Virtio and the Chamber of Secrets

Interface design for Confidential Computing Systems

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Unicorns by stable diffusion

Red Hat

OASIS

Agenda

- How are Confidential Computing and Virtio related
- Untrusted Virtio
  - Status and Issues
- Trusted Virtio
  - Status and Issues
- Migration
- Summary

Confidential Computing / VMs

- Reduce VM's trust in the hypervisor.

Can protect or migitate	No mitigation
1)Code execution 2)Rollback attacks 3)Information leaks 4)(some) physical access	DoS

- In fact, DoS is the main mitigation measure
- Virtio is used **heavily**
- Requirement: avoid introducing more trust in HV

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Standard Virtio device models

Software (virtio, vhost, vhost-user)	Hardware (Passthrough with VFIO)	Mixed (vdpa)

device is accessible to HV
- access directly
- trap and emulate

Should not be trusted

Device driver MUST protect the guest VM.

Protecting guest: DMA

- SWIOTLB (lookaside buffer):
  limited memory accessible to untrusted devices
- Driver (through DMA API) copies data to/from guest memory
- Protects against TOCTOU
  - (basic) support since Virtio 1.0
  - Allocation/copy overhead

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Input validation

- Constant vigilance required
- Virtio drivers fuzzed
  - Net
  - Block
  - Console
  - 9P
  - Vsock
- Transient execution: Spectre v1?

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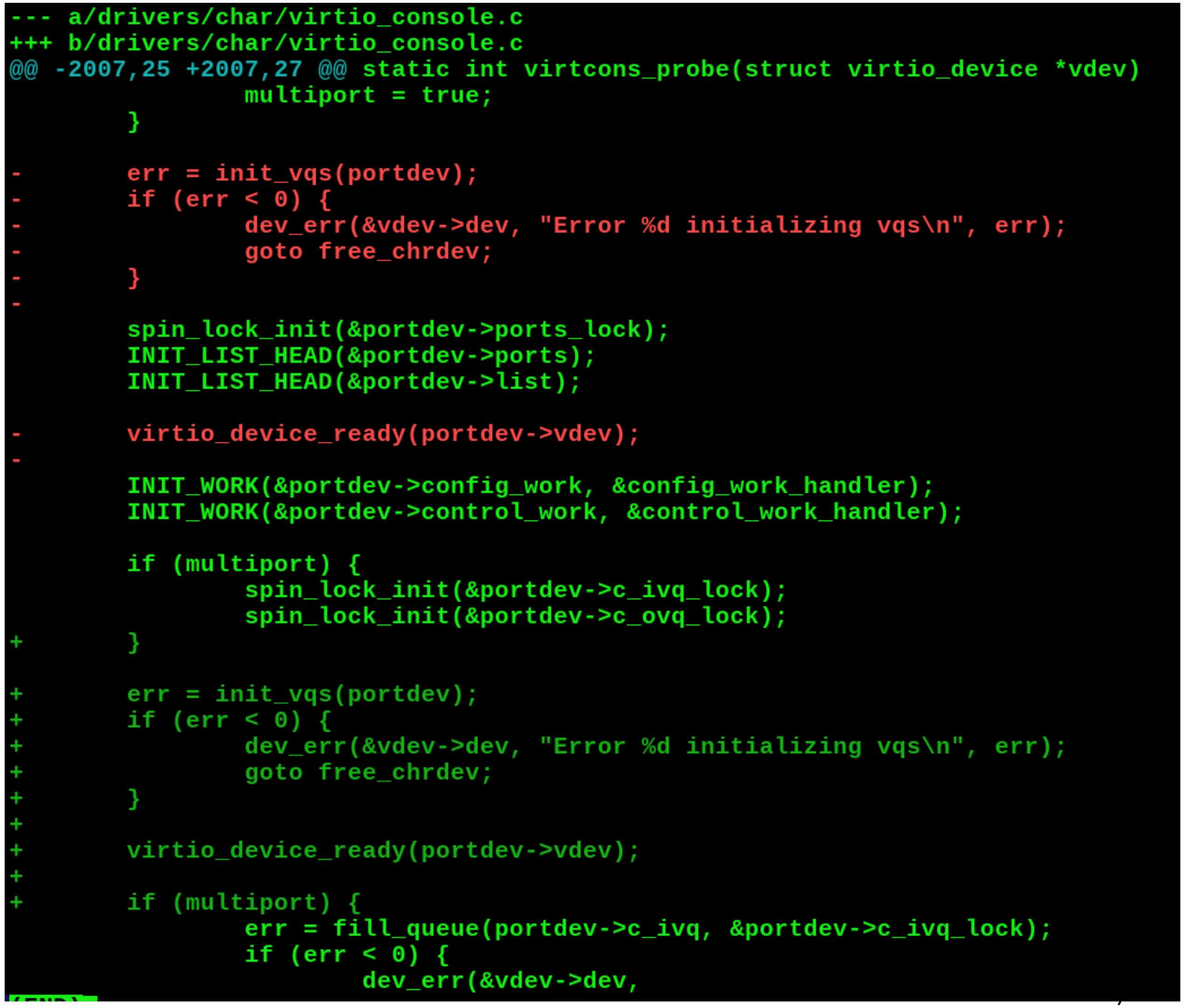
Initialization and cleanup bugs



```
--- a/drivers/char/virtio_console.c
+++ b/drivers/char/virtio_console.c
@@ -2007,25 +2007,27 @@ static int virtcons_probe(struct virtio_device *vdev)
                multiport = true;
        }

-       err = init_vqs(portdev);
-       if (err < 0) {
-               dev_err(&vdev->dev, "Error %d initializing vqs\n", err);
-               goto free_chrdev;
-       }
-
        spin_lock_init(&portdev->ports_lock);
        INIT_LIST_HEAD(&portdev->ports);
        INIT_LIST_HEAD(&portdev->list);

-       virtio_device_ready(portdev->vdev);
-
        INIT_WORK(&portdev->config_work, &config_work_handler);
        INIT_WORK(&portdev->control_work, &control_work_handler);

        if (multiport) {
                spin_lock_init(&portdev->c_ivq_lock);
                spin_lock_init(&portdev->c_ovq_lock);
+       }

+       err = init_vqs(portdev);
+       if (err < 0) {
+               dev_err(&vdev->dev, "Error %d initializing vqs\n", err);
+               goto free_chrdev;
+       }
+
+       virtio_device_ready(portdev->vdev);
+
+       if (multiport) {
                err = fill_queue(portdev->c_ivq, &portdev->c_ivq_lock);
                if (err < 0) {
                        dev_err(&vdev->dev,
```

Stack/application level protection

- TLS
- Dmcrypt
- Dmintegrity
- Rollback protection?

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More devices

- Virtio-input (since we have console)
- Virtio-scsi (since we have blk)
- Virtio-snd (why not?)
- Virtio-rng (needed?)

Possible?

- Virtio-fs ?
- Virtio-crypto ?
- Virtio-pmem?
- Virtio-balloon ? Could be useful.

Audit/Fuzzing challenges

- + __iomem
- + dma_addr_t
- - dma_sync

Note: unlike __user

Filtering

- Device filter
  - Guest decides which drivers to allow
  - If not allowed, probe does not run
- Features
  - Virtio has a lot of flexibility, reducing attack surface is desired
  - Limit the supported features, configurations?

restore trust in devices

- Bring device into TCB
- MUST NOT be accessible to HV
- For PCI devices - TDISP

TDISP in action

- TEE Device Interface Security Protocol
- End to end encryption of guest to device communication
- Designed to protect against many types of software and physical attacks

Locking

- HV is still responsible for device discovery, some setup (e.g. scan/sriov) and allocation to guests
- To assigned device to guest, it has to be locked
- Can not be changed by HV while locked

Measurement report

- DEVICE_INTERFACE_REPORT
- Signed by device
- E.g. MMIO_RANGES
- Can include device specific info

TDISP limitations

- 3 main ways to access a PCI device:

IO R/W	Memory R/W	Config R/W

- Only memory encrypted
- HV can trap and emulate IO/Config
- Insecure

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PCI Config uses in Virtio

- RO – helps driver locate registers
  - Common cfg / device cfg / vq notification / ISR / shared memory
- RW – gateway for 32-bit firmware if memory is > 4G
  - Slow

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Using measurement for RO config

- Arguably a bug that the TDISP spec does not include this
- Add ranges or RO registers to the report
- Alternatively, add to device specific area in the report
- We then need to define format for this area – worth it?

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Using lock to protect config

- Disable RW registers upon lock
- Give up on 32 bit / high memory support

Avoid PCI Config

- Relocate to a known offset in PCI Memory
- Possibly verbatim or with consmetic changes, to minimize driver work

- Compatiblity: detect TDISP? Unattractive
- Or, allocate new device IDs

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VDPA

- VDPA: a mixed device
  - Data path – passthrough
  - Control path - emulated
- Popular due to hardware simplicity
- What does control path include:
  - Programming queues (size/address)
  - Reset
  - Features, etc

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VDPA vs TDISP

- Does not seem practical
- HV can redirect DMA arbitrarily
- Confuse guest by lying about features
- Or device config
- Include in DEVICE_INTERFACE_REPORT / DEVICE_SPECIFIC INFO?
- Practical?
- VDPA can not tweak. Negates benefits?

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VFIO/virtio

- VDPA-like trick to implement a transitional device over a modern device
- VIRTIO_ADMIN_CMD_LEGACY:
  - Exposes direct access to VF’s IO memory through PF
- MUST be disabled upon interface lock

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VM Migration

- Moving state between devices: SRC, DST
- By the HV
- But how do we prevent HV attacks?

Migration: untrusted Virtio

- HV saves state from SRC and restore on DST
- can corrupt the state
  - but then it can, anyway
- Guest must validate at all times

Memory tracking: untrusted Virtio

- Device can change memory as it is migrated
- HV can track changes (e.g. shadow VQ) and re-copy
- Can corrupt memory
  - But it is public, so it can anyway
- Guest must copy and validate at all times

Migration: TDISP Virtio

- Can not trust HV
- On SRC device saves state in encrypted and signed form
- On DST device checks the signature and restores the state
- A bit vague

Memory tracking: TDISP Virtio

- Device tracks memory changes
- Signals the HV to retransmit
- Leaks which memory pages are accessed
- Rollback protection?

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Summary

- Many improvements possible
- Non-trusted Virtio - driver work
- Trusted Virtio – spec work

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Questions? New Virtio MLs

- Virtio-comment@lists.linux.dev - driver/device devel
- Virtio-dev@lists.linux.dev - spec development

- Courtesy of Linux Foundation

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