VGPU ON KVM
VFIO BASED MEDIATED DEVICE FRAMEWORK

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NVIDIA

AGENDA

Background / Motivation

Mediated Device Framework – Overview

Mediated Device Framework – Deep-Dive

Current Status

Demo

Future work

TODAY, HOW GPU PRESENTED INSIDE KVM VM

VFIO device pass-through [1]

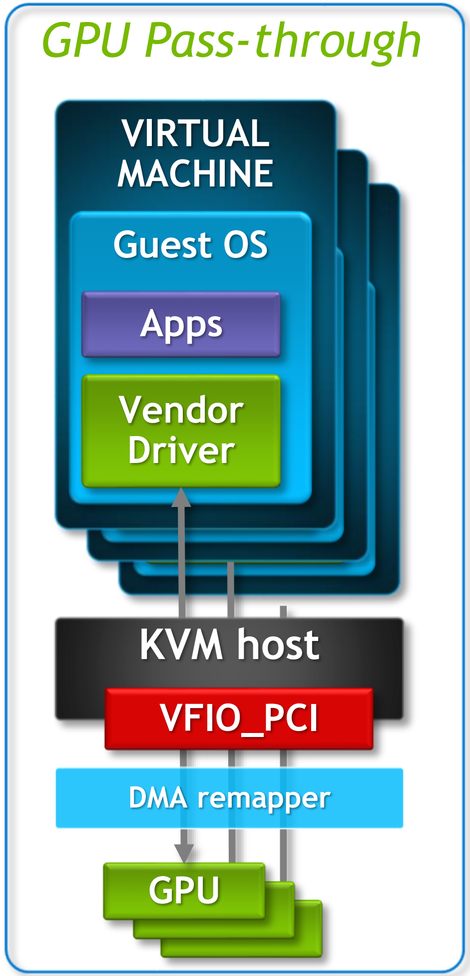
Great performance

Full API compatibility – GPU vendor driver inside the virtual machine

Poor density – limited by PCI-E resource

Minimal visibility of the device on the host – generic vfio_pci owns this device, and only perform enable/disable/route interrupts, reset the device

Difficult to cover all graphics workload – either underutilized or too small to scale



WHAT IS VGPU?

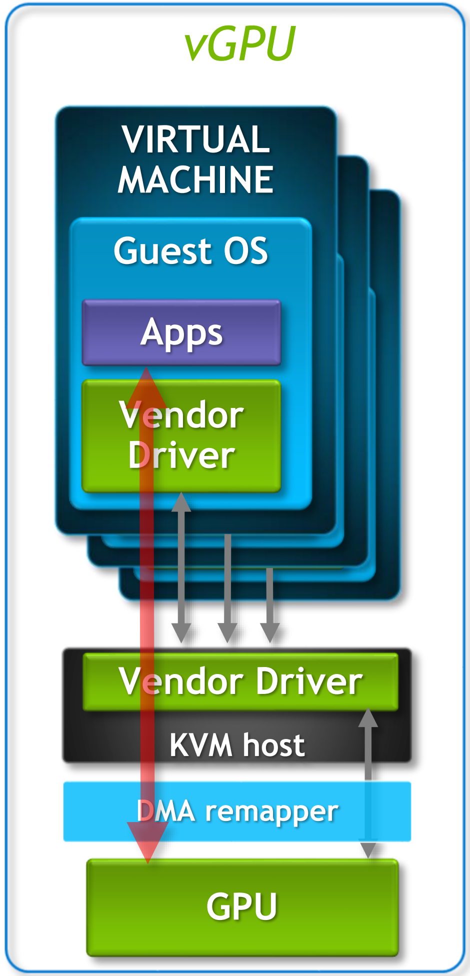
High level overview

Physical GPU shared among multiple virtual machines

Great performance and suitable for different workload

Full API compatibility – GPU vendor driver inside the virtual machine

Full device visibility to the hypervisor/host – allows for device-specific features such as dynamically monitoring and tuning performance, detailed error reporting, etc.



I/O VIRTUALIZATION

SR-IOV and mediated solutions

SR-IOV devices - supported by standard VFIO PCI (Direct Assignment) today

Established QEMU VFIO/PCI driver, KVM agnostic and well-defined UAPI

Virtualized PCI config /MMIO space access, interrupt delivery

Modular IOMMU, pin and map memory for DMA

Mediated devices – non SR-IOV, require vendor-specific drivers to mediate sharing

Leveraging existing VFIO framework, UAPI

Vendor driver - Mediated Device – managing device’s internal I/O resource

MEDIATED DEVICE FRAMEWORK

A common framework for mediated I/O devices

Mediated core module (new)

- Mediated bus driver, create mediated device
- Physical device interface for vendor driver callbacks
- Generic mediate device management user interface (sysfs)

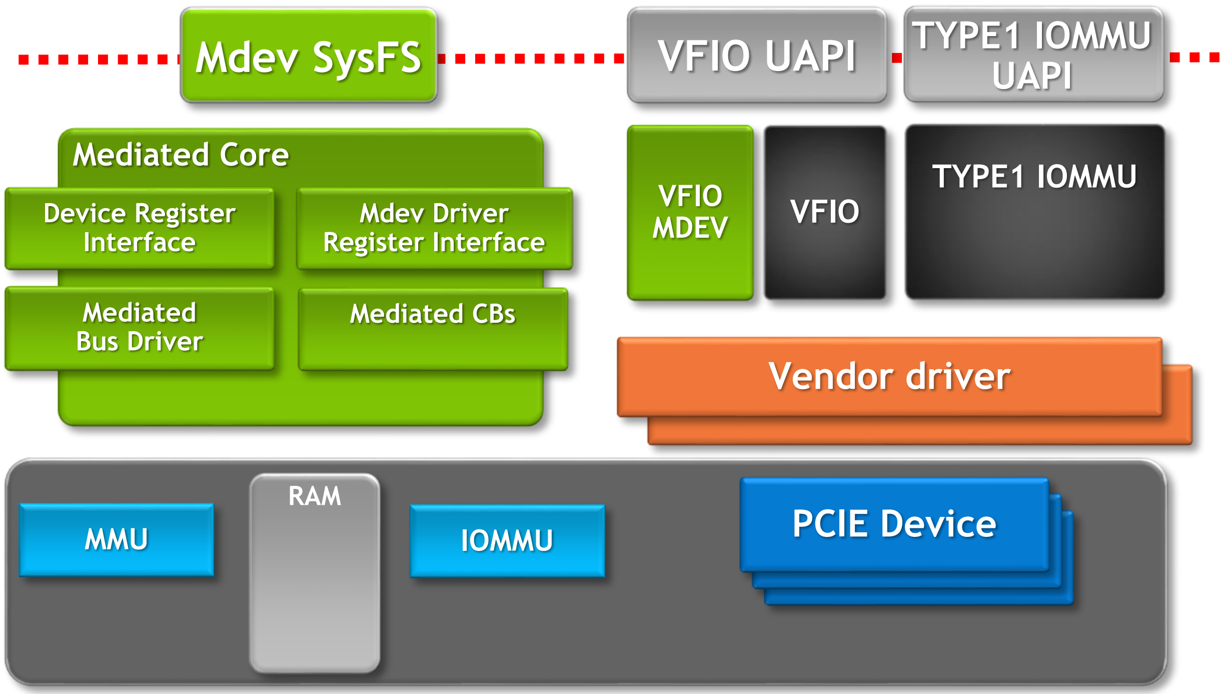
Mediated device module (new)

- Manage created mediated device, fully compatible with VFIO user API

VFIO IOMMU driver (enhancement)

- VFIO IOMMU API TYPE1 compatible, easy to extend to non-TYPE1

MEDIATED DEVICE FRAMEWORK

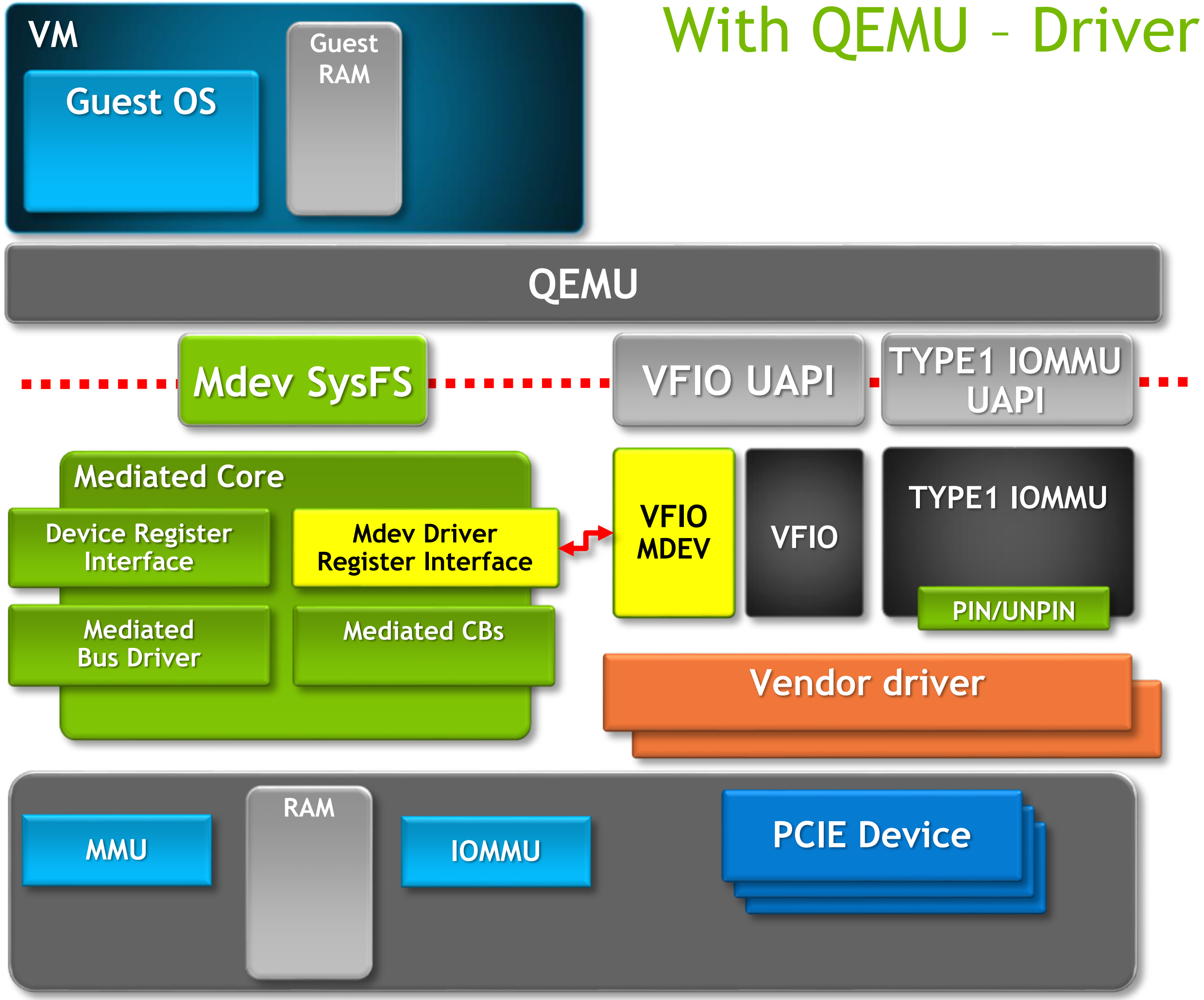


MEDIATED DEVICE FRAMEWORK - INITIALIZATION

MEDIATED DEVICE FRAMEWORK

With QEMU – Driver Initialization

Registers VFIO MDEV as driver



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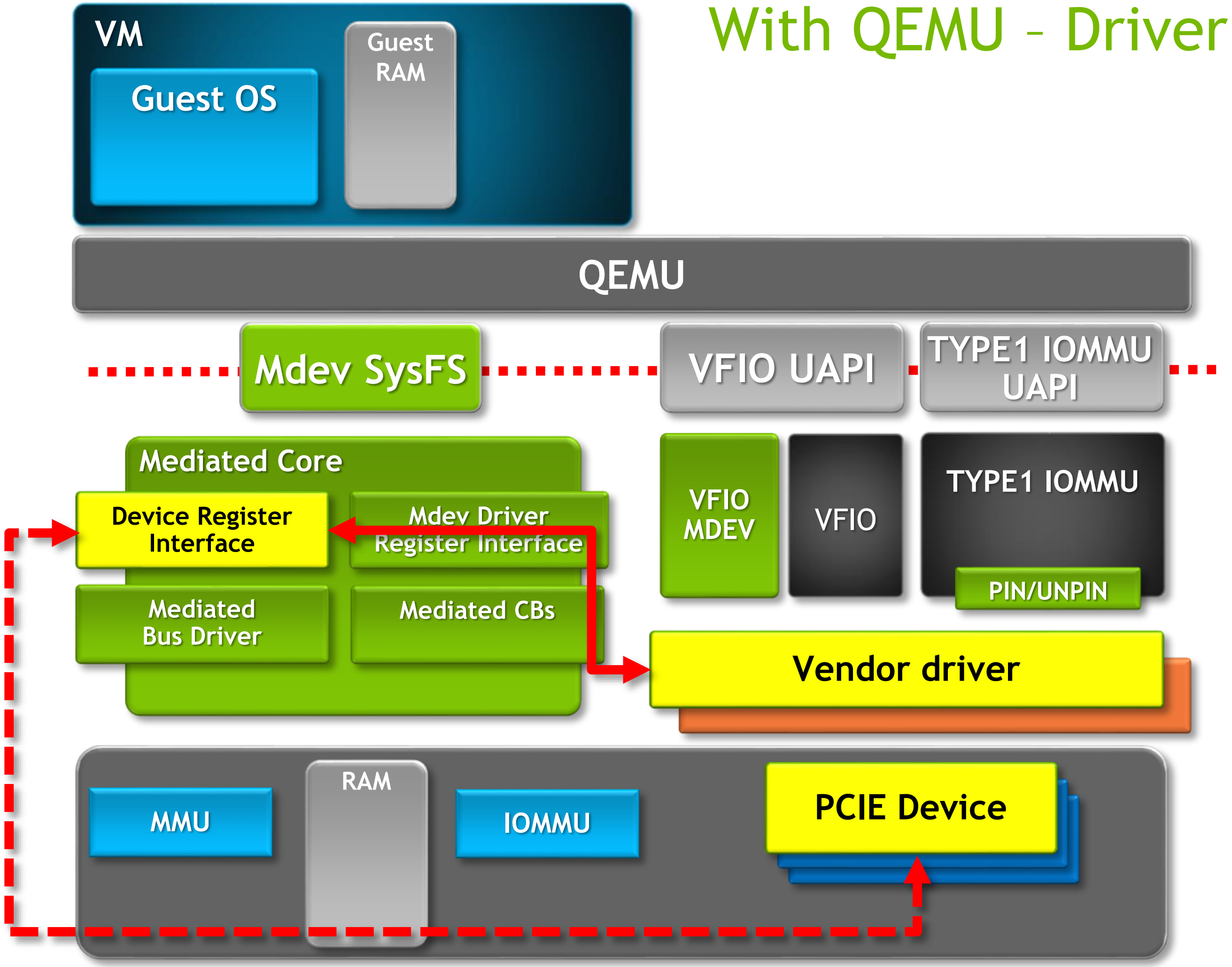

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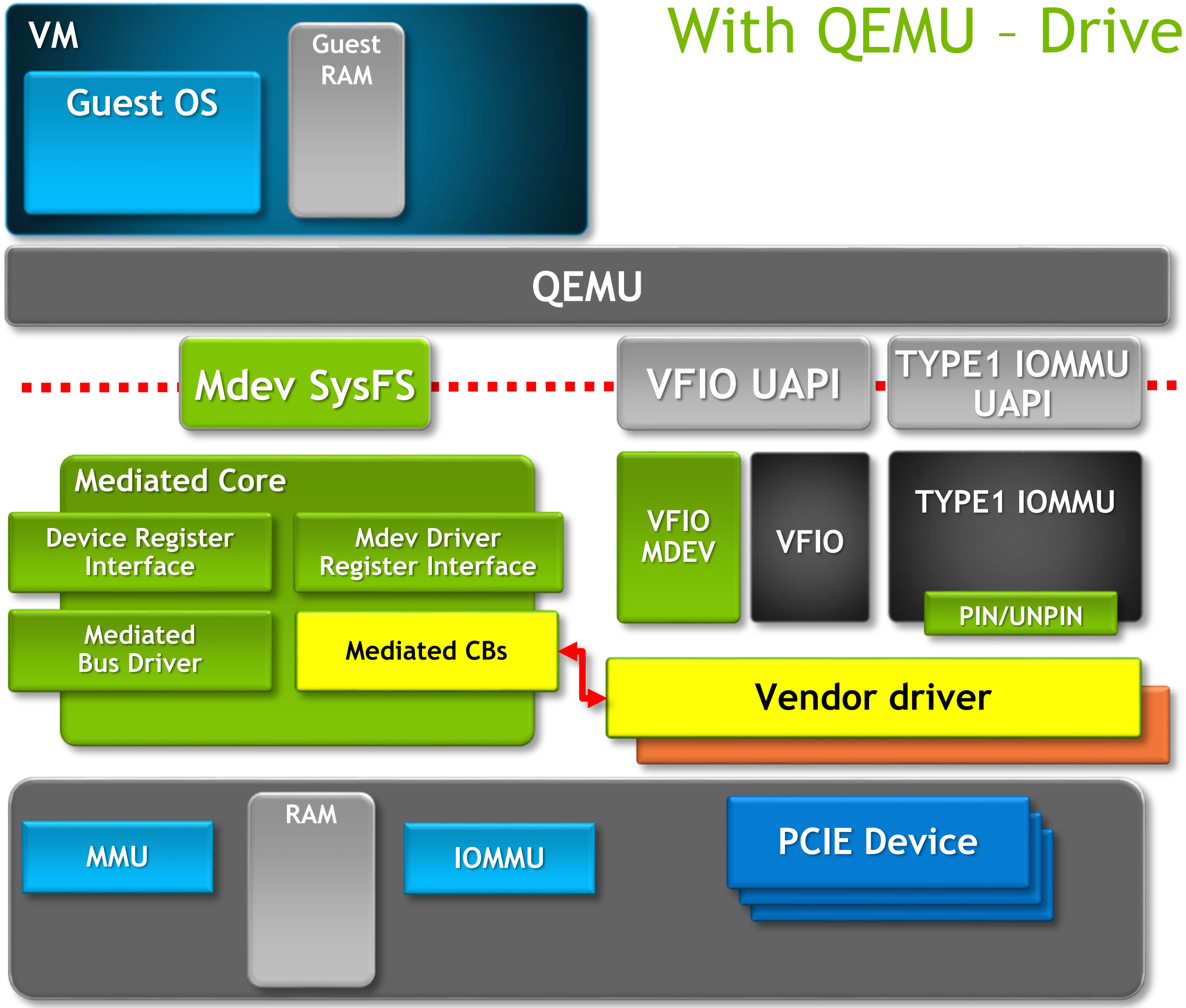

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Registers VFIO MDEV as driver

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Vendor driver registers Mediated CBs

MEDIATED DEVICE FRAMEWORK

Mediated Device sysfs

After vendor driver device registration, under physical device sysfs:

mdev_create : create a virtual device (aka mdev device)

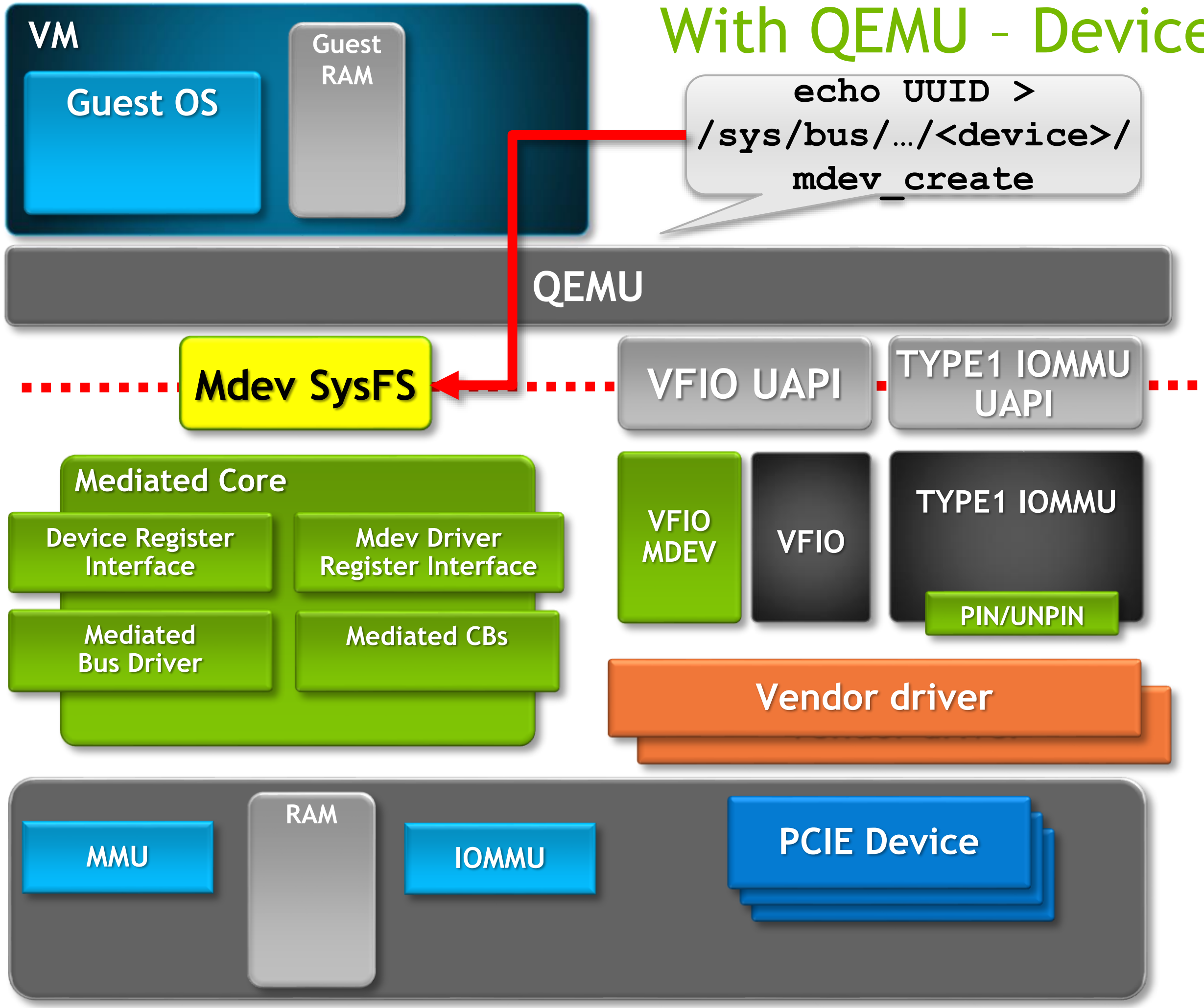
mdev_destroy : destroy a mdev device

mdev_supported_types : supported mdev and configuration of this device

Mdev node: /sys/bus/mdev/devices/$mdev_UUID/

online: start and stop virtual device

MEDIATED DEVICE FRAMEWORK



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User writes mdev sysfs to create mdev device

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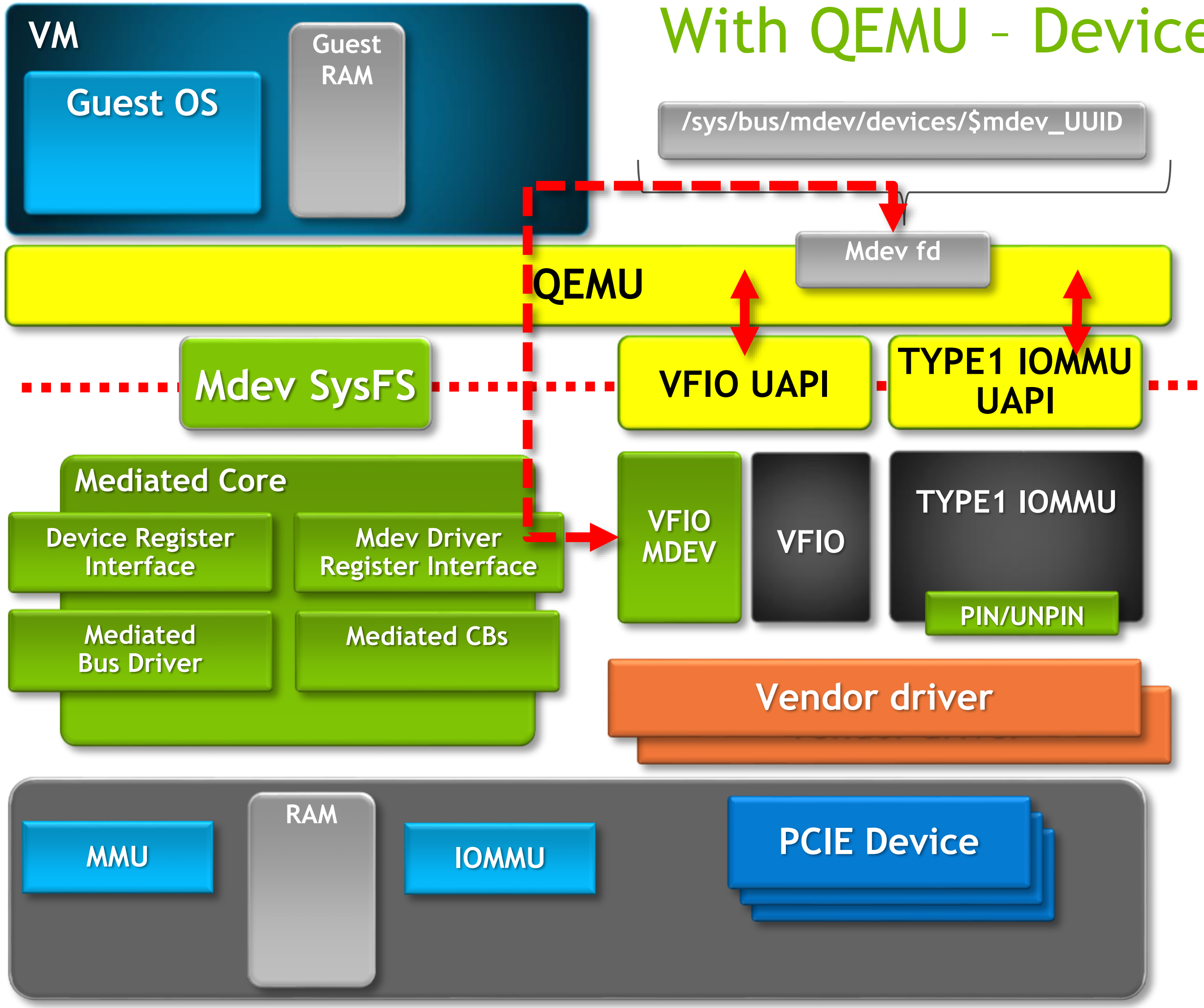

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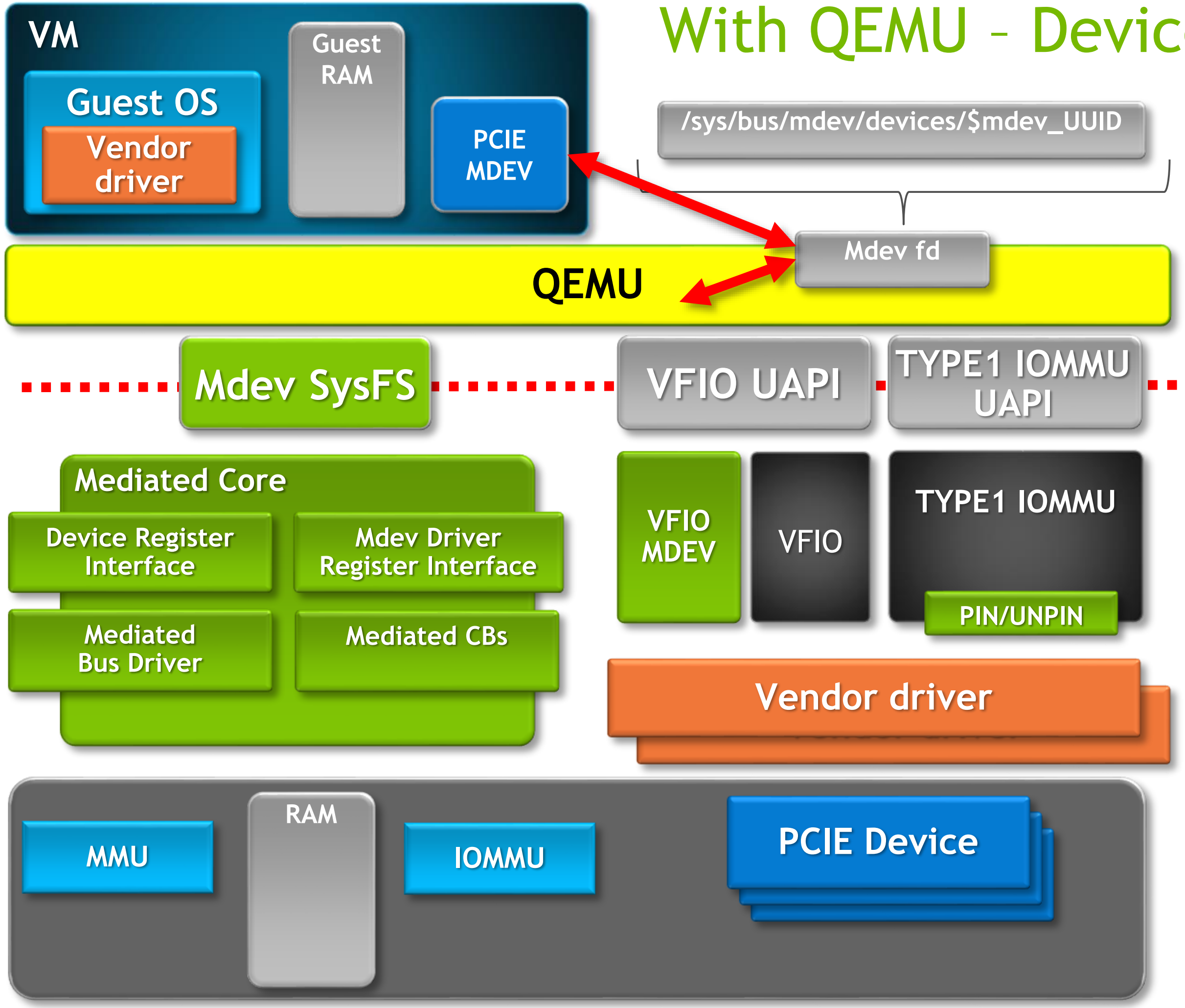

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QEMU access device fd and present it into VM

MEDIATED DEVICE ACCESS - EMULATED

MEDIATED DEVICE ACCESS

Emulated vs Passthrough

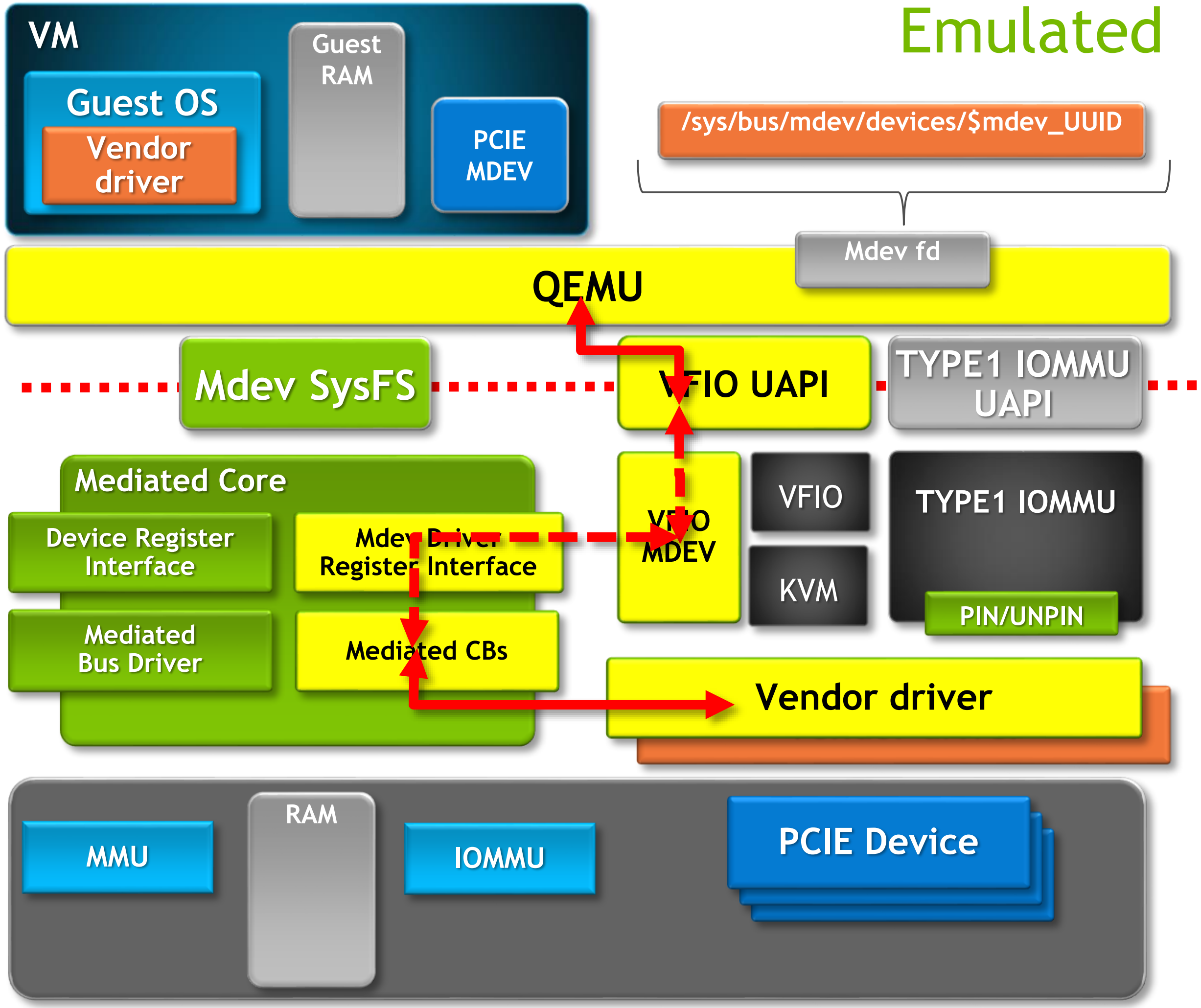
Virtual device memory region are presented inside guest for consistent view of vendor driver

Access to emulated regions are redirected to mediated vendor driver for virtualization support

Access to passthrough region are directly sent to device corresponding region for max performance

- 1st access redirected to mediated vendor driver for CPU page table setup

MEDIATED DEVICE ACCESS



QEMU gets region info via VFIO UAPI from vendor driver thru VFIO MDEV and Mediated CBs

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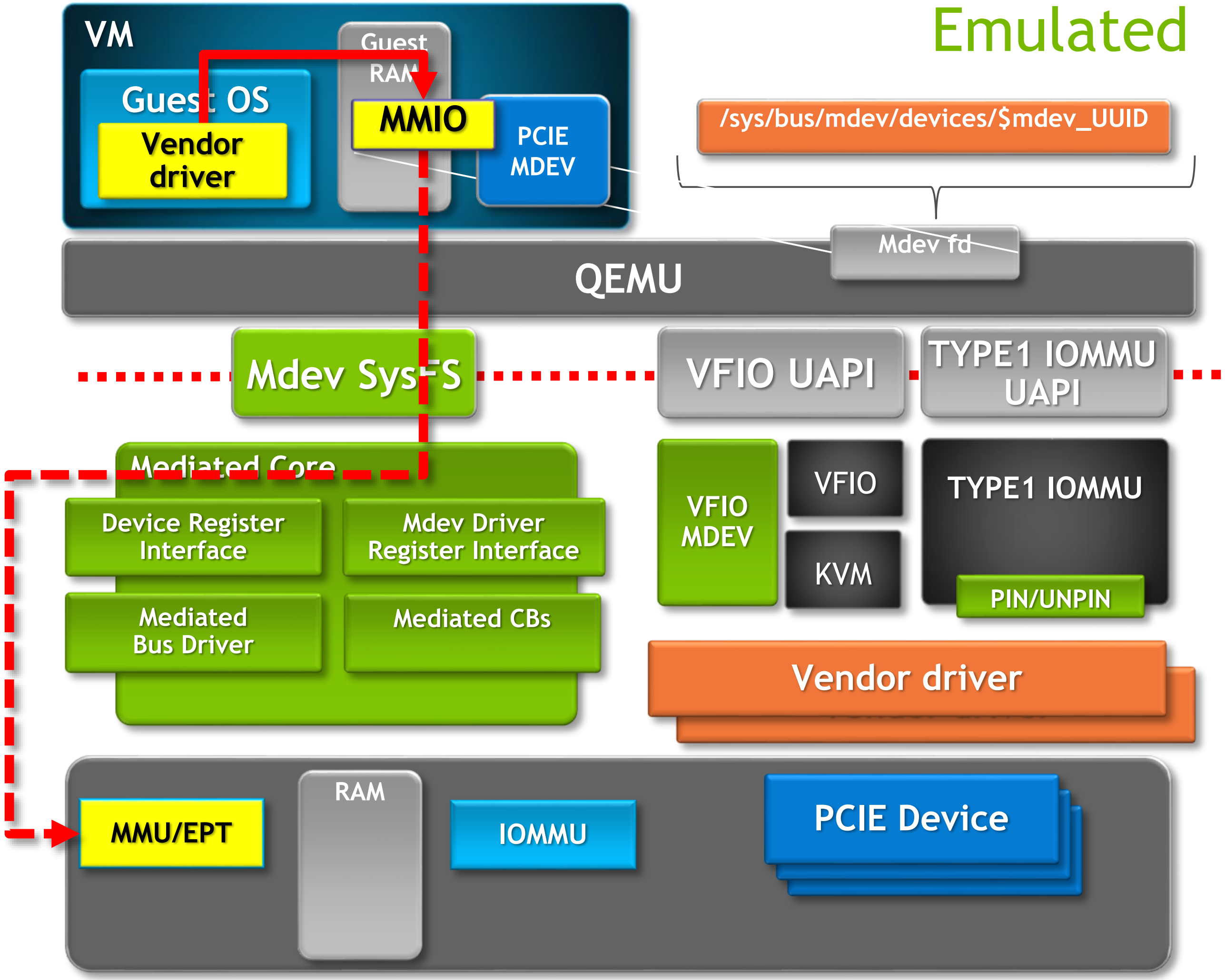

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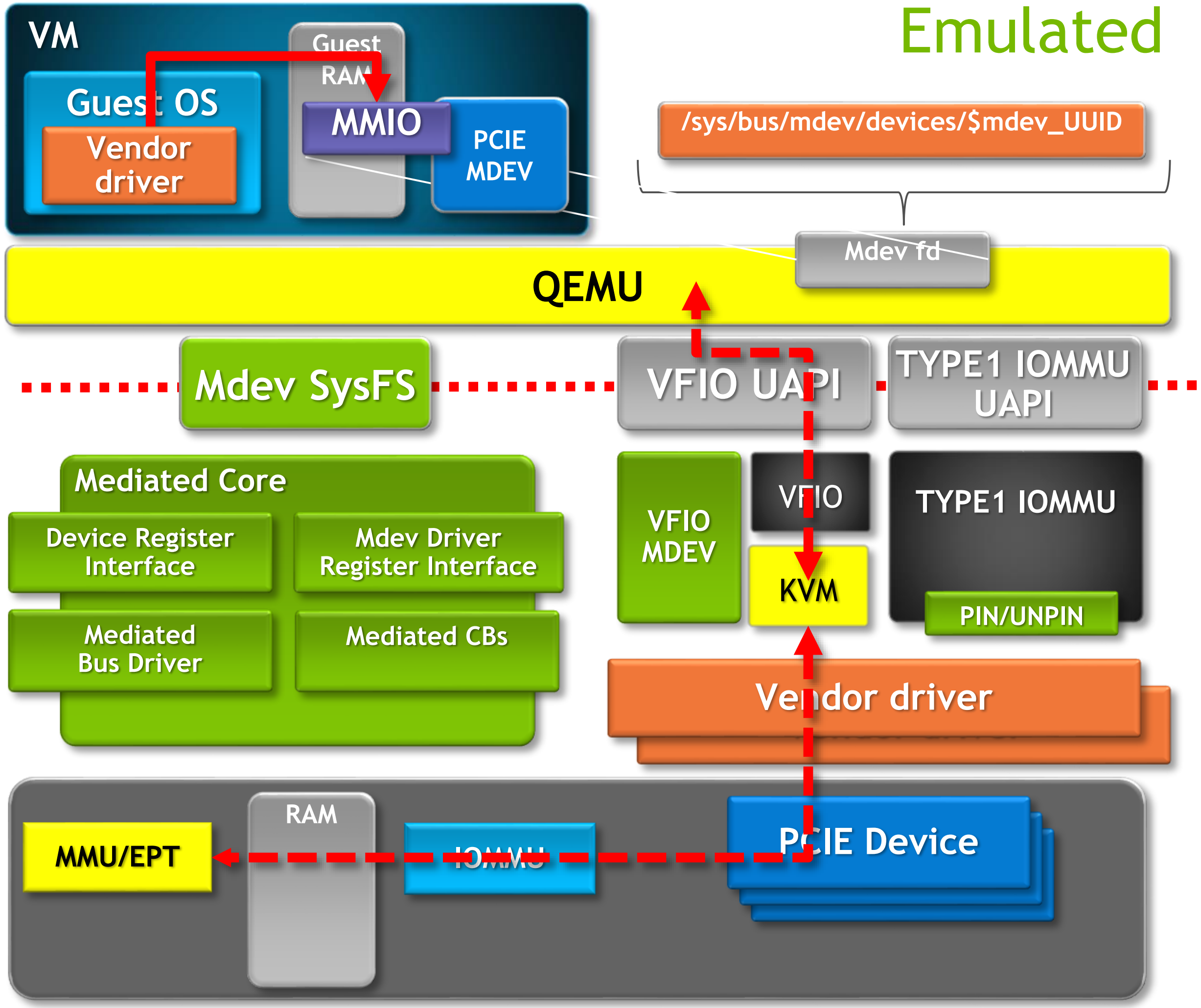

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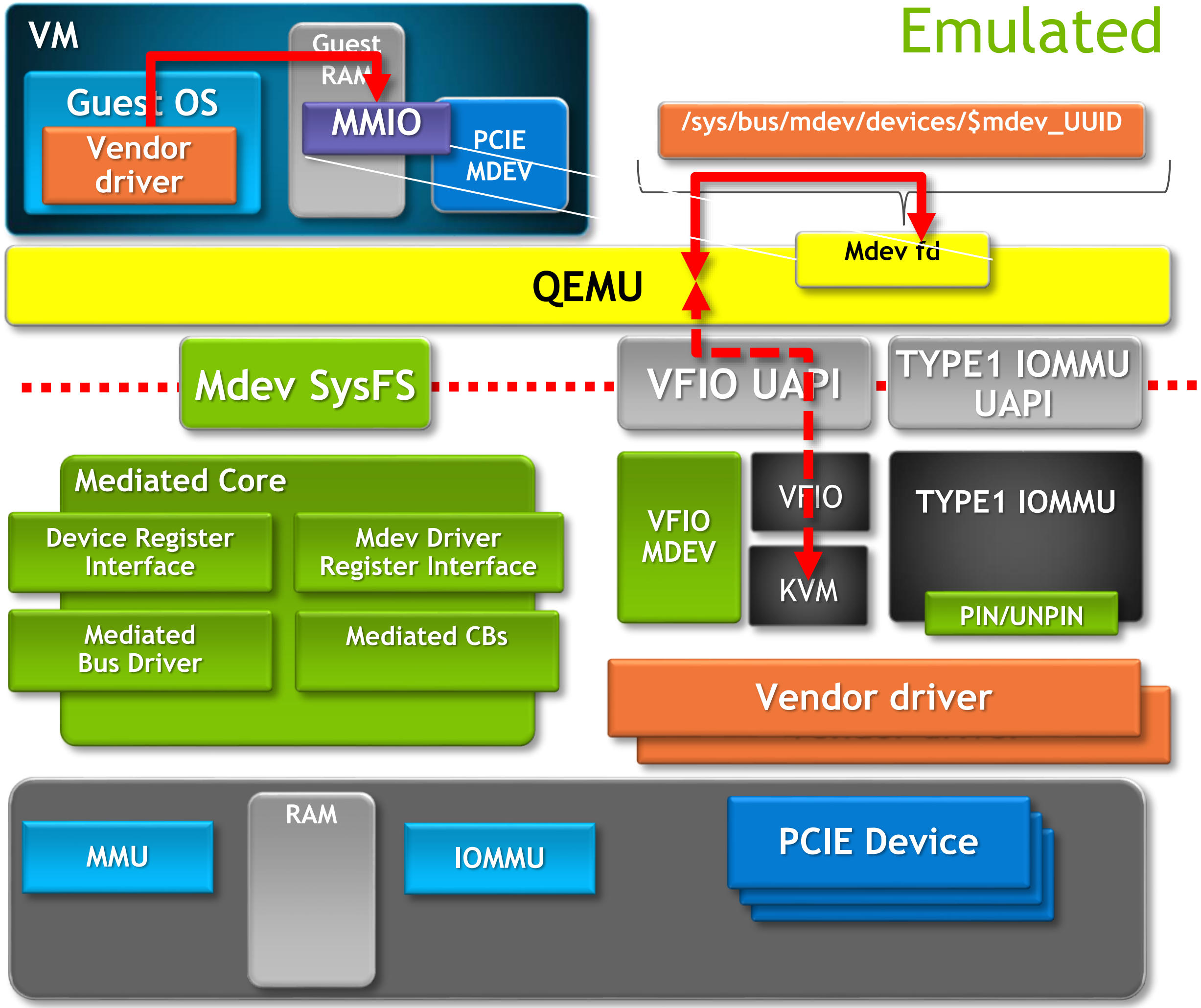

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QEMU convert request from KVM to R/W access to MDEV fd

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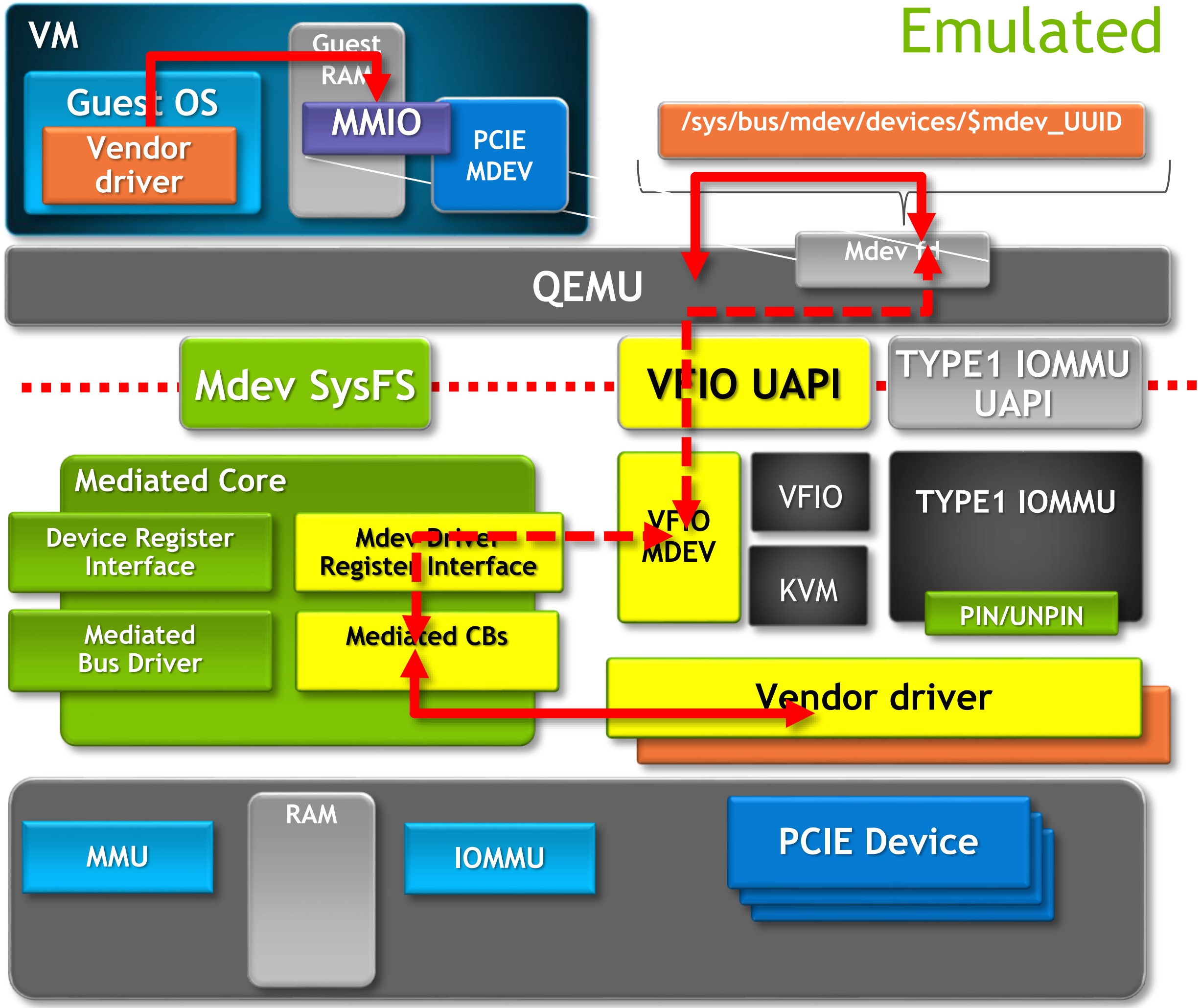

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QEMU convert request from KVM to R/W access to MDEV fd

RW handled by vendor driver via Mediated CBs and VFIO MDEV

MEDIATED DMA TRANSLATION

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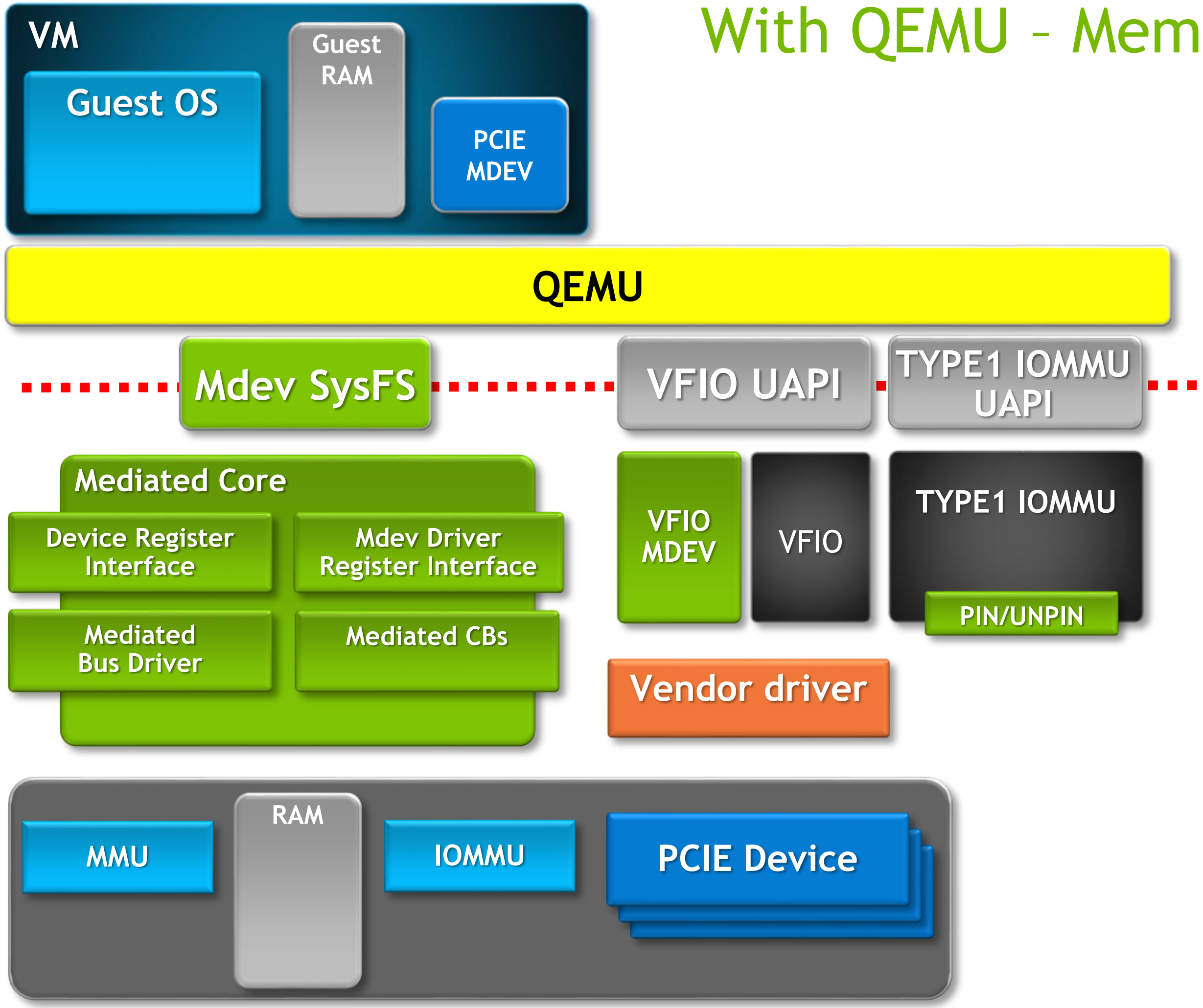
With QEMU – Memory Tracking

QEMU Starts



MEDIATED DMA TRANSLATION

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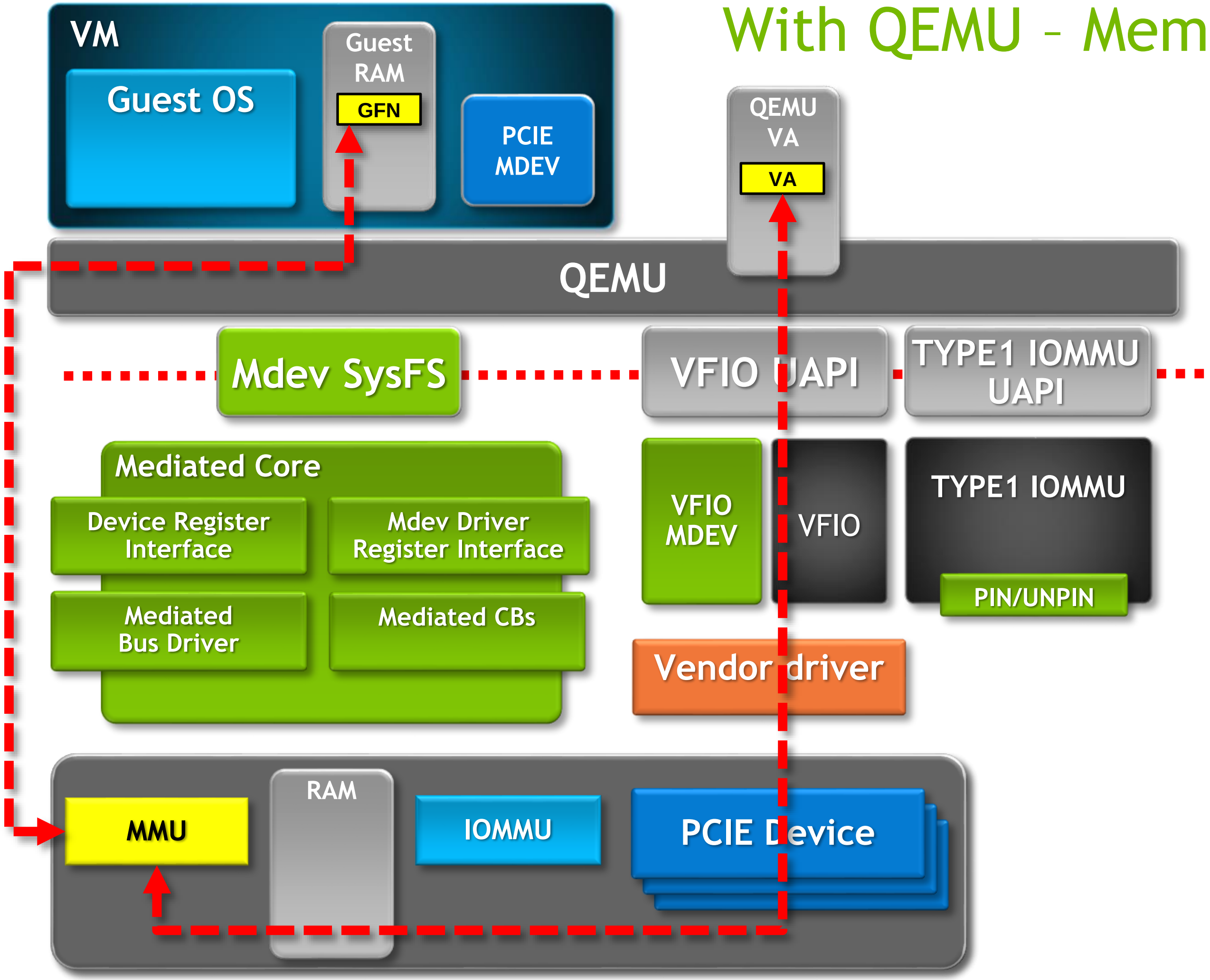

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Memory regions gets added by QEMU

MEDIATED DMA TRANSLATION

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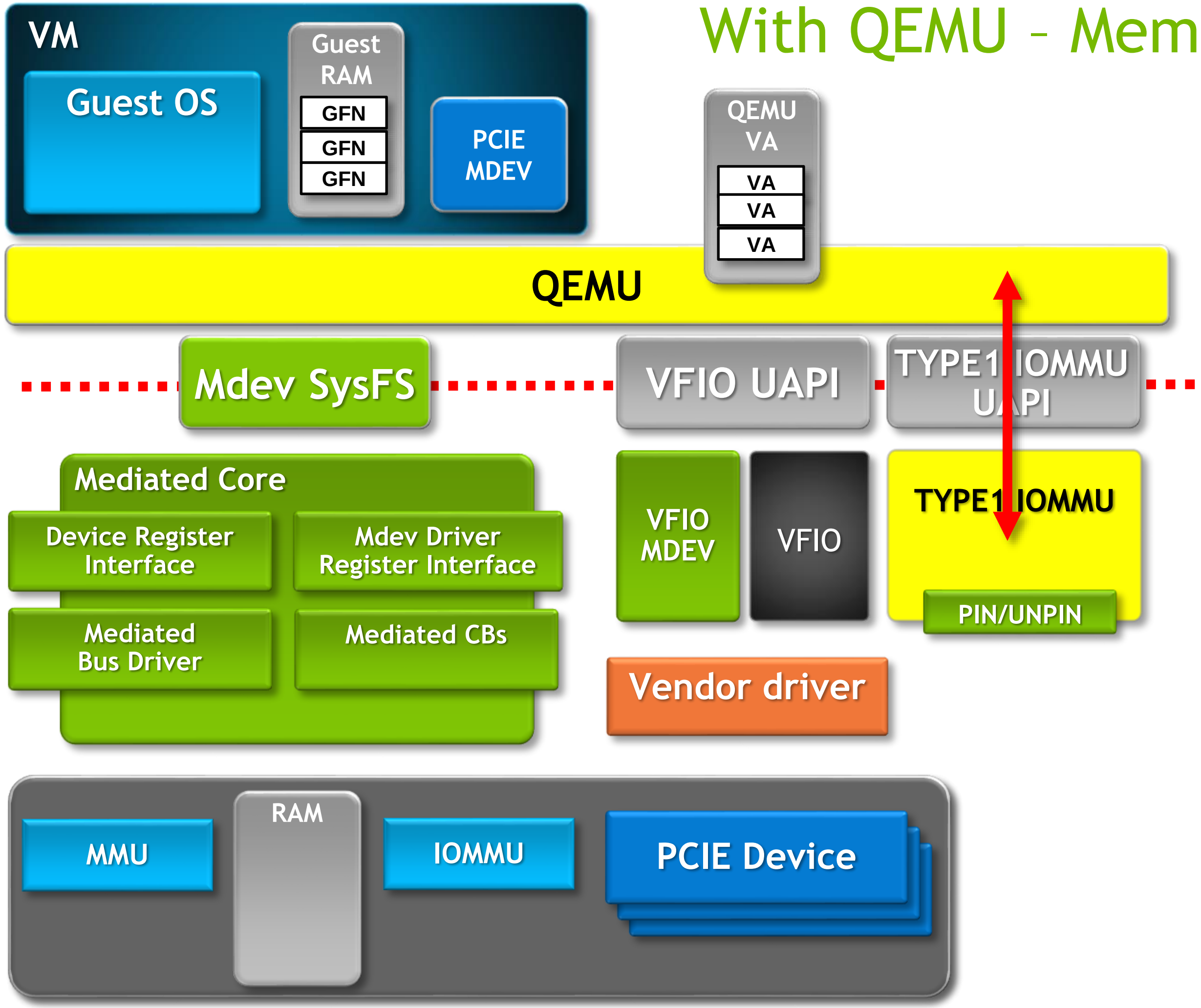

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QEMU calls VFIO_DMA_MAP via Memory listener

MEDIATED DMA TRANSLATION

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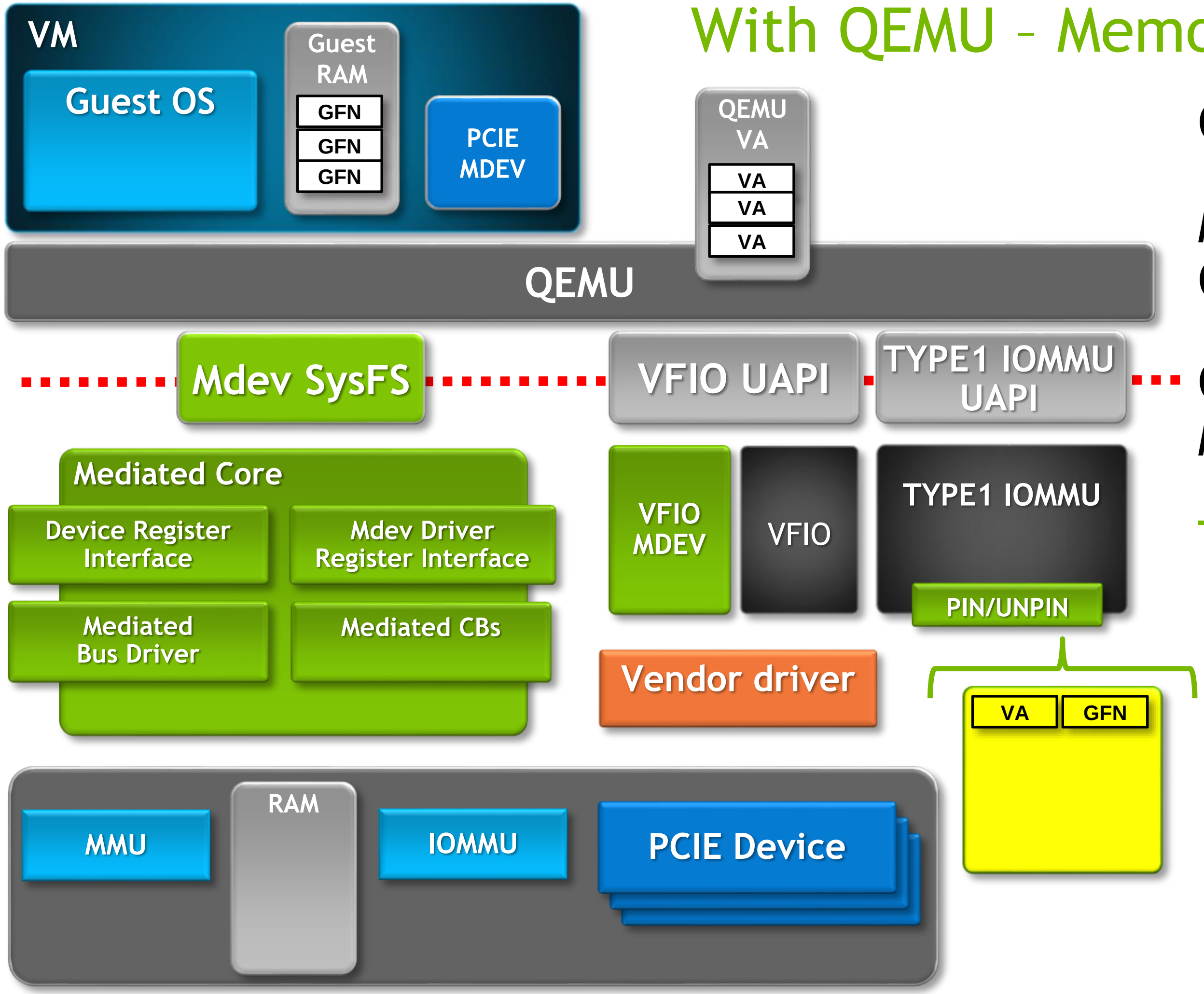

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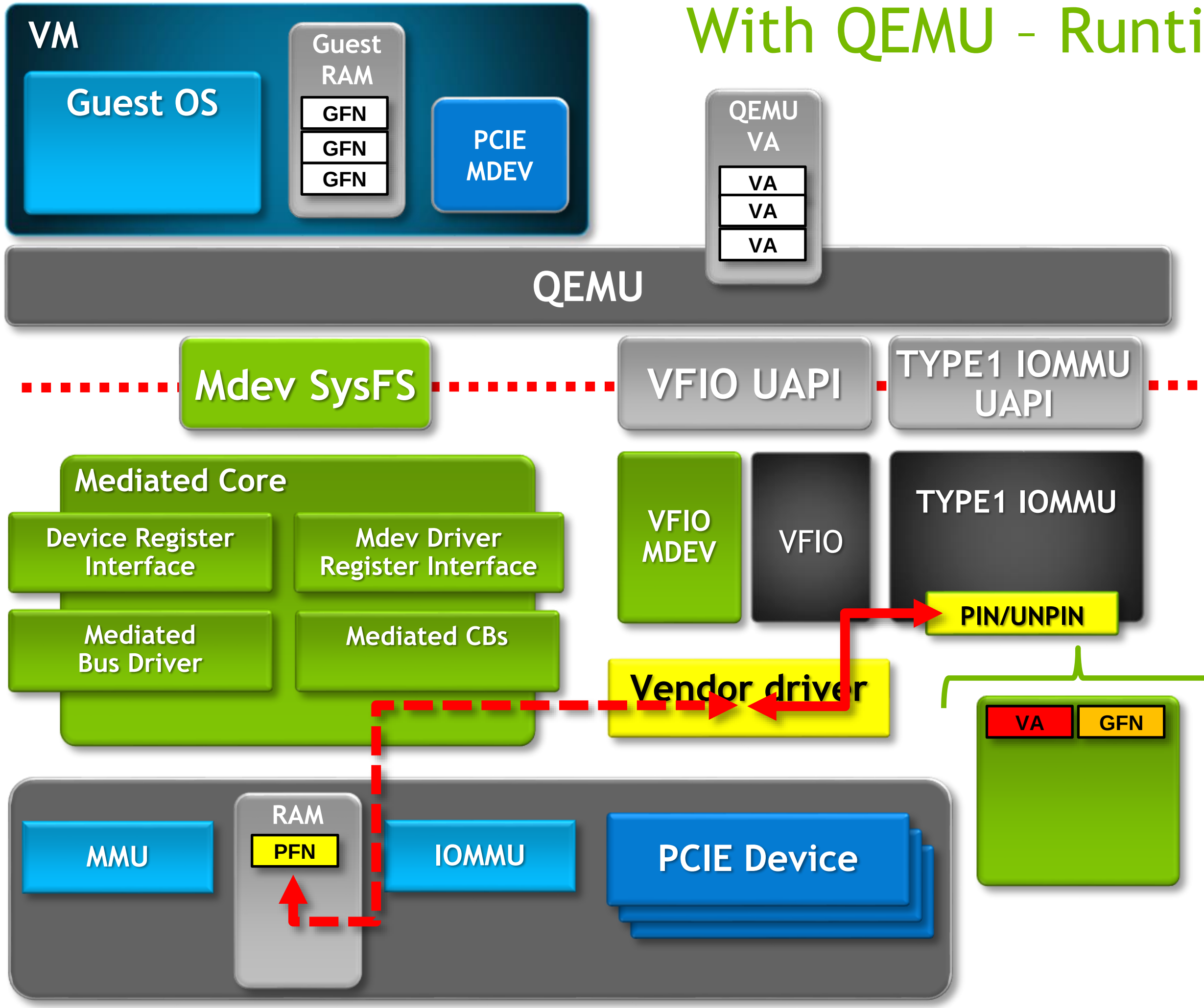
TYPE1 IOMMU tracks <VA, GFN>

MEDIATED DMA TRANSLATION

With QEMU – Runtime Memory pinning



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Vendor driver pin/translate GFN by TYPE1 IOMMU to get PFN

MEDIATED DMA TRANSLATION

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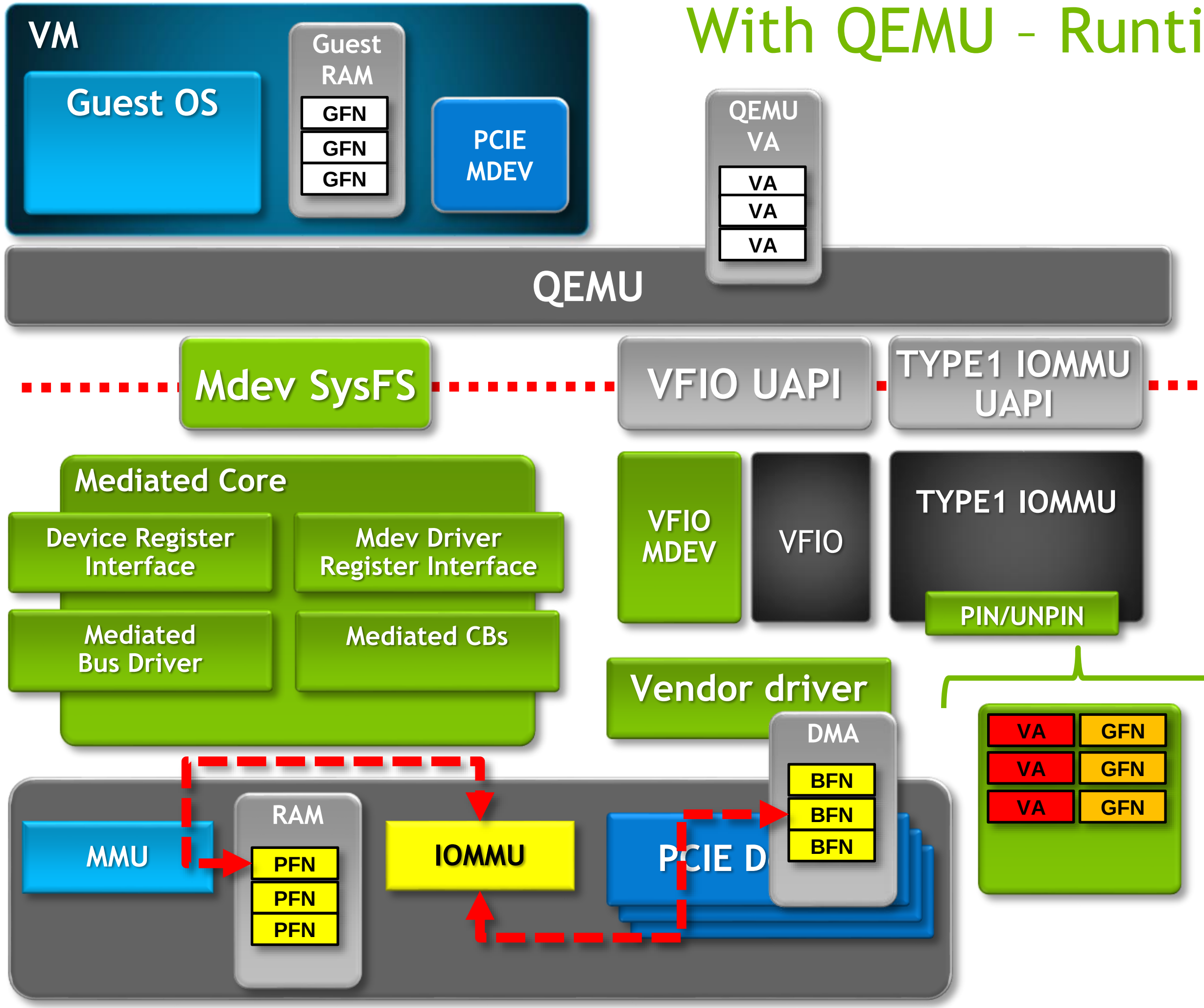


QEMU Starts

Memory regions gets added by QEMU

QEMU calls VFIO_DMA_MAP via Memory listener

TYPE1 IOMMU tracks <VA, GFN>

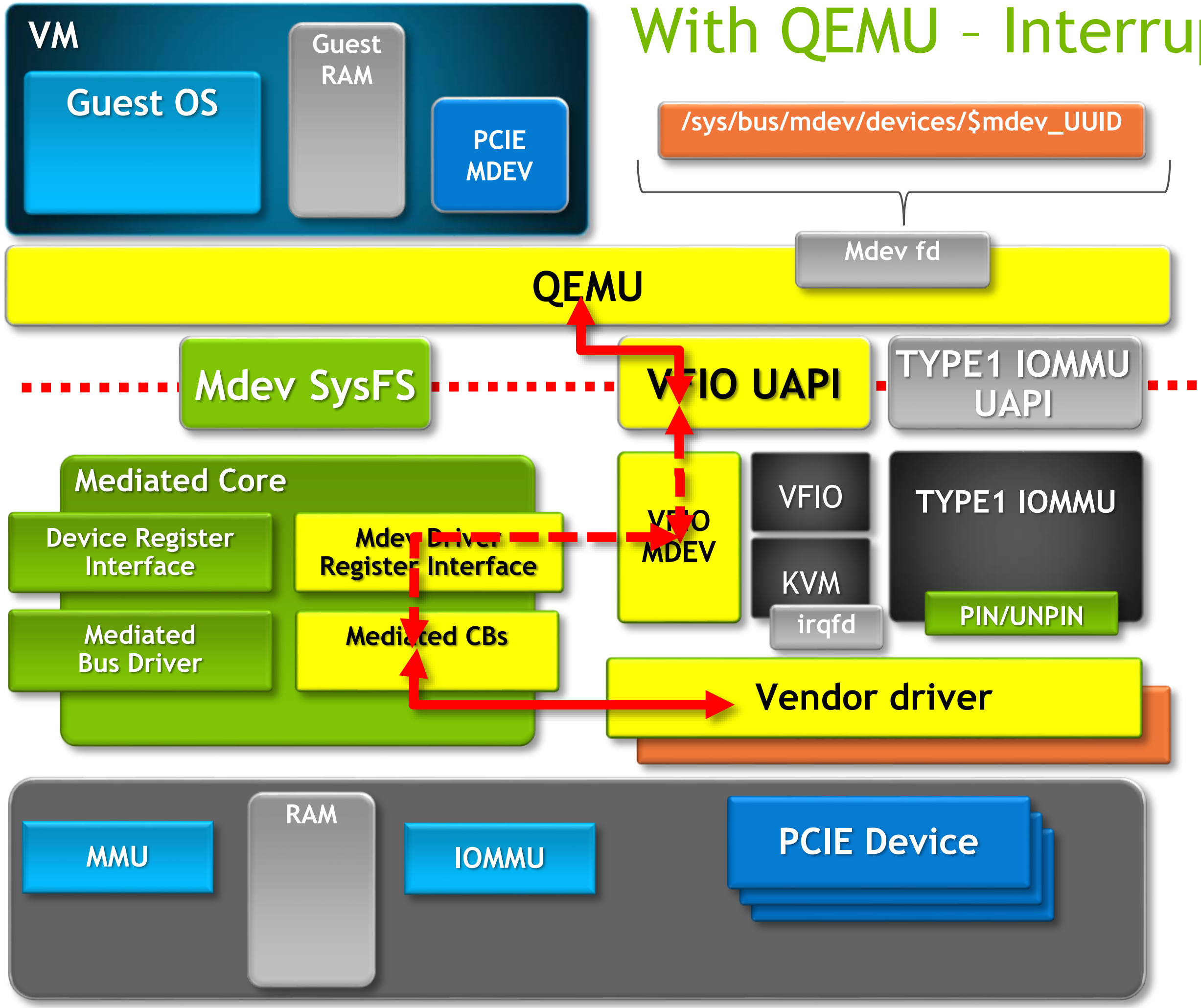
Vendor driver pin/translate GFN by TYPE1 IOMMU to get PFN

Vendor driver call pci_map_sg to map PFNs to BFN, program DMA

MEDIATED DEVICE - INTERRUPT

MEDIATED DEVICE FRAMEWORK

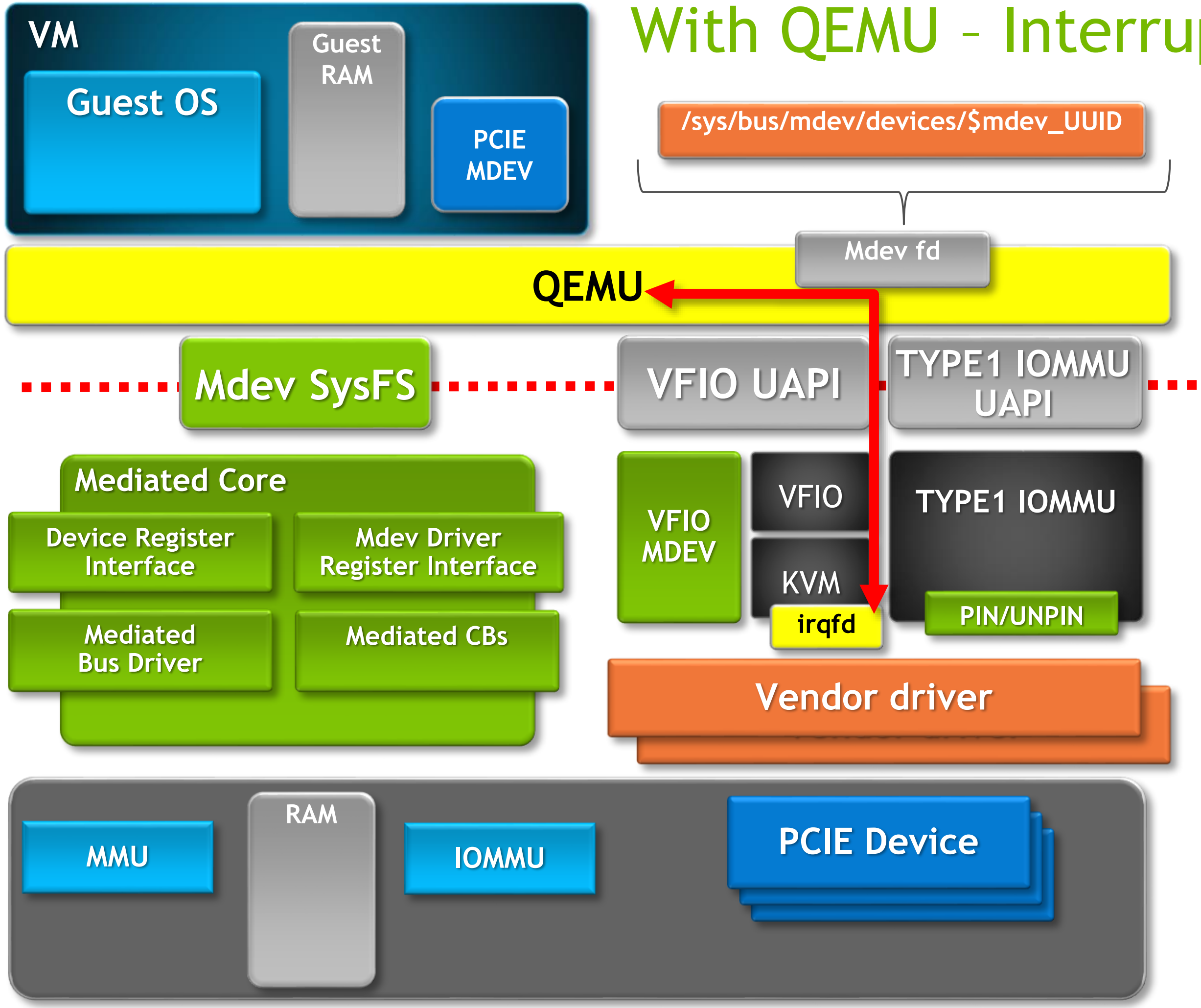
With QEMU – Interrupt Setup



QEMU query MDEV supported interrupt type, provided by vendor driver

MEDIATED DEVICE FRAMEWORK

With QEMU – Interrupt Setup



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QEMU setups up KVM IRQFD

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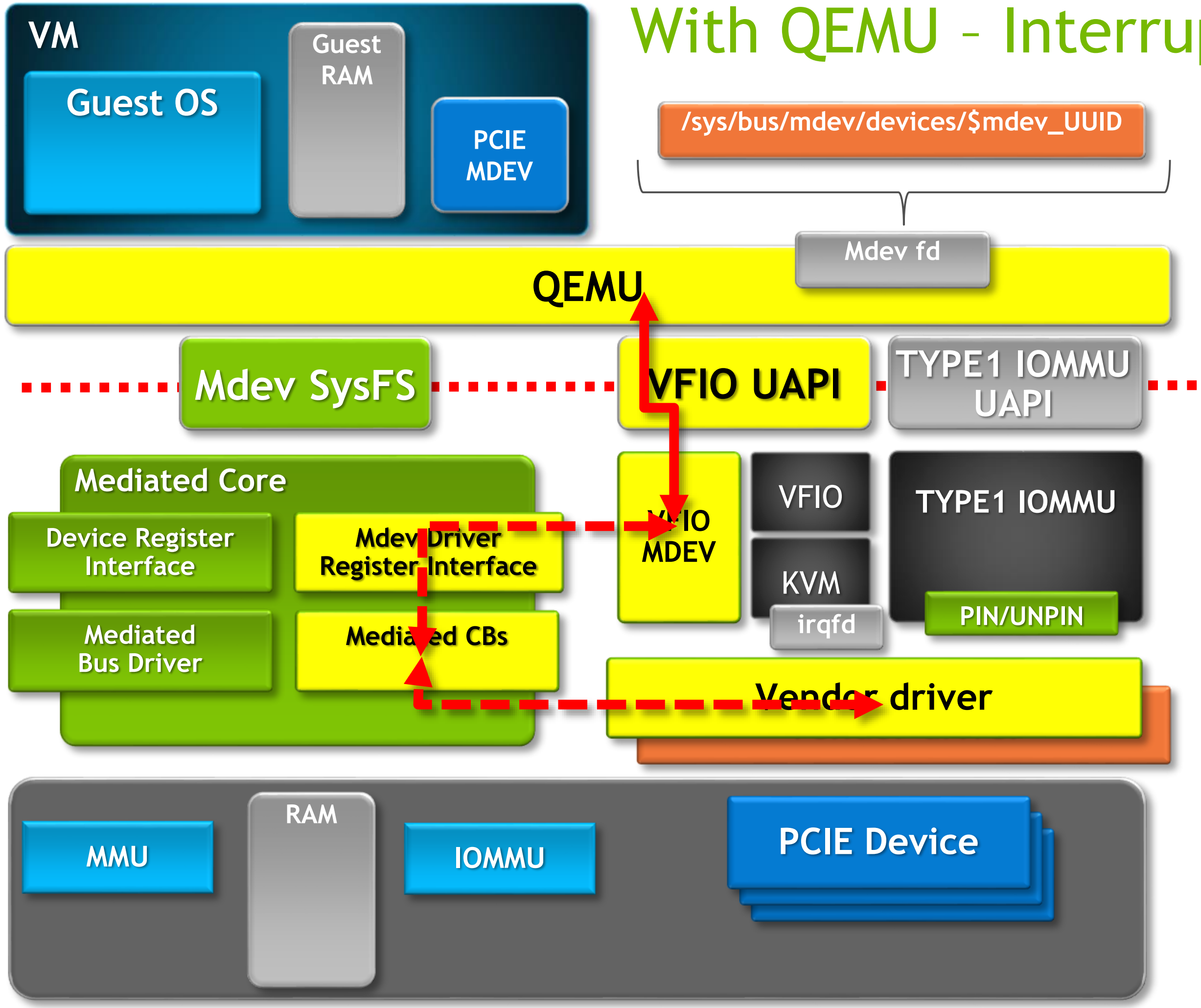

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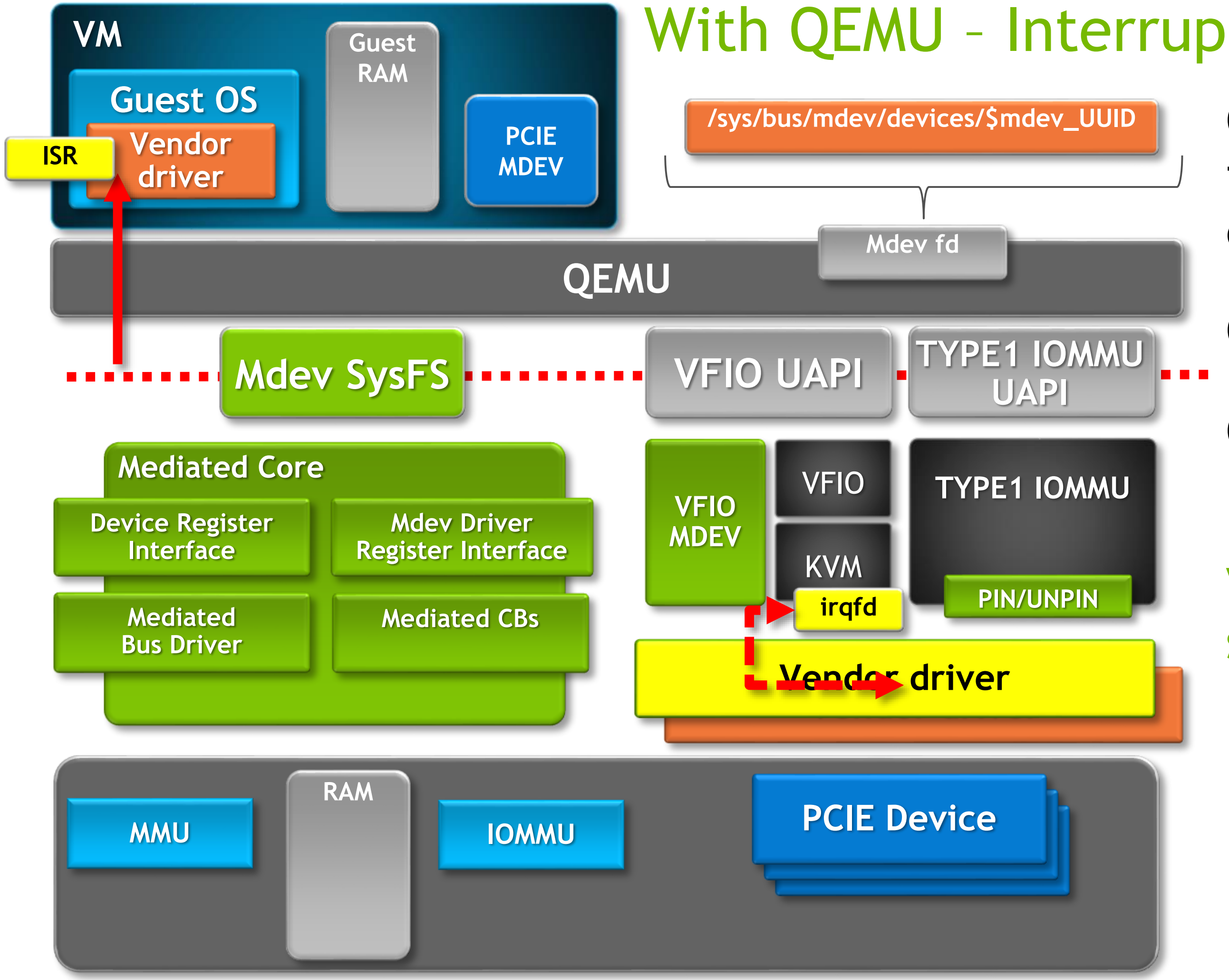
QEMU notifies the vendor driver IRQFD via VFIO PCI UAPI

MEDIATED DEVICE FRAMEWORK

With QEMU – Interrupt injection in runtime



QEMU query MDEV supported interrupt type, provided by vendor driver

QEMU setups up KVM IRQFD

QEMU notifies the vendor driver IRQFD via VFIO PCI UAPI

Vendor driver inject interrupt by signaling on eventfd, trigger guest ISR

MEDIATED DEVICE - CURRENT STATUS

CURRENT STATUS

Upstream

[PATCH v7] is sent out by Kirti Wankhede on 08/24/2016

- vfio: Mediated device Core driver
- vfio: VFIO driver for mediated devices
- vfio iommu: Add support for mediated devices
- docs: Add Documentation for Mediate devices

Tested with Linux kernel 4.7

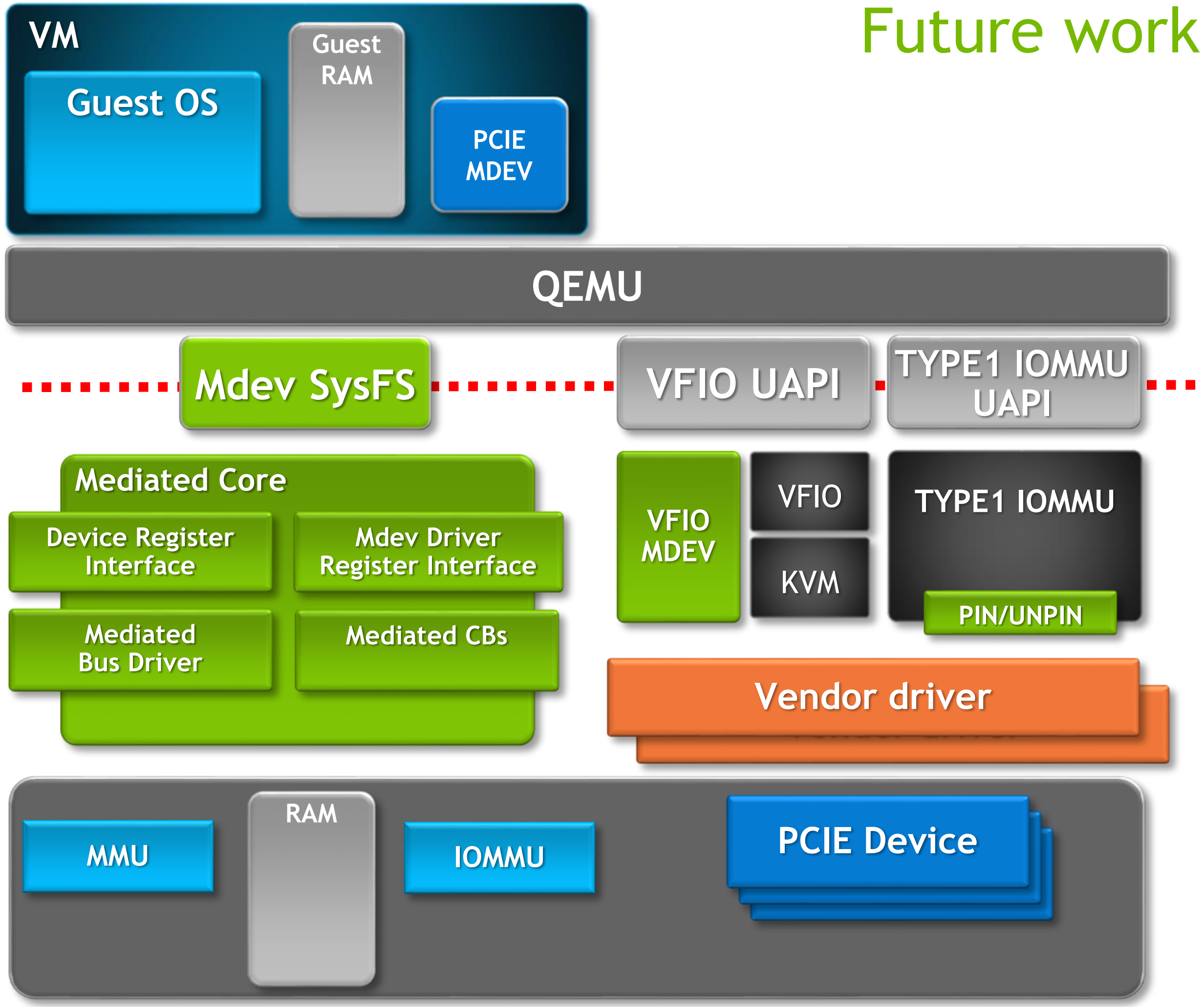
- Multiple mediated device per VM
- Multiple VFIO passthru device per VM
- Mixed mediated device and VFIO passthru device

DEMO: NVIDIA VGPU

MEDIATED DEVICE FRAMEWORK – FUTURE WORK

MEDIATED DEVICE FRAMEWORK

Future work



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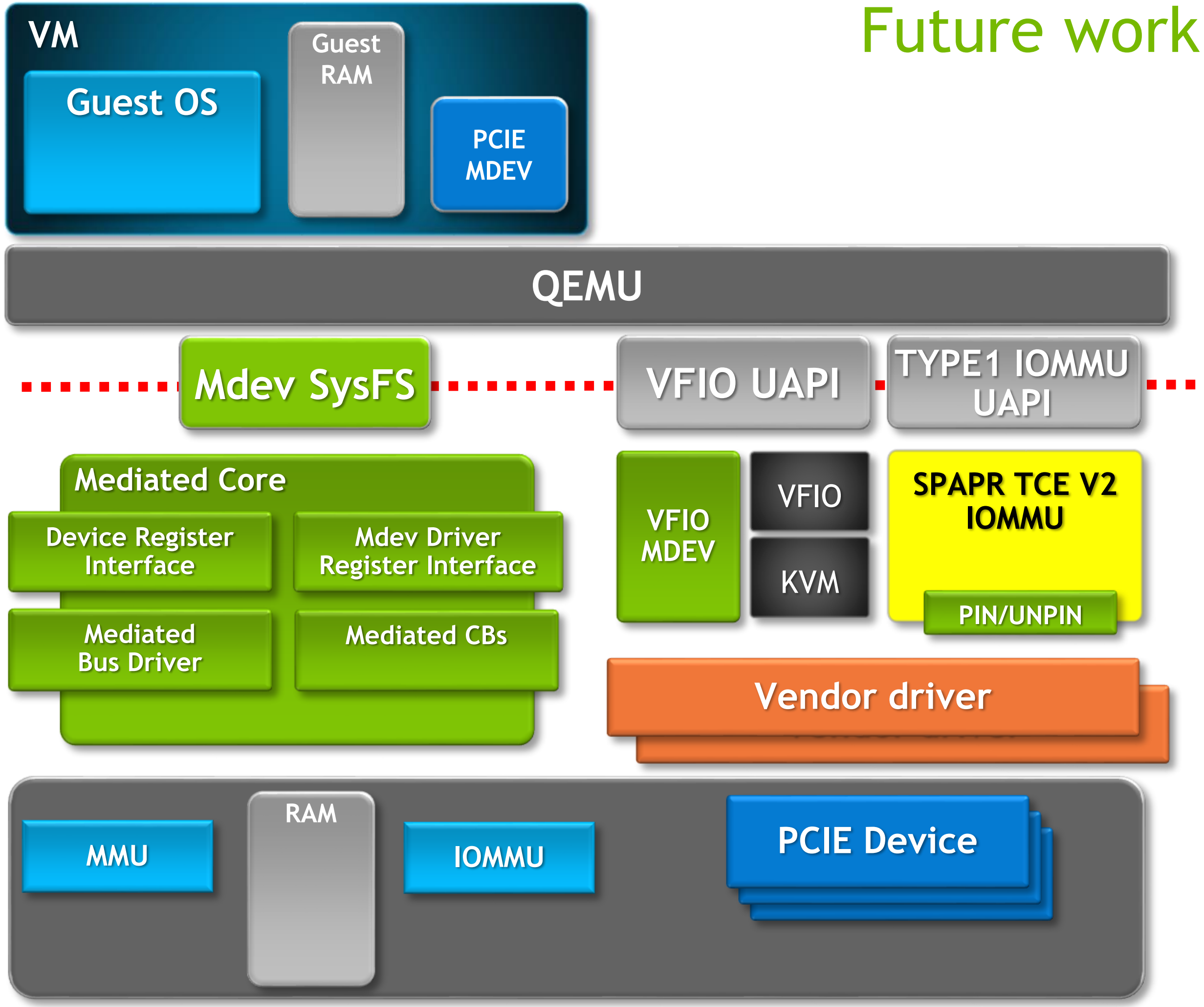

Future work

POWER support – by extend pin/unpin to SPAPR TCE v2 IOMMU

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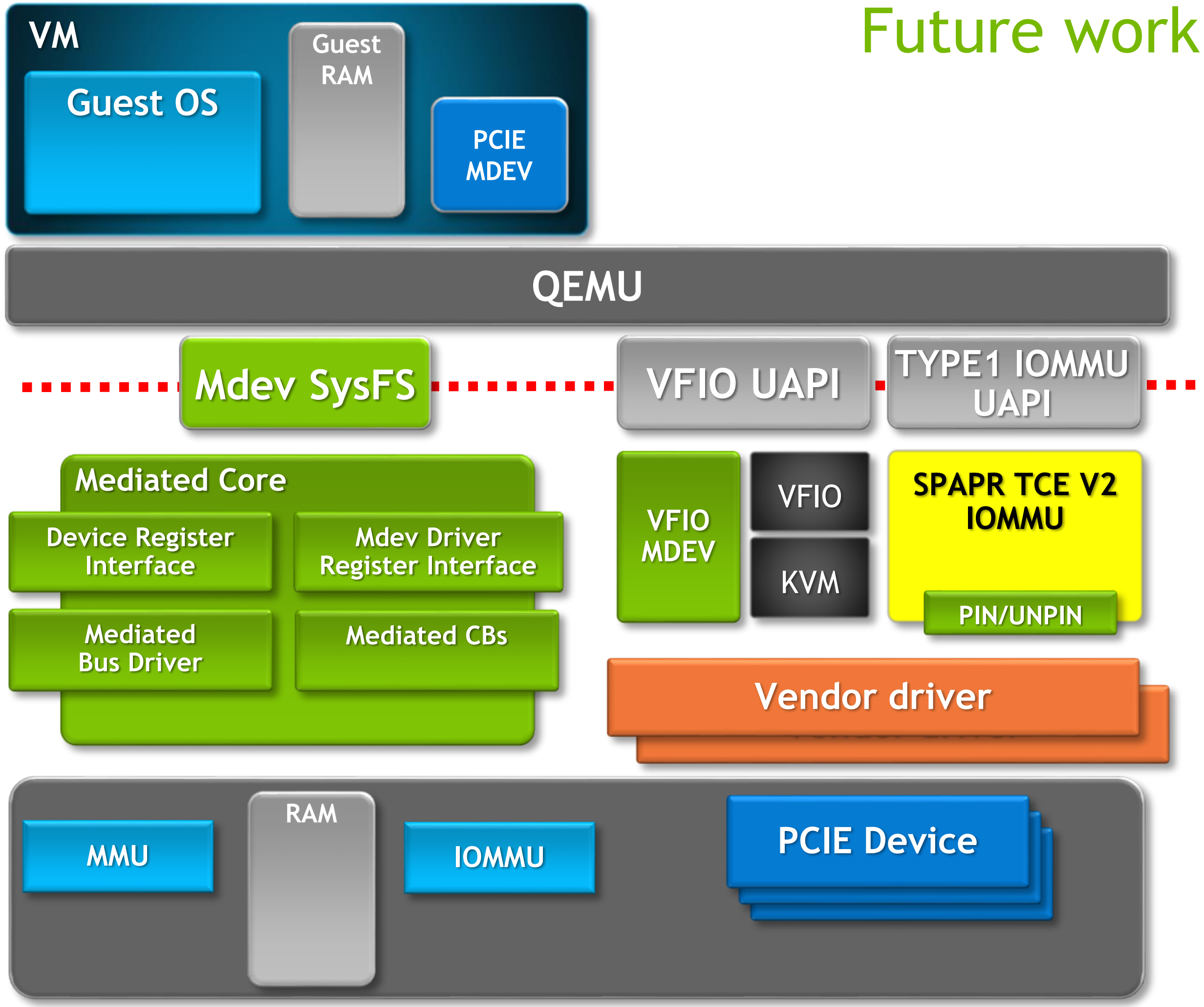

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Libvirt integration

REFERENCE

[1] An Introduction to PCI Device Assignment with VFIO - Alex Williamson, Red Hat

[Qemu-devel] [PATCH v7 0/4] Add Mediated device support
https://lists.nongnu.org/archive/html/qemu-devel/2016-08/msg03798.html

[libvirt] [RFC] libvirt vGPU QEMU integration

https://www.redhat.com/archives/libvir-list/2016-August/msg00939.html

QUESTIONS?