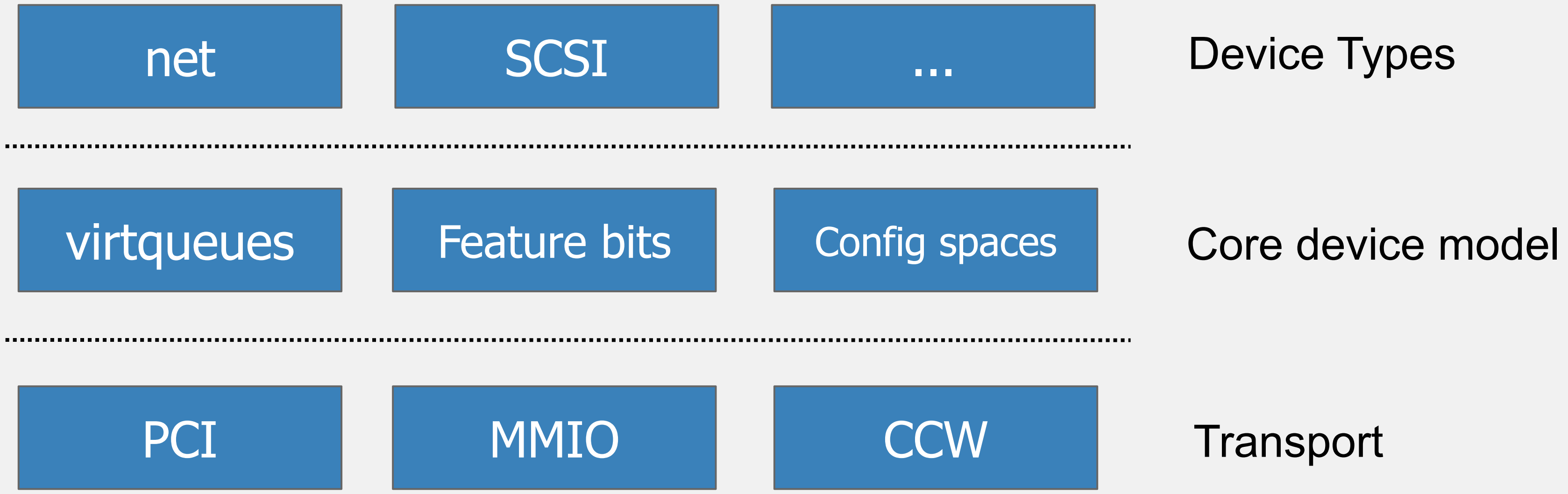
vDPA support in Linux kernel

Jason Wang
Senior Principal Software Engineer
jasowang@redhat.com

Outline

- Virtio architecture review
- Why vDPA
- vDPA support in Kernel
- Conclusion
- Q&A

Virtio architecture overview



Software implementation of virtio device

- Several types of virtio devices implemented in software
  - Qemu, vhost-kernel, vhost-user
- Good:
  - Unified device interface for guest
  - Good application usability in guest
  - Live migration support
- Not good:
  - Extra CPU/management cost due to dedicate thread(s)
  - Can’t reach wirespeed due to software overhead

Full hardware implementation of virtio

- A device that is fully compatible with virtio spec
  - control + datapath
  - wirespeed
  - no CPU overhead compared to software dataplane
  - unified API
  - no vendor lock

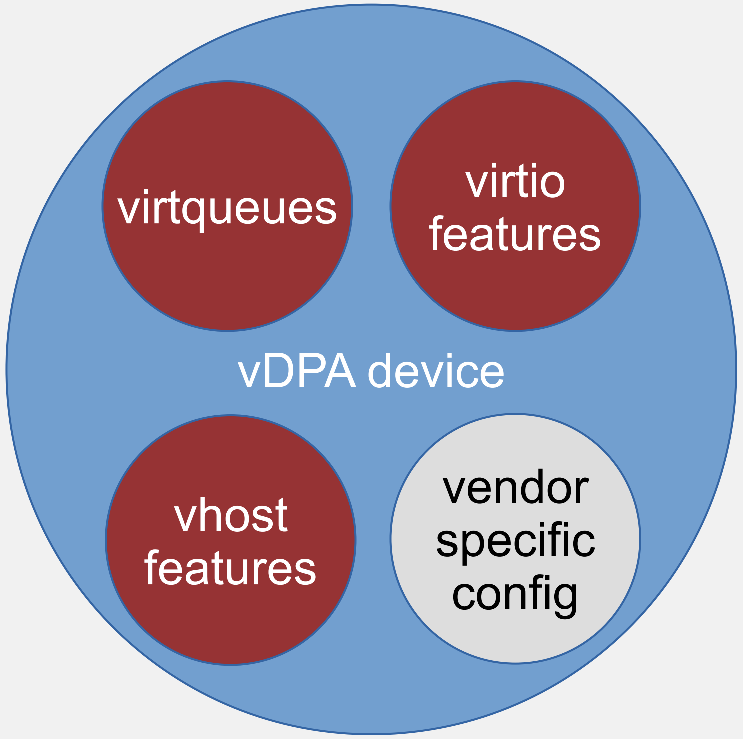
Issues of hardware virtio implementation

- Current virtio is not designed to be virtualized
  - No support for live migration
- Hard to be integrated with existing hardware
  - Modern hardware is much more complicated
  - Redesign the mature control path is a challenge
- Vendor add-on values requires extensions
- Manageability
  - Lacking features for e.g VF provisioning ...

Why vDPA?

- What is vDPA
  - vhost Data Path Acceleration (originally)
  - virtio Data Path Acceleration
- vDPA is a kind of hardware that has
  - virtio compatible datapath (defined by virtio spec)
  - vendor specific control path (functional equivalent or superset of virtio)
  - vhost features: device state recovery or dirty page tracking (optional)

vDPA device – hardware perspective



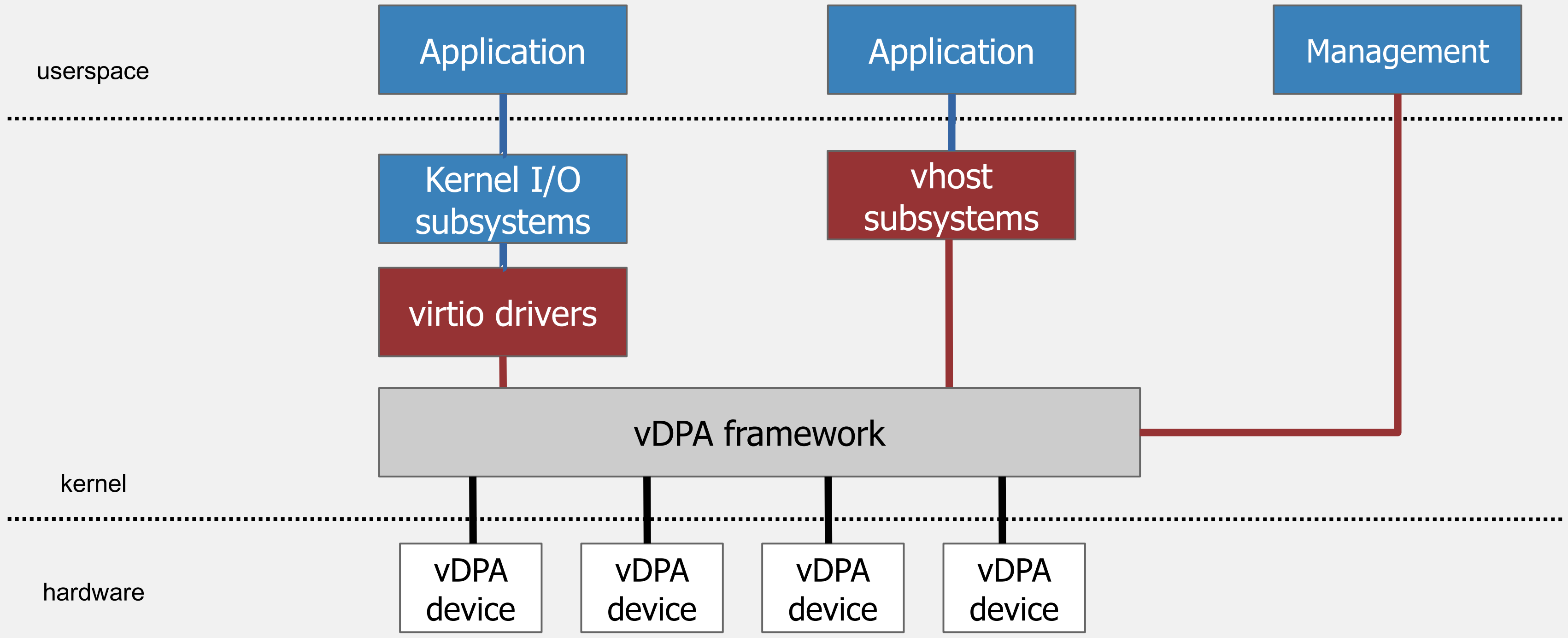
Why vDPA

- Advantages of hardware virtio implementation
  - unified datapath
  - wirespeed
- Plus (functional superset of virtio)
  - live migration support
  - vendor specific add-on features(values)
- But still has gaps for E2E delivery if exposing raw vDPA device
  - exposing the complexity and difference to upper layer?
  - integration with existing subsystems or inventing the wheel?
  - manageability, vendor specific management API?
  - heavyweight driver?

vDPA kernel framework

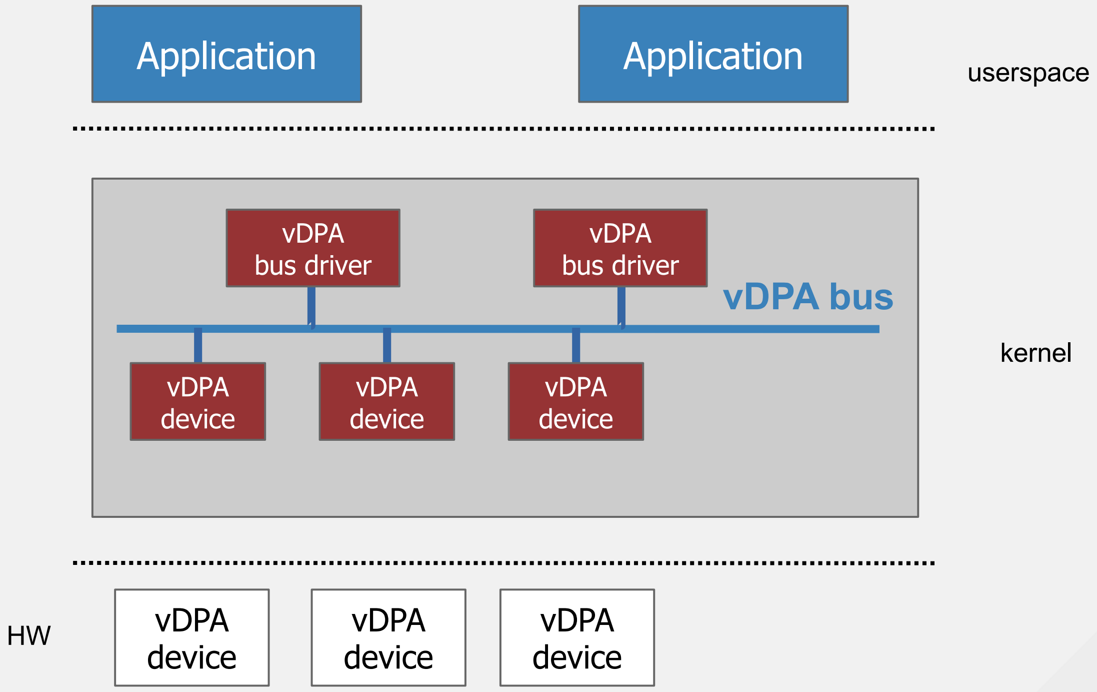
- Bridging the usability and manageability gap
- A framework with the following features is required
  - hiding the complexity and difference
  - presenting a unified device and management API
  - seamless integration with the existing subsystems
  - serving for both userspace drivers and kernel drivers
  - bus/device agnostic
  - lightweight driver

vDPA framework overview



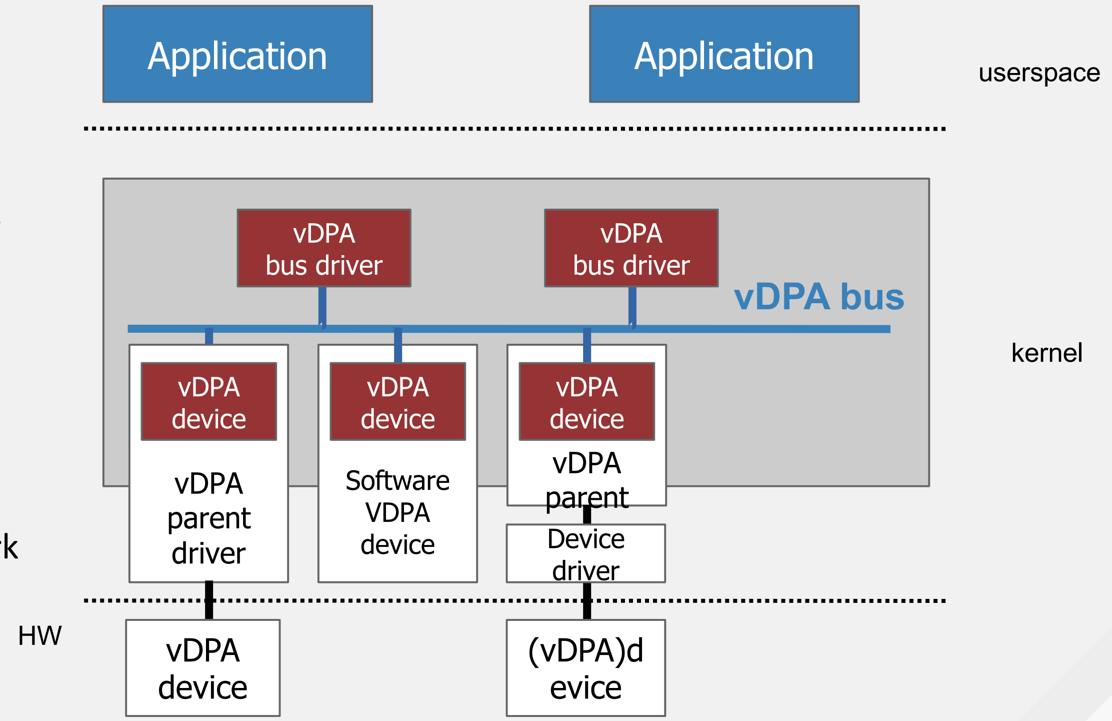
vDPA bus for abstracting hardware

- vDPA bus
  - different vDPA devices and drivers to be attached
  - communication protocol (confi operations)
- vDPA device
  - device abstraction provided by vDPA parent device driver
  - vDPA attributes
- vDPA bus driver
  - connect vDPA device to kernel subsystems
  - using config operations to control vDPA device



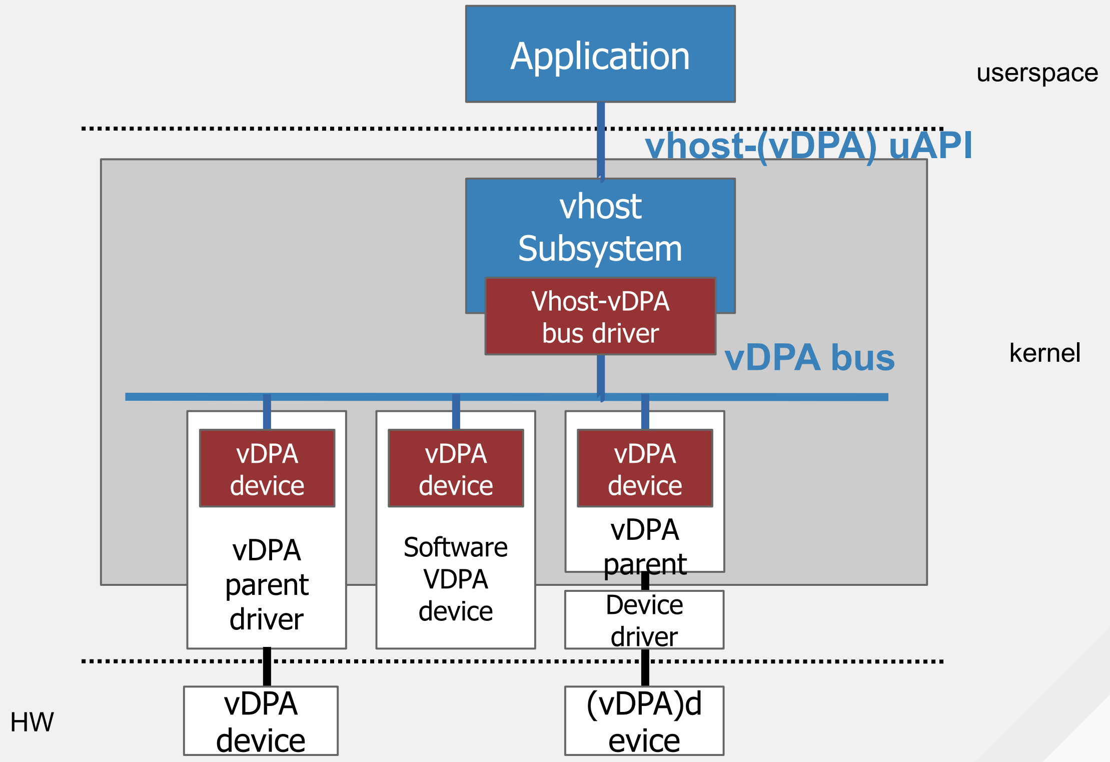
vDPA parent

- vDPA device for common abstraction:
  - attribues
  - config operations: virtio, interrupt, doorbell, DMA, vhost
- vDPA parent (device) for providing this abstraction
- Parent can be any type, e.g:
  1) parent device driver
  2) intermediate layer on top of another device driver or framework
  3) software device (or proxy)



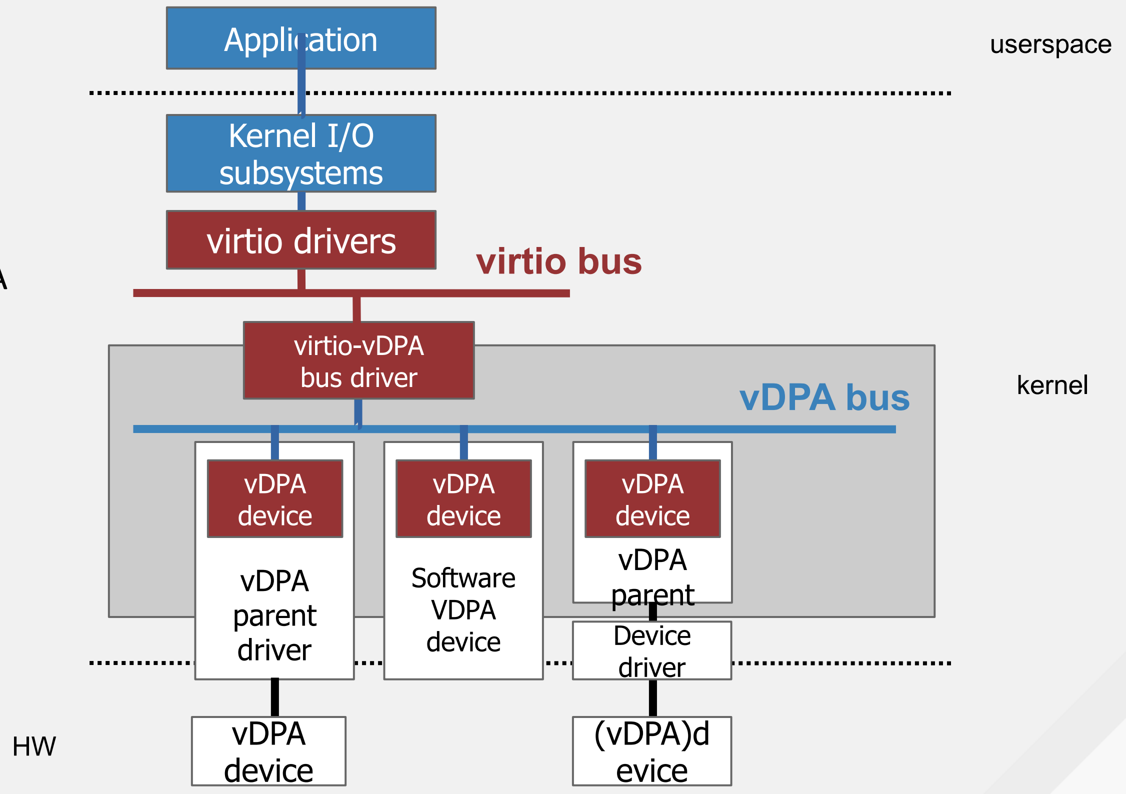
vhost-vDPA bus driver

- Present a vhost device to vhost subsystem
- Serve userspace drivers
  - VM/Qemu vhost backend
  - DPDK virtio PMD
- Reusing vhost generic uAPI for datapath setting
- New dedicated vhost-vDPA uAPI for a full device abstraction
  - control path commands:
    - config space access
    - status set/get
    - config interrupt
    - ...



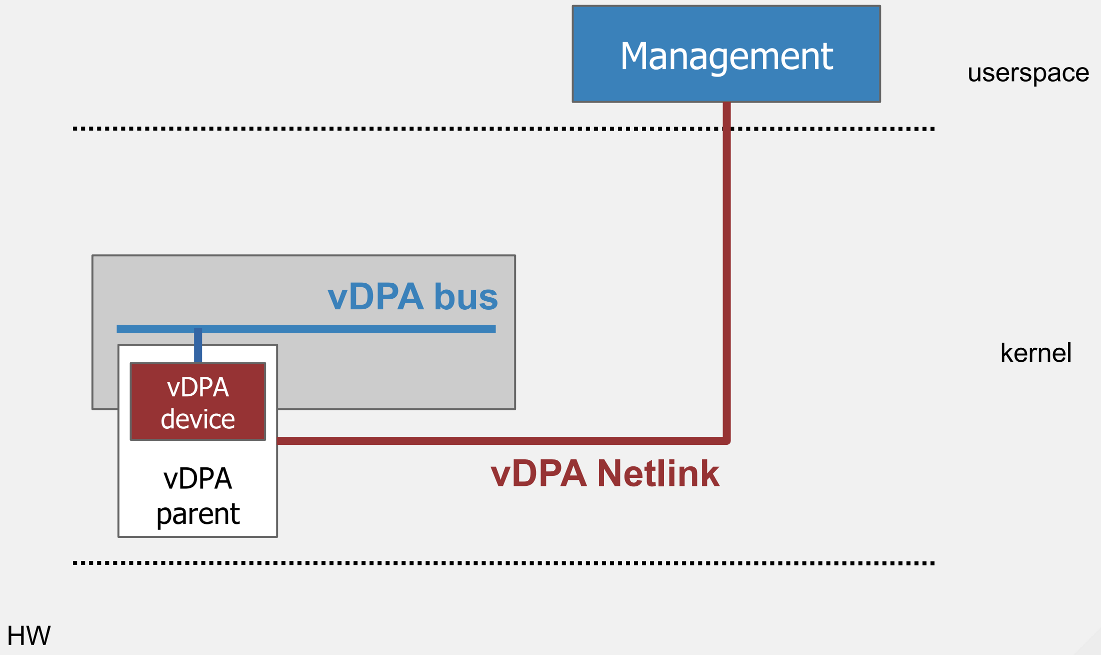
virtio-vDPA bus driver

- Present a virtio device to virtio bus
- A kernel visible virtio interface via virtio drivers via a new virtual transport (vDPA transport)
- used by various kernel subsystems as if they are virtio device
  - Networking subsystem
  - Storage stack
  - Io-uring, etc
- bare metal or containerized app



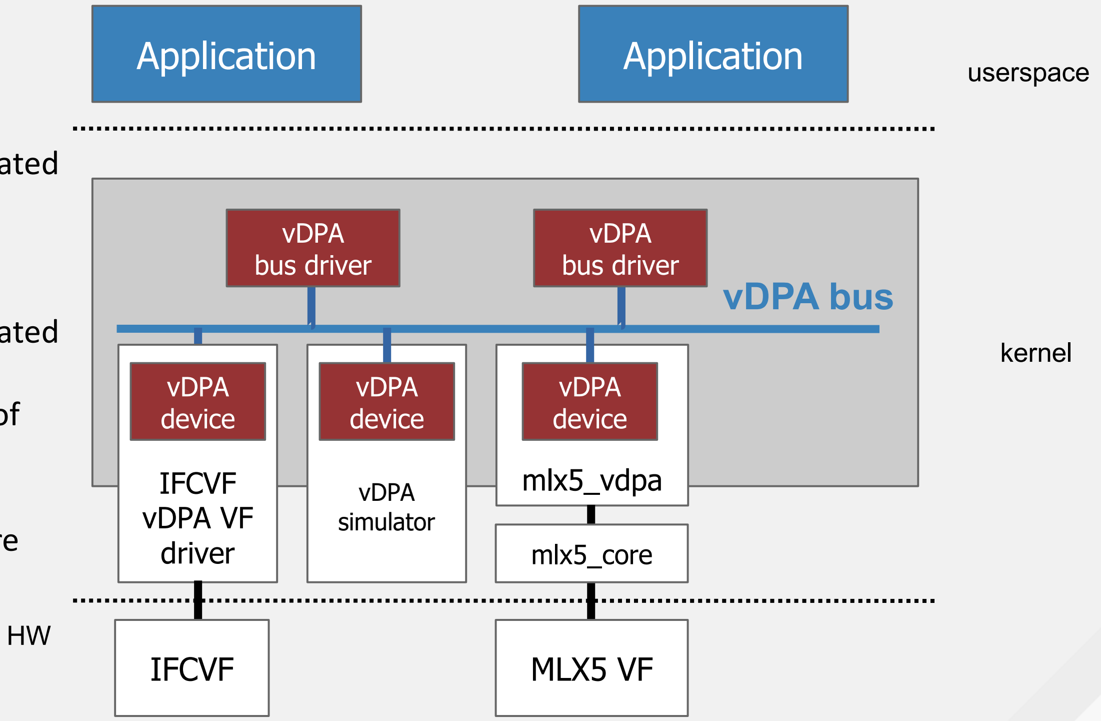
Netlink based management API

- A dedicated vDPA specific netlink protocol for:
  - lifecycle management: create/destroy, enable/disable
  - Provisioning
- A new "vdpa" program will be integrated with iproute2
- All vDPA parent device is required to implement the vDPA netlink protocol



vDPA parents

- Intel IFCVF
  - vDPA is implemented through a dedicated VF
  - parent is a PCI VF device driver
- Mellanox mlx5_vdpa
  - vDPA is implemented through a dedicated VF
  - parent is a intermediate layer on top of mlx5_core module
- VDPA simulator
  - vDPA is implemented through software emulation
- More is being developed
  - ADI or subfunction, endpoint device



Status

features	status
basic function: vDPA core, vDPA bus drivers	merged in Linux
IFCVF/mlx5e/simulator device	merged in Linux
basic Qemu support	merged in Qemu
netlink based management API	WIP
live migration support	WIP
control virtqueue support	WIP
devices other than networking	WIP

TODO

features	status
vDPA device API Documentation	planned
vhost-vDPA uAPI Documentation	planned
SVA or vSVA support	planned
dirty page tracking through hardware	planned
virtio specification extension	planned

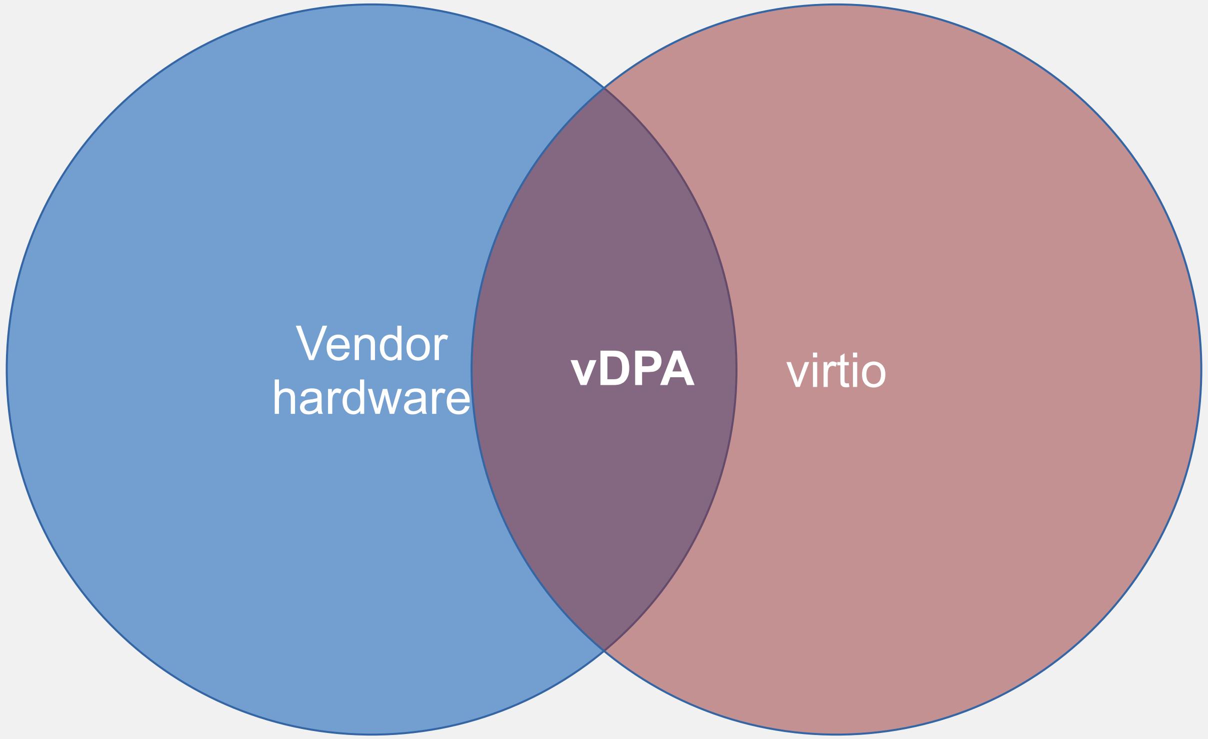
Conclusion

- vDPA device in introduced
  - device has virtio datapath with vendor specific control path and vhost features
- vDPA framework in Linux Kernel
  - vDPA bus and device for abstracting and present a unified device interface
  - vDPA bus drivers for connecting vDPA device to various kernel subsystems
- wire speed virtio with best usability and manageability:
  - no vendor lock
  - live migration (cross vendor/backends)
  - unified management interface
  - mature software stack, virtio ecosystem

Reference

- Steve's vDPA presentation on KVM Forum 2018
  - https://events19.linuxfoundation.org/wp-content/uploads/2017/12/Cunming-Liang-Intel-KVM-Forum-2018-VDPA-VHOST-MDEV.pdf
- Redhat blogs for virtio/vDPA
  - series I: https://www.redhat.com/en/virtio-networking-series
  - series II: https://www.redhat.com/en/blog/virio-networking-series-advanced
- Virtio specification
  - https://docs.oasis-open.org/virtio/virtio/v1.1/virtio-v1.1.html
- Subscribe to virtio-networking mailing list
  - virtio-networking@redhat.com

vDPA is coming to real life



Please contact to us

- Please contact to us if you want any help:
  - hardware virtio/vDPA implementation
  - driver implementation
  - deployment and integration with management stack
  - feature requirement for implementing your vDPA hardware
  - virtio-networking@redhat.com or jasowang@redhat.com

Thanks