

QEMU/KVM Hardening

Check AppArmor setup

To ensure your Debian host and Debian guests are fully secured, let's pick up where we left off with the AppArmor verification. Run the clean filter command on your host:

```
# aa-status | grep -E "enforce|qemu"
```

What to check next based on your output:

- Scenario A: QEMU processes are under “processes are in enforce mode” Your current VMs are successfully sandboxed. You are ready to move on to other hardening steps like CPU Pinning or resource limits.
- Scenario B: QEMU processes are under “processes are unconfined” Your VMs are running unprotected. We need to fix the qemu.conf abstraction layers or check if virt-aa-helper is failing due to custom disk paths (e.g., if your VM disks are stored outside of /var/lib/libvirt/images).
- Scenario C: You see profile names but no active processes This means the security profiles exist, but no Debian guest VMs are currently powered on.

Normally on recent Debian versions AppArmor is automatically enabled. If needed you can also force it in /etc/libvirt/qemu.conf by removing the comment for the following line:

```
security_driver = "apparmor"
```

After this restart libvirt-daemon:

```
# systemctl restart libvirtd.
```

CPU Security Mitigations and Architecture (CPU Passthrough)

If your Virt-Manager configuration uses a generic CPU model (like qemu64), the Debian guest kernel does not know the exact physical architecture of your host CPU. Here is why this is important for your single-VM Debian Trixie setup:

The Risk: Side-Channel Vulnerabilities (Spectre / Meltdown)

If your Virt-Manager configuration uses a generic CPU model (like qemu64), the Debian guest kernel does not know the exact physical architecture of your host CPU.

* The Problem: Without knowing the exact hardware, the Debian guest cannot apply the correct kernel-level mitigations for CPU vulnerabilities (such as Spectre, Meltdown, or Downfall). * The Threat:

A malicious process running inside your Debian guest could potentially exploit these hardware flaws to break out of the virtual machine boundary and read the memory of your host system.

How to check your current CPU model:

1. Open Virt-Manager and open your VM details (lightbulb icon).
2. Click on the CPUs section on the left.
3. Look at the Model field.

How to harden it:

Change the model to host-passthrough.

* What it does: It tells QEMU to mirror your physical host CPU exactly into the guest, including all safety flags and microcode extensions. * Why it's secure: The Debian guest kernel will immediately detect your exact CPU type and automatically load the correct security patches and mitigations at boot. * Bonus: It significantly improves performance because the guest can use your CPU's native instructions (like AES-NI for hardware-accelerated encryption).

Network containing

To limit a KVM guest to only reach one specific gateway, you must block all other traffic using iptables or nftables on the Linux host. Because virt-manager does not have a built-in button for this, the cleanest way is to use a libvirt hook script. This script automatically applies network restrictions every time the VM starts.

Step 1: Find your VM's network interface

Run this command on your host to find the virtual interface name while the VM is running and note the Interface name (e.g., vnet0 or vnet1):

```
# virsh domiflist <Your-VM-Name>
-----
Interface    Type      Source    Model    MAC
-----
vnet2        network  default   virtio    41:52:e0:7e:d3:aa
```

Step 2: Create a Libvirt hook script

Libvirt can execute scripts when VMs start. We will use a qemu hook to isolate the traffic. Open a terminal on your host and create the hook directory if it does not exist.

```
# mkdir -p /etc/libvirt/hooks/qemu.d
```

Create and edit the hook file and paste the following script (replace vnet0 and 192.168.122.1 with your actual interface and allowed gateway):

```
# nano /etc/libvirt/hooks/qemu.d/vm-gateway-only-access
-----

#!/bin/bash

set -euo pipefail

NFT="/usr/sbin/nft"
VM_NAME="$1"
VM_MAC=$(/usr/bin/virsh domiflist "$1" | awk '/:[0-9a-fA-F]/ {print $5}')
LIBVIRT_BRIDGE="virbr0"
HOST_INTERFACE="enp2s0"
BLOCKED_IPV4_RANGES="{ 192.168.0.0/16 }"
BLOCKED_IPV6_RANGES="{ 2001:1c00:2e07:fa0a::/64, fd00::/48 }"
TABLE="vm_filter"
CHAIN="vm_${VM_NAME//[a-zA-Z0-9_]/_}"

install_rules()
{
    "$NFT" delete table inet "$TABLE" 2>/dev/null || true
    "$NFT" add table inet "$TABLE"
    "$NFT" add chain inet "$TABLE" "$CHAIN" '{ type filter hook forward
priority -300; policy accept; }'

    # Allow established and related return traffic
    "$NFT" add rule inet "$TABLE" "$CHAIN" ct state established,related
accept

    # Allow only VM -> 192.168.178.1
    "$NFT" add rule inet "$TABLE" "$CHAIN" ether saddr "$VM_MAC" ip daddr
"$BLOCKED_IPV4_RANGES" drop
    "$NFT" add rule inet "$TABLE" "$CHAIN" ether saddr "$VM_MAC" ip6 daddr
"$BLOCKED_IPV6_RANGES" drop

    # ALLOW remaining traffic from the VM out to the internet via enp2s0
    "$NFT" add rule inet "$TABLE" "$CHAIN" ether saddr "$VM_MAC" oifname
"$HOST_INTERFACE" accept
}

remove_rules()
{
    "$NFT" delete table inet "$TABLE" 2>/dev/null || true
}

case "${2:-}" in
    start)
        [[ "$1" == "$VM_NAME" ]] && install_rules
        ;;
end
```

```

    stopped)
        [[ "$1" == "$VM_NAME" ]] && remove_rules
        ;;
esac

exit 0

```

Step 3: Make the script executable and restart libvirt

Make the script executable:

```
# chmod +x /etc/libvirt/hooks/qemu
```

Restart the libvirt service to load the new hook:

```
# systemctl restart libvirtd
```

Now, every time you start this specific VM, the host firewall will block all network traffic unless it is explicitly sent to or from your chosen gateway IP. If you are using nftables instead of iptables, or if you need help finding the exact subnet/gateway IP of your virt-manager network, let me know!

Check if the firewall settings are created and removed with:

```
# nft list ruleset
```

The firewall settings will look something like:

```

table inet vm_filter {
    chain vm_Debian13_ESP {
        type filter hook forward priority raw; policy accept;
        ct state established,related accept
        ether saddr 51:44:60:7e:d3:fe ip daddr 192.168.0.0/16 drop
        ether saddr 51:44:60:7e:d3:fe ip6 daddr { 2001:1c00:2e07:fa0a::/64,
fdaa:66:67::/48 } drop
        ether saddr 51:44:60:7e:d3:fe oifname "enp2s0" accept
    }
}

```

Kernel Samepage Merging (KSM)

In Linux, KSM (Kernel Samepage Merging) is a feature that scans your system's RAM looking for identical memory pages. When it finds matching pages, it merges them into a single, shared page using a mechanism called Copy-on-Write (CoW)

- The ksm service controls the actual raw kernel thread (ksmd) that does the heavy lifting.
- The ksmtuned service is a user-space daemon. It actively watches your system and dynamically adjusts the tuning parameters of the kernel thread (like how fast it scans memory) based on how many QEMU/KVM instances are currently running.

The Security Risk: Side-Channel Attacks

While KSM is great for saving RAM on high-density servers, it introduces a major security flaw called a Memory Side-Channel / Cache-Leak Attack. [1, 2] Because memory pages are shared between the host and the guest, a malicious process inside your Debian guest can perform precise timing measurements on memory access. By deliberately modifying a page and measuring how long it takes to process, the guest can figure out if that same data exists elsewhere in the host system's RAM. This can allow an attacker to bypass virtualization barriers and leak sensitive host data (like cryptographic keys or passwords). [2, 5]

Even if you only run a single Debian guest, KSM can still merge identical pages between your one guest and the Debian host operating system. If `ksmtuned` kicks in and starts aggressive page merging, the side-channel attack vector remains open between your isolated guest and your underlying hypervisor.

Check if KSM is running

To check if `ksmtuned` and the underlying Kernel Samepage Merging (KSM) engine are active on your Debian Trixie host, run these diagnostic commands:

```
systemctl status ksmtuned ksm
```

What to look for: If it says `Active: active (running)`, it is active. If it says `Active: inactive (dead)` or `loaded (...; masked)`, it is successfully disabled.

How to completely disable KSM

To ensure no memory deduplication happens at all, you should permanently stop and disable both the tuning daemon and the kernel driver: [5]

1. Stop and mask the services so they can never be started by other system triggers:

```
sudo systemctl disable --now ksm ksmtuned
sudo systemctl mask ksm ksmtuned
```

2. Force the kernel to instantly unshare any pages it has already merged:

```
echo 2 | sudo tee /sys/kernel/mm/ksm/run
```

(Setting this to 2 completely disables the engine and forces the kernel to unmerge everything immediately. Setting it to 0 only stops it from scanning new pages). [2, 5]

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