Running Linux in Less than class G

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Agenda

- What is the problem? And is it yours too?
- CP Privilege Class
- CP Commands for Linux
- Diagnose Codes for Linux
- Various other z/VM Resources
- Conclusion
Past: VM systems in trusted environment

- VM used to run in protected environment of the computing center
  - Virtual machine running CMS applications
  - Exposures of the system well understood
  - Access restricted to well-behaving employees
  - Fairly large skilled staff to monitor and manage the system
Present: z/VM running Linux virtual machines

- z/VM used to run Linux virtual machines
  - Linux servers probably not managed by VM staff
  - Access not restricted to trusted employees
  - Maybe even connected to the Internet

- Given enough servers and enough time, one or more may be hacked
  - Security policy, logging, monitoring
  - Firewalls, proxy servers, multi-tier applications
Linux on z/VM different from discrete servers?

- Linux virtual machines run on the same z/VM system and share more than just the network
- A hacker with root access can eventually make the virtual machine do anything that CP allows it to do
  - Somewhat like access to your virtual raised floor
- May impact Linux servers for other customers
- Systems Management work and Infrastructure may be affected
Linux on z/VM different from CMS?

- CMS virtual machines are typically single-user
  - One person for one virtual machine
- Different audience and different exposures
- Linux is using things in a different way
  - More virtual storage, more disk space
  - New function
- Linux does not need all function that CMS uses
The Problem

- Make sure that a compromised Linux virtual machine does not a form risk for z/VM integrity
  - Restrict access to z/VM function to the absolute minimum
  - Harden security for the z/VM function that Linux needs
  - Do not cripple the other virtual machines

Issues identified are at worst Denial of Service

Abuse does not provide unauthorized access, but may restrict others with authorized access
Solving the problem

- **Start with a fairly relaxed scheme (like for CMS)**
  - Try to think of what may hurt and protect that
  - Every time some exploit is discovered, try to repair it
  - May get caught by new function in next release

- **Determine minimum requirements for Linux**
  - Analyze possible exploits or risks for each of these
  - Permit access when no risk observed
  - Or find alternative to avoid the exploit
CP Privilege Class

- Framework to control which users can issue which CP commands
- Commands are classified by function in groups
- Much more granular than root versus non-root

<table>
<thead>
<tr>
<th></th>
<th>System Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>System Resource Operator</td>
</tr>
<tr>
<td>C</td>
<td>System Programmer</td>
</tr>
<tr>
<td>D</td>
<td>Spooling Operator</td>
</tr>
<tr>
<td>E</td>
<td>System Analyst</td>
</tr>
<tr>
<td>F</td>
<td>Service Representative</td>
</tr>
<tr>
<td>G</td>
<td>General User</td>
</tr>
</tbody>
</table>
CP Privilege Class

- CP Class for users specified in the CP Directory
- Assigned corresponding to their role
- General users get class G
- Special users get class G plus some more

```
USER JOHNDOE ******** 16M 32M G
  INCLUDE IBMDFLT
  MDISK 191 3390 101 10 LX3W03 MR
USER RVDHEIJ ******** 16M 2047M CEG
  INCLUDE IBMDFLT
  MDISK 191 3390 1 100 LX3W03 MR
  MDISK 192 3390 1876 125 LX3L05 MR ALL
```
CP Privilege Class

- **Too restrictive for some installations**
  - One special command comes with a lot more power

- **Redefining Command Privilege Classes**
  - Additional new privilege classes I-Z, 1-6
  - CP commands can be assigned to the new classes

```
MODIFY CMD MSGNOH IBMCLASS B PRIVCLASS BM
```

  - Also as statements in the system configuration file
  - Previously done with User Class Restructure
  - Fine-tuned access to privileged commands
CP Privilege Class

- **Take some privileged commands out of the standard CP class**
  - E.g. move SHUTDOWN to a separate privilege class
  - Sometimes less work than defining a new class
  - Used to be the safe approach with UCR

- **External Security Manager can restrict further**
  - RACF/VM can control access to various resources
CP Commands

- **Linux does not need all power class G provides**
- **Not all can hurt, but a lot of work to investigate**

<table>
<thead>
<tr>
<th>COMMANDS</th>
<th>ADJUNCT</th>
<th>ADSTOP</th>
<th>ATTN</th>
<th>BEGIN</th>
<th>CHANGE</th>
<th>CLOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIAL</td>
<td>COUPLE</td>
<td>CPFORMAT</td>
<td>CPU</td>
<td>DEFINE</td>
<td>DETACH</td>
<td></td>
</tr>
<tr>
<td>INDICATE</td>
<td>IPL</td>
<td>LINK</td>
<td>LOADVFCB</td>
<td>LOCATEVM</td>
<td>LOGON</td>
<td></td>
</tr>
<tr>
<td>LOGOFF</td>
<td>MESSAGE</td>
<td>NOTREADY</td>
<td>ORDER</td>
<td>PURGE</td>
<td>QUERY</td>
<td></td>
</tr>
<tr>
<td>READY</td>
<td>REDEFINE</td>
<td>REQUEST</td>
<td>RESET</td>
<td>RESTART</td>
<td>REWIND</td>
<td></td>
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<tr>
<td>SCREEN</td>
<td>SEND</td>
<td>SET</td>
<td>SIGNAL</td>
<td>SILENTLY</td>
<td>SLEEP</td>
<td></td>
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<tr>
<td>MSG</td>
<td>SPOOL</td>
<td>SPXTAPE</td>
<td>STOP</td>
<td>STORE</td>
<td>SYSTEM</td>
<td></td>
</tr>
<tr>
<td>TAG</td>
<td>TERMINAL</td>
<td>TRACE</td>
<td>TRANSFER</td>
<td>UNCOUPLE</td>
<td>UNDIAL</td>
<td></td>
</tr>
<tr>
<td>VDELETE</td>
<td>VINPUT</td>
<td>VMDUMP</td>
<td>XAUTOLOG</td>
<td>XSPOOL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CP Commands used by Linux

- **A few CP commands issued by kernel and drivers**
  
  QUERY TERMINAL
  
  TERM CONS 3215 (is default)
  
  TERM AUTOCR OFF
  
  IPL (only for reboot)
  
  SET PAGEX ON (when PFAULT lacks)

- **Create a new privilege class L with only these commands and use that class instead of G**

- **Applications in Linux could use many more**
CP Commands with privilege class ANY

- CP commands in ANY available in any class
- Most can be moved to class G
  - Some are needed pre-logon capabilities
  - Possible lockout with SET PRIVCLAS

<table>
<thead>
<tr>
<th>COMMANDS</th>
<th>DIAL</th>
<th>DISCONNECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOGON</td>
<td>LOGOFF</td>
<td>MESSAGE</td>
</tr>
<tr>
<td>Q BYUSER</td>
<td>Q COMMAND</td>
<td>Q PRIVCLAS</td>
</tr>
<tr>
<td>Q USERS</td>
<td>SET PRIVCLAS</td>
<td>SILENTLY</td>
</tr>
<tr>
<td>SLEEP</td>
<td>UNDIAL</td>
<td></td>
</tr>
</tbody>
</table>
CP Commands for Linux

- We can drastically restrict the commands available to Linux virtual machines
  - Can be done without impacting other users
  - Should be flexible enough for production servers
  - May be too rigid for development work

- You do not have to treat all Linux virtual machines the same
  - Consider to match network access (e.g. public, DMZ)
Diagnose Codes

- **Pseudo instruction that allows a virtual machine to access CP function through a well defined API**
  - z/VM 4.4 defines 81 different diagnose codes

- **IBM Defined Diagnose Codes assigned CP classes**
  - User Class Restructure like with CP commands
  - Almost all are assigned privilege class ANY (68 in z/VM 4.4)
  - No impact for existing users when moved to class G
CP Diagnose Codes used by Linux

- **SuSE SLES8 kernel of March 2004**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>08</td>
<td>Virtual console function</td>
<td>Control per CP command</td>
</tr>
<tr>
<td>44</td>
<td>Voluntary time slice end</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>Get storage size</td>
<td></td>
</tr>
<tr>
<td>210</td>
<td>Retrieve device info</td>
<td></td>
</tr>
<tr>
<td>214</td>
<td>Pending page release</td>
<td>Can not be disabled</td>
</tr>
<tr>
<td>250</td>
<td>Block I/O</td>
<td>Used by diagnose I/O</td>
</tr>
<tr>
<td>258</td>
<td>PFAULT macro</td>
<td>For pseudo page fault</td>
</tr>
</tbody>
</table>
CP Diagnose Codes used by Linux (optional)

- Recent Linux development can exploit more CP function through diagnose codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>4C</td>
<td>Generate Accounting Records</td>
<td>In cpint-1.1.3</td>
</tr>
<tr>
<td>10</td>
<td>Release Pages</td>
<td>Collaborative Memory Management</td>
</tr>
<tr>
<td>64</td>
<td>NSS Manipulation</td>
<td>Used by xip2 and dcss block device</td>
</tr>
<tr>
<td>DC</td>
<td>Control Application Monitor</td>
<td>Used by applmon driver</td>
</tr>
<tr>
<td></td>
<td>Data Collection</td>
<td></td>
</tr>
</tbody>
</table>
CP Diagnose Codes for Linux

- Possible exploits may be less obvious
  - Hard to use does not mean hard to abuse
  - E.g. Diagnose 7C Logical Device Support Facility
    Would bypass any fences you have in VM TCP/IP tn3270

- Consider different privilege classes for different type of Linux virtual machines

- Future Linux kernels and applications will be able to use more CP function
Shared Segments

- **Allows virtual machine to attach shared storage**
  - Shared segment identified by name
  - Linux support maps segment into kernel address space

- **Access is through Diagnose 64**
  - Granted default access depends on definition

<table>
<thead>
<tr>
<th>SR</th>
<th>Shared R/O</th>
<th>Binaries, Libraries, Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW</td>
<td>Exclusive R/W</td>
<td>Swap space</td>
</tr>
<tr>
<td>SW</td>
<td>Shared R/W</td>
<td></td>
</tr>
</tbody>
</table>
Shared Segments

- **Reasons to restrict access to DCSS**
  - Licensed code or secret data to be read
  - Resource consumption (especially for EW type)

- **Plain z/VM control: NAMESAVE**
  - Per-segment option in the CP directory
  - Provides only one level of access (possibly harmful)
Shared Segments

- **Additional control through ESM like RACF/VM**
  - Possible to audit all segment access
  - Control access to restricted segments

- **Relatively new development for Linux on zSeries**
  - Still need to learn what the proper use is and how to prevent what is not
  - Be aware that Linux DCSS is much bigger than for CMS
Network Access

- **With z/VM 4.4 probably use VSWITCH**
  - Scales better than dedicated OSA devices
    - Less memory resources
    - Cheaper than virtual router
    - No obvious maximum number of connections
  - Supports VLAN to separate traffic

- **Looks like a LAN but is not that bad**
  - Does not allow sniffing other’s traffic
Network Access

- **Unrestricted Guest LAN**
  - Allows any VM user to couple to the Guest LAN

- **Restricted Guest LAN**
  - Requires explicit permission (through GRANT)

- **Without the COUPLE it makes no difference**
  - CP Directory entry takes care of COUPLE
  - But you need it if you want VLAN support
Network Access

- **Virtual Router may be necessary**
  - When no outboard switch is available with VLAN support
  - For advanced things like bandwidth management

- **Connection between server and virtual router**
  - Separate Guest LAN per customer or group of servers
  - IUCV based point-to-point connection
  - CTC based point-to-point connection
    - May want the virtual router to initiate the COUPLE
Inter-user Communication Vehicle - IUCV

- **Between virtual machines**
  - CMS clients and application servers
  - Point-to-point connection with TCP/IP server
  - Protected by CP directory statements

- **Between CP and a virtual machine**
  - System services (like *MONITOR, *ACCOUNT)

- **Linux use of IUCV is limited**
  - Connection to a virtual router
  - Connecting to legacy applications
Inter-user Communication Vehicle - IUCV

- **Protection is frequently overlooked**
  - IUCV ALLOW and IUCV ANY bypass all protection
  - Default DDR install shows some bad examples

- **Some applications allow screening of connections**
  - This may not prevent illegal open connections: DoS

- **Protect against a Denial of Service**
  - Set MAXCONN as low as possible for Linux
  - Set MAXCONN high enough for trusted servers
Spool Space

- **Linux does not currently use spool files**
  - Linux applications use different means to communicate
  - The Unit Record drivers are not commonly used

- **Possible Denial of Service if Linux used spool**
  - Filling spool space with large spool files
  - Confuse (poorly written) servers with unwanted files
  - Could use RACF/VM to protect spool

- **Without the devices and CP commands: no risks**
Spool Space

- **One exception: the virtual console**
- **Would be nice to spool the virtual console**
  - Without the SPOOL command we can not start spooling
  - If Linux can start spooling, it can also stop or suspend it
- **Logging the secondary console**
  - Could make PROP the secondary console
  - Be aware that Linux could flood the console and create problems
Alternative Approach – Two Phase Startup

- **Define privilege class in the directory as GL**
- **Specify IPL CMS in the directory**
  - Do all you have to do in the PROFILE EXEC
  - Issue a SET PRIVCLAS =L and then IPL Linux
  - Only use resources controlled by privilege class (no SFS)
  - Make sure the 191 can not be modified for next IPL
  - Class L exclude the SET PRIVCLAS to prevent going back
- **Instead of CMS one could use an “IPLer”**
  - Small stand-alone program to issue CP commands and IPL
Conclusion

- Known issues are all “Denial of Service” type
  - A DoS can turn into an exposure if it locks the guards out
- z/VM offers a lot of function to harden the system
- You need to make your own compromises (if any)
  - Understand your environment, your audience and which risks to accept
  - Running hostile Linux servers in an existing environment offers some challenges
- You’re never done – it always can be done better