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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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!
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!
Penguins and Bears, Oh My!

Penguin Diseases 101
“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
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!
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!
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
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
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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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.
If QDIO network, **ping** broadcast (**Bcast**) address shown by **ifconfig**:

```bash
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!
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!
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:

```bash
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:

```bash
CP SPOOL CONSOLE START NAME yyyyymmdd hh:mm:ss
```

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

May want to centralize console collection:

```bash
CP SPOOL CONSOLE START TO CONSAVER
```
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
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
```
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.
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 yyyyymmdd”, perhaps

Vendor console management products exist
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
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!!!
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**
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!)
**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
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)
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”
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
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
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

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

<table>
<thead>
<tr>
<th>Process</th>
<th>queue</th>
<th>privilege</th>
<th>start/limit</th>
<th>deadline time</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINUX902</td>
<td>Q3 PS</td>
<td></td>
<td>00013577/00013567</td>
<td>-232.0 A00</td>
</tr>
<tr>
<td>LINUX901</td>
<td>Q3 PS</td>
<td></td>
<td>00030109/00030099</td>
<td>-231.7 A00</td>
</tr>
<tr>
<td>VSCS</td>
<td>Q1 R</td>
<td></td>
<td>00000128/00000106</td>
<td>-208.7 A00</td>
</tr>
<tr>
<td>VMLINUX3</td>
<td>Q3 IO</td>
<td></td>
<td>00052962/00051162</td>
<td>-.9398 A00</td>
</tr>
<tr>
<td>VMLINUX3 MP01</td>
<td>Q3 PS</td>
<td></td>
<td>00000000/00000000</td>
<td>.0612 A00</td>
</tr>
<tr>
<td>LINUX123</td>
<td>E3 R</td>
<td></td>
<td>00177823/00196608</td>
<td>5255. A00</td>
</tr>
</tbody>
</table>

- **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…
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)
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:

```bash
# 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!
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

<table>
<thead>
<tr>
<th>Filesystem</th>
<th>Size</th>
<th>Used</th>
<th>Avail</th>
<th>Use%</th>
<th>Mounted on</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>592M</td>
<td>94M</td>
<td>464M</td>
<td>17%</td>
<td>/</td>
</tr>
<tr>
<td>none</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>/proc</td>
</tr>
<tr>
<td>none</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>/dev/pts</td>
</tr>
<tr>
<td>/dev/dasd/0000/part1</td>
<td>485M</td>
<td>17M</td>
<td>468M</td>
<td>4%</td>
<td>/tmp</td>
</tr>
</tbody>
</table>
```

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
free command displays system memory use:

```bash
# 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!
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  

<table>
<thead>
<tr>
<th>PID</th>
<th>USER</th>
<th>PRI</th>
<th>NI</th>
<th>SIZE</th>
<th>RSS</th>
<th>SHARE</th>
<th>STAT</th>
<th>%CPU</th>
<th>%MEM</th>
<th>TIME</th>
<th>COMMAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>6250</td>
<td>root</td>
<td>17</td>
<td>0</td>
<td>1060</td>
<td>1060</td>
<td>844</td>
<td>R</td>
<td>5.9</td>
<td>0.5</td>
<td>0:01</td>
<td>top</td>
</tr>
<tr>
<td>6142</td>
<td>root</td>
<td>9</td>
<td>0</td>
<td>2320</td>
<td>2320</td>
<td>1828</td>
<td>S</td>
<td>0.3</td>
<td>1.2</td>
<td>0:02</td>
<td>sshd</td>
</tr>
<tr>
<td>1</td>
<td>root</td>
<td>9</td>
<td>0</td>
<td>556</td>
<td>540</td>
<td>492</td>
<td>S</td>
<td>0.0</td>
<td>0.2</td>
<td>0:02</td>
<td>init</td>
</tr>
<tr>
<td>2</td>
<td>root</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>SW</td>
<td>0.0</td>
<td>0.0</td>
<td>0:00</td>
<td>kmcheck</td>
</tr>
<tr>
<td>3</td>
<td>root</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>SW</td>
<td>0.0</td>
<td>0.0</td>
<td>0:00</td>
<td>keventd</td>
</tr>
</tbody>
</table>

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
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 xxxxx` (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
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…
Penguin Forensics

Recording Evidence
Before Burying the Body
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
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
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

- Analyze standalone dumps with lcrash, too
Linux Debugging Tools

Kernel breakpoint tools:

- KProbes (Kernel Probes):
- 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
Zapping Linux bugs:

- Visit www.ibm systemsmag.com and search

Mastering Linux debugging techniques:

- www.ibm.com/developerworks/library/l-debug/?n=l-8152
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
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!
Velocity Software (ESALPS):  www.velocity-software.com
Perfman:  www.perfman.com
sar (part of sysstat):  freshmeat.net/projects/sysstat/
ksymoops:  www.gnu.org/directory/devel/debug/ksymoops.html
RUNNABLE EXEC (virtual machine status): email me
Contact Information and Credits

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