

Help! My (Virtual) Penguin Is Sick!

Or

Aptenodytes Patagonicus Problems on z/VM*

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The Resource for Users of IBM zSeries & S/390 Systems
ZJOURNAL



*** 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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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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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



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 `tracert` to Linux from user's machine

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



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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



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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 `tracert` 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



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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 nnnnnnnn 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 yyymmdd*”, 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)



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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”



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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



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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

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...



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)



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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**



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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



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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!



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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



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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`



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Other Performance Measurements

`/proc/chandev` shows state of devices

- Useful if other evidence suggests a device problem

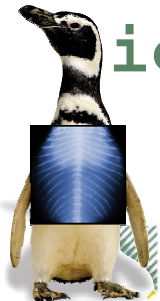
Learn useful CP commands:

- `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



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`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)



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



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 (LINUX-1208-01) at www.ibm.com/servers/eserver/zseries/os/linux/pdf/139dmp24.pdf
- Analyze standalone dumps with `lcrash`, too



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.operators.com/LTT/index.html
- Strace (System call Trace):
Included in most modern distros (or Google it)



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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.ibmssystemsmag.com and search

Mastering Linux debugging techniques:

- www.ibm.com/developerworks/library/l-debug/?n=1-8152



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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



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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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