps, more dump capabilities…
- Still mostly not standard features, however — optional installs

Log Levels

`syslogd` (syslog daemon) collects and writes messages from various services, applications

- Of course, it has to be running to be useful!
- Can centralize messages from multiple systems

Level of messages to be logged is configurable

- Understanding logging levels for your services/applications is essential to ensuring FFDC

Standard Linux **`syslogd`** isn't very smart/flexible

- Insufficiently granular in many cases
- Uses UDP—messages get lost due to network congestion
- Alternatives exist, e.g., syslog-ng (**`www.balabit.com`**)

Cores

Traditional *ix dumps were “core files”

- Created when applications did something blatantly illegal
- Created in current working directory, either **`core`** or **`core.pid`**

Most distributions ship with cores disabled

- Average user wouldn’t know what to do with them!
- May contain sensitive data from running applications

bash **`ulimit -c`** size enables (current login)

- **`ulimit -c unlimited`** means “dump everything”
- **`ulimit -c`** displays current setting (any value > 0 = enabled)
- See **`man bash`** for details

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Dumps

LKCD (**lcrash**) — Linux Kernel Crash Dump

- Must be installed *before* the problem occurs
- **lcrash** is the "IPCS" tool to analyze the dump

As a VMer, I want to **VMDUMP** a sick penguin:

```
#CP VMDUMP 0-END TO MAINT
```

- Use IBM **vmconvert** to convert to LKCD format
- VM Dump Tool is programmable, could also handle

Standalone dump available for z/Linux

- IBM mini-manual: Using the Dump Tools (LNUX-1208-01) at **www.ibm.com/servers/eserver/zseries/os/linux/pdf/l39dmp24.pdf**
- Analyze standalone dumps with **lcrash**, too

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Linux Debugging Tools

Kernel breakpoint tools:

- KProbes (Kernel Probes):
  `www-128.ibm.com/developerworks/library/l-kprobes.html`
- DProbes (Dynamic KProbes):
  `sourceforge.net/projects/dprobes/`

Kernel event (trace table) logging:

- LTT (Linux Trace Toolkit):
  `www.opersys.com/LTT/index.html`
- Strace (System call Trace):
  Included in most modern distros (or Google it)

More Linux Debugging Tools

Memory debuggers:

- YAMD (Yet Another Malloc Debugger): **`www.cs.hmc.edu/~nate/yamd/`**
- NJAMD (Not Just Another Malloc Debugger): **`fscked.org/proj/njamd.shtml`**

General debugger:

- gdb (The GNU Project Debugger): **`www.gnu.org/software/gdb/gdb.html`**

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Learning to Debug Linux

Zapping Linux bugs:

- Visit **`www.ibmsystemsmag.com`** and search

Mastering Linux debugging techniques:

- **`www.ibm.com/developerworks/library/l-debug/?n-l-8152`**

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FFDC: What To Save

Linux data

- System log files
- Application log files
- Any core files
- Application configuration files

VM data

- VM console logs
- CP command output
- Trace files
- Monitor data
- Performance monitor reports
- Any dumps
- Guest directory entries

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Conclusion

Summary

To the VMer, Linux is obscure and opaque

To the Linux expert, VM is the same!

To provide proper support, learn to use the tools

- Both VMers and Linux folks can learn from each other

As always, use the community

- **linux-390@marist.edu**: z/Linux mailing list
- **ibmvm@listserv.uark.edu**: z/VM mailing list

z/VM and Linux — even better together!

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Resources

Velocity Software (ESALPS): `www.velocity-software.com`

RMF PM: `www.ibm.com/servers/eserver/zseries/zos/rmf/rmfhtmls/pmweb/pmlin.html`

Perfman: `www.perfman.com`

sar (part of sysstat): `freshmeat.net/projects/sysstat/`

ksymoops: `www.gnu.org/directory/devel/debug/ksymoops.html`

Performance tips: `www.vm.ibm.com/perf/tips/linuxper.html`

RUNNABLE EXEC (virtual machine status): email me

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Contact Information and Credits

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