ORACLE

Safe harbor statement

The following is intended to outline our general product direction. It is intended for information purposes only, and may not be incorporated into any contract. It is not a commitment to deliver any material, code, or functionality, and should not be relied upon in making purchasing decisions.

The development, release, timing, and pricing of any features or functionality described for Oracle's products may change and remains at the sole discretion of Oracle Corporation.

Multi-process QEMU

2019 KVM Forum

John Johnson
Elena Ufimtseva
Jag Raman
Oracle Virtualization
November 1, 2019

Agenda

1 Architecture overview

2 Current status and usage

Agenda

1 Architecture overview

2 Current usage and status

QEMU as cloud HV

- **QEMU is HV of choice in many cloud environments**
- **Public clouds can host VMs from many customers**
  - Vast majority of these customers are running workloads in the cloud
    - taking advantage of the scalability and flexibility of public clouds
  - But some can be malevolent actors
    - trying to look into other customers' VMs
- **Public clouds need to plan for the worst case**

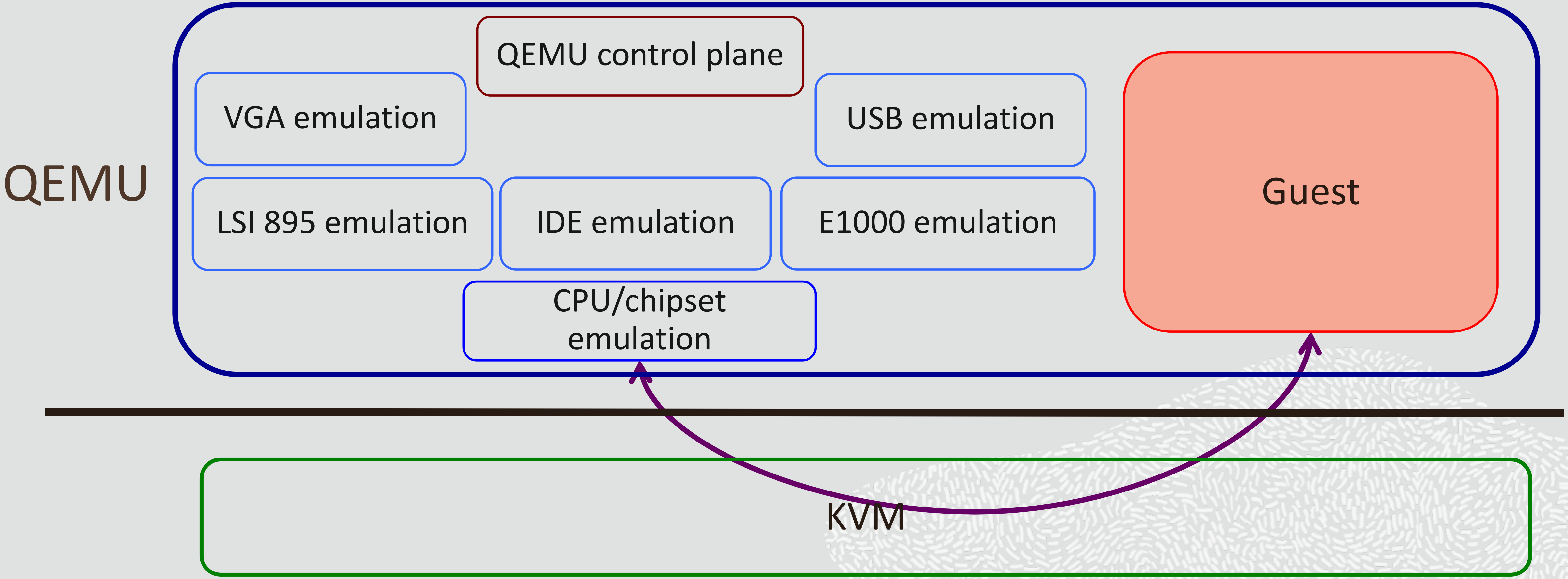
Cloud defense mechanisms

- **Use a different HV**
  - But QEMU provides many features desirable in a cloud environment
- **Minimize QEMU**
  - Reduce attack surface by configuring as few devices and services as possible
  - Use virtio devices and virtio-user daemons to further reduce surface
  - But this reduces 'lift and shift' capability since existing OS instances may rely on legacy devices
- **Run each QEMU instance in its own container**
  - Place each VM's data in the container
  - Use SELinux or AppArmour policies to restrict access of processes within each container
  - These policies apply to processes, and QEMU is a single process

Monolithic QEMU

- **QEMU is a monolithic process that combines many different functionalities**
  - VM control plane
    - Initial guest setup and monitoring
    - Live-migration, hot-plug, storage snapshots etc.
  - CPU and chipset emulation
    - Executes guest under KVM
    - Handles guest exits, interrupts, etc.
  - IO device Emulation
    - SW emulation of IO devices
- **All these functionalities require QEMU to access many host services**
- **Any exploit can allow a malevolent guest to gain all of QEMU’s access rights**

Current monolithic QEMU



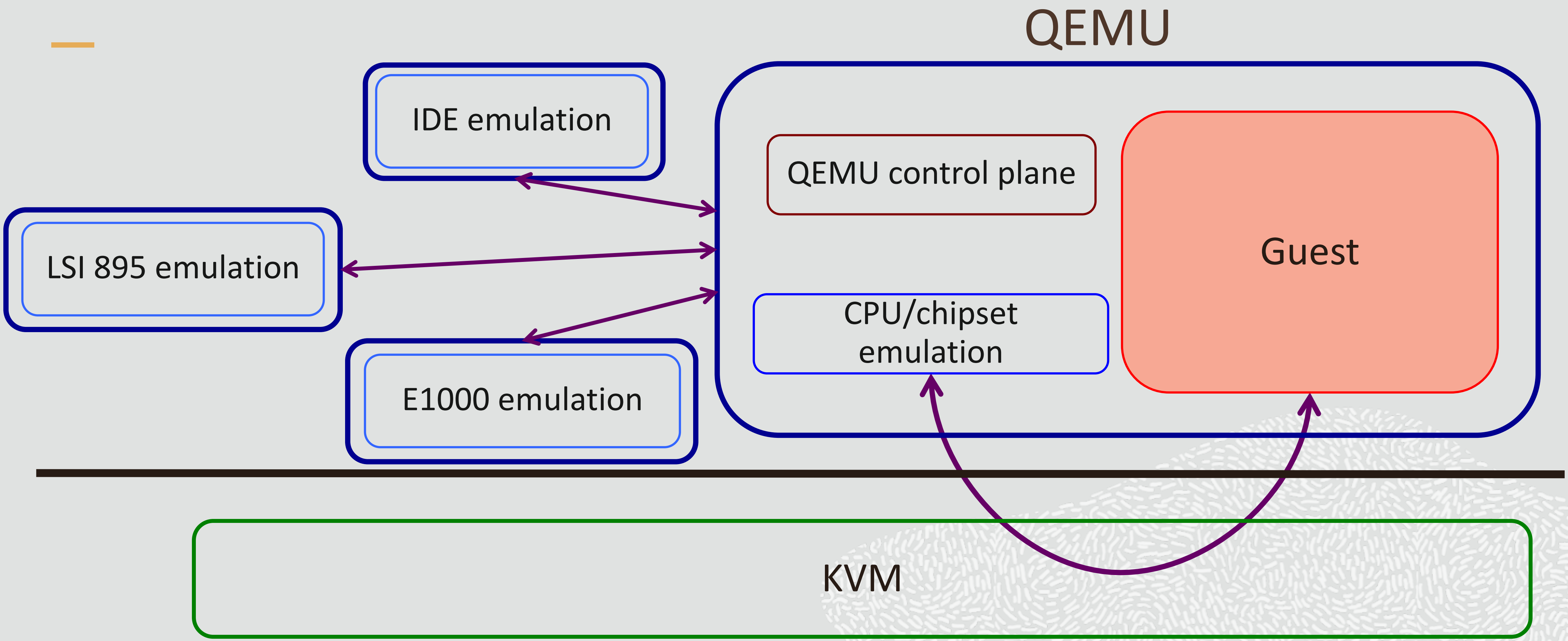
Running QEMU in multiple processes

- **Many security policies are process based**
  - SELinux has rules to limit processes as what files or device objects it can access
  - Seccomp can limit processes as what system calls they can execute
- **Separating QEMU into multiple processes allows finer-grained privileges to be assigned to each one**
  - Disk controller emulation process only given access to disk images belonging to the guest
    - iSCSI emulation can be limited to iSCSI ports and storage host IPs
  - All device emulation processes can be limited from using fork() or exec() to create a host shell

Device emulation in separate process

- **Good place to start for a number of reasons**
    - Largest surface a malevolent guest could attack
        - provided by the large number of devices QEMU can emulate
    - Ease of implementation
        - device emulation internally implemented as objects within QEMU
        - object method boundaries can be used as process separation point
    - Scalability
        - number of processes can scale to number of devices in VM

QEMU with device emulation in separate processes



QEMU object model

- **Class-based inheritance model**

  "object" is super-class
- **"machine" class models platform**

  Initializes emulated system configuration
- **"device" class models IO devices**

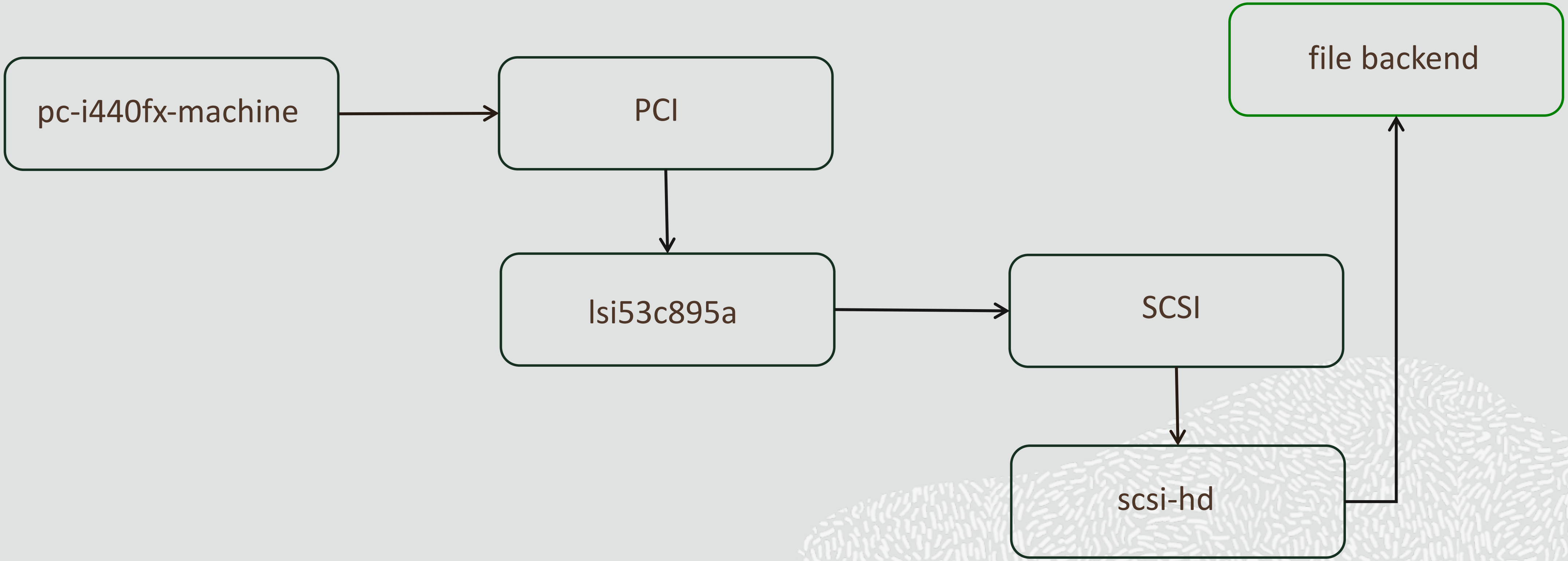
  Most device emulation code is in objects of this sub-class
- **"bus" class models IO buses**

  Enumerates child devices of an IO bus

QEMU initialization

- **QEMU command line options are parsed**
  - -machine, -device, -blockdev options parsed
- **Device backends initialized**
  - Placed on lists so they can be found by their associated device objects
- **Machine object initialized**
  - Hand crafts platform built-in device objects
    - host bridge, IDE, APIC, serial, etc.
- **Device objects initialized**
  - Looking up any backends they need

QEMU objects for SCSI drive



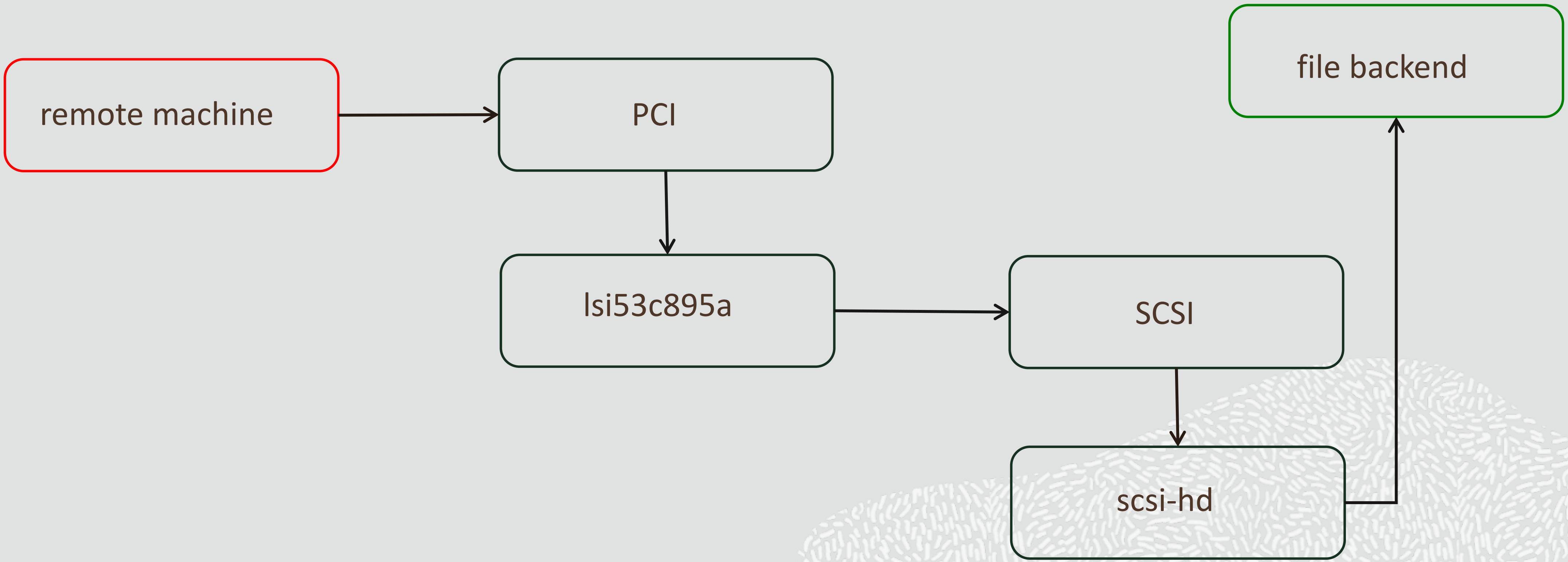
Emulation process

- **Runs unmodified device and bus objects from monolithic QEMU**
  - Built from same QEMU source tree
  - Startup handshake to ensure QEMU and remote process are from same build
- **Runs unmodified device backends from monolithic QEMU**
  - Also built from QEMU tree
  - Same command line arguments used in both QEMU and remote process
- **New remote machine class object**
  - Replaces machine object in monolithic QEMU
  - Performs similar functions
    - creates initial machine from configuration messages from QEMU
    - handles interrupt and IOMMU requests from device models

Emulation process cont.

- **Proxy service to talk to QEMU**
  - Instantiates machine object
  - Instantiates device objects from QEMU configuration messages
  - Creates device backends from command line arguments
  - Routes requests from QEMU to device objects
    - e.g., guest reads and writes to address space of device
  - Routes machine requests back to QEMU
    - e.g., IOMMU mapping requests

Emulation process



QEMU changes

- **New remote process manager**
  - Manages communication with emulation process
  - Created with new “–remote” command line argument
    - *-remote rid=<rid>,socket=<socket path>*
      - communicates with existing process over given socket
    - *-remote rid=<rid>,command=“<emulation process args>”*
      - creates socket and executes given command
- **No Device backends - only needed in emulation process**

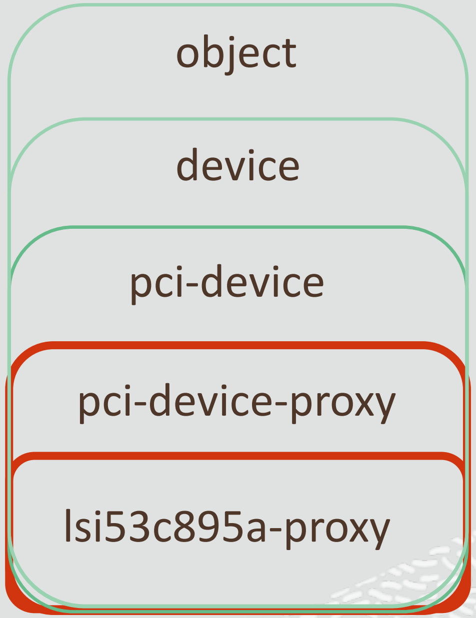
QEMU changes

- **Proxy objects replace the device emulation objects**
  - Forwards guests events, such as MMIOs, to emulation process
  - Specified by new rid=<rid> option for -device
    - *-device lsi53c895a,id=scsi0* specifies traditional emulation within QEMU
    - *-device lsi53c895a,id=scsi0,rid=disk-proc* specifies remote emulation
    - “disk-proc” is ID of remote process manager to forward requests to
  - Exist in QEMU at same point the object and bus hierarchy as device object it replaces
    - e.g., LSI SCSI proxy is a sub-class of “pci-device” and is a child of a PCI bus object
- **Not all devices emulation objects need proxies**
  - Only those with guest interactions
  - e.g., SCSI controller does, but SCSI devices do not

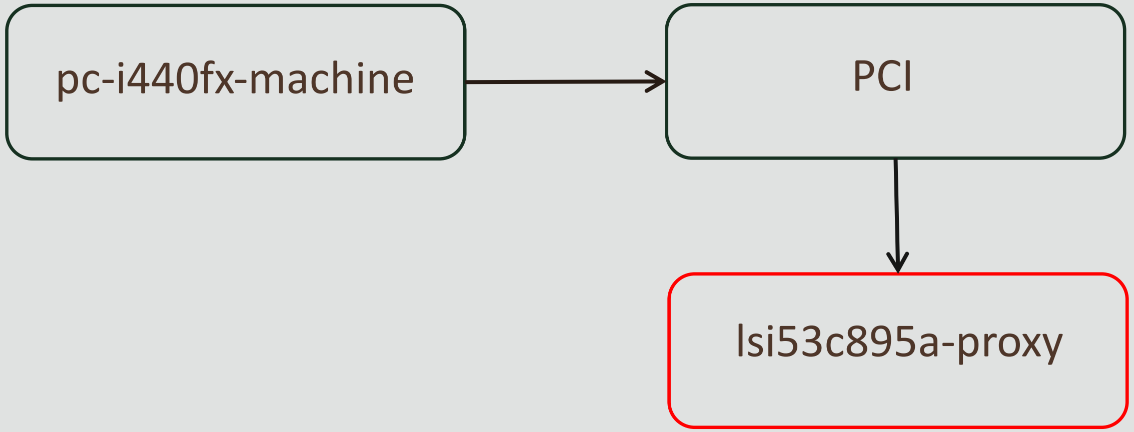
Proxy object hierarchy for LSI SCSI controller

- “pci-device-proxy” class forwards guest config space reads and writes to emulation process, mostly for BARs and interrupts

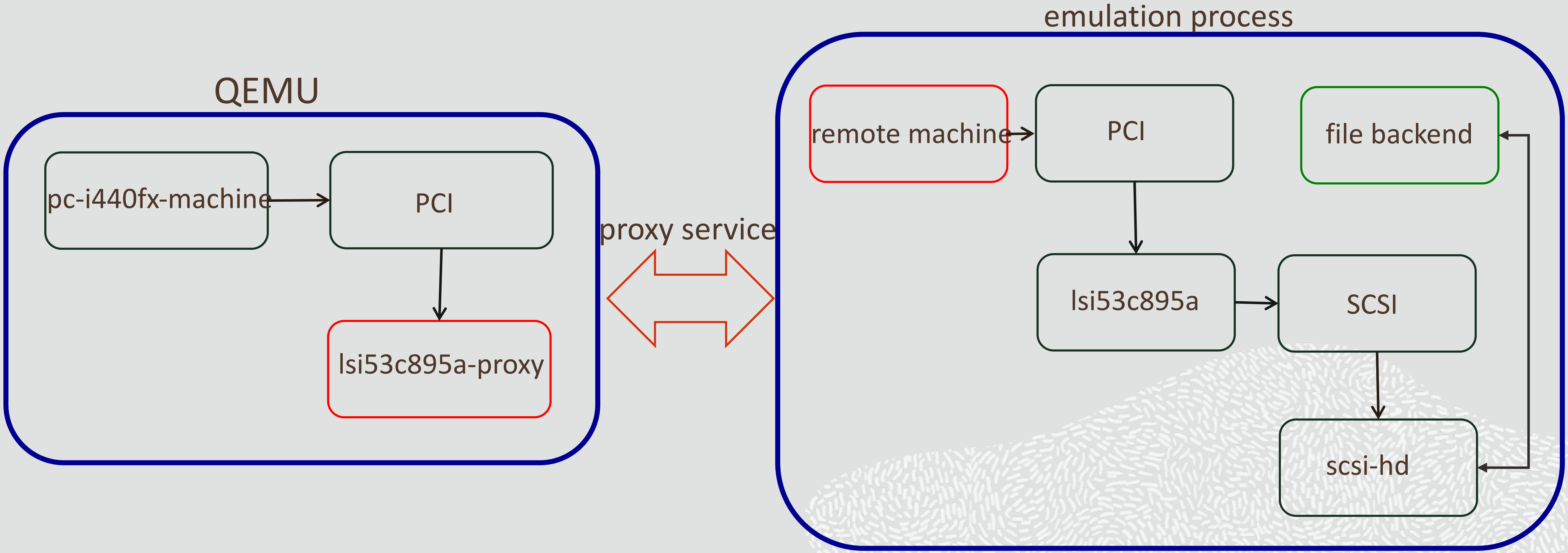
- “lsi53c895a-proxy” class forwards guest MMIOs to the device memory space to emulation process.



QEMU objects left behind



Putting it all together



Agenda

1 Architecture overview

2 Current usage and status

I want to try it!

- **Clone it from** *http://github.com/oracle/qemu*
- **Configure it with --enable-mpqemu**
- **More command-line options?**

  Not really! “-remote”, “rid=”
- **One device per process?**

  Nope!
- **One remote process?**

  Nope, can have more!

Try with lsi53c895a

```
qemu-system-x86_64 -name "aww_qemu" -machine q35,accel=kvm \
-smp sockets=1,cores=1,threads=1 -m 2048 \
-object memory-backend-file,id=mem,mem-path=/dev/shm/,size=2G,share=on \
-numa node,memdev=mem  -drive format=raw,file=/root/ol7.qcow2  \
-device lsi53c895a,id=lsi0,rid=8 \
-device scsi-hd,id=drive2,drive=drive_image2,bus=lsi0.0,scsi-id=0,rid=8 \
-remote rid=8,command=”-drive id=drive_image2,,file=/root/remote-process-disk.img” \
-boot d -monitor stdio -vnc :0
```

Functionality

- ❑ QMP monitor and HMP commands
- ❑ Device hot-plug
- ❑ Live Migration
- ❑ SELinux policies
- ❑ Libvirt support

Teach your device to run in a separate process

- **Write proxy object for QEMU**
  Leverage current PCI proxy for PCI devices

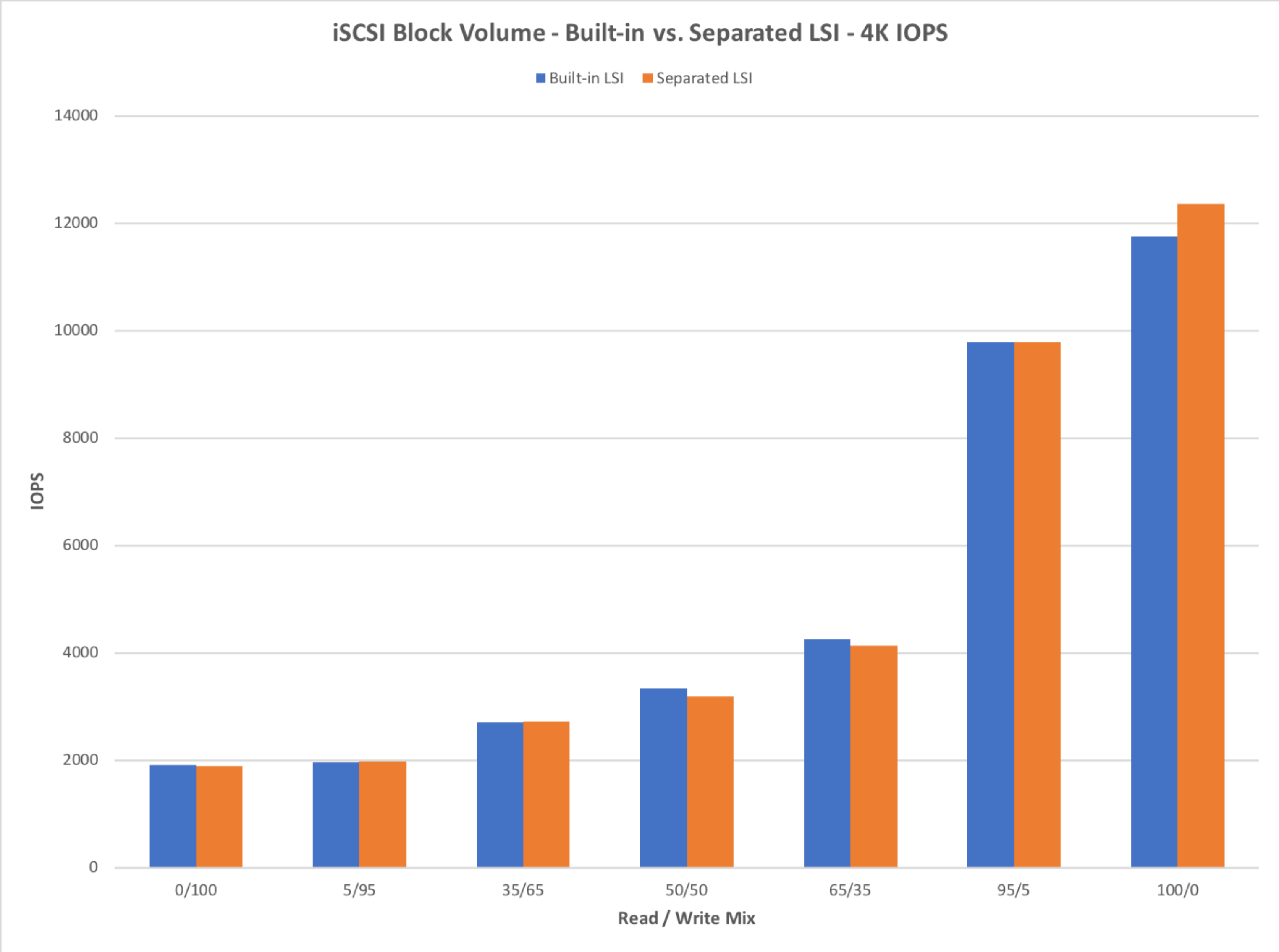
- **Add your device's object to remote process build**

- **Add QMP/HMP commands that manage your device to remote process build**

Future work

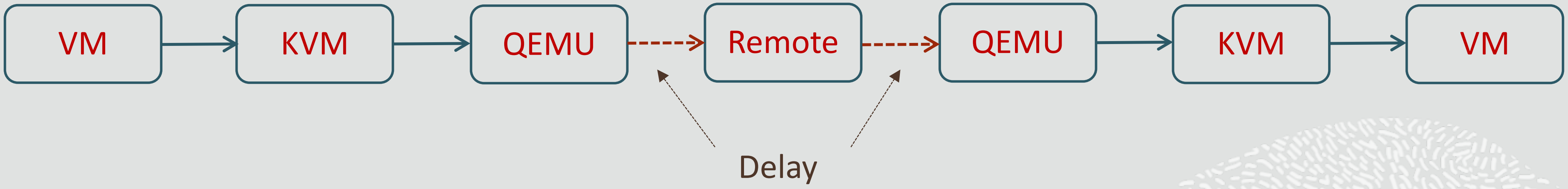
- ❑ **Work with KVM/QEMU community, address feedback more efficiently**
- ❑ **Add more device types**
- ❑ **Improve performance**
  - Shorten path for MMIOs
- ❑ **Security hardening**
- ❑ **Libvirt support upstreaming**

Performance



MMIO Acceleration

- **Impact on CPU usage**
- **Delay in processing MMIO**
  - Return to QEMU
  - Syscall overhead



- **Accelerated MMIO processing**

Thank you

John, Elena and Jag