Unified I/O Page Table Management for Passthrough Devices

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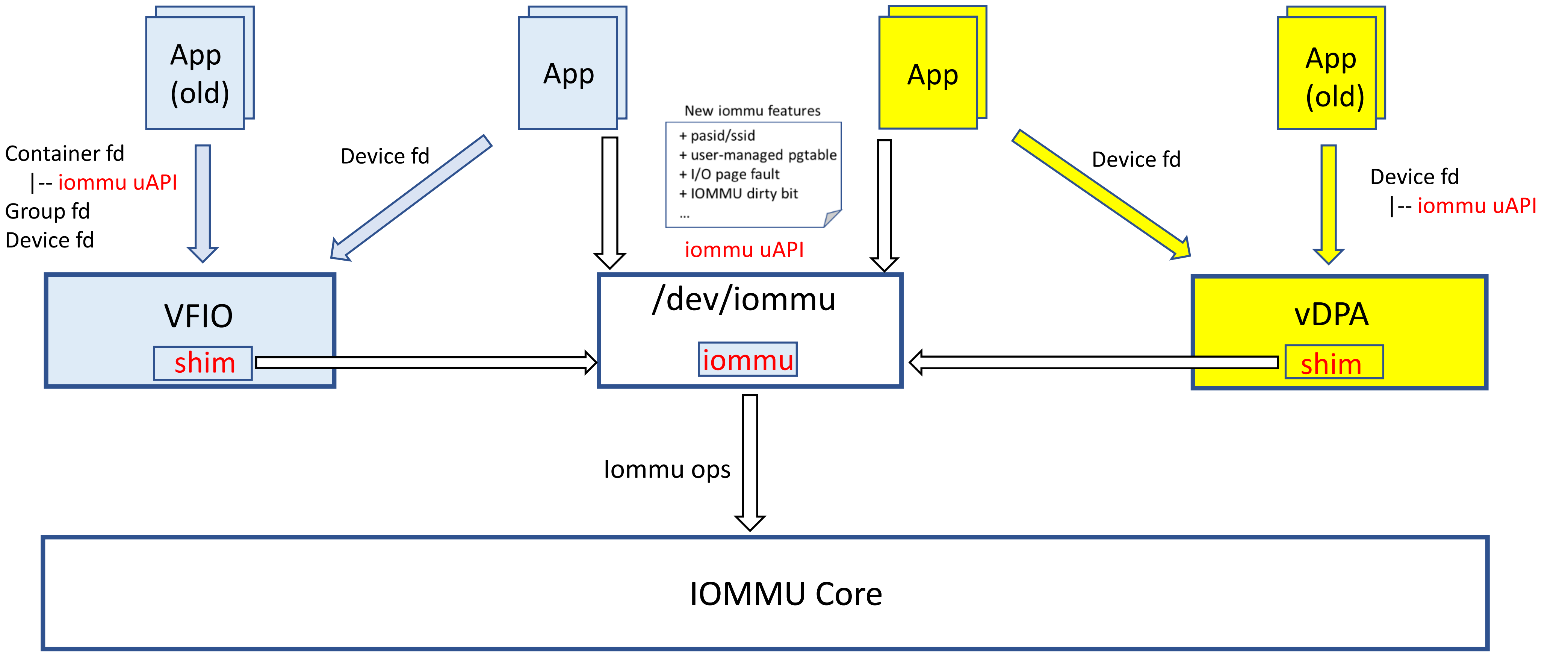
Agenda

- A brief background
- Development plan
- Manage security context for user-initiated DMAs
- Miscellaneous opens if time allows

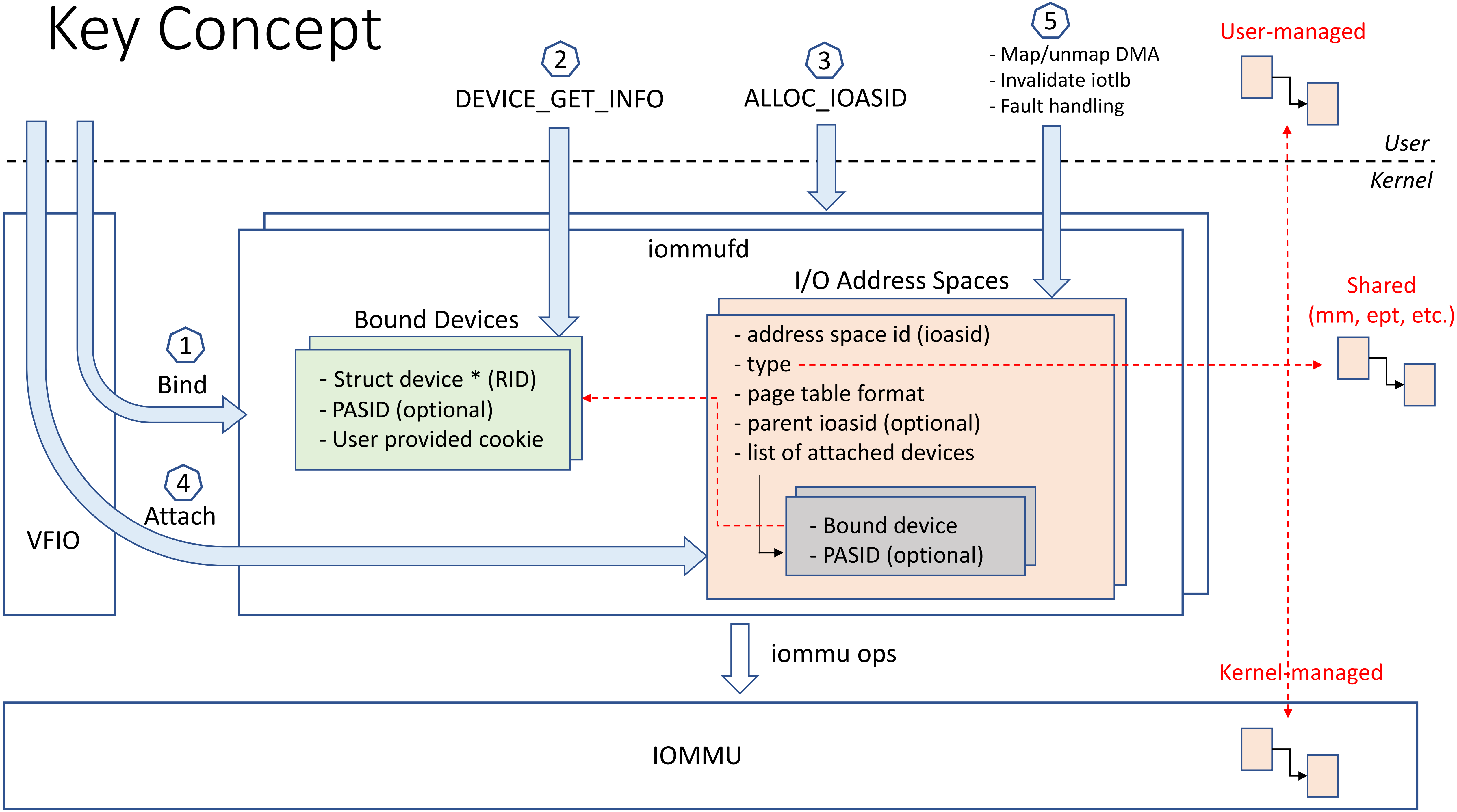
Proposal for a Unified Framework



* Thank Jason Gunthorpe for initiating this idea!

* Please refer to [link] for a full design proposal

Key Concept



2 DEVICE_GET_INFO

3 ALLOC_IOASID

5
- Map/unmap DMA
- Invalidate iotlb
- Fault handling

User-managed

User

Kernel

iommufd

I/O Address Spaces

Bound Devices

1 Bind

- Struct device * (RID)
- PASID (optional)
- User provided cookie

- address space id (ioasid)
- type
- page table format
- parent ioasid (optional)
- list of attached devices

- Bound device
- PASID (optional)

Shared
(mm, ept, etc.)

4 Attach

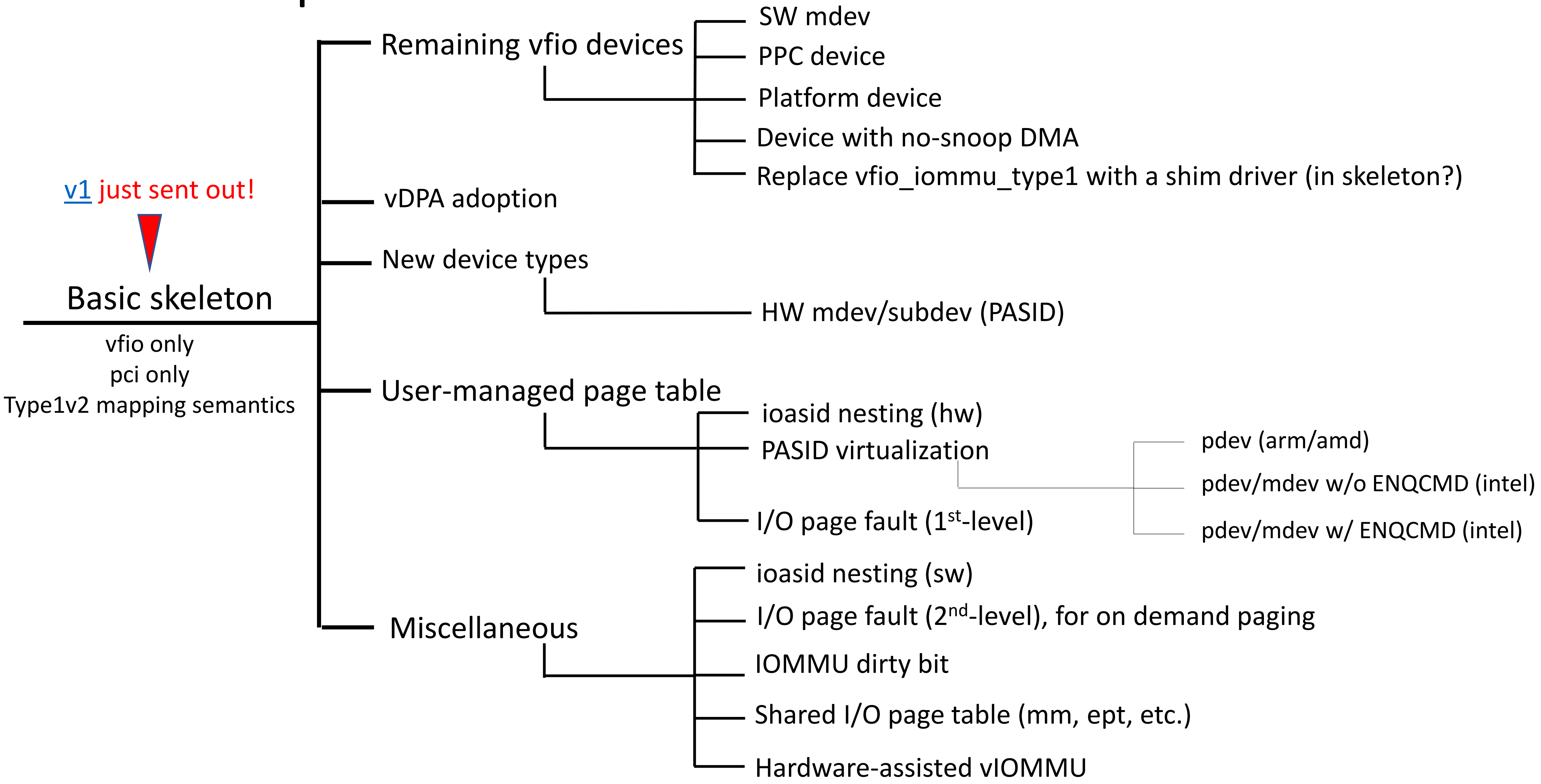
VFIO

iommu ops

Kernel-managed

IOMMU

Development Plan



v1 just sent out!

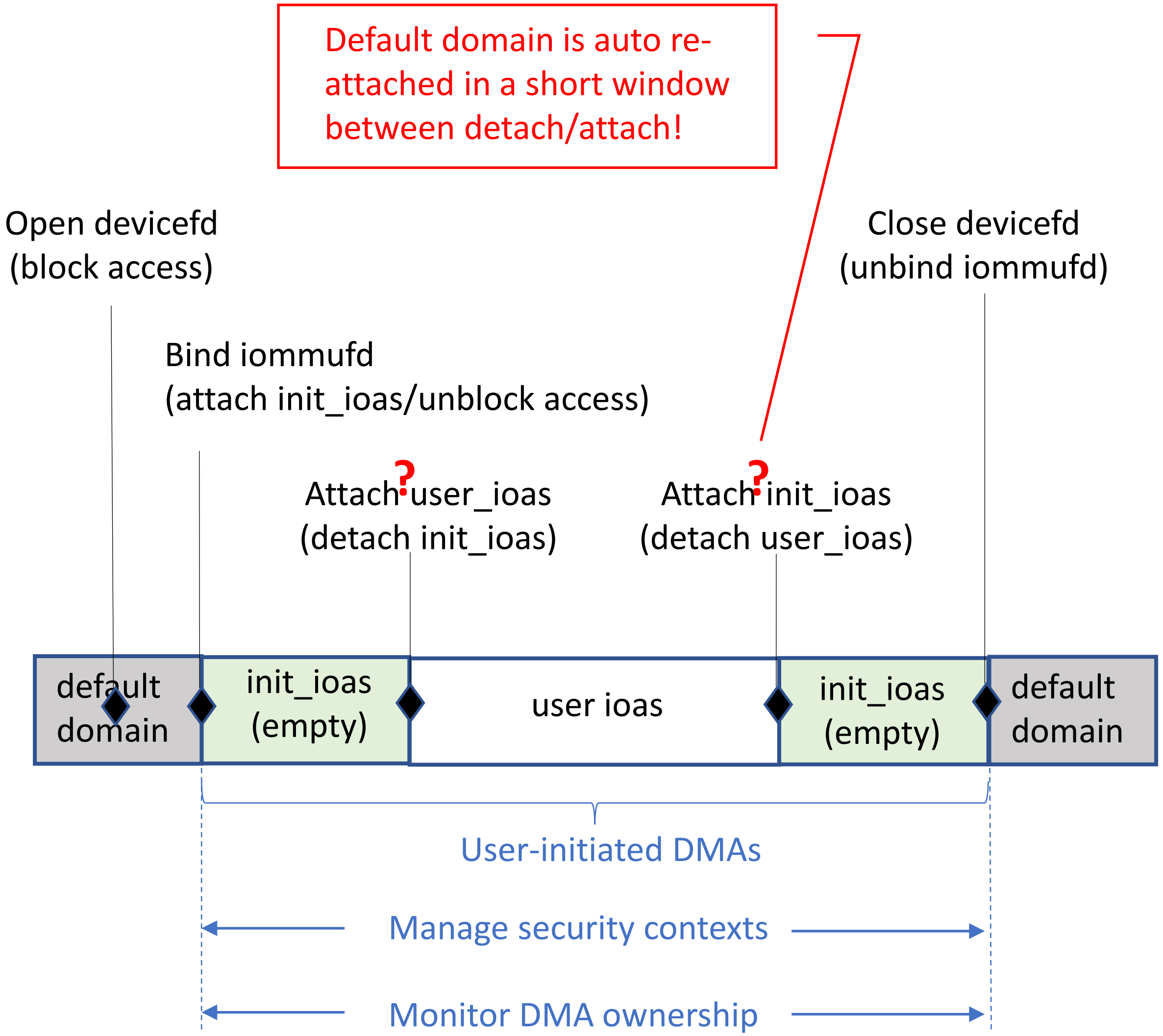
- Basic skeleton
  - vfio only
  - pci only
  - Type1v2 mapping semantics
- Remaining vfio devices
  - SW mdev
  - PPC device
  - Platform device
  - Device with no-snoop DMA
  - Replace vfio_iommu_type1 with a shim driver (in skeleton?)
- vDPA adoption
- New device types
  - HW mdev/subdev (PASID)
- User-managed page table
  - ioasid nesting (hw)
  - PASID virtualization
    - pdev (arm/amd)
    - pdev/mdev w/o ENQCMD (intel)
    - pdev/mdev w/ ENQCMD (intel)
  - I/O page fault (1st-level)
- Miscellaneous
  - ioasid nesting (sw)
  - I/O page fault (2nd-level), for on demand paging
  - IOMMU dirty bit
  - Shared I/O page table (mm, ept, etc.)
  - Hardware-assisted vIOMMU

Need community collaboration. Many tasks can be done in parallel!

Manage User-initiated DMAs

- Establish a secure context (iommu unmanaged domain) which restricts user-initiated DMAs to
  - process memory
  - sibling devices in the same group
- Guarantee exclusive DMA ownership on the group, i.e. devices in the group must be
  - Bound to the owner driver (e.g. vfio), or
  - Bound to a driver known DMA-safe (e.g. pci-stub), or
  - Driverless
- iommufd can copy what vfio does today, with one exception
  - Need manage multiple security contexts due to decoupled bind/attach
- Current IOMMU API has problem on the transition between unmanaged domains
  - Default domain is automatically re-attached after detaching from previous context

Need cooperation from IOMMU core!



Default domain is auto re-attached in a short window between detach/attach!

Open devicefd (block access)

Bind iommufd (attach init_ioas/unblock access)

Attach user_ioas (detach init_ioas) ?

Attach init_ioas (detach user_ioas) ?

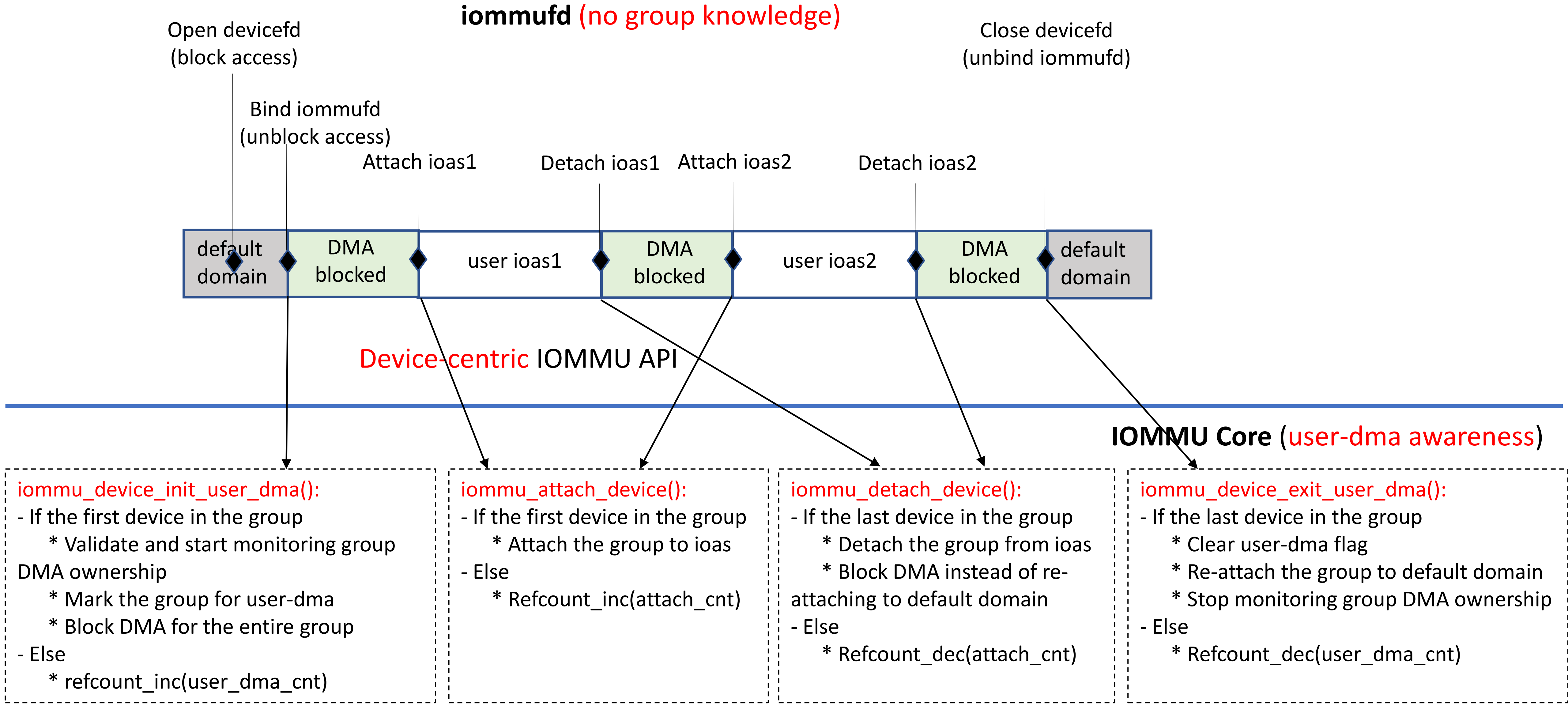
Close devicefd (unbind iommufd)

User-initiated DMAs

Manage security contexts

Monitor DMA ownership

Manage User-initiated DMAs (Cont.)



iommufd (no group knowledge)

Open devicefd
(block access)

Bind iommufd
(unblock access)

Attach ioas1

Detach ioas1

Attach ioas2

Detach ioas2

Close devicefd
(unbind iommufd)

default domain | DMA blocked | user ioas1 | DMA blocked | user ioas2 | DMA blocked | default domain

Device-centric IOMMU API

IOMMU Core (user-dma awareness)

```
iommu_device_init_user_dma():
- If the first device in the group
     * Validate and start monitoring group
DMA ownership
     * Mark the group for user-dma
     * Block DMA for the entire group
- Else
     * refcount_inc(user_dma_cnt)
```

```
iommu_attach_device():
- If the first device in the group
     * Attach the group to ioas
- Else
     * Refcount_inc(attach_cnt)
```

```
iommu_detach_device():
- If the last device in the group
     * Detach the group from ioas
     * Block DMA instead of re-
attaching to default domain
- Else
     * Refcount_dec(attach_cnt)
```

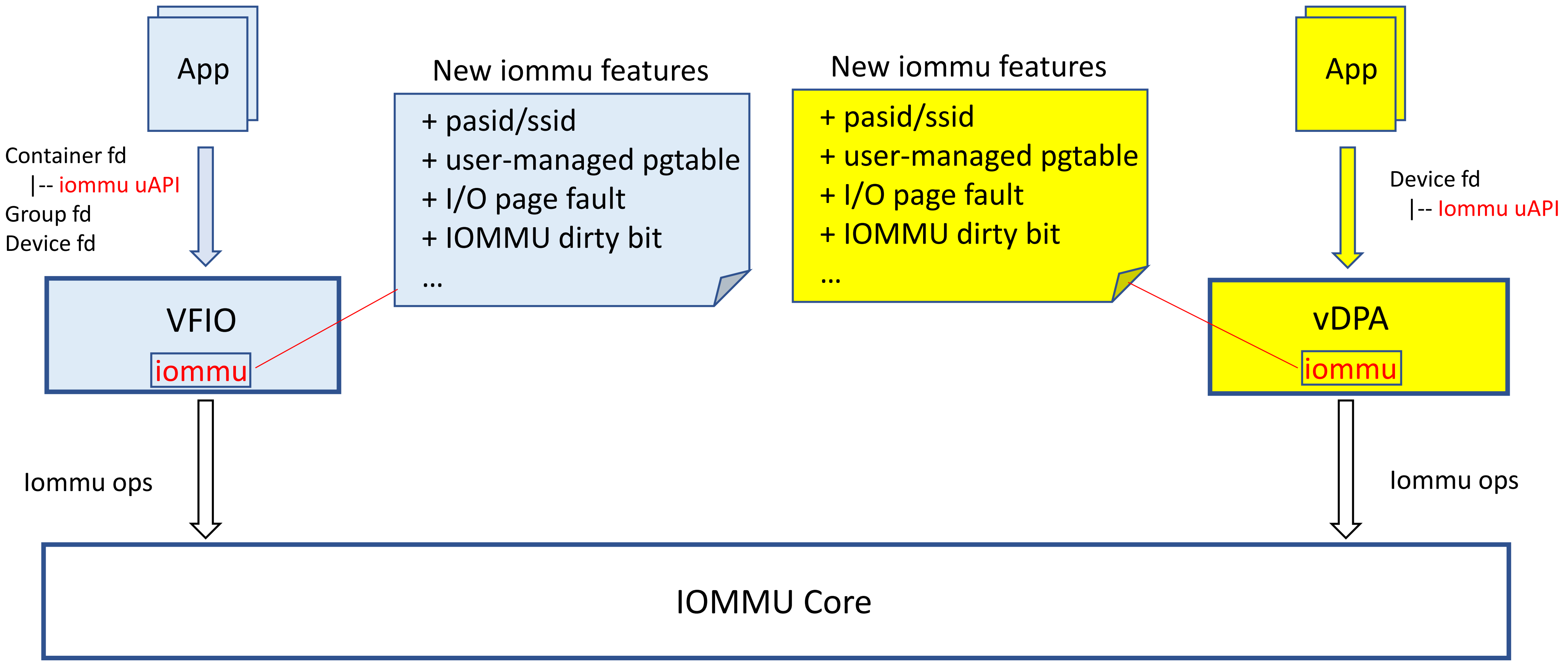
```
iommu_device_exit_user_dma():
- If the last device in the group
     * Clear user-dma flag
     * Re-attach the group to default domain
     * Stop monitoring group DMA ownership
- Else
     * Refcount_dec(user_dma_cnt)
```

If time allows

- ioasid naming conflict
    - fd-local software handle vs. hw asid (pasid/ssid, /drivers/iommu/ioasid.c)
- Module name and devnode
    - iommufd (/dev/iommu) vs. uiommu (/dev/uiommu)
    - Other options?
- /dev/vfio/devices/ hierarchy
    - A plain layout mixing all types together
        - /dev/vfio/devices/0000:00:14.2 (pci)
        - /dev/vfio/devices/PNP0103:00 (platform)
        - /dev/vfio/devices/83b8f4f2-509f-382f-3c1e-e6bfe0fa1001 (mdev)
    - Subdirectories based on device types
        - pci, platform, ccw, etc.
        - Pdev vs. mdev
- Do we need to build iommufd as a separated module?
- Convert vfio_iommu_type1 to a shim driver

Backup

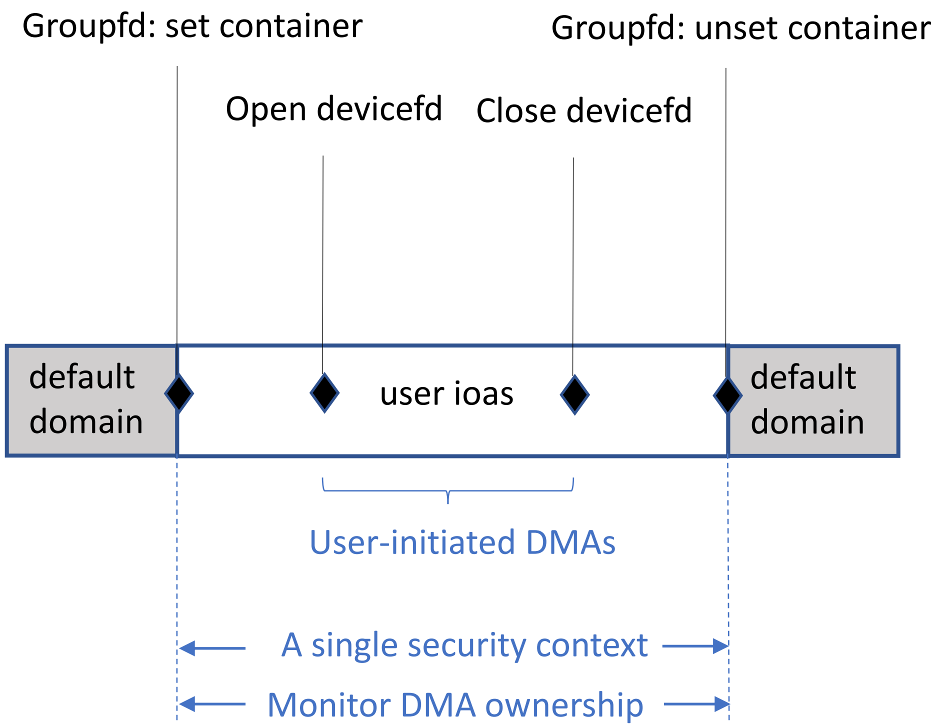
Current Situation



Not a scalable architecture moving forward!

Manage User-initiated DMAs

Current VFIO


Groupfd: set container
Groupfd: unset container
Open devicefd
Close devicefd
default domain
user ioas
default domain
User-initiated DMAs
A single security context
Monitor DMA ownership