

Virtio: An I/O virtualization framework for Linux

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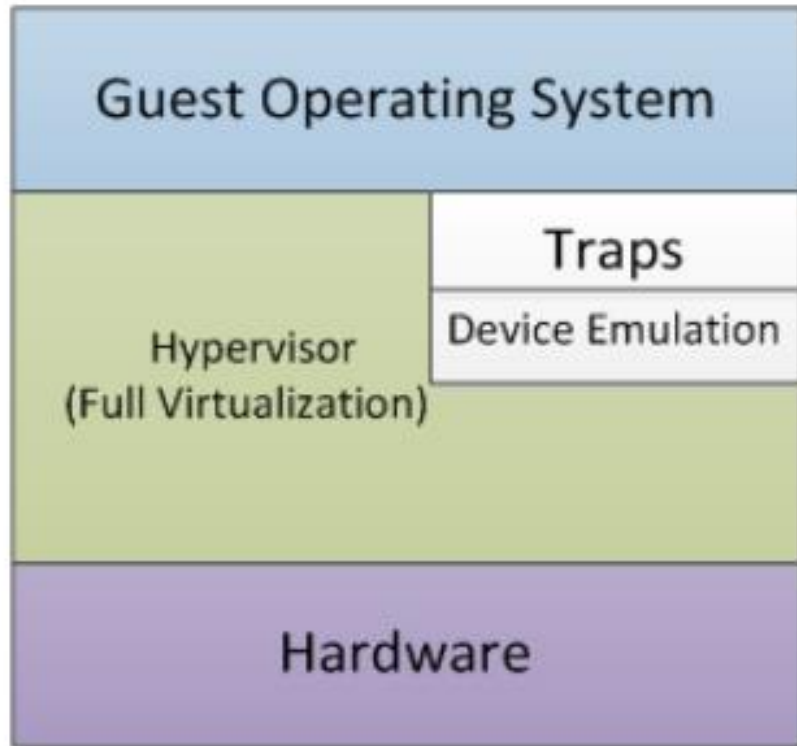
Agenda

- Motivation
- Full Virtualization vs Paravirtualization
- Virtio Architecture
- Virtio Transport Layer
- Vring
- Data Exchange Flow
- Interrupt Handling (speculative)
- Example : VirtIO Block Device Driver

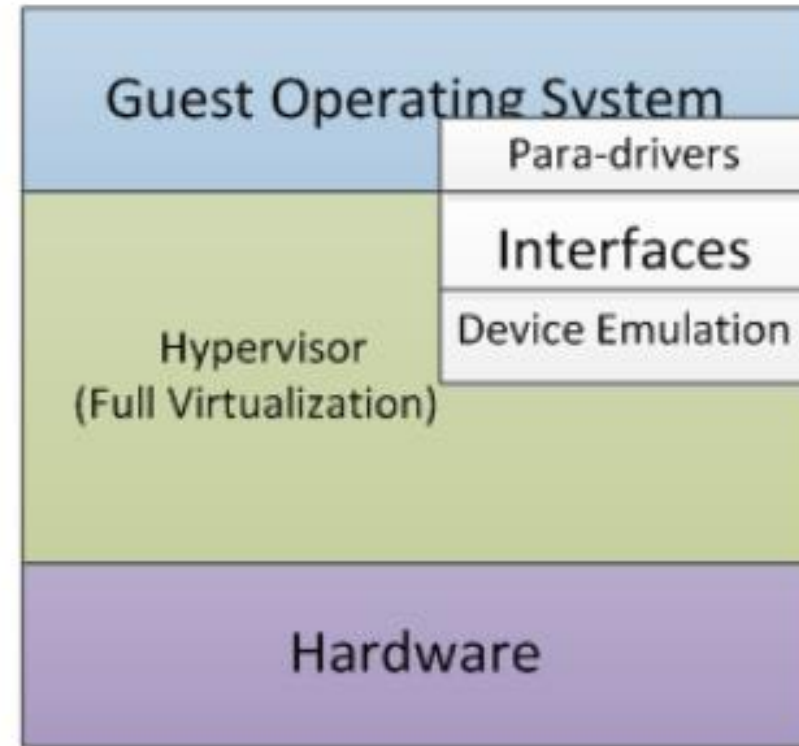
Motivation

- Linux supports 8 distinct virtualization systems:
 - Xen, KVM, VMWare, ...
 - Each of these has its own block, console, network, ... drivers
- VirtIO – The three goals
 - Driver unification
 - Uniformity to provide a common ABI for general publication and use of buffers
 - Device probing and configuration

Full Virtualization vs Paravirtualization



Full virtualization



Para-virtualization

Full Virtualization vs Paravirtualization

- **Kernel's device communication with VMware (emulated):**

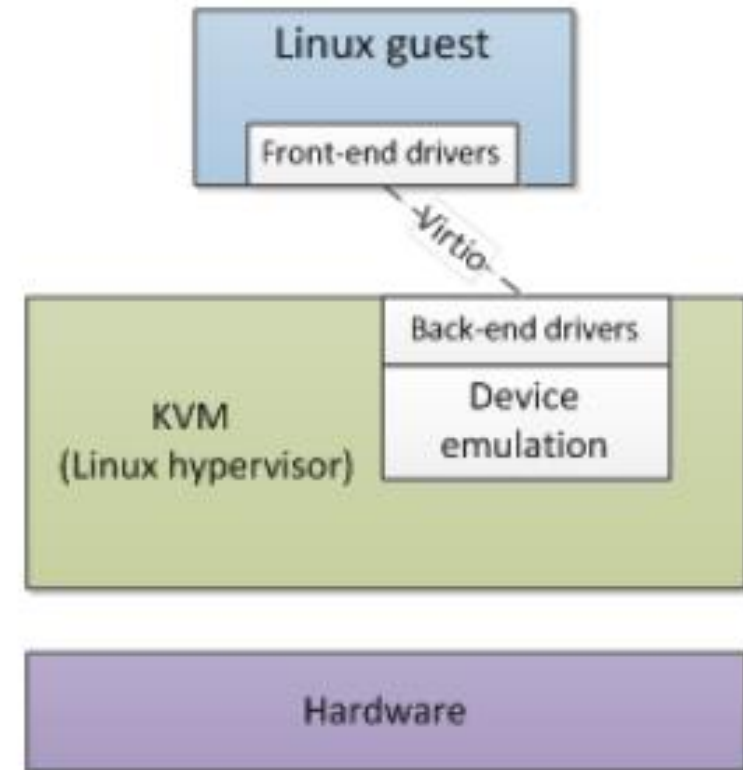
```
void nic_write_buffer(char *buf, int size)
{
    for (; size > 0; size--) {
        nic_poll_ready();           // many traps
        outb(NIC_TX_BUF, *buf++);  // many traps
    }
}
```

- **Kernel's device communication with hypervisor (hypercall):**

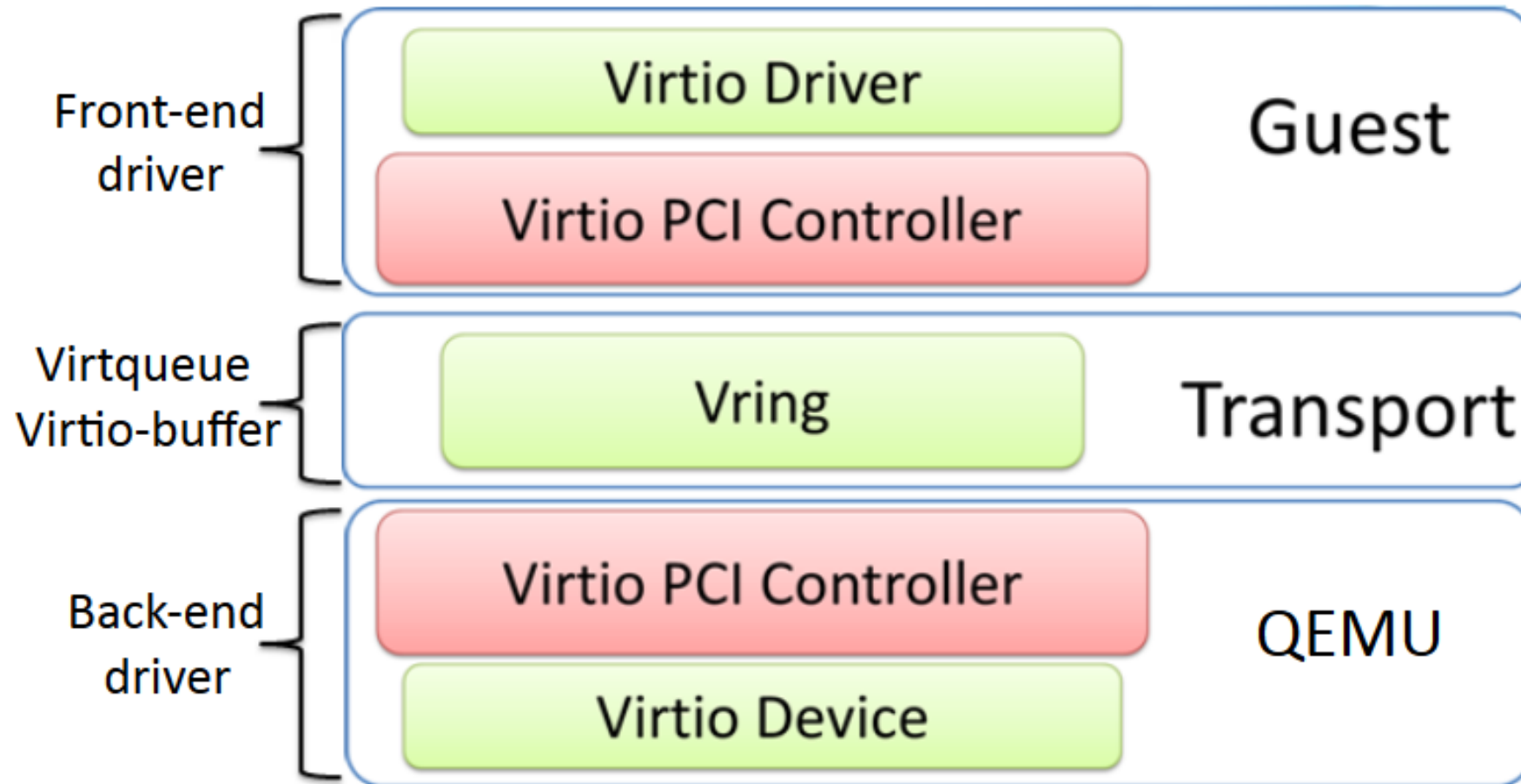
```
void nic_write_buffer(char *buf, int size)
{
    vmm_write(NIC_TX_BUF, buf, size); // one trap
}
```

VirtIO Architecture

- Front End Driver
 - A kernel module in the guest OS
 - Accepts I/O requests from the user process
 - Transfer I/O requests to back-end driver
- Back-end Driver
 - Accepts I/O requests from front-end driver
 - Perform I/O operation via physical device



VirtIO Architecture



VirtIO Transport layer

- Virtqueue
 - It is a part of the memory of the guest OS
 - A channel between front-end and back-end
 - It is an interface Implemented as **Vring**
 - Vring is a memory mapped region between QEMU and guest OS
 - Vring is the memory layout of the virtqueue abstraction

```
struct virtqueue_ops {
    int (*add_buf)(struct virtqueue *vq,
                  struct scatterlist sg[],
                  unsigned int out_num,
                  unsigned int in_num,
                  void *data);

    void (*kick)(struct virtqueue *vq);
    void (*get_buf)(struct virtqueue *vq,
                   unsigned int *len);
    void (*disable_cb)(struct virtqueue *vq);
    bool (*enable_cb)(struct virtqueue *vq);
};
```


Vring

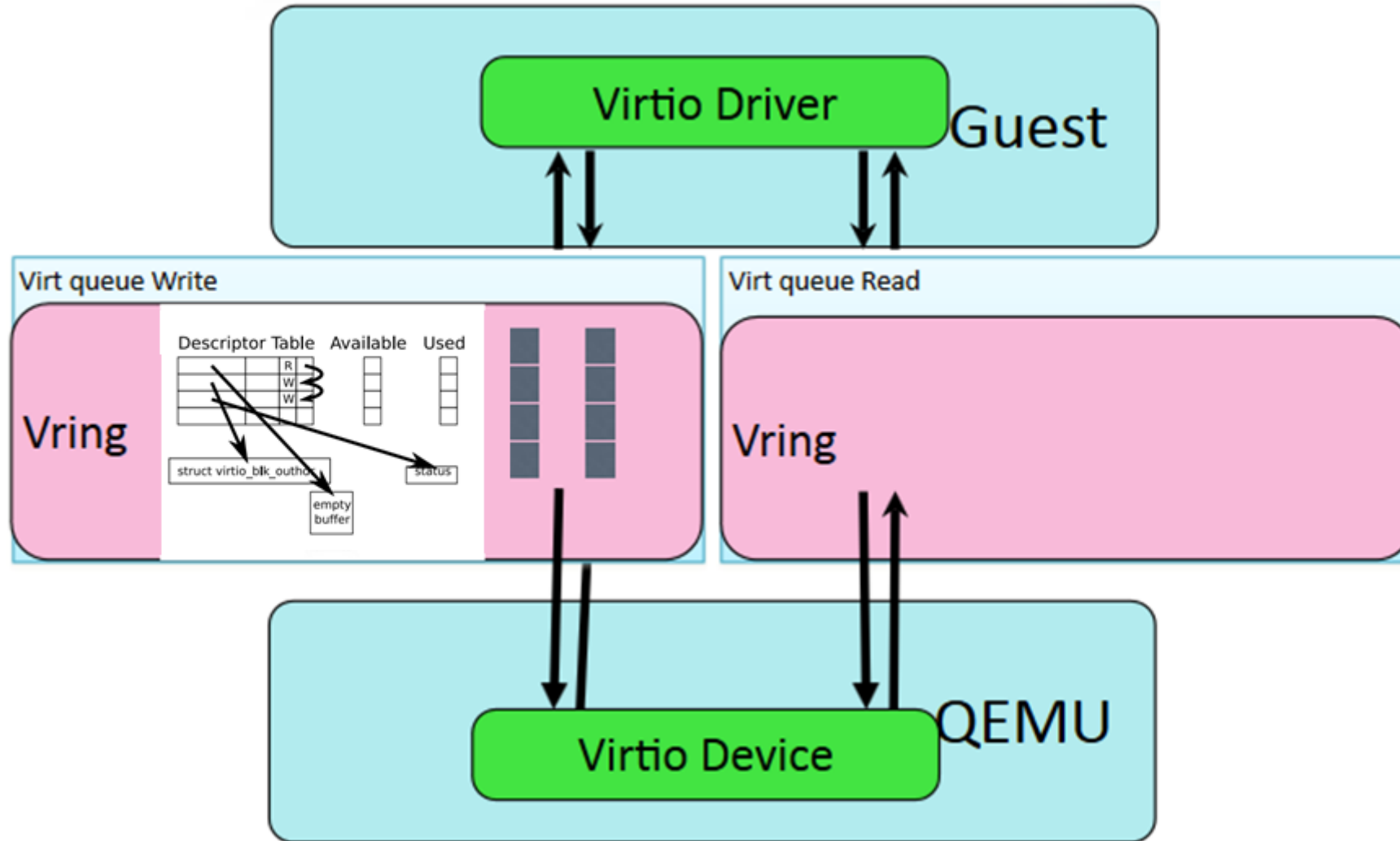
```
struct vring_desc
{
    __u64 addr;
    __u32 len;
    __u16 flags;
    __u16 next;
};
```

Vring Descriptor structure

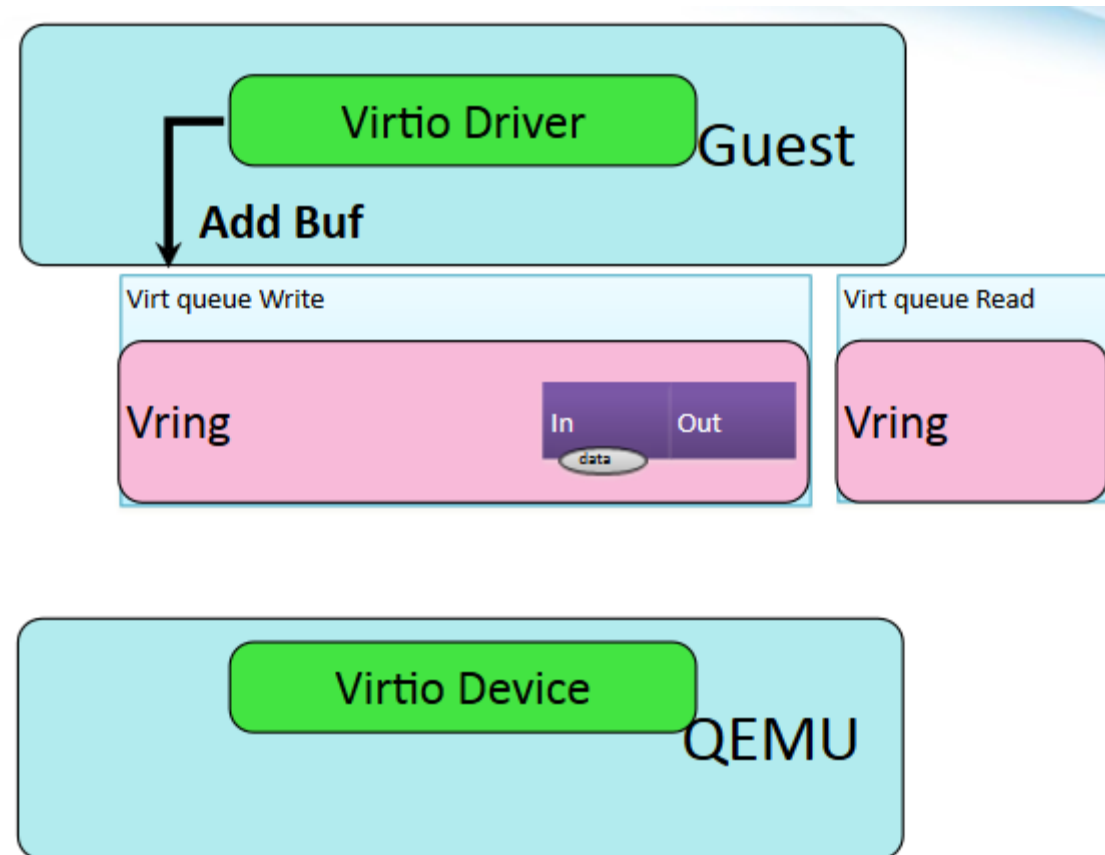
```
struct vring_avail
{
    __u16 flags;
    __u16 idx;
    __u16 ring[NUM];
};
```

Vring available structure

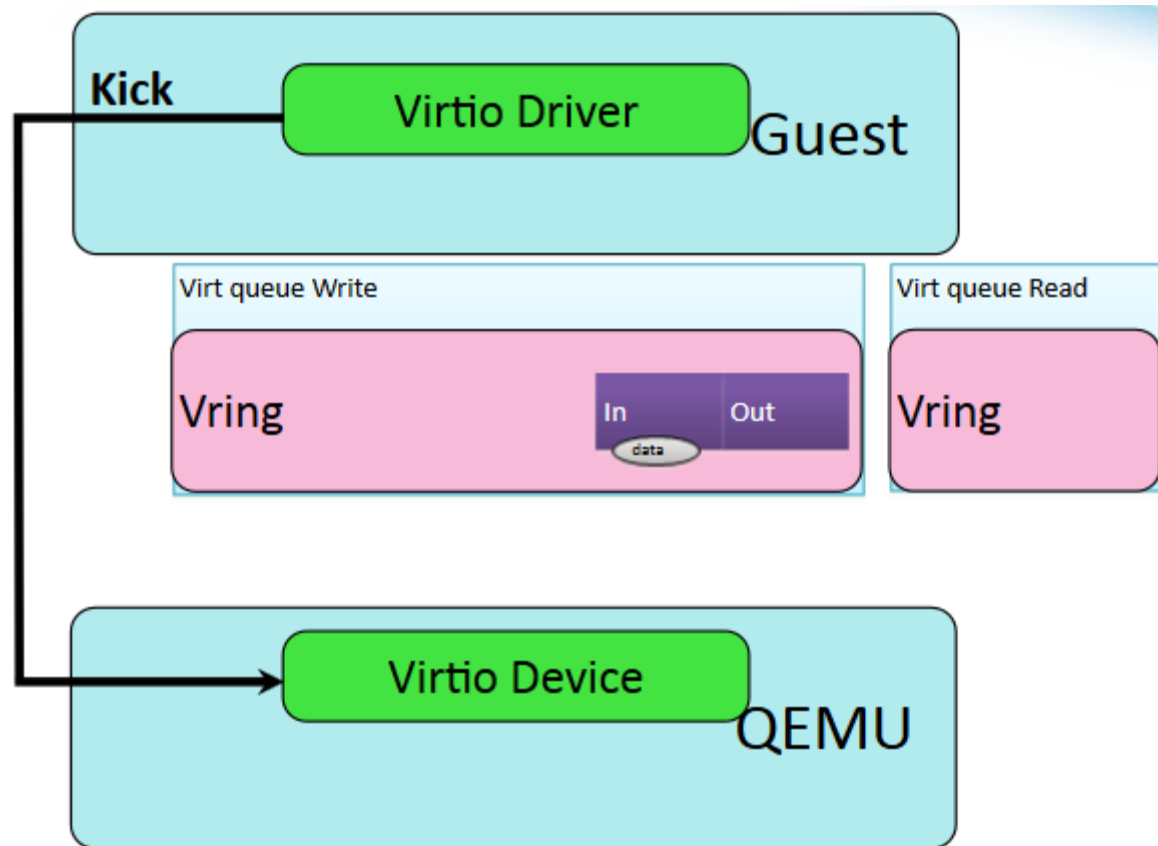
Vring



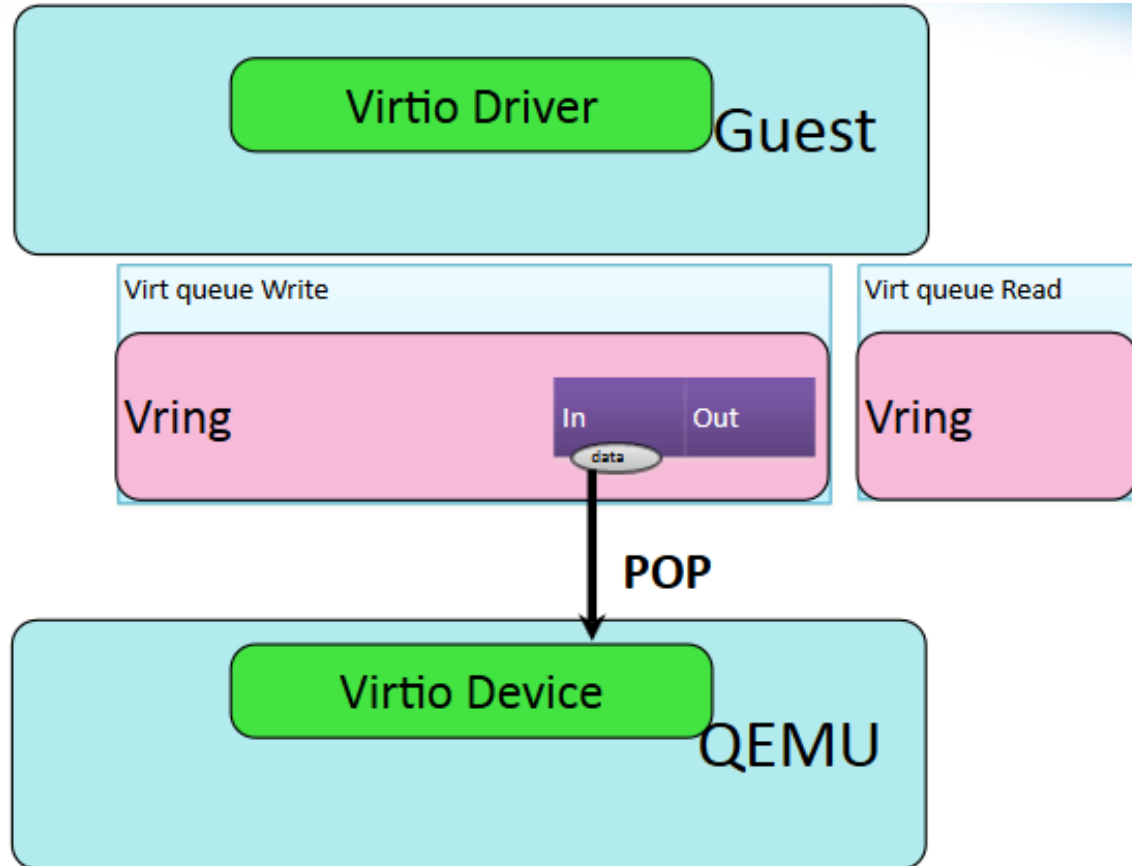
Data Exchange Flow



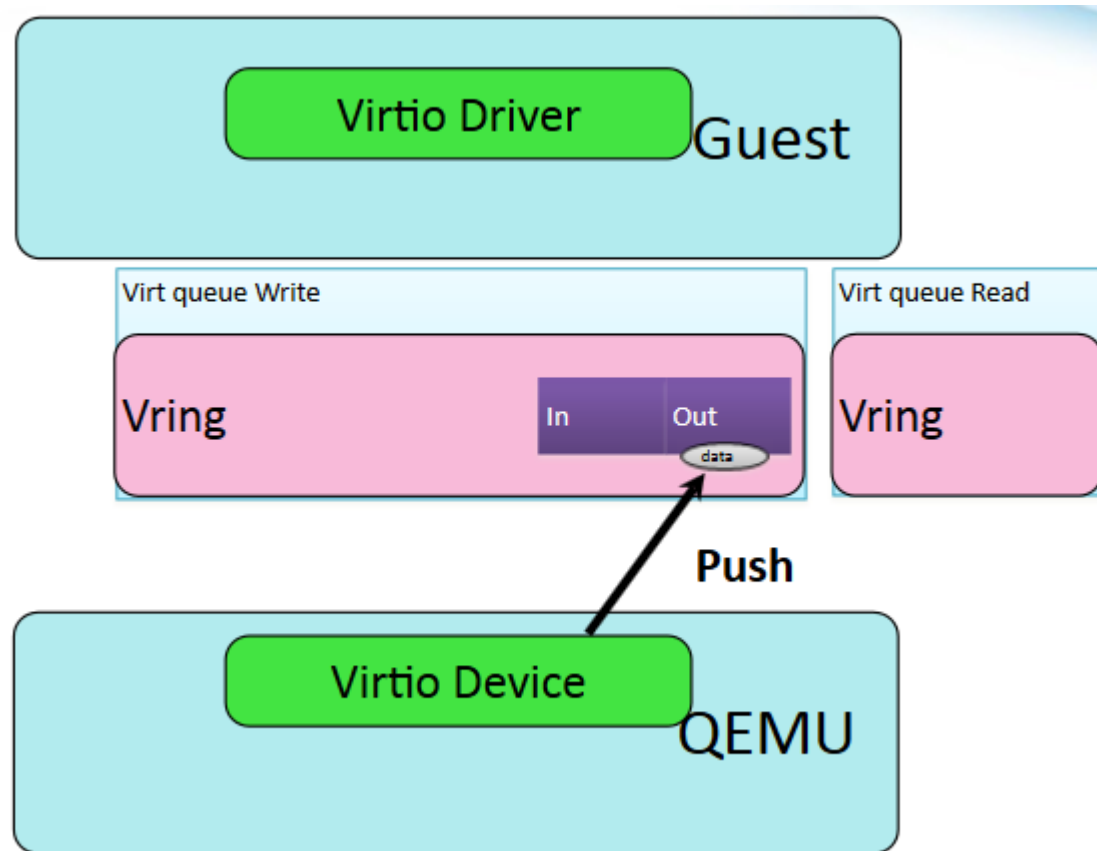
Data Exchange Flow



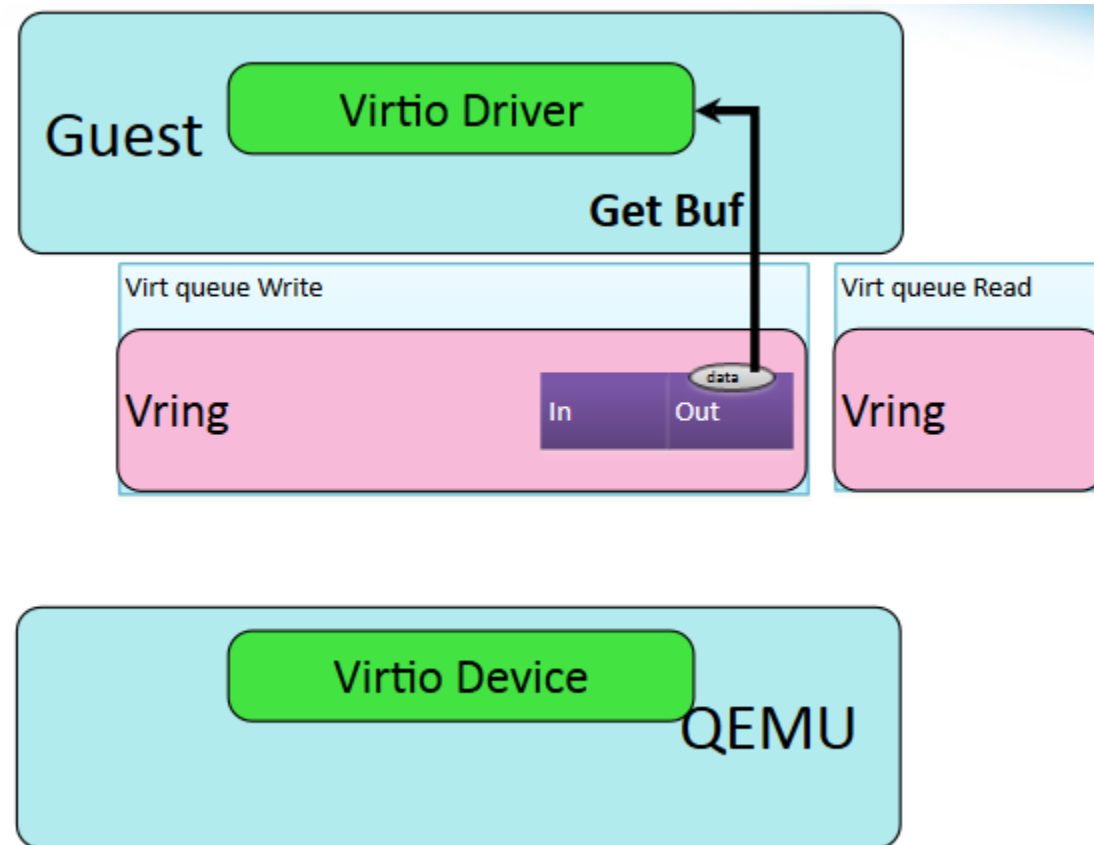
Data Exchange Flow



Data Exchange Flow



Data Exchange Flow



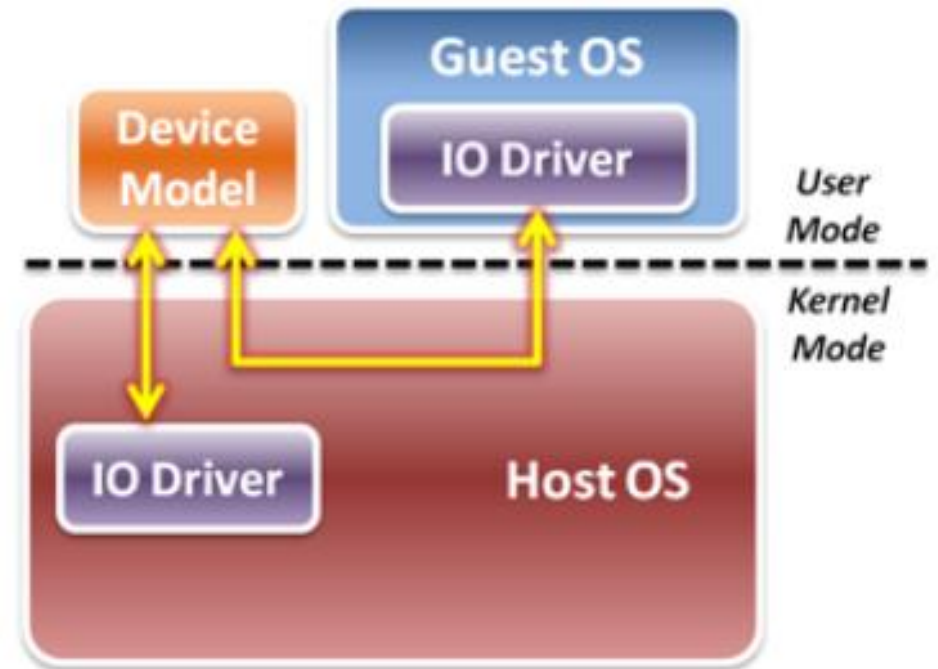
Interrupt Handling

- 2) There is one QEMU process for each guest system. When multiple guest systems are running, the same number of QEMU processes are running.

Fujitsu's : Kernel Based Virtual Machine Technology white paper

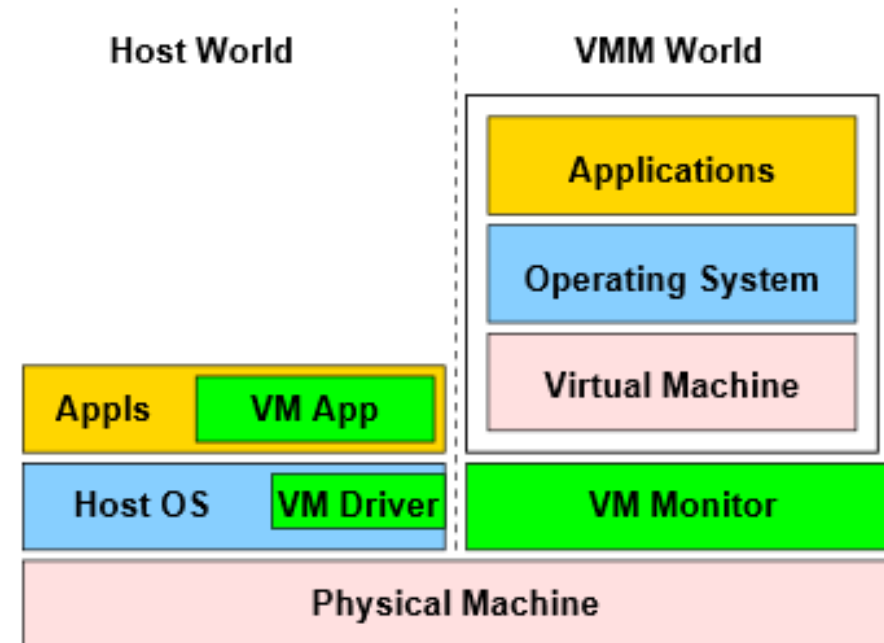
`disable_cb` is a hint that the guest doesn't want to know when a buffer is used: this is the equivalent of disabling a device's interrupt. The driver registers a callback for the virtqueue when it is initialized, and the virtqueue call

Taken from: Rusty Russel's Virtio paper



Interrupt handling (VMWare Workstation)

- Hosted virtual machine model splits the virtualization software between a virtual machine monitor that virtualizes the CPU, an application the uses a host operating system for device support, and an operating system driver for transitioning between them



VirtIO Driver Example – VirtIO Block Driver

```

struct virtio_blk_outhdr
{
    __u32 type;
    __u32 ioprio;
    __u64 sector;
};
    
```

Figure 1: Header structure of block device

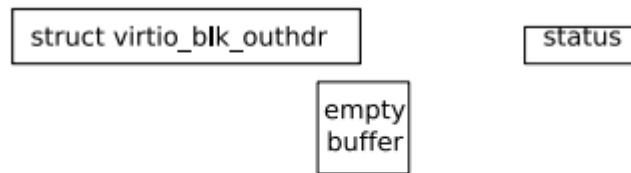


Figure 2: Ingredients for a virtio block read

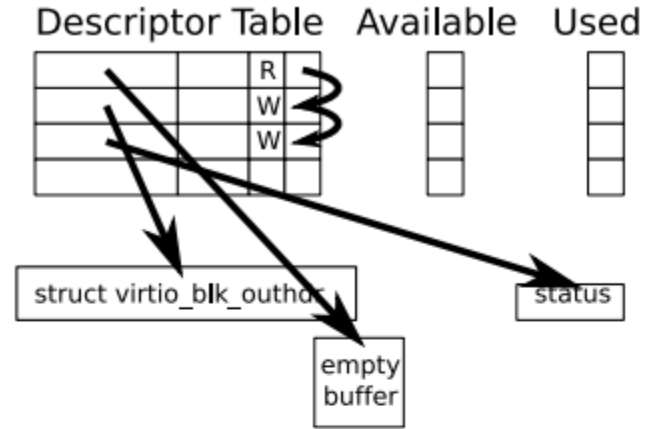


Figure 3: Virtio request placed into descriptor table

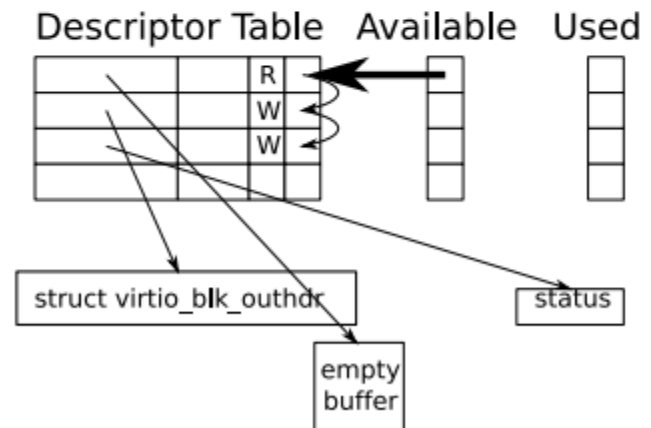


Figure 4: Virtio block read ready to be serviced

References

- ftp://ftp.os3.nl/people/nsijm/INR/Week%201/papers/32_virtio_Russel.pdf
- <http://www.ibm.com/developerworks/library/l-virtio/>
- <http://bit.ly/1ZtUPah>
- http://www.linuxinsight.com/files/kvm_whitepaper.pdf
- <http://lxr.free-electrons.com/source/include/linux/virtio.h?v=2.6.34>
- 15-410 lecture slides
- Fujitsu's Kernel-based Virtual Machine Technology white paper
- Quamranet's Kernel based Virtualization Driver white paper