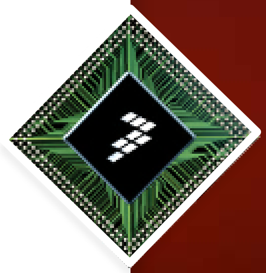
VFIO for Platform Devices

Bharat Bhushan, Stuart Yoder



October 2013

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Agenda

- VFIO
- Platform Devices
- vfio-platform
  - Platform bus wildcards
  - Binding issues
  - Dealing with complex devices
  - QEMU

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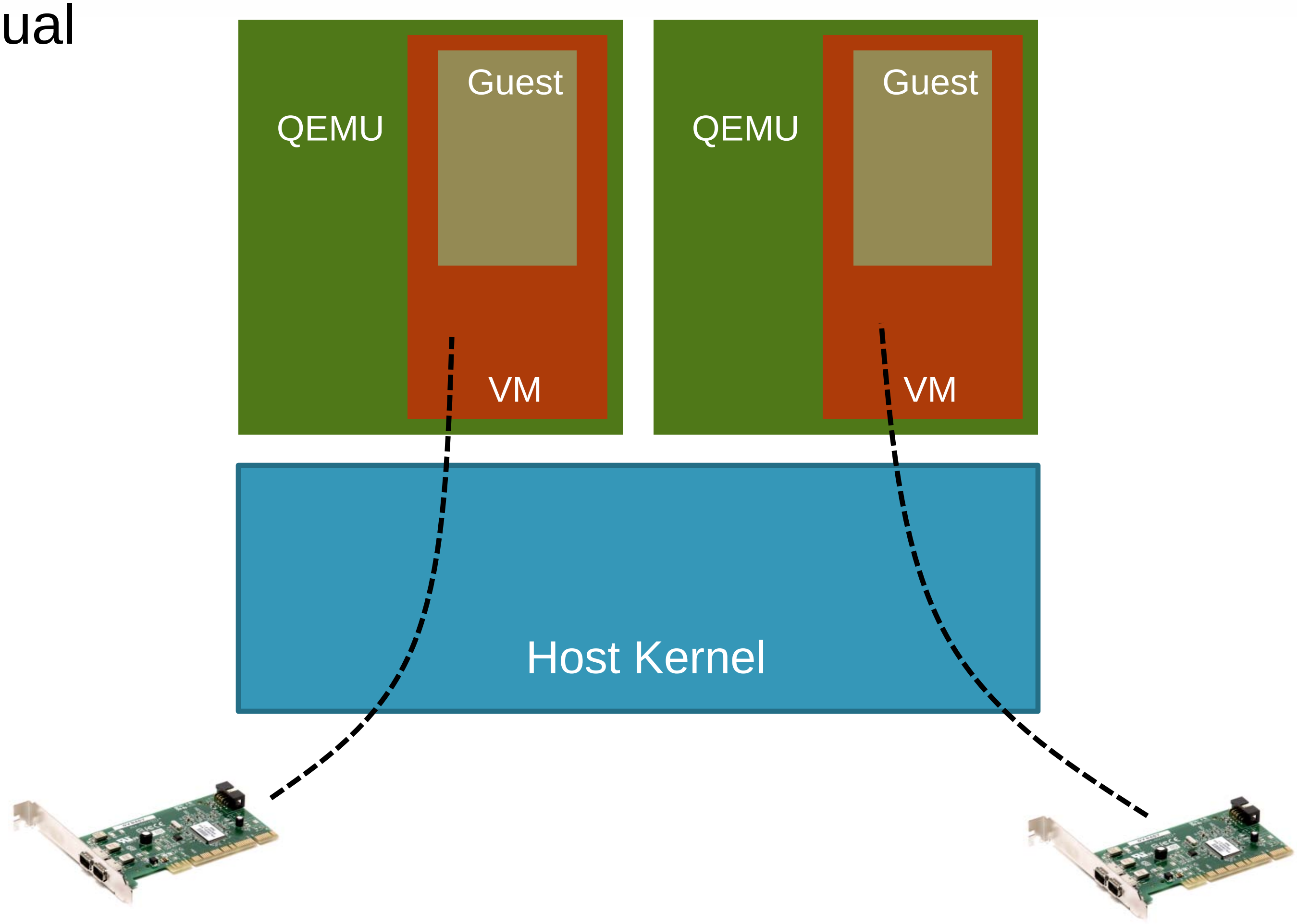
QEMU/KVM – Device Pass-through

Goal: assign physical I/O devices to virtual machines



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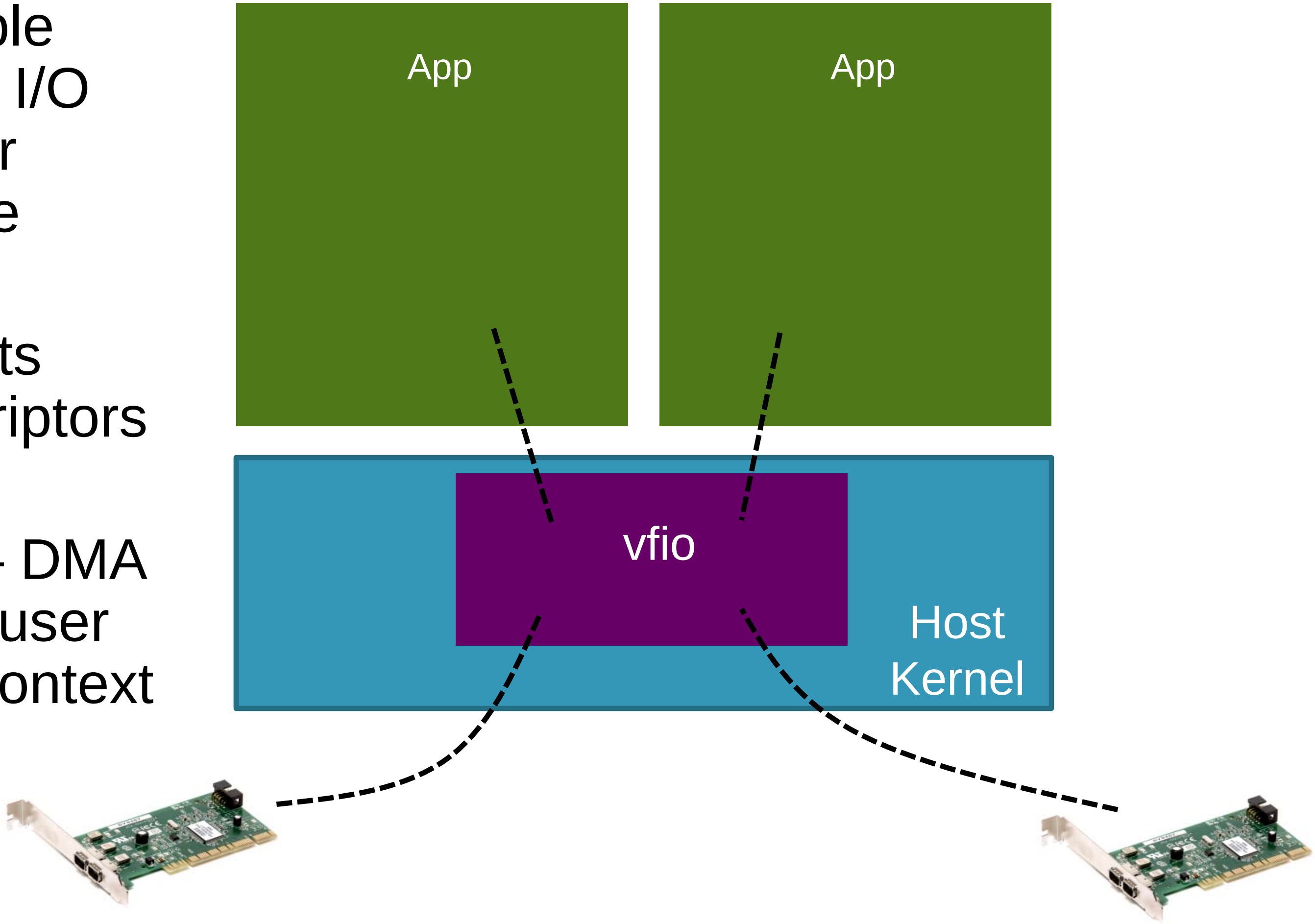
What is VFIO?

- Generic framework to expose I/O devices to user space

- Exposes mappable regions (e.g. PCI I/O and mem) to user space through file descriptors
- Exposes interrupts through file descriptors (eventfd)
- IOMMU support– DMA is isolated to the user space software context



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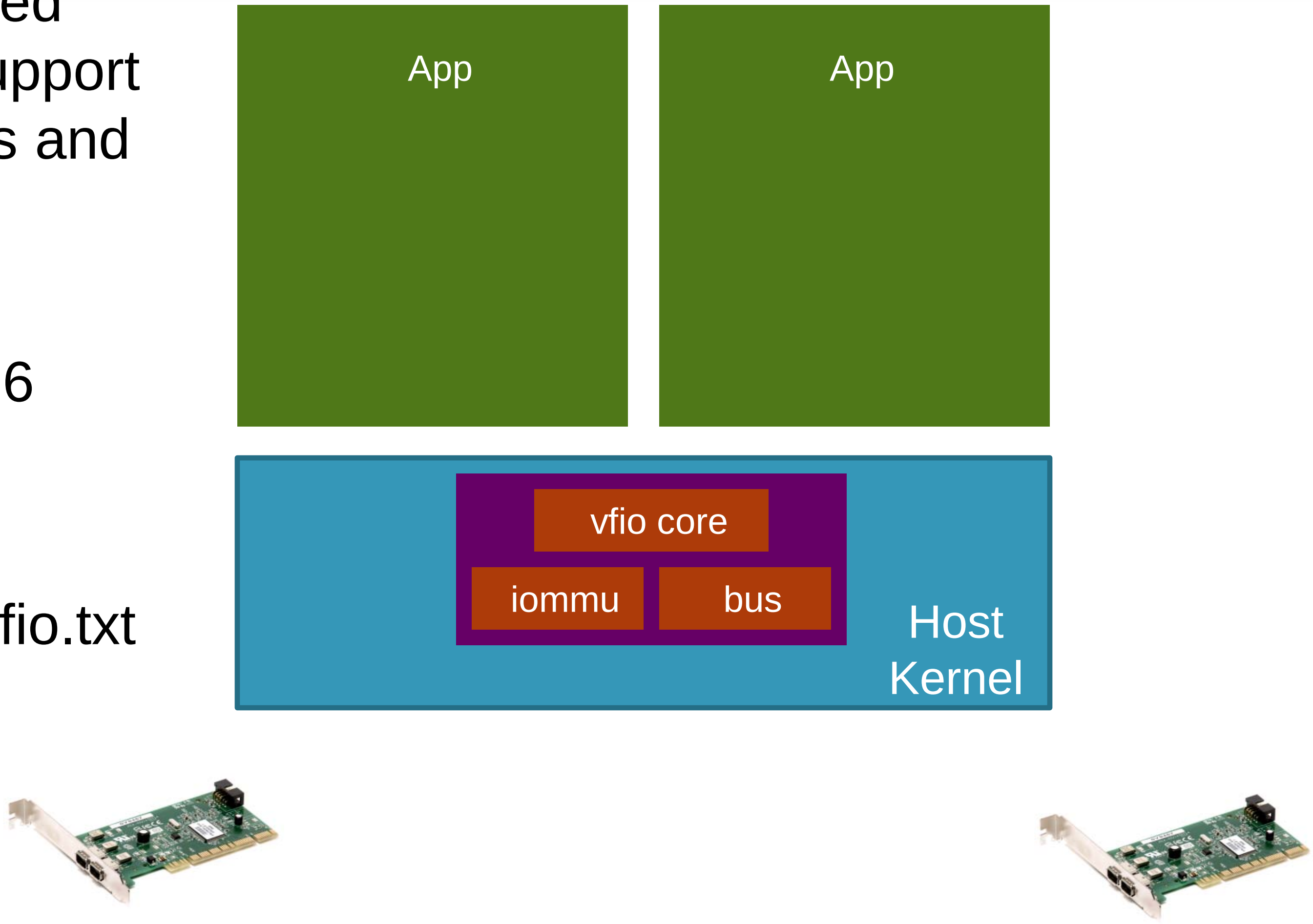
VFIO

- VFIO has a layered architecture to support different IOMMUs and busses
- In kernel since 3.6
- See Documentation/vfio.txt



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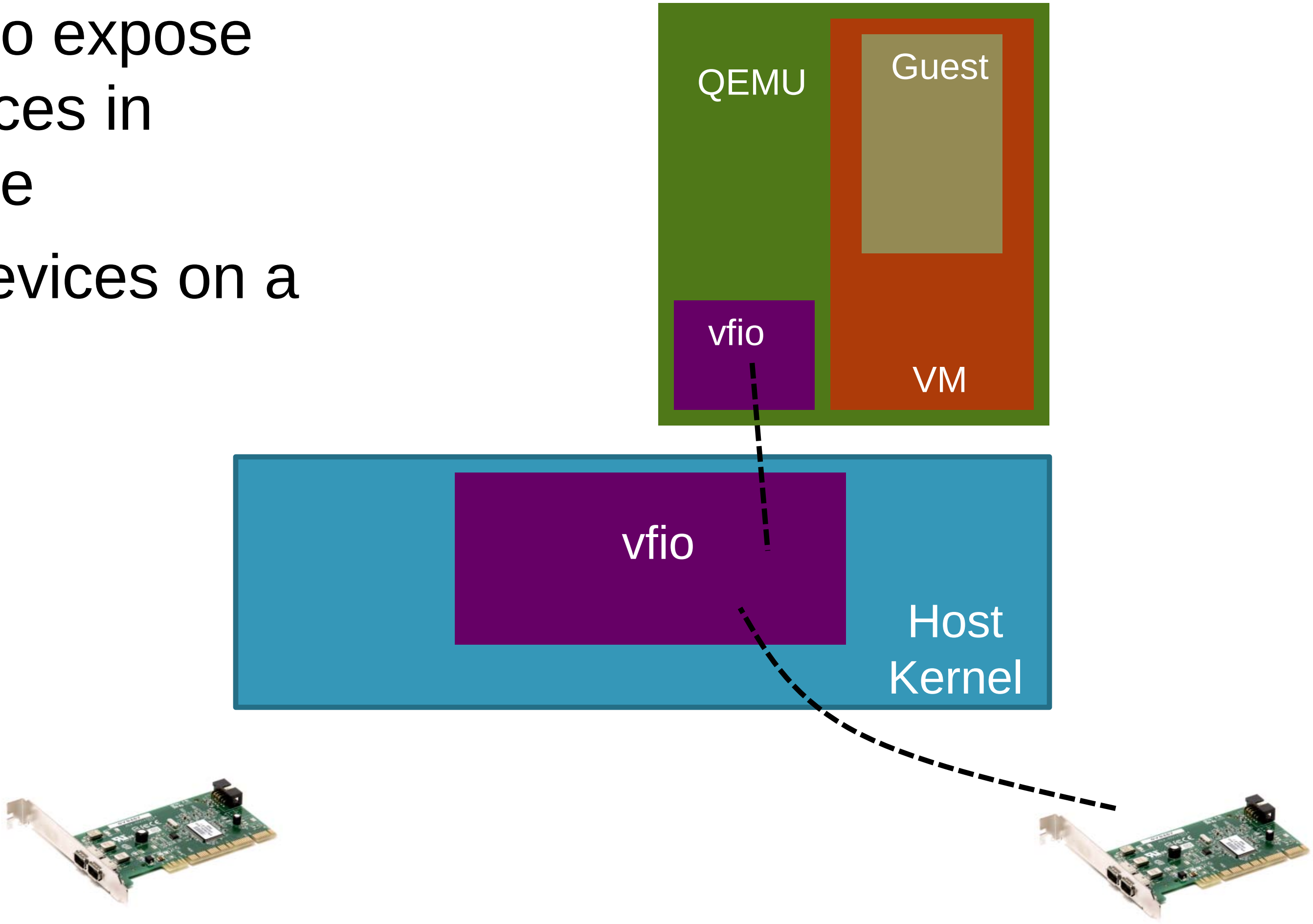
The Other Side of the Problem: User Space

- QEMU uses vfio mechanisms to expose device resources in virtual machine
- Guest sees devices on a virtual bus



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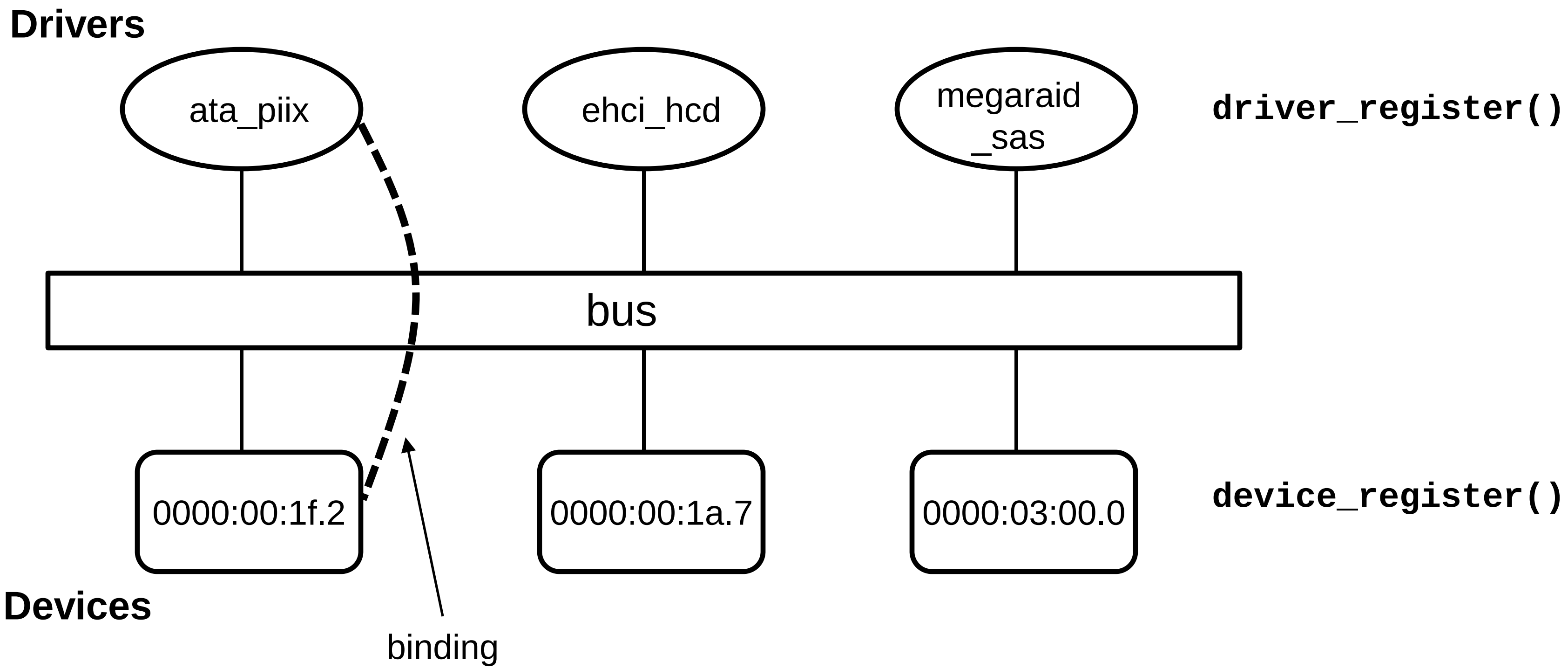
The Linux® Driver Model



Drivers

ata_piix

ehci_hcd

megaraid_sas

`driver_register()`

bus

0000:00:1f.2

0000:00:1a.7

0000:03:00.0

`device_register()`

Devices

binding

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vfio-pci binding/unbinding example

- Assume PCI device 0000:06:0d.0 is to be passed to user space

```
$ lspci -n -s 0000:06:0d.0
06:0d.0 0401: 1102:0002 (rev 08)
```

```
$ echo 0000:06:0d.0 >
  /sys/bus/pci/devices/0000:06:0d.0/driver/unbind
```

```
$ echo 1102 0002 > /sys/bus/pci/drivers/vfio-pci/new_id
```

vfio-pci functions as a “meta” driver– binding to any PCI device type

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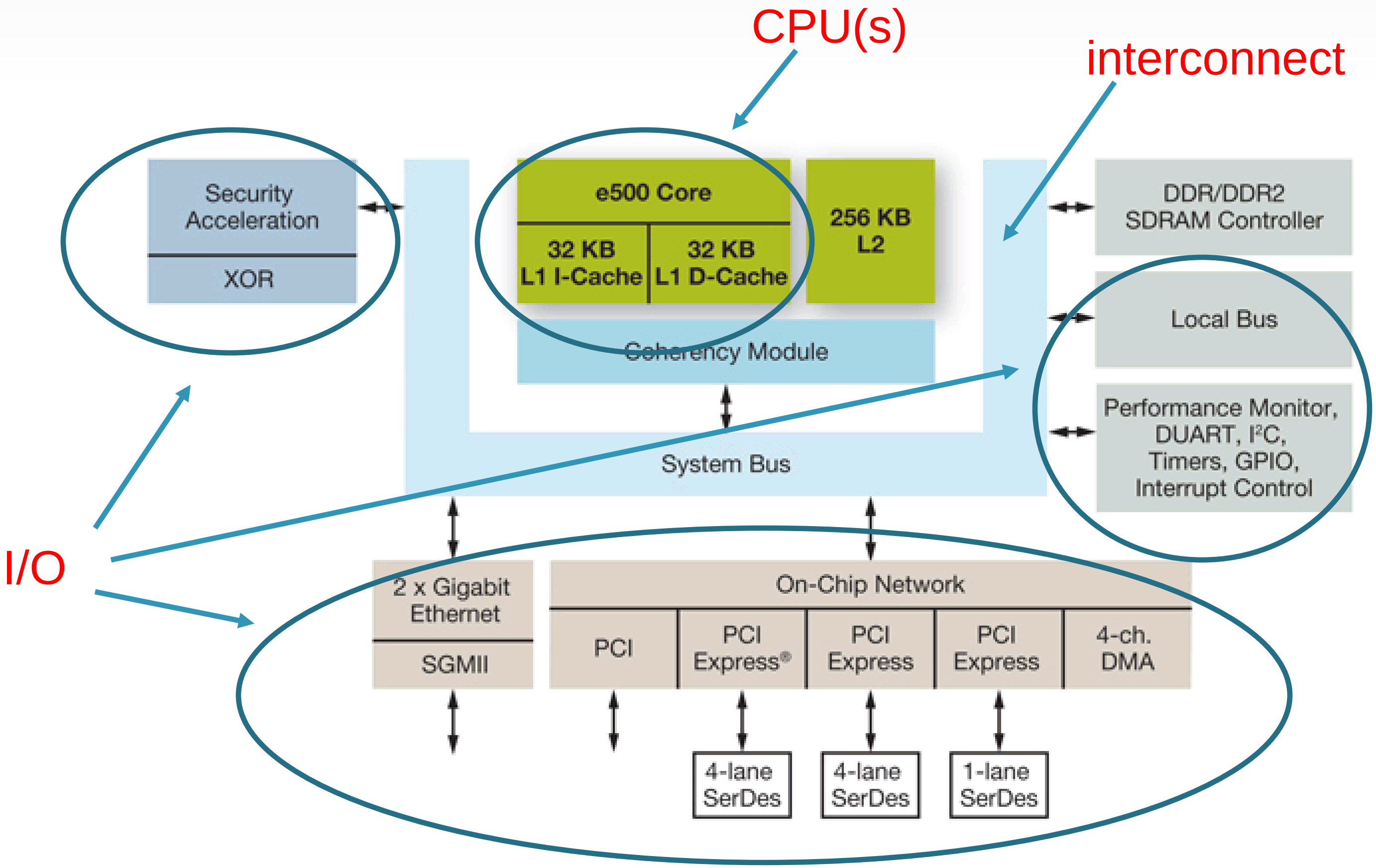
Anatomy of a system-on-a-chip (SoC)



CPU(s)

interconnect

I/O

Security Acceleration

XOR

e500 Core

32 KB L1 I-Cache

32 KB L1 D-Cache

256 KB L2

Coherency Module

System Bus

DDR/DDR2 SDRAM Controller

Local Bus

Performance Monitor, DUART, I^2C, Timers, GPIO, Interrupt Control

2 x Gigabit Ethernet

SGMII

On-Chip Network

PCI

PCI Express®

PCI Express

PCI Express

4-ch. DMA

4-lane SerDes

4-lane SerDes

1-lane SerDes

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Platform Bus, Platform Devices

- Most SoC I/O can’t be ‘discovered’ by an OS
- Linux is told via a device tree what devices exist
- Platform drivers register with the platform bus
- Platform devices register with the platform bus…based on parsing dev tree

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vfio-platform

- Existing vfio mechanisms can be used for platform devices:
  - Exposing mappable regions
  - Exposing interrupts
  - DMA mapping

- A small handful of issues need to be solved

- Current vision of vfio-platform does **not** solve pass-through for all platform devices. Complicated devices with convoluted cross-device entanglements will be an issue.

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Example: UART

1 region

1 interrupt

```
serial0: serial@4500 {
        compatible = "fsl,ns16550", "ns16550";
        reg = <0x4500 0x100>;
        clock-frequency = <200000000>;
        interrupts = <42 2 0 0>;
};
```

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Bind to vfio-platform

```
$ echo 12ce0000.i2c > /sys/bus/platform/drivers/s3c-i2c/unbind
$ echo 12ce0000.i2c > /sys/bus/platform/drivers/vfio-platform/bind
```

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```

Two problems:

- Platform bus doesn’t have a ‘wildcard' mechanism that allows vfio-platform to bind to any platform device…i.e. we need vfio-platform to act as a ‘meta’ driver.

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Bind to vfio-platform

```
$ echo 12ce0000.i2c > /sys/bus/platform/drivers/s3c-i2c/unbind
$ echo 12ce0000.i2c > /sys/bus/platform/drivers/vfio-platform/bind
```

Two problems:

- Platform bus doesn’t have a ‘wildcard' mechanism that allows vfio-platform to bind to any platform device…i.e. we need vfio-platform to act as a ‘meta’ driver.

- We want vfio driver binding to devices **only** by explicit request, but the Linux driver core doesn’t support this.
  - Without this mechanism both PCI and platform vfio face the racy situation where two drivers support a device type and it is ambiguous as to which of the two drivers will bind to the device

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Platform Bus Wildcard

```
@@ -727,6 +727,10 @@ static int platform_match(struct device *dev, struct device_driver *drv)
   struct platform_device *pdev = to_platform_device(dev);
   struct platform_driver *pdrv = to_platform_driver(drv);

+  /* the driver matches any device */
+  if (pdrv->match_any_dev)
+          return 1;
+
   /* Attempt an OF style match first */
   if (of_driver_match_device(dev, drv))
           return 1;
diff --git a/include/linux/platform_device.h b/include/linux/platform_device.h
index ce8e4ff..2d25d50 100644
--- a/include/linux/platform_device.h
+++ b/include/linux/platform_device.h
@@ -178,6 +178,7 @@ struct platform_driver {
   int (*resume)(struct platform_device *);
   struct device_driver driver;
   const struct platform_device_id *id_table;
+  bool match_any_dev;
 };
```

http://www.spinics.net/lists/kvm/msg97195.html

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sysfs_bind_only

```
New
struct device_driver {
  const char          *mod_name; /* used for built-in modules */

  bool suppress_bind_attrs;  /* disables bind/unbind via sysfs */
+ bool sysfs_bind_only;  /* only allow bind/unbind via sysfs */

  const struct of_device_id   *of_match_table;
  const struct acpi_device_id *acpi_match_table;
```

http://www.spinics.net/lists/kvm/msg97198.html

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Race condition for unbound devices

```
$ echo 12ce0000.i2c > /sys/bus/platform/drivers/s3c-i2c/unbind
```

- problem: a hotplug event could cause rebind device to standard driver before vfio binds to the device
  - (mostly a problem for PCI)

- proposal: define new device flag that means ‘explicit bind only’

```
$ echo 1 > /sys/devices/12ce0000.i2c/sysfs_bind_only
$ echo 12ce0000.i2c > /sys/bus/platform/drivers/s3c-i2c/unbind
```

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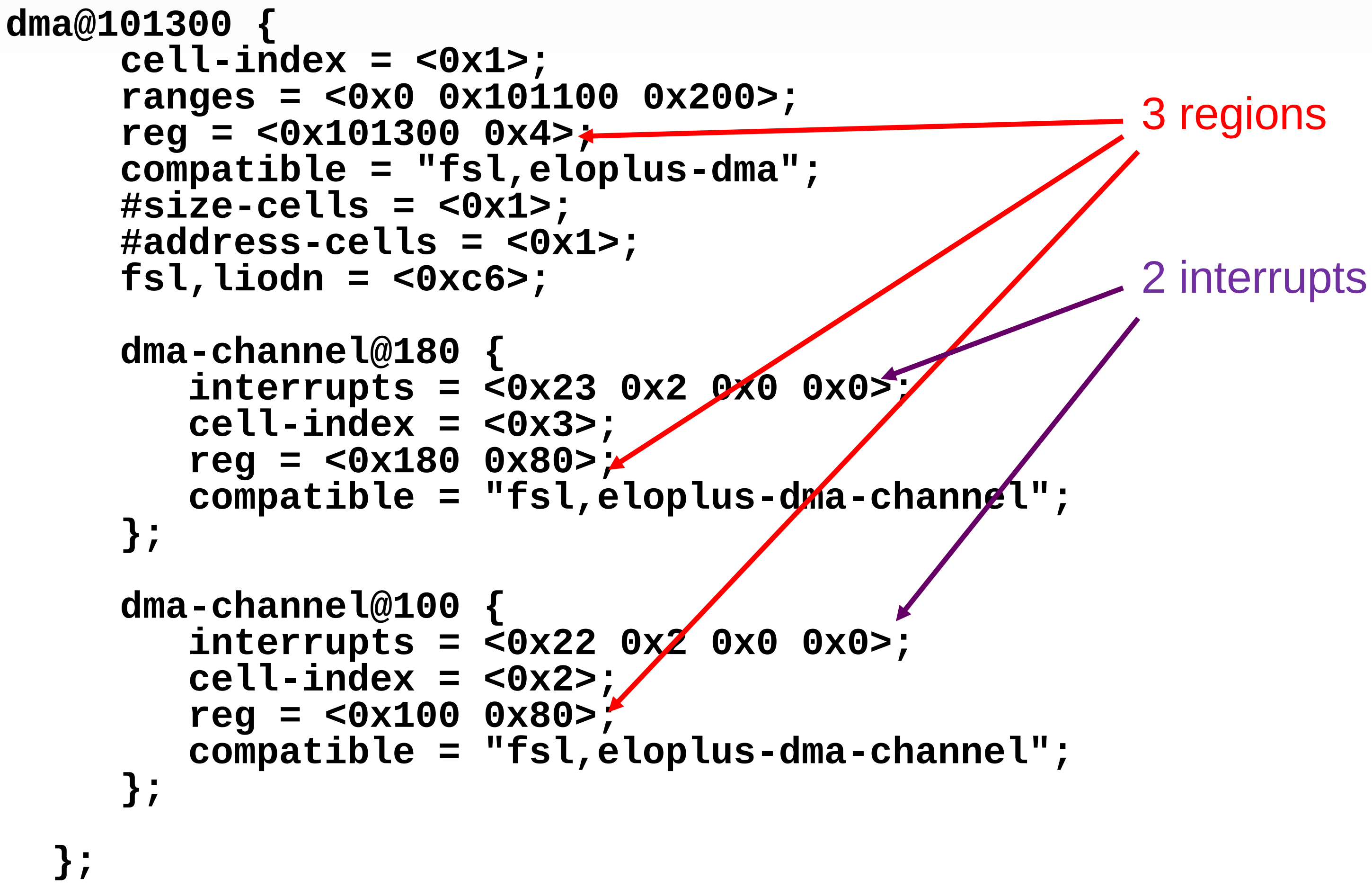
Example: DMA engine



```
dma@101300 {
     cell-index = <0x1>;
     ranges = <0x0 0x101100 0x200>;
     reg = <0x101300 0x4>;
     compatible = "fsl,eloplus-dma";
     #size-cells = <0x1>;
     #address-cells = <0x1>;
     fsl,liodn = <0xc6>;

     dma-channel@180 {
        interrupts = <0x23 0x2 0x0 0x0>;
        cell-index = <0x3>;
        reg = <0x180 0x80>;
        compatible = "fsl,eloplus-dma-channel";
     };

     dma-channel@100 {
        interrupts = <0x22 0x2 0x0 0x0>;
        cell-index = <0x2>;
        reg = <0x100 0x80>;
        compatible = "fsl,eloplus-dma-channel";
     };

  };
```

3 regions

2 interrupts

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Dealing with Complex Devices

- For multi-node devices need a way to correlate vfio resources to device tree nodes

- RFC proposal is to extend VFIO_DEVICE_GET_REGION_INFO and VFIO_DEVICE_GET_IRQ_INFO with additional flags and some appended structs so user can do any needed correlation

- Example: VFIO_DEVTREE_REGION_INFO_FLAG_PATH

```
struct vfio_devtree_info_path {
       u32 len;
       u8 path[];
}
```

http://www.spinics.net/lists/kvm/msg93593.html

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Additional Issue: reset

- When a user space process exits, vfio expects to be able to reset a device.
- There is no standard way to do this for platform devices.

- Possible solution: device-specific reset logic in vfio somewhere

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QEMU

- The other side of platform device pass-through is how QEMU exposes the platform device to user space
- No mechanism right now to dynamically add system devices and dynamically allocate IRQs.   Work in progress.
- QEMU will have device specific drivers that have awareness of how to generate guest device tree nodes:

```
qemu-system-ppc
  ...
  -device vfio-fsl-dma,device=/sys/bus/platform/devices/ffe100300.dma
  ...
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