Session 9564

z/VM Security and Integrity: How it Works

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Integrity
What is system integrity?

1. The ability of the hypervisor (CP) to operate without interference or harm, intentional or not, from the guest virtual machines

2. The inability of a virtual machine to circumvent system security features and access controls

3. The ability of the hypervisor to protect virtual machines from each other
System Integrity

- But how is that actually done?
- Answer: Interpretive Execution Facility
Interpretive Execution Facility

- Start Interpretive Execution (SIE) instruction runs a virtual machine
  - Registers, PSW (Program Status Word), memory
  - Interception conditions (a.k.a. "SIE break")
    - Time slice expires
    - Unassisted I/O
    - Instructions that require hypervisor assist
  - Certain program interrupts

- Runs until interception condition raised

- Uses hypervisor-maintained address mapping to convert guest addresses to real addresses
  - Region, Segment, Page
  - Zone offset
Q. What is a virtual machine?
A. An execution environment that conforms to the rules specified in the System z Principles of Operation
   – What the virtual machine sees as “real” is a virtual reality created by the underlying hypervisor
   – Fixed or Variable memory mapping, with or without overcommitment
Interpretive Execution Facility

- The only virtualization technology on the market that provides not one, but two levels of hardware support for virtualization.
- The need exists for both “hard” partitioning (LPAR) and “soft” partitioning (z/VM)
Virtual I/O

- SIE break – CP examines I/O request
  - Translates CCW virtual addresses to real addresses
  - Pins user pages in memory
  - Looks for harmful operations
  - Alters minidisk cylinder locations, if required
  - Inserts device limits whenever possible
    - DEFINE EXTENT for minidisks
A virtual machine has access to a “minidisk”

CP translates virtual disk location (0-99) to an actual location

DEFINE EXTENT I/O command forces control unit to confine I/O to the actual disk extent
I/O Hardware Assist

- Interpretive Execution Facility handles I/O request
  - No SIE break, so no involvement of CP
  - CP and hardware share address tables

- Dedicated QDIO devices only
  - OSA and Fibre Channel (FCP)
Security vs. Integrity

- Security is only meaningful in the presence of system integrity!
  - Integrity prevents bypass of security controls
  - Audit trail confirms conformance
Security
What is System Security?

- **Authentication**
- **Authorization**
- **Audit**

An integrated set of system functions that control access to a system and its resources, and that provide a record of those accesses.
What is System Security?

- **Authentication**
  Reliably identify the people and processes that access your system and its resources

- **Authorization**

- **Audit**
Authentication

- Three forms of identification
  - What you have (key)
  - What you know (password)
  - Who you are (fingerprint)

- Combinations may be used
  - Two-factor authentication ("2FA")
Authentication

- z/VM uses a password or phrase to establish your identity
  - Logon
  - FTP
  - Rexec
  - NFS
  - …

- z/VM does not provide two-factor authentication
Passwords

- They are stored in clear text in USER DIRECT
- They are obfuscated in the object directory
- External Security Managers such as RACF provide for secure, encrypted passwords
- Password phrases require External Security Manager
  - 100 characters
  - Mixed case
  - Special characters
  - Blanks
What is System Security?

- **Authentication**
  - Ensure that a user has access only to system resources specifically permitted and within scope of responsibility.

- **Authorization**
  - Applies to commands, interfaces, and data.

- **Audit**
Command / Function authorization security flow

- Directory privilege
  - Privilege class
  - Option

- Additional ESM privilege check

- Audit
Privilege Class

- First line of protection is the **privilege class**
  - A to Z and 1 to 9
    - IBM uses A through H
  - Each class identifies a defined set of commands and DIAGNOSE functions
  - Class “any” functions can be used by any virtual machine without regard to the virtual machine’s privilege class

- Specified in USER DIRECT

- Most virtual machines have class G (“general”)

- Trusted virtual machines have class A, B, C, D, and/or E
  - Potential to bypass system integrity and security controls
  - Give only to system administrators and trusted servers
Matrix Management of Privilege

<table>
<thead>
<tr>
<th>Command or function</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>Any</th>
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<tr>
<td>QUERY TIME</td>
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<td>X</td>
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<tr>
<td>QUERY NAMES</td>
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<td>SHUTDOWN</td>
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<tr>
<td>ATTACH</td>
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<td>X</td>
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<td>QUERY RDR ALL</td>
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<td>SAVESEG (create a shared memory object)</td>
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<td>LOGOFF</td>
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<td>X</td>
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<td>LOGON</td>
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<td></td>
<td>X</td>
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<td>DISPLAY HOST (hypervisor) memory</td>
<td>X</td>
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<tr>
<td>STORE HOST memory</td>
<td>X+</td>
<td>X</td>
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<tr>
<td>DIAG 0x64 - Access a shared memory object</td>
<td>X</td>
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<tr>
<td>DIAG 0x08 - Issue a hypervisor command</td>
<td>X</td>
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</tbody>
</table>

+ Can be restricted to specific virtual machines via ESM
Privilege Class

- Excess privilege is the root of all Evil
  - DO NOT give extra privilege to untrusted virtual machines!

- DO use the COMMAND statement in the directory
  - Runs with all privileges

- DO use automation

- DO change the privilege classes assigned to commands and DIAGNOSE instructions
  - MODIFY CMD SHUTDOWN PRIVCLASS S
  - MODIFY CMD QUERY SUBCMD NAMES IBMCLASS G PRIVCLASS Z
  - MODIFY DIAGNOSE 8 PRIVCLASSES ABCDE
    - Bad idea!
z/VM native resource access controls

- Virtual Switches and Guest LANs
  - SET VSWITCH NET9 GRANT ALAN
  - Associate with a VLAN: VLAN 10
  - Allow sniffing: PROMISCUOUS
  - Disallow sharing: ISOLATION DROP

- Minidisks
  - Read, write, multi-write passwords
  - LINK in USER DIRECT automatically grants access

- Shared memory
  - DEFSYS/DEFSEG with RSTD option
  - NAMESAVE statement in USER DIRECT grants access

- Shared virtual machines
  - LOGONBY statement (maximum 8 users)
z/VM native resource access controls

- Special passwords
  - NOLOG: User cannot logon or be authenticated
  - NOPASS: Password not required
  - LBYONLY: Accessible only via LOGON BY
  - AUTOONLY: User can only be XAUTOLOGed; no authentication possible
Network: VLAN-aware Virtual Switch

Each guest authorized to one or more VLANs

Access port

Trunk port

VLAN 10

VLAN 20

OSA plugged into [real] trunk port
External Security Manager resource access controls

- Virtual Switches and Guest LANs
  - Minidisks
    - ACLs
  - Shared memory
- Shared virtual machines
  - LOGON BY
- Spool files
- Terminals (restricted login)
- Mandatory access controls
  - Multiple security zones (projects)
- Further restrictions on certain commands and functions (e.g. STORE HOST)
Mandatory Access Controls

- Mandatory access controls override discretionary controls
  - Users are assigned to one or more named projects
    - Minidisks, guest LANs, VSWITCHes, and VLAN IDs all represent data in those same projects
  - Users can only access data in their assigned projects
  - Overrides user- or admin-given permissions
Mandatory Access Controls

System overrides users’ wishes
What is System Security?

- **Authentication**

- **Authorization**

- **Audit**

Knowing what security-relevant events have occurred

- Who has entered the system
- Who was denied access to the system
- Resources accessed
- Resources denied
- Functions used
- Where
- When
Audit

- The audit trail is management’s assurance that the system is being operated according to policy

- It is the most important data asset
  - How do you know that your business data has not had unauthorized out-of-band updates?

- External Security Manager
  - Full record of any command or system interface
  - Includes reporting tools

- CP records some activity in the accounting data
  - Logon, logoff, link to disk, dedicated device usage, APPCVM CONNECT, SET PRIVCLASS, virtual network traffic
  - Minimal controls over what is collected
Security Components

- RACF Security Server

- LDAP

- SSL/TLS
  - Telnet
  - FTP
  - SMTP
  - Transparent SSL/TLS also available
    - E.g. for a simple web server

- DIRMAINT
IBM Commitment

- Continued investment
  - Built on 40+ years of previous investment
  - CP/67
  - Common Criteria (ISO)

- Prompt response to incidents reported to the IBM Support Center
IBM Commitment

- No public disclosure of IBM System z vulnerabilities
  - May disclose to individuals or groups that have demonstrated to IBM a legitimate need to know

- Commitment published in z/VM General Information manual
Common Criteria

- Common Criteria ensures
  - A set of meaningful security functions
    - Access control
    - Audit
  - Extensive testing of those functions
  - Effective processes
  - Good documentation
  - Developed by US National Security Agency

- Assurance levels 1 through 7
  - Evaluation by accredited firms
  - Certification by government agencies
  - CommonCriteriaPortal.org
Common Criteria

- **Controlled Access Protection Profile (CAPP)**
  - Discretionary access controls
  - “I choose to give you access”
  - User- or administrator-controlled access

- **Labeled Security Protection Profile (LSPP)**
  - Mandatory access controls (MAC)
  - System overrides user
  - Security clearances and compartmentalization enforced
Common Criteria

- z/VM compliance
  - Includes CP, TCP/IP stack with telnet, and RACF
    - First evaluation: z/VM 5.1, October 2005, EAL 3+
    - Second evaluation: z/VM 5.3, August 2008, EAL 4+

- z/VM 5.4 was **not** certified.
  - “Designed to meet the requirement”

- z/VM 6.1 certification is underway!!
  - Operating System Protection Profile with labeled security extensions, EAL 4+
Customer Commitments

- Define and deploy a security policy
- Examine audit trails periodically
- Apply recommended service
Summary

- z/VM was designed to host virtual machines
- System z hardware provides facilities used by z/VM to ensure the integrity of the system is maintained
- Backed by more than 40 years of practical experience in maintaining virtual machines
- IBM’s commitment remains strong
- Customer-defined security policy is key to success
Summary

- An external security manager such as RACF Security Server is recommended
  - Privileged command audit trail
  - Encrypted passwords
  - ACLs for minidisks instead of passwords
  - Finer grain of control

- A full discussion of z/VM security and integrity features can be found in publication GM13-0145-01 (April 2005)
  - Link at http://www.VM.ibm.com/security
Reference Information

- Alan Altmark
  - Alan_Altmark@us.ibm.com

- z/VM Secure Configuration Guide

- IBM Redbook “Security on z/VM”

- System z Security

- z/VM Home Page
  - http://www.vm.ibm.com