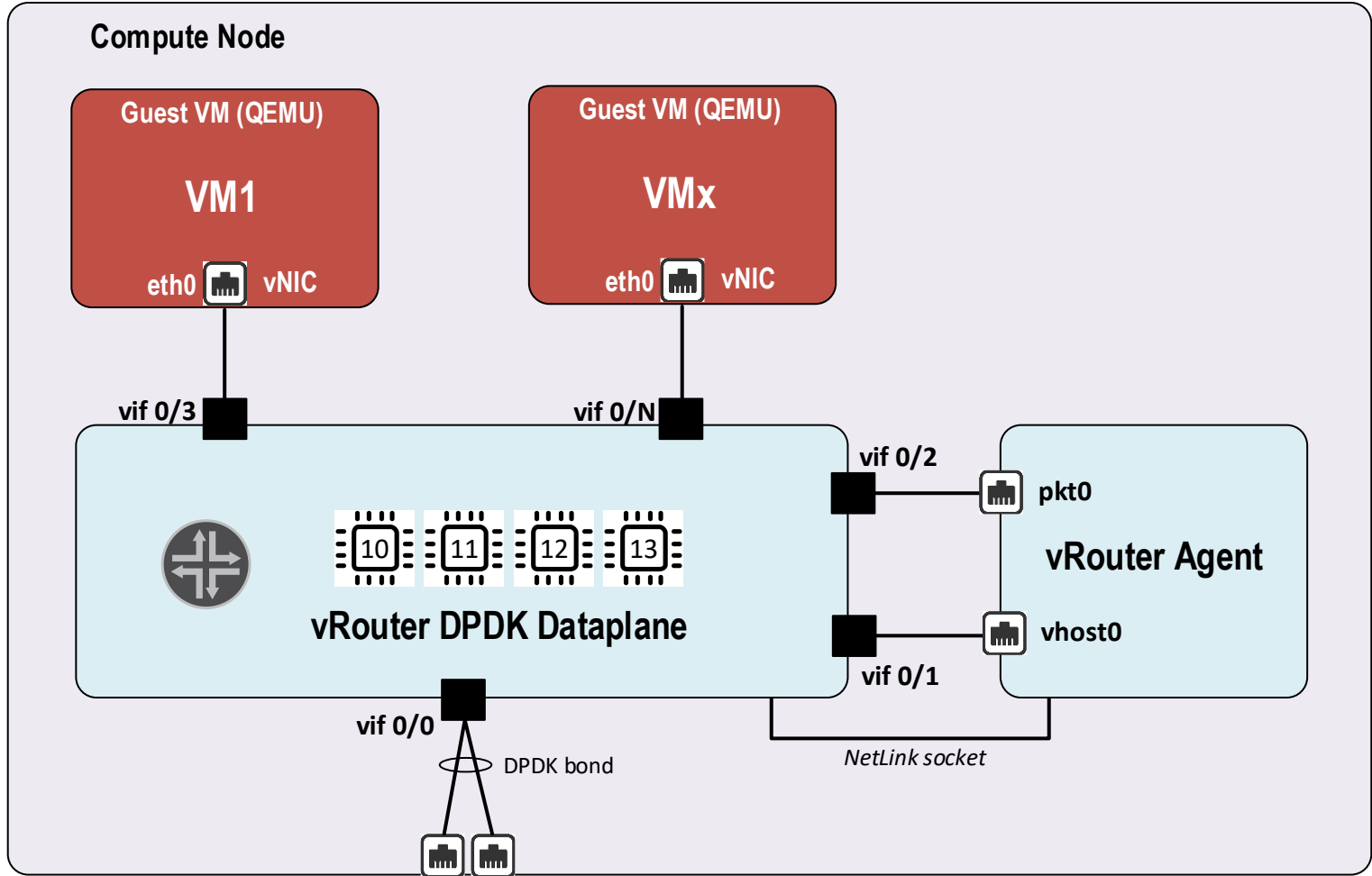


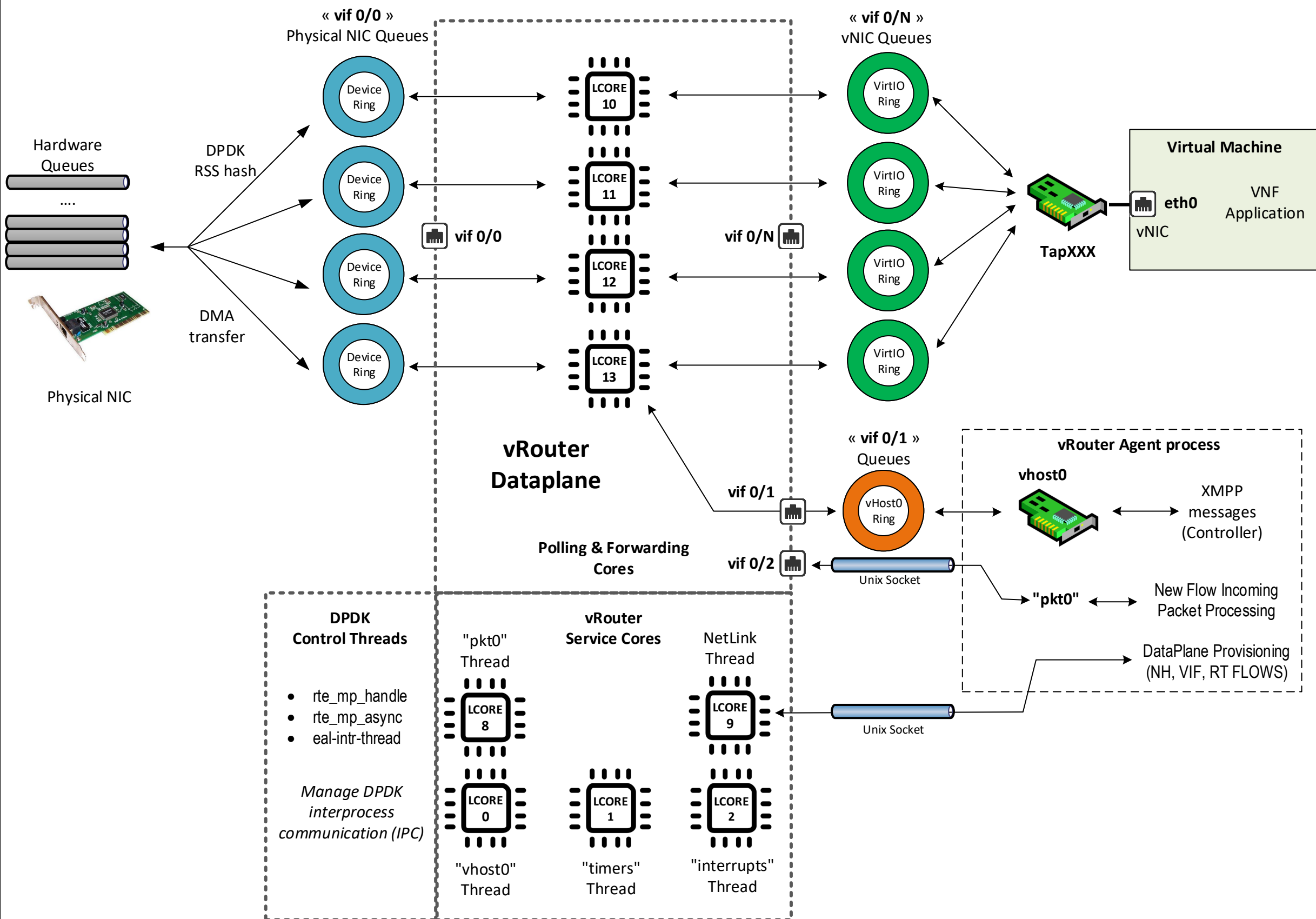
Title: vrouter overview

version: 1.0

date: 25/03/2020



Title: vRouter interfaces overview	
version: 1.0	date: 27/03/2020

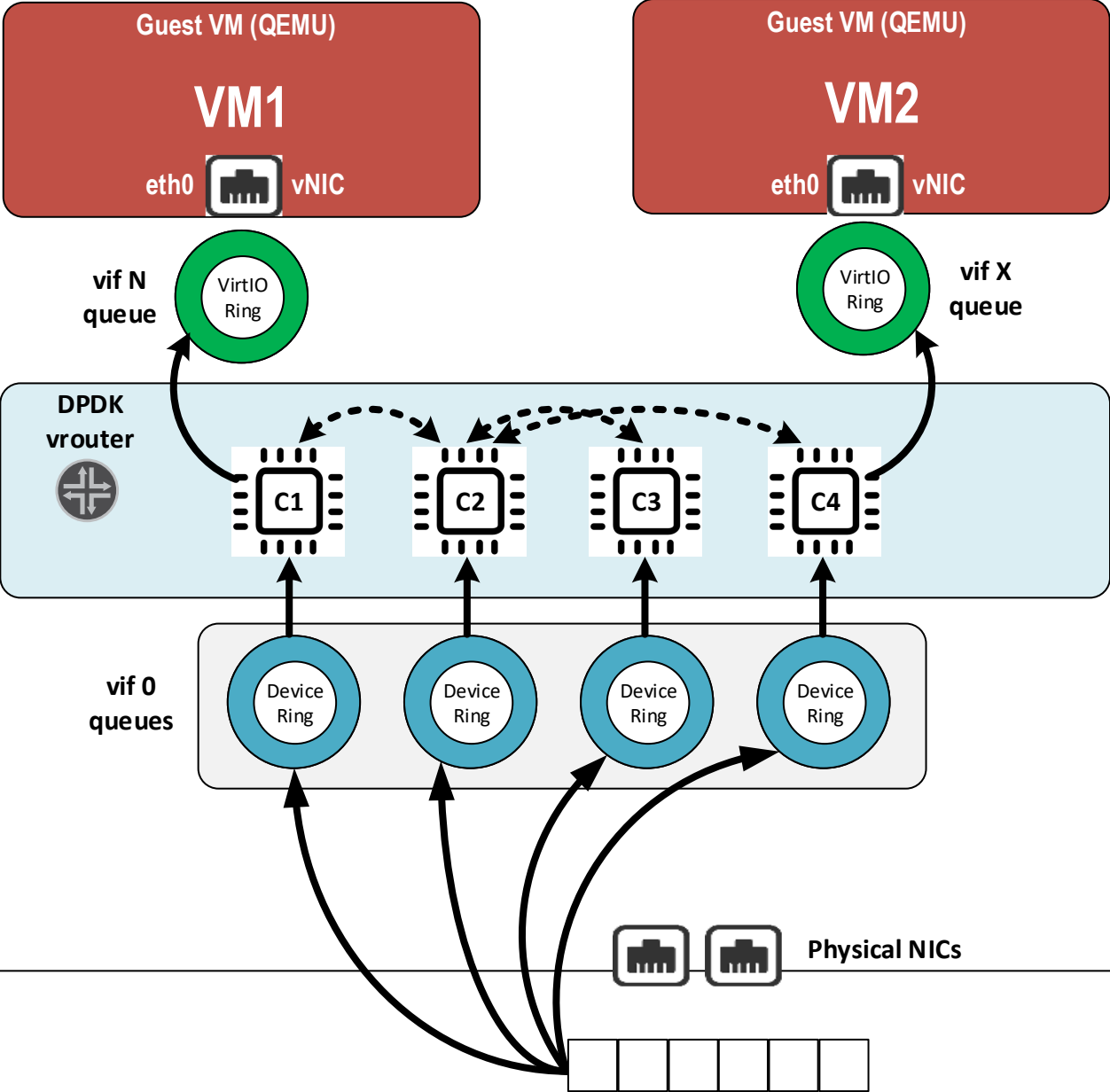


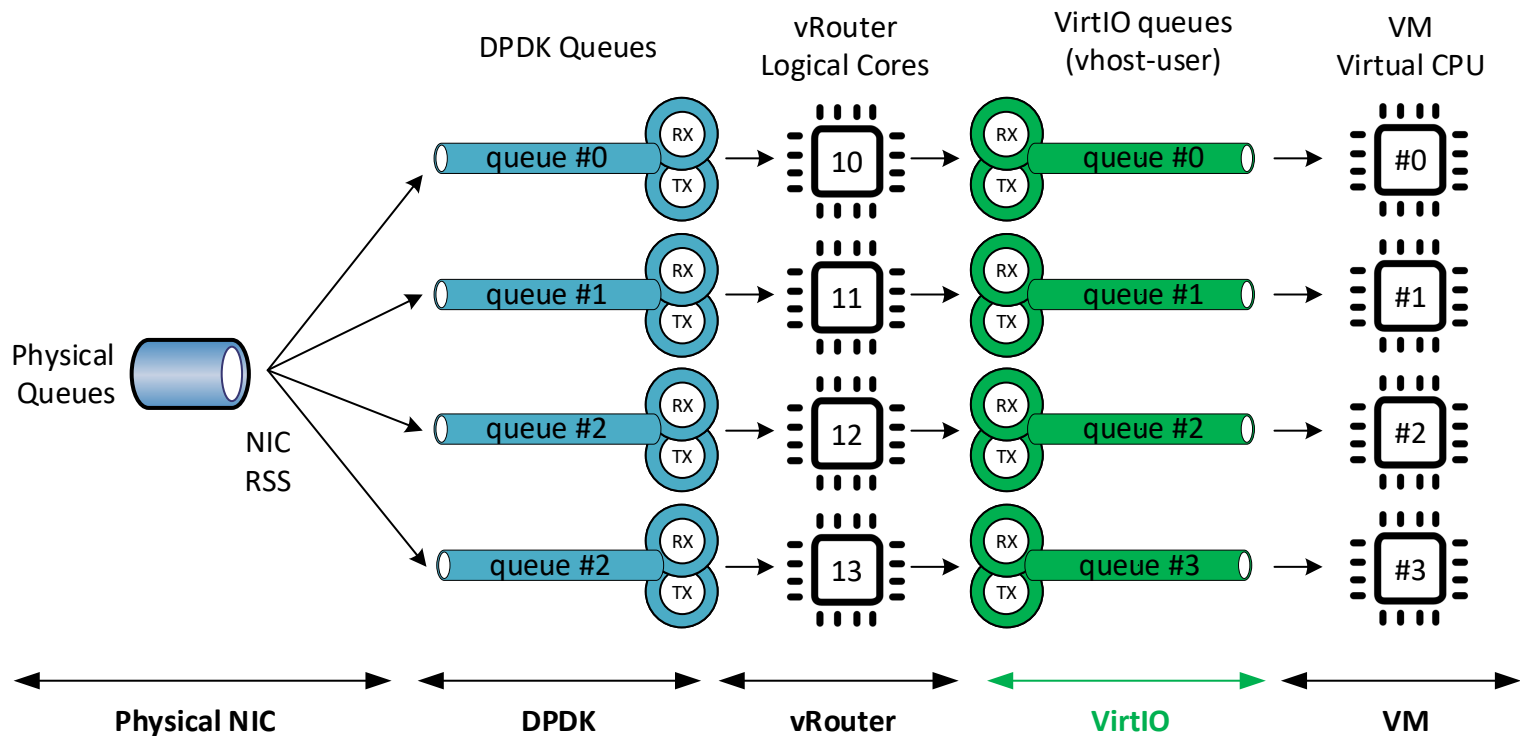
Title: vRouter Internal Architecture

version: 1.1

date: 22/05/2020

Compute Node





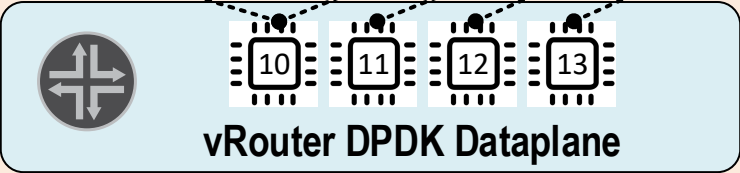
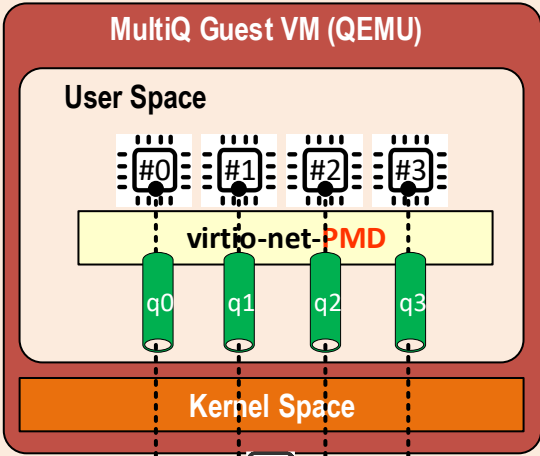
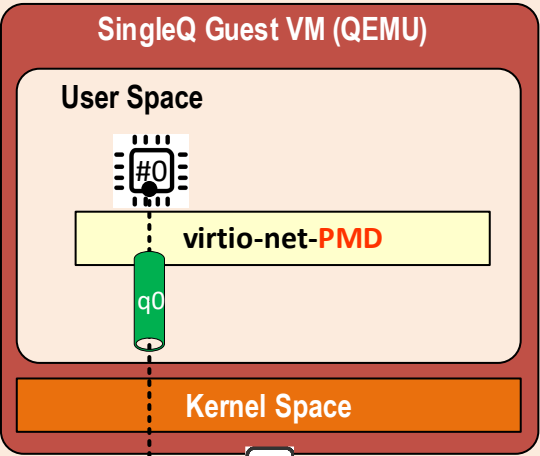
Title: DPDK End to End Packet Processing

version: 1.0

date: 27/03/2020

Compute Node

User Space



Kernel Space

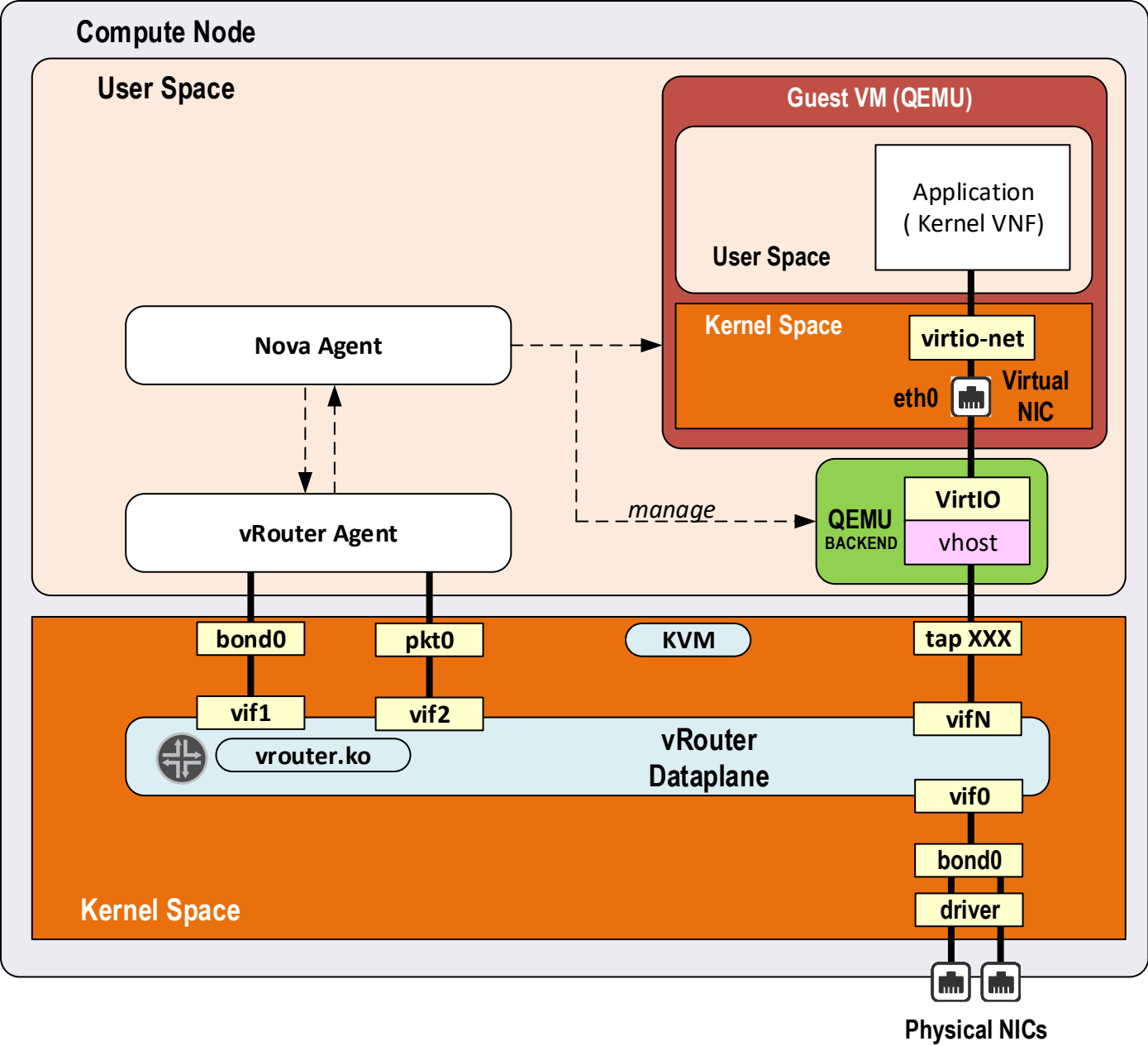


Physical NICs

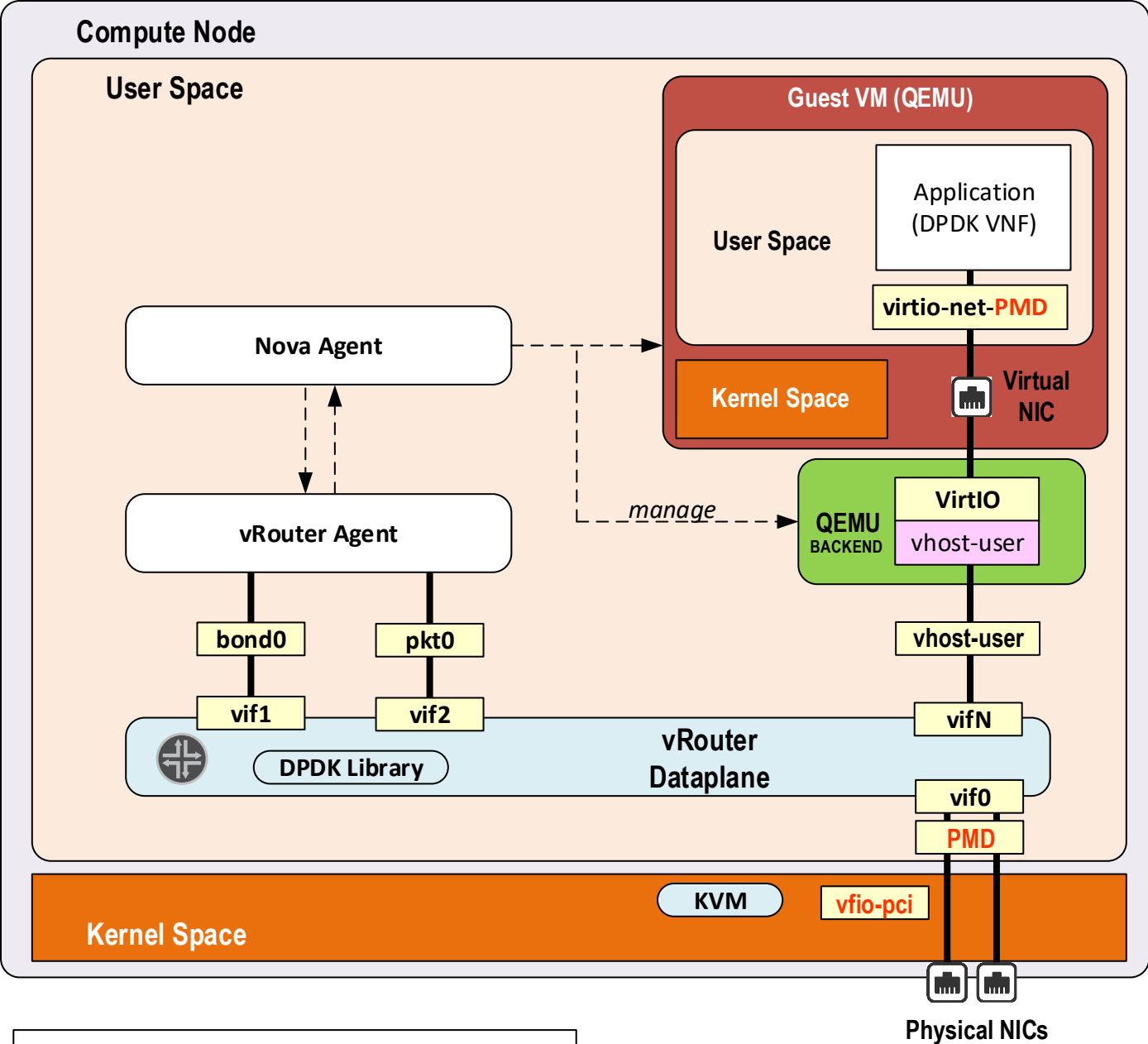
Title: SingleQ versus MultiQ VNF

version: 1.0

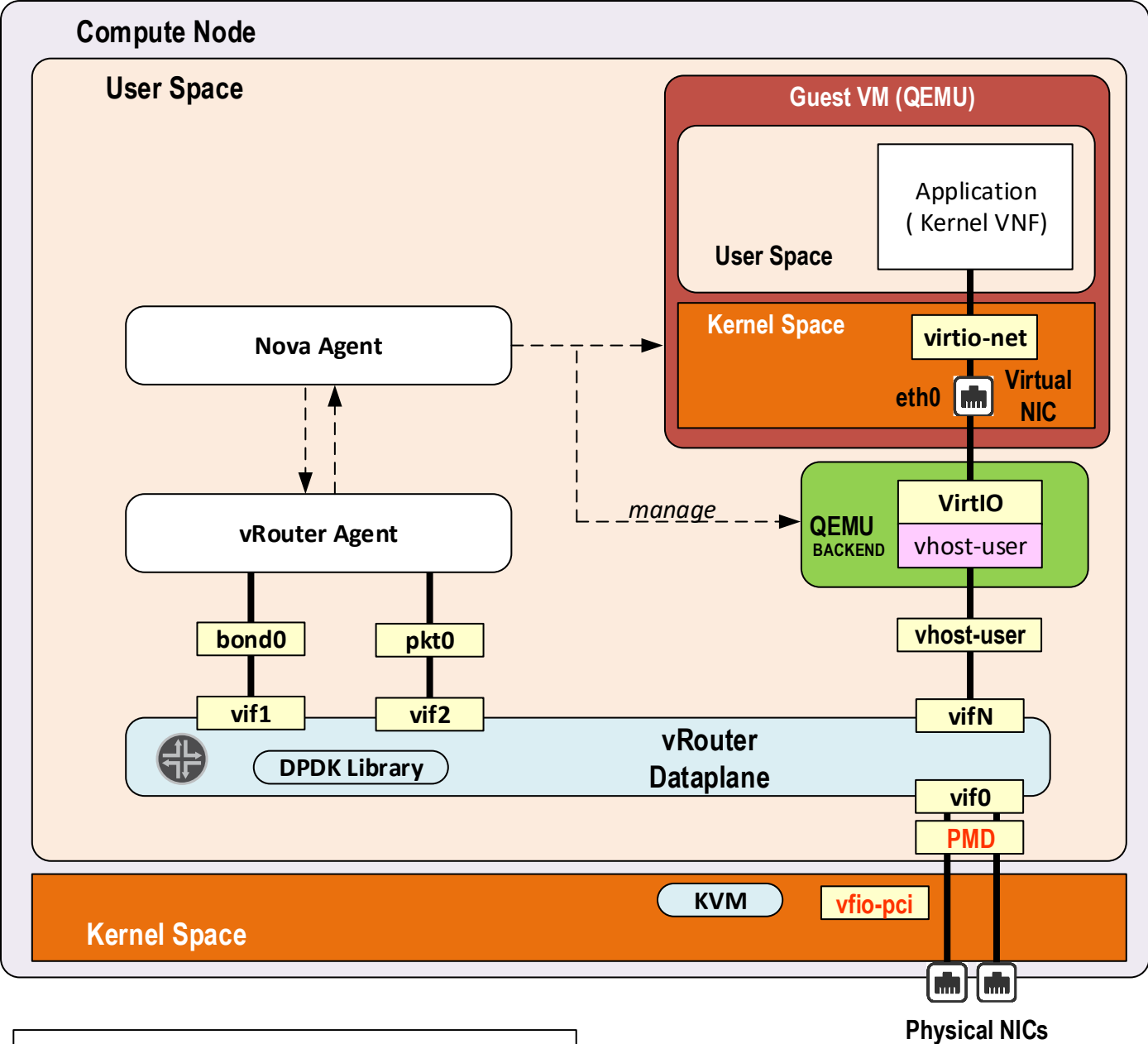
date: 27/03/2020



Title: Kernel vRouter details	
version: 1.0	date: 25/03/2020



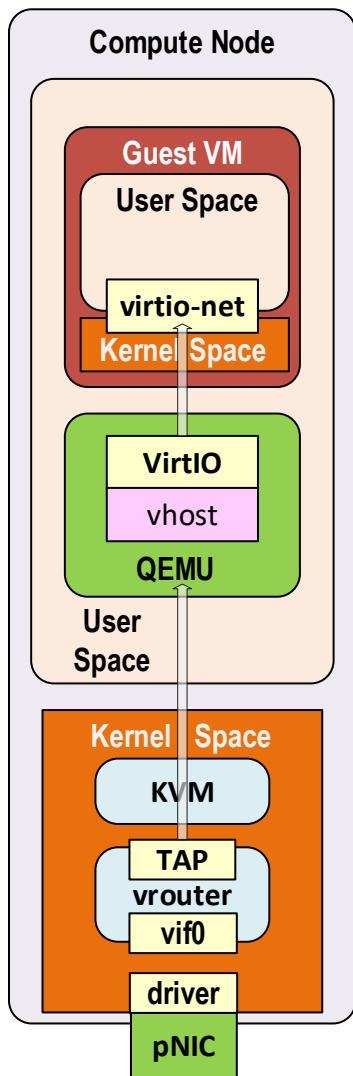
Title: DPDK vRouter details (DPDK App)	
version: 1.0	date: 25/03/2020



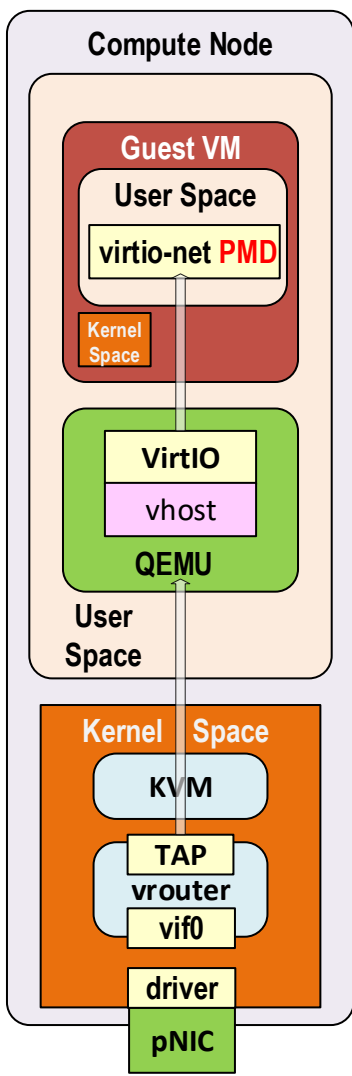
Title: DPDK vRouter details (Kernel App)	
version: 1.0	date: 25/03/2020

Kernel Mode vRouter

Virtio-net (Kernel)

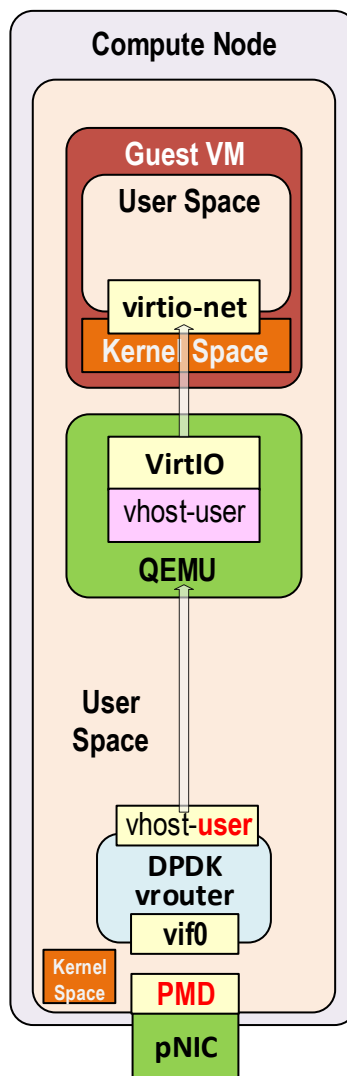


DPDK (user)

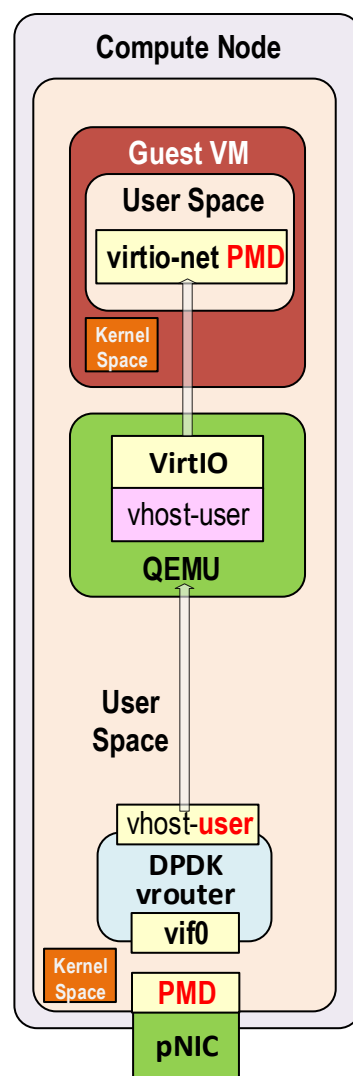


DPDK vRouter

Virtio-net (Kernel)



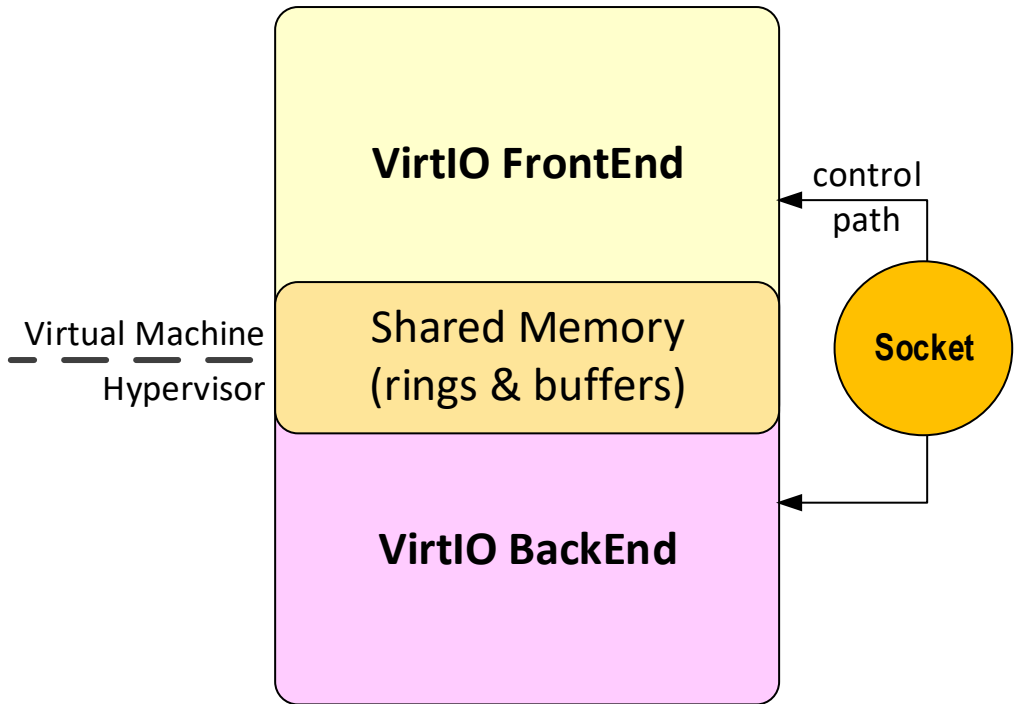
DPDK (user)



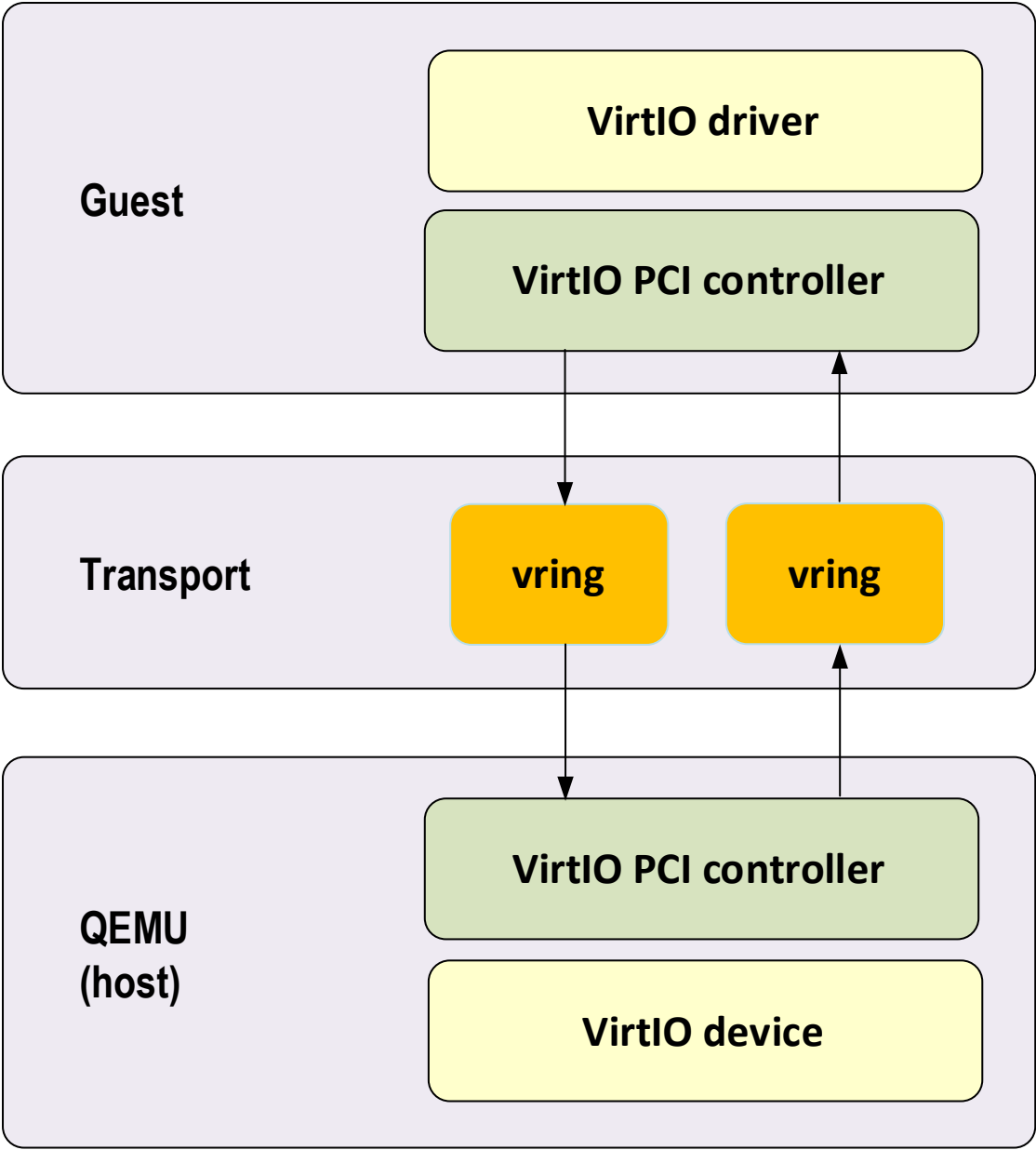
Title: Kernel vRouter All Cases

version: 1.1

date: 22/05/2020



Title: VirtIO overview	
version: 1.0	date: 25/03/2020



Title: VirtIO driver and device	
version: 1.0	date: 02/06/2020

Compute Node

User Space

QEMU process

Guest VM

User Space

Kernel Space

eth0



Virtual
NIC

virtio-net driver
(virtio frontend)

Shared Memory

virtqueues

Buffers

TX
Ring

RX
Ring

virtio-net-device
(virtio backend)

irq

PCI
BAR

Notification
Messages

vmexit

Kernel Space

TAP



kvm.ko

Title: VirtIO Net

version: 1.0

date: 04/06/2020

Compute Node

User Space

QEMU process

Guest VM

User Space

Kernel Space

eth0



Virtual NIC

virtio-net driver (virtio frontend)

Shared Memory

virtqueues

Buffers

TX Ring

RX Ring

PCI BAR

virtio-net-device (virtio backend)

Notification Messages

setup

vhost-net

kvm.ko

spawn

vhost worker

ioevent FD

IRQ FD

Kernel Space

TAP

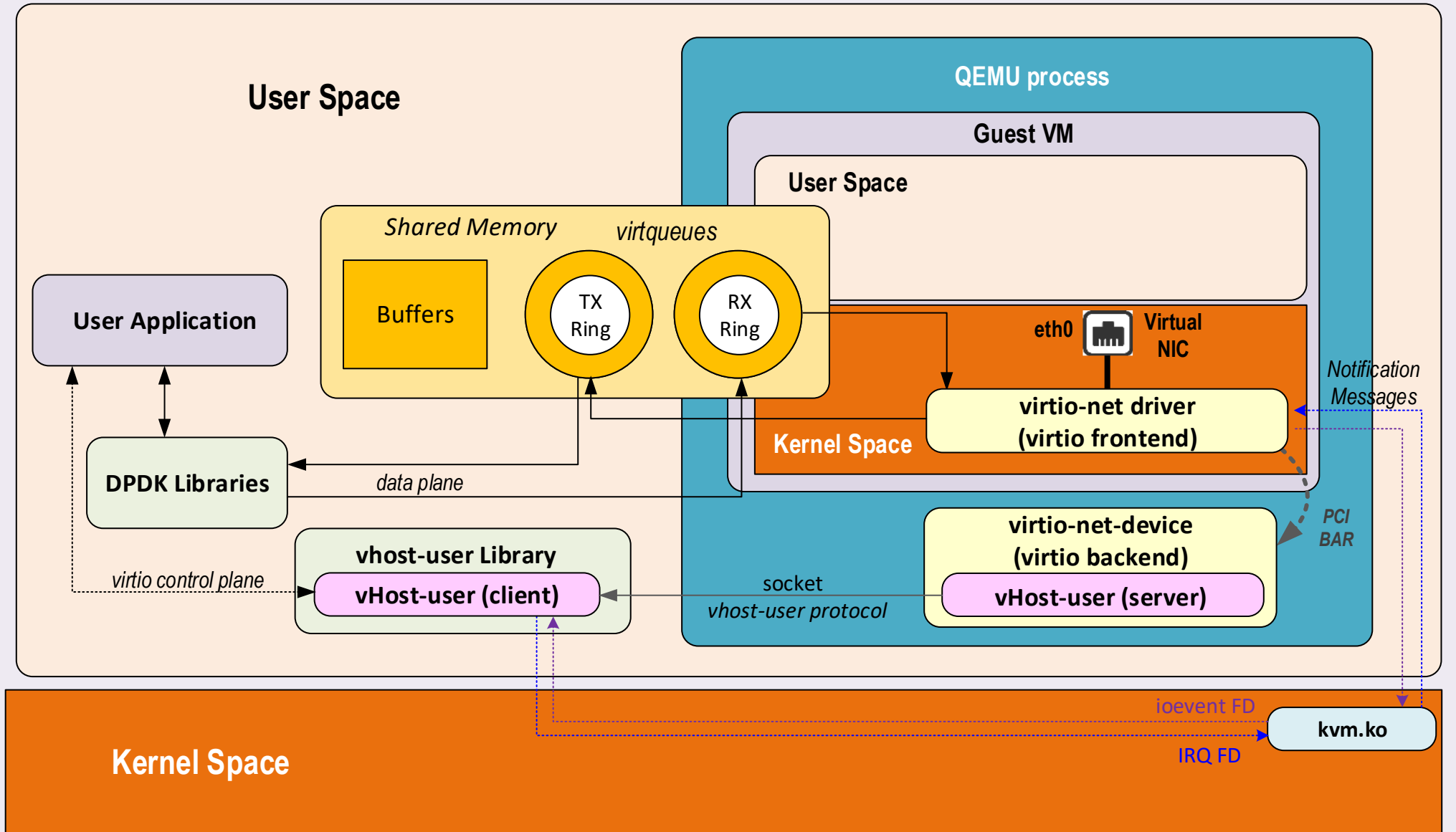


Title: vHost Net

version: 1.0

date: 04/06/2020

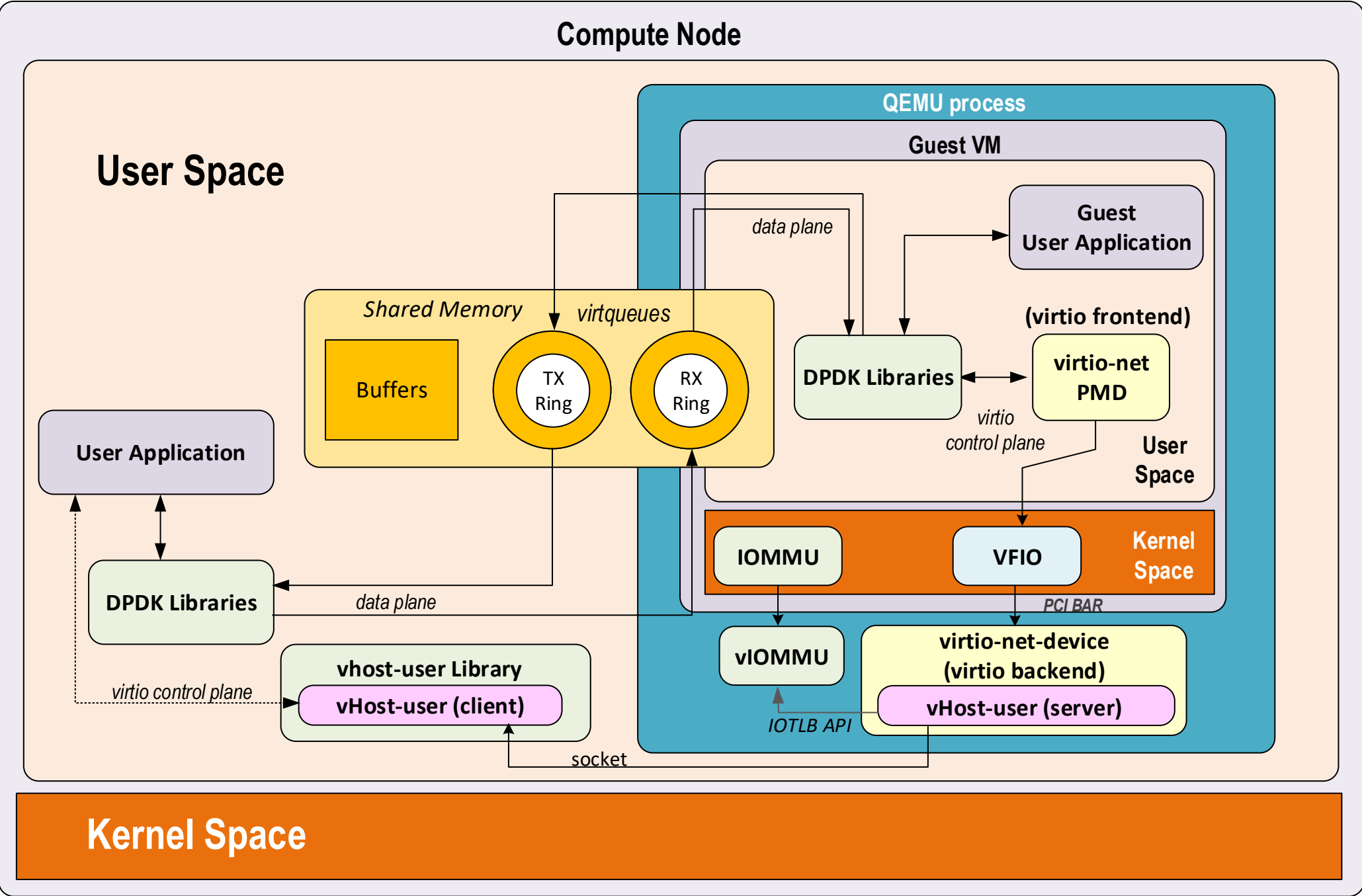
Compute Node



Title: vHost User

version: 1.0

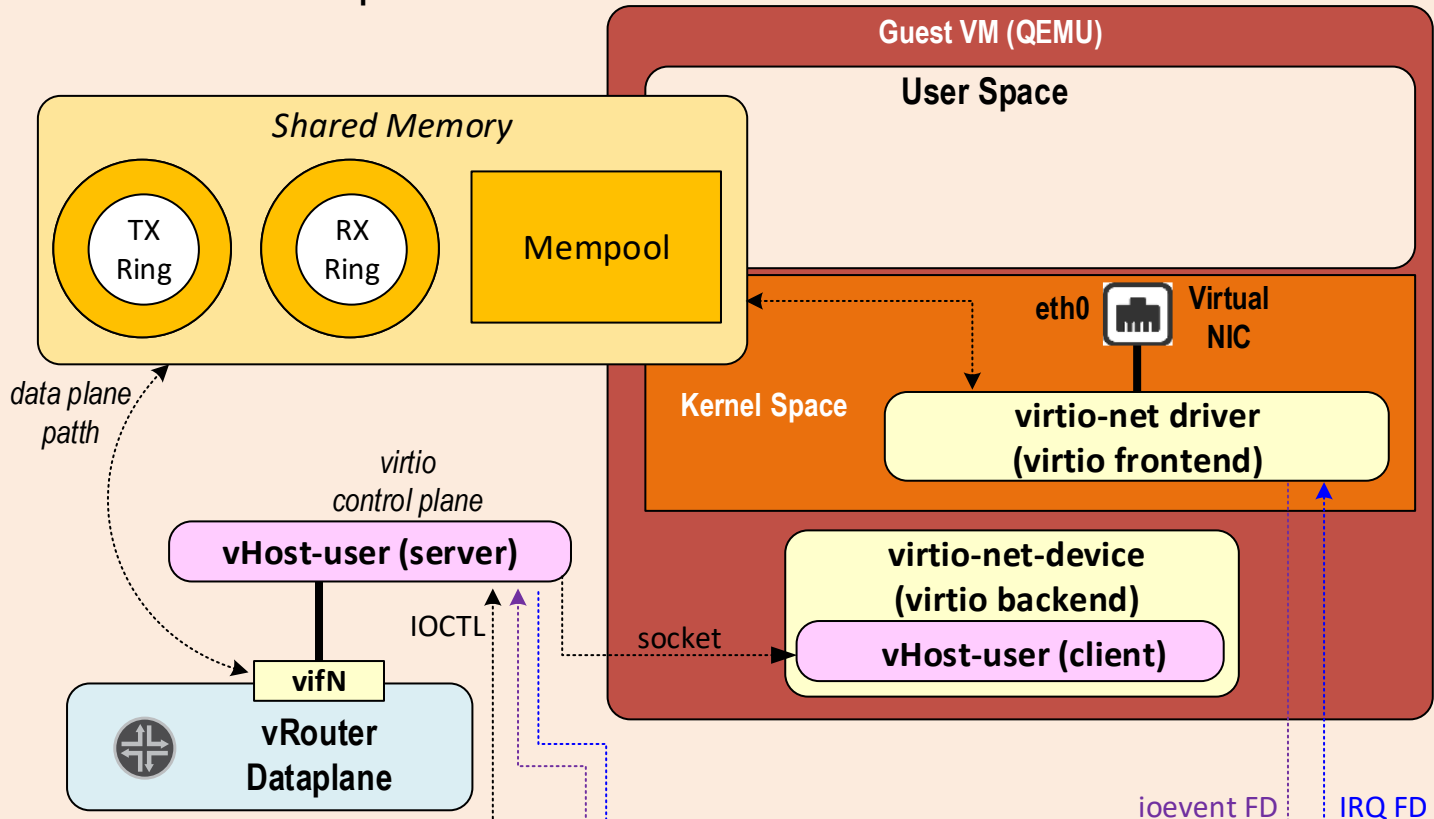
date: 04/06/2020



Title: VirtIO PMD (full DPDK)	
version: 1.0	date: 04/06/2020

Compute Node

User Space

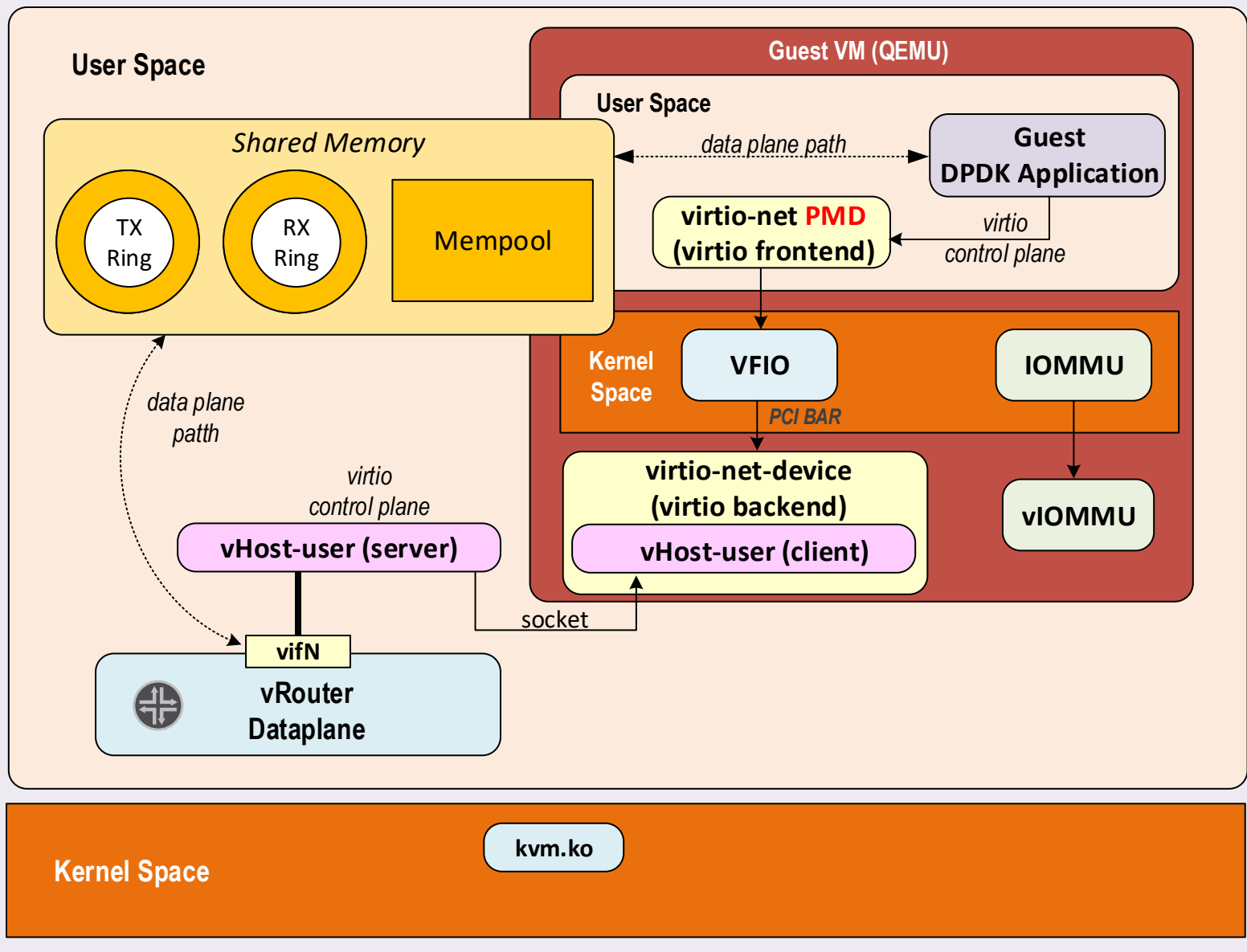


VirtIO details (Kernel App)

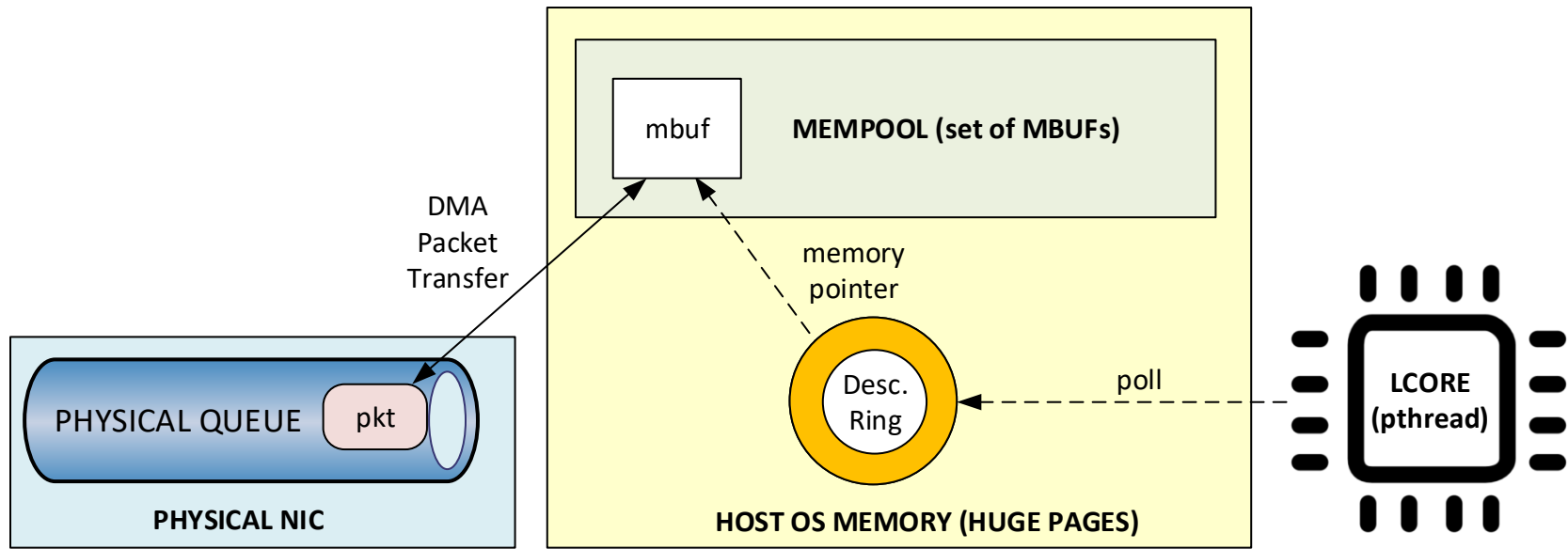
version: 1.0

date: 04/06/2020

Compute Node



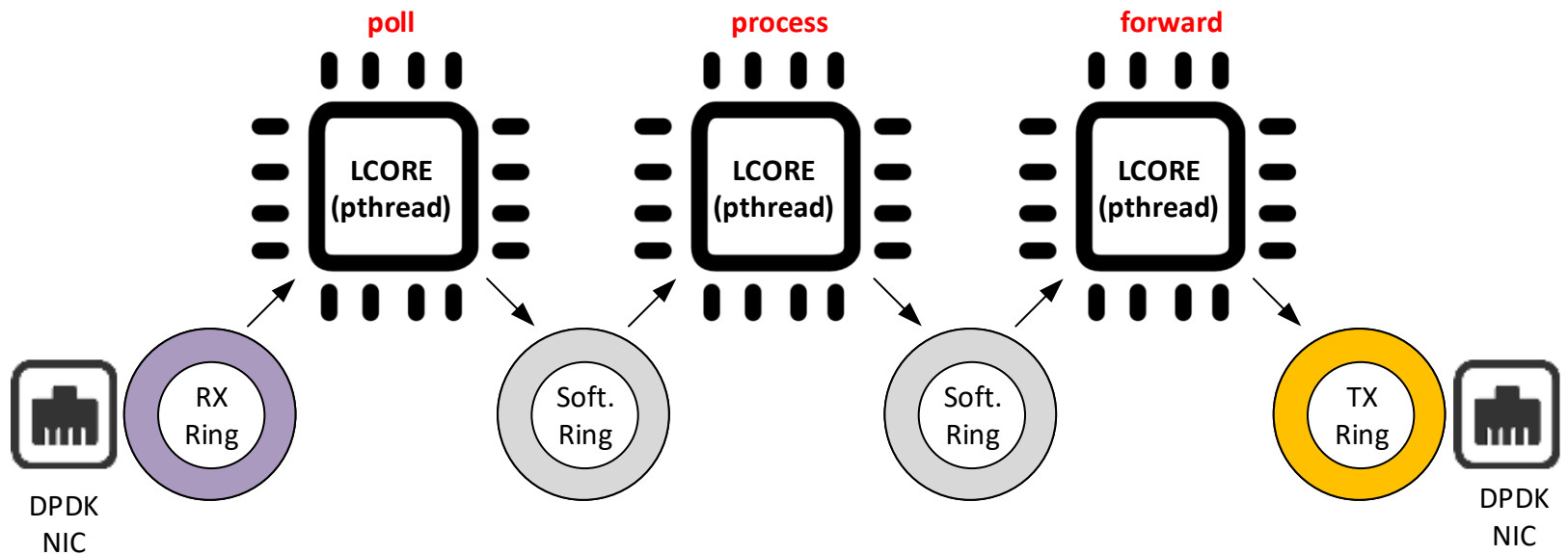
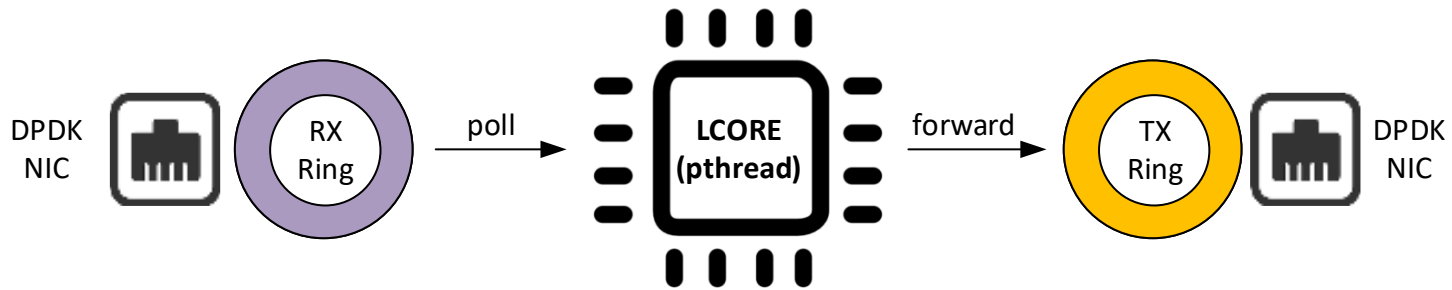
VirtIO details (DPDK App)	
version: 1.0	date: 04/06/2020



Title: DPDK High Level Components

version: 1.0

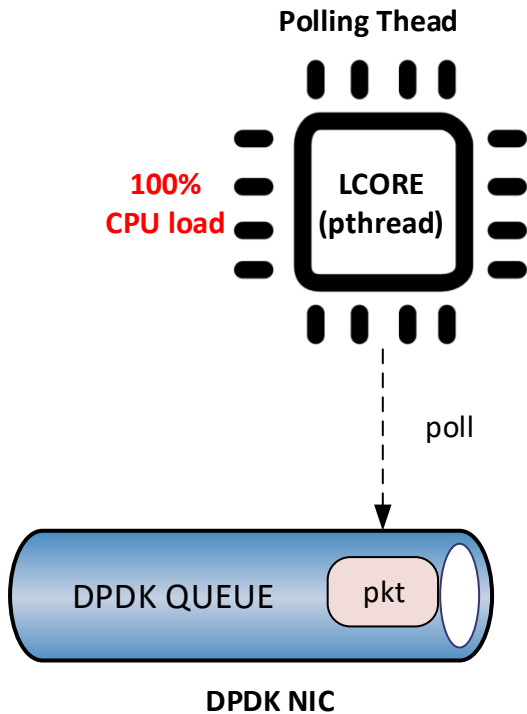
date: 02/06/2020



Title: DPK Packets processing models

version: 1.0

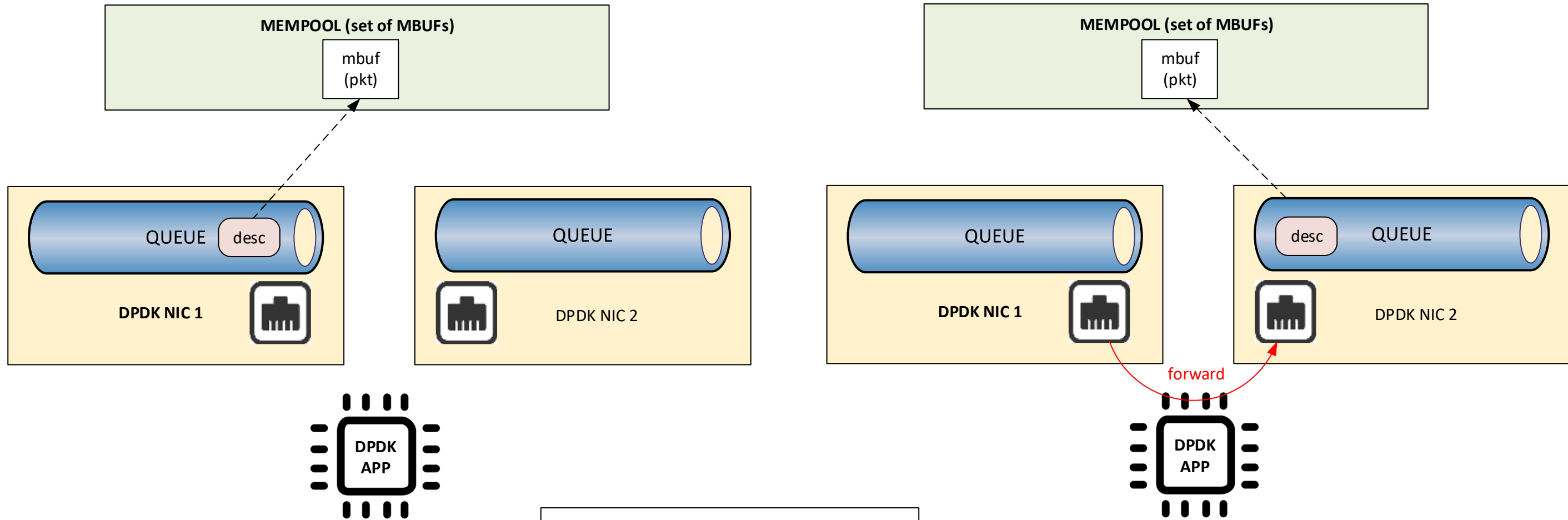
date: 02/06/2020



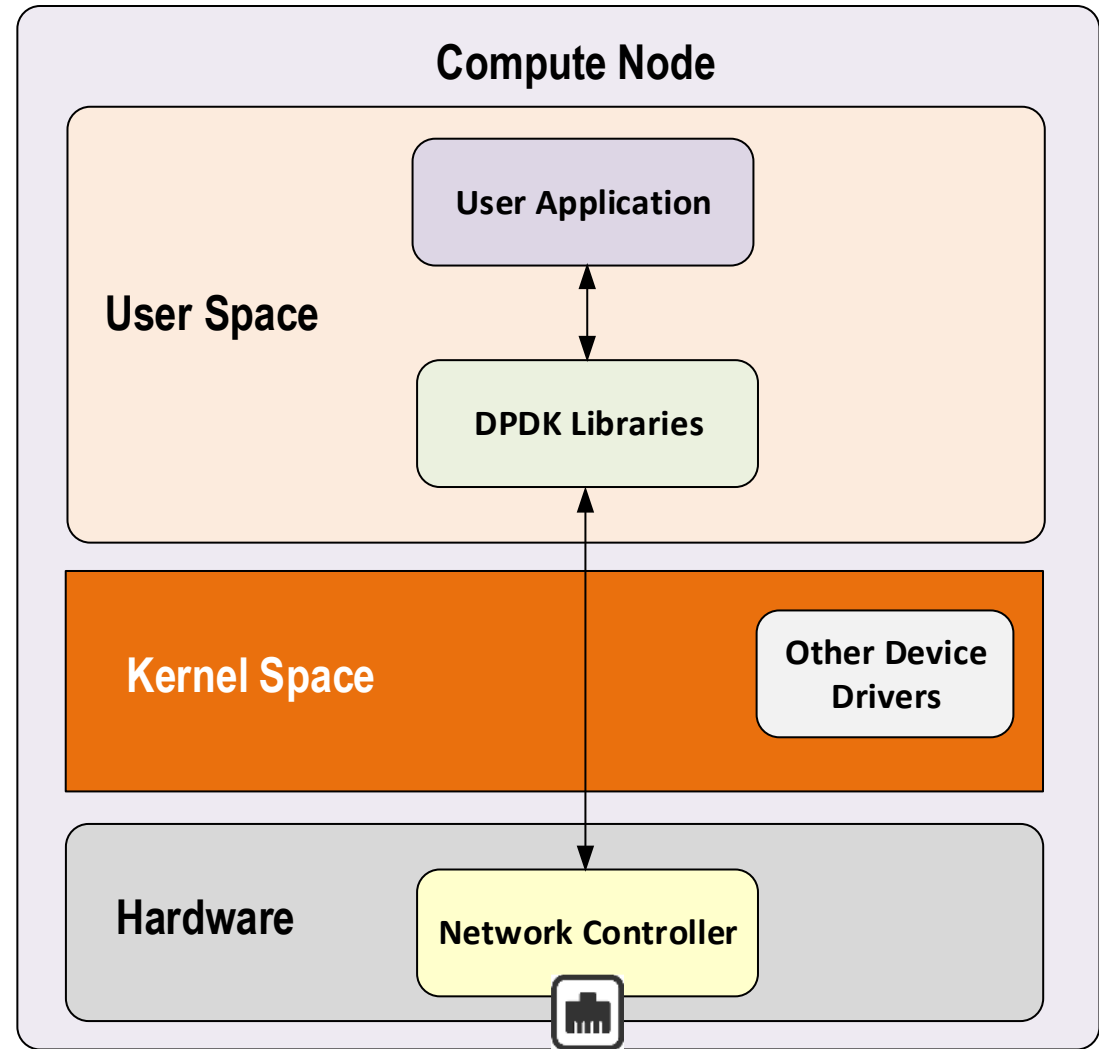
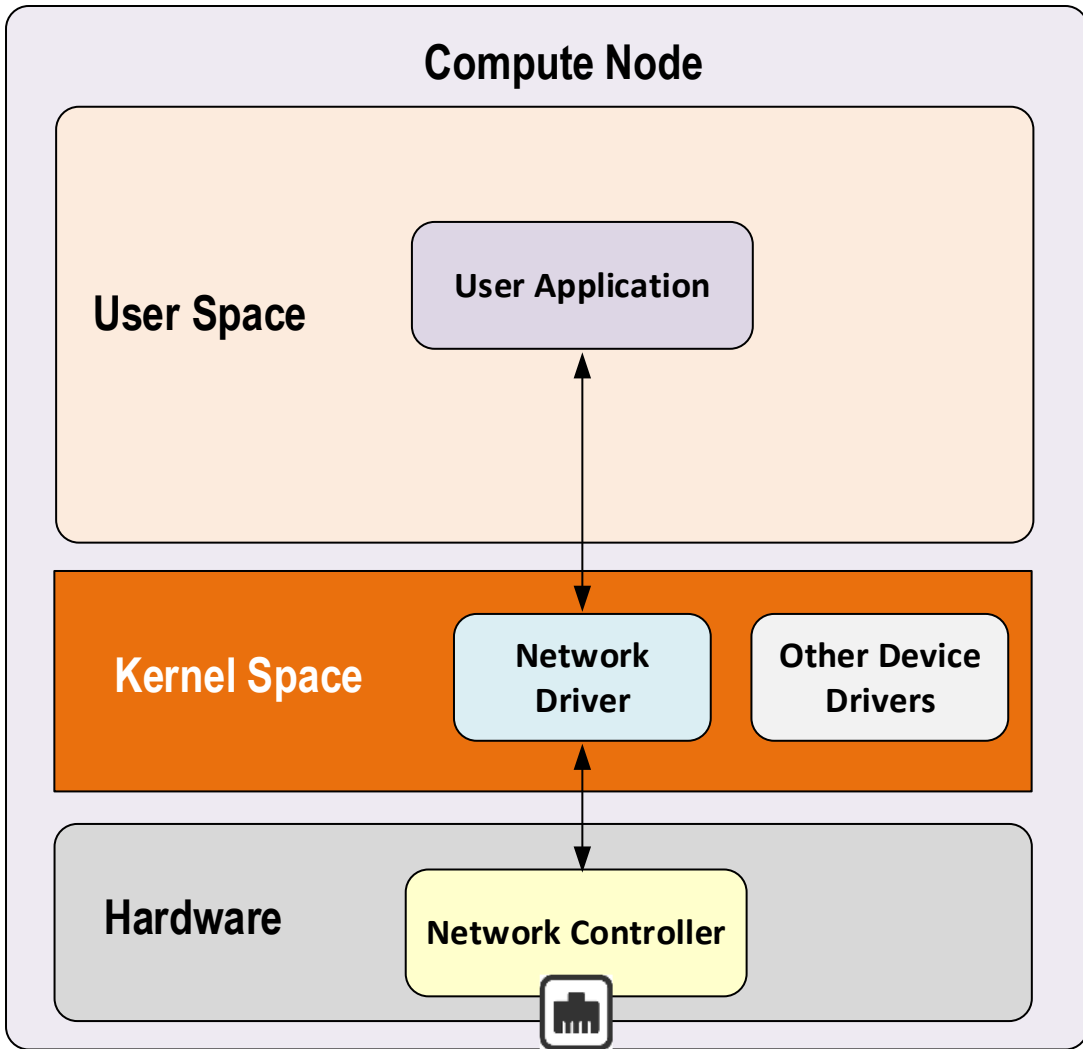
Title: DPDK polling

version: 1.0

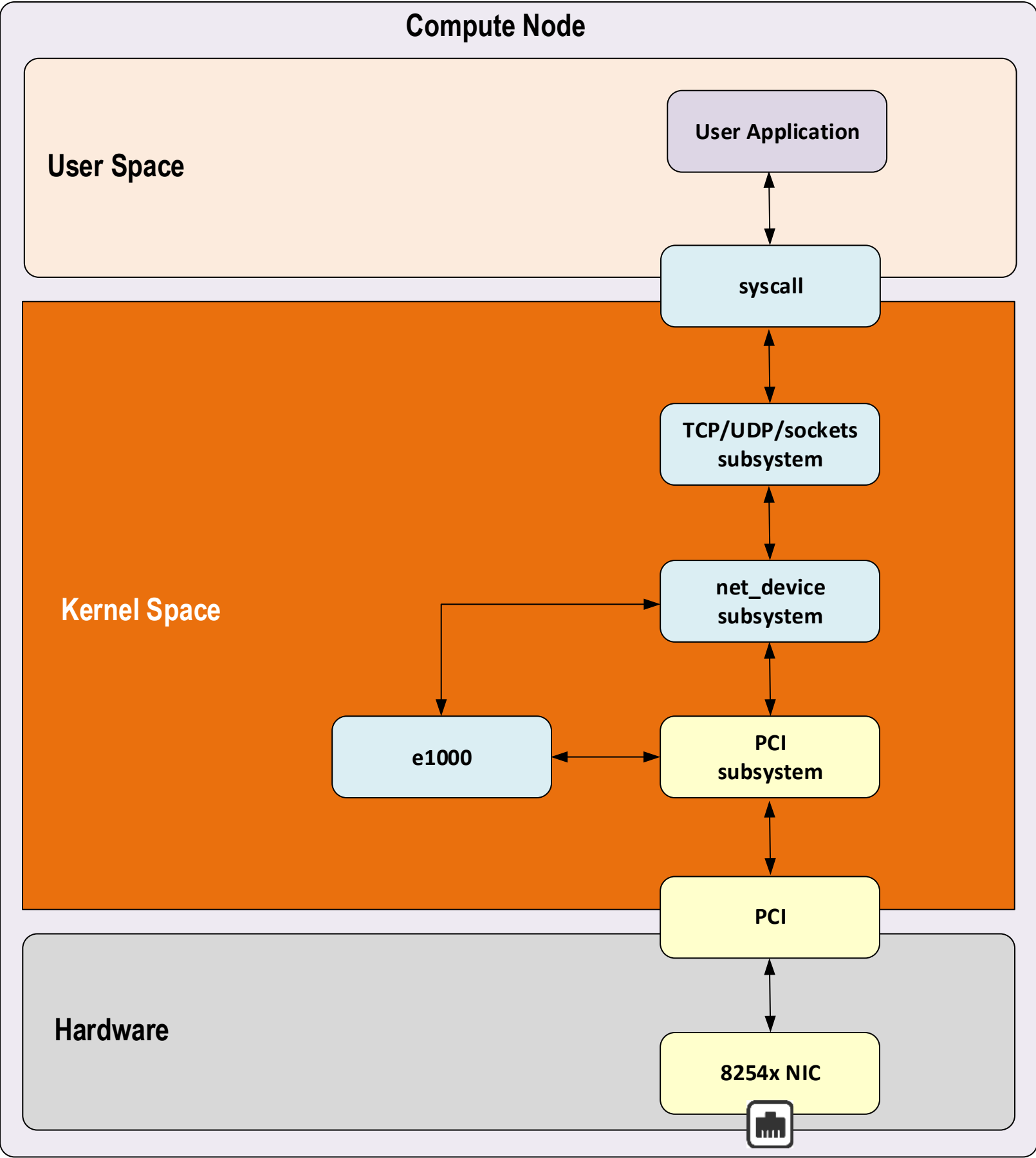
date: 02/06/2020



Title: DPDK Packet Forwarding	
version: 1.0	date: 03/06/2020



Title: DPDK versus NIC Kernel Overview	
version: 1.0	date: 30/05/2020



Title: NIC Kernel Driver	
version: 1.0	date: 30/05/2020

Compute Node

User Space

User Application

**Socket
API**

Kernel Space

Driver

**Ring
buffers**

DMA transfer

Hardware

**RX/TX
physical queues**



Title: NIC Kernel Driver – Packet Processing

version: 1.0

date: 30/05/2020

Compute Node

User Space

User Application

ioctl()
(Socket API)

Kernel Space

syscalls

Virtual File
System (VFS)

Kernel API
(copy_for_user,
io_write)

Hardware

Configuration
Registers



Title: NIC Kernel Driver – Configuration

version: 1.0

date: 30/05/2020

Compute Node

User Space

User Application

DPDK
API

Ring
buffers

DMA transfer

Kernel Space

user space
device enabler

DMA transfer

Hardware

RX/TX
physical queues



Title: NIC PMD Driver – Packet Processing

version: 1.0

date: 02/06/2020

Compute Node

User Space

User Application

DPDK API

PMD

Memory
Mapped
Registers

Kernel Space

user space
device enabler

Hardware

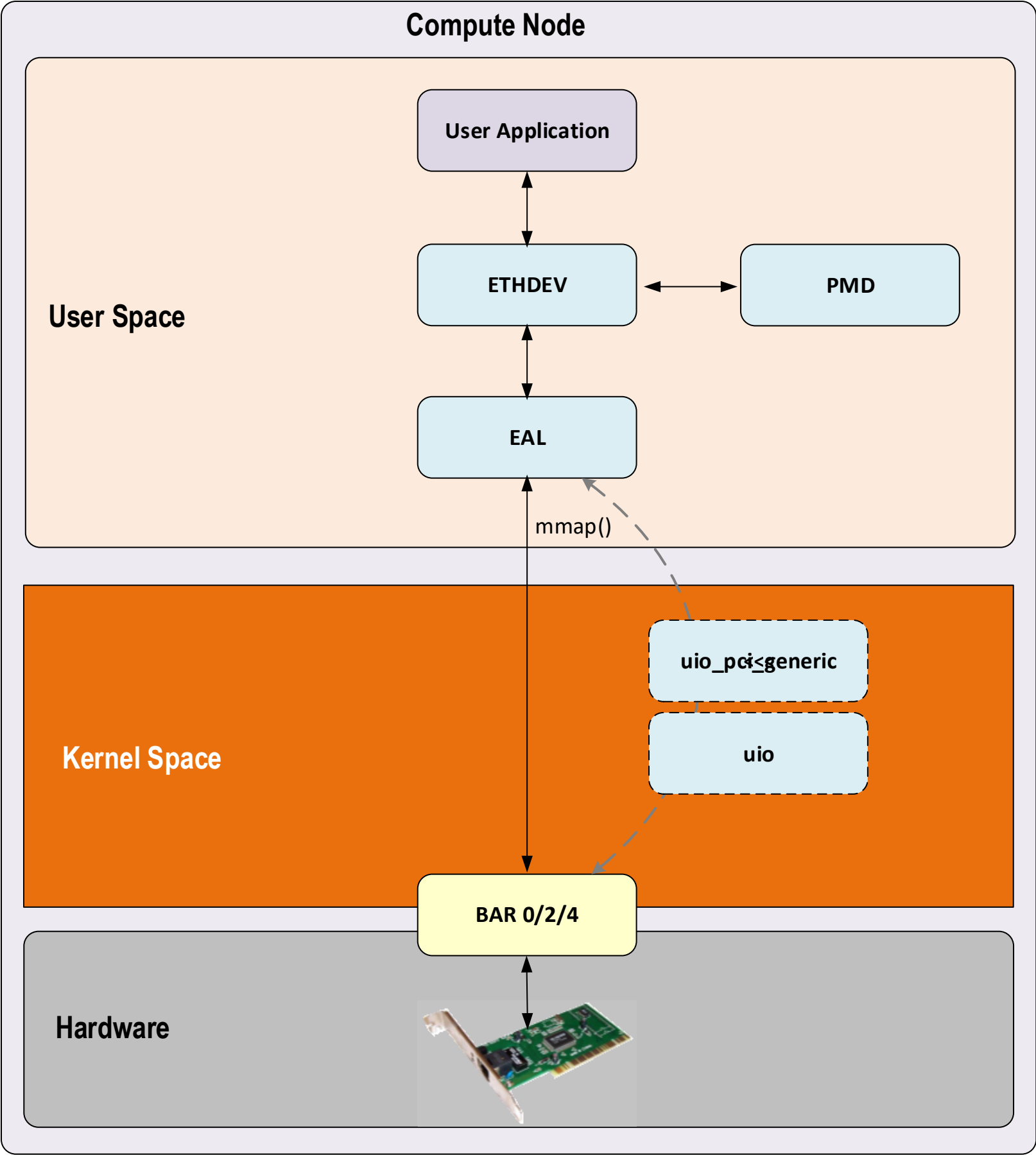
Configuration
Registers



Title: NIC PMD Driver – Configuration

version: 1.0

date: 02/06/2020



Title: DPDK NIC Configuration	
version: 1.0	date: 02/06/2020

Compute Node

User Space

Guest VM

User Space

User Application

DPDK
PCI NIC

Read/Write

Assign

Kernel Space

VFIO

viOMMU

Virtual
PCI NIC

Emulated
Hardware



Assign

Huge Pages Memory

Guest
huge pages

map

NIC
registers and queues

map

Kernel Space

VFIO

IOMMU

Physical
PCI NIC

Hardware



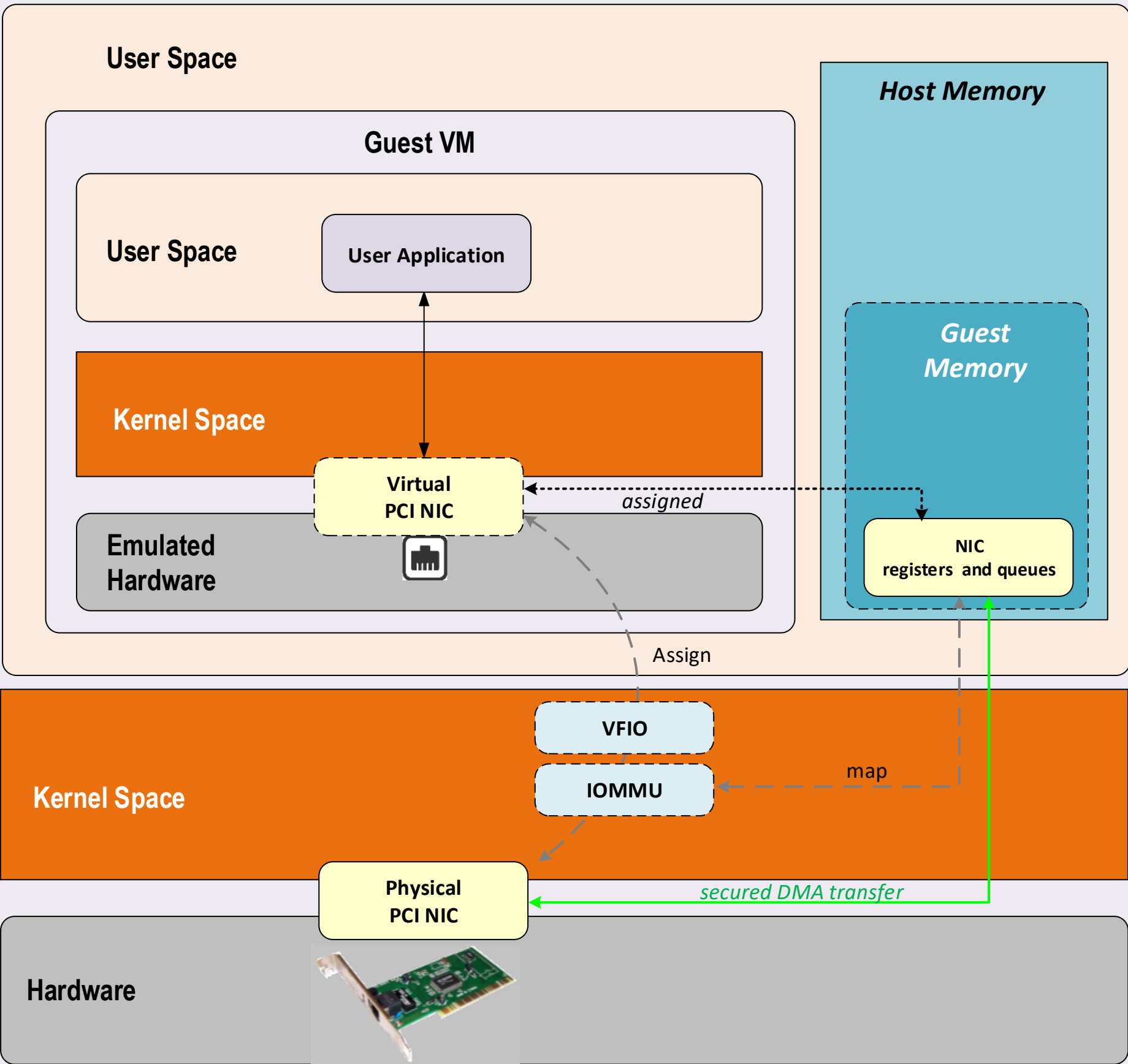
secured DMA transfer

Title: DPDK VFIO and IOMMU

version: 1.0

date: 02/06/2020

Compute Node



Title: VFIO device assignment

version: 1.0

date: 02/06/2020

Compute Node

User Space

Guest VM

User Space

User Application

Kernel Space

Virtual
PCI NIC

Emulated
Hardware

QEMU process

LibVirt



KVM

Kernel Space

Physical
PCI NIC

Hardware



Title: QEMU-KVM-LibVirt

version: 1.0

date: 02/06/2020

Compute Node

User Space

Guest VM

User Space

User Application

DPDK
PCI NIC

Read/Write

Assign

Kernel Space

VFIO

viOMMU

Virtual
PCI NIC

emulated DMA transfer

Emulated
Hardware

Huge Pages Memory

*Guest
huge pages*

map

NIC
registers and queues

Kernel Space

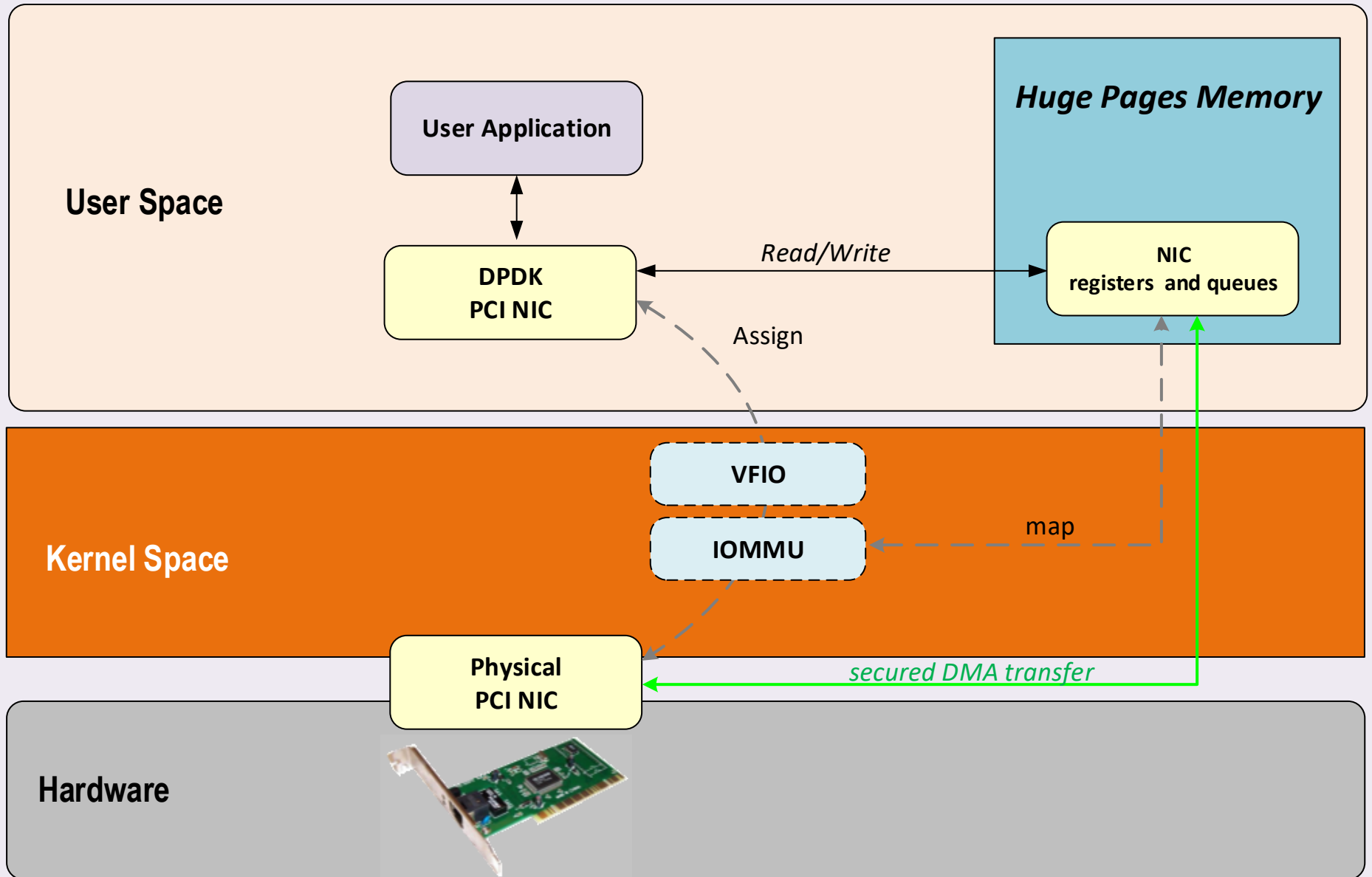
Hardware

Title: DPDK VFIO and emulated NIC

version: 1.0

date: 02/06/2020

Compute Node



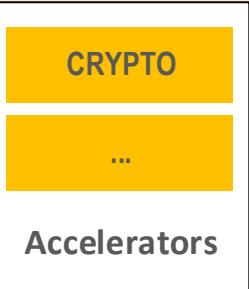
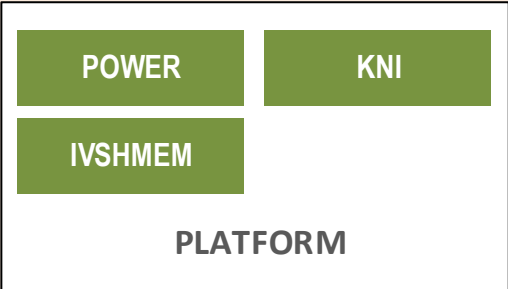
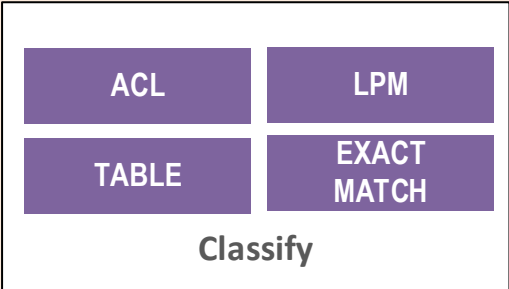
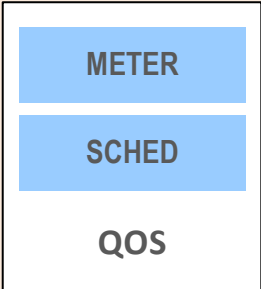
Title: DPDK VFIO and physical NIC

version: 1.0

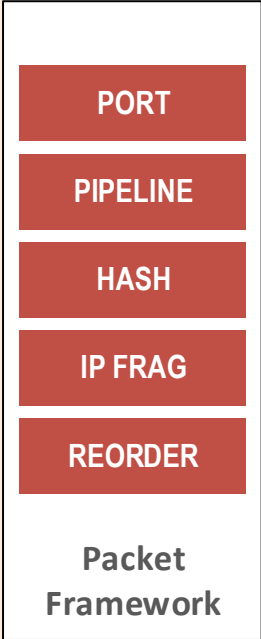
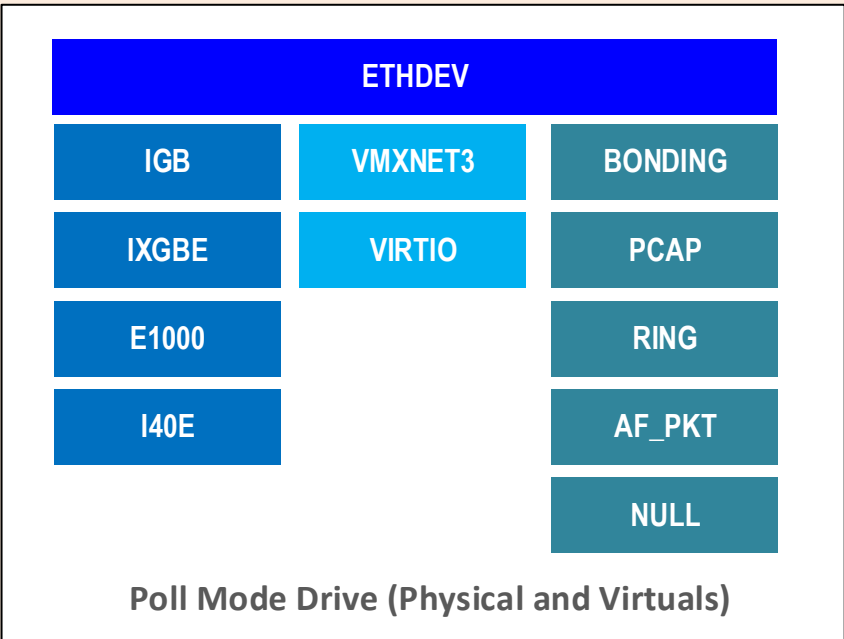
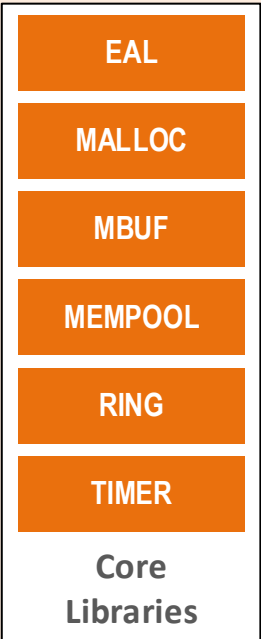
date: 02/06/2020

Compute Node

DPDK Application

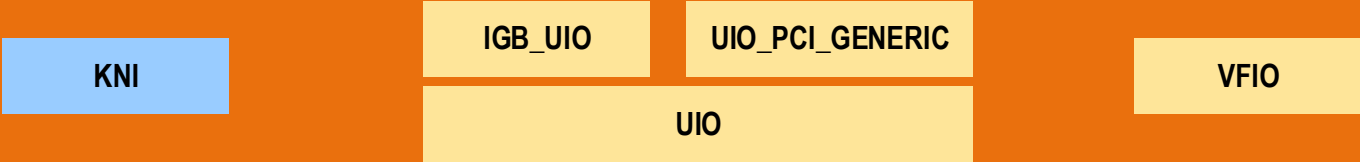


User Space

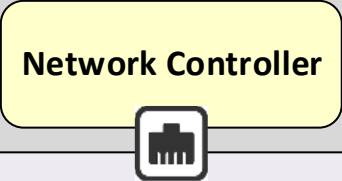


DPDK Library Framework

Kernel Space



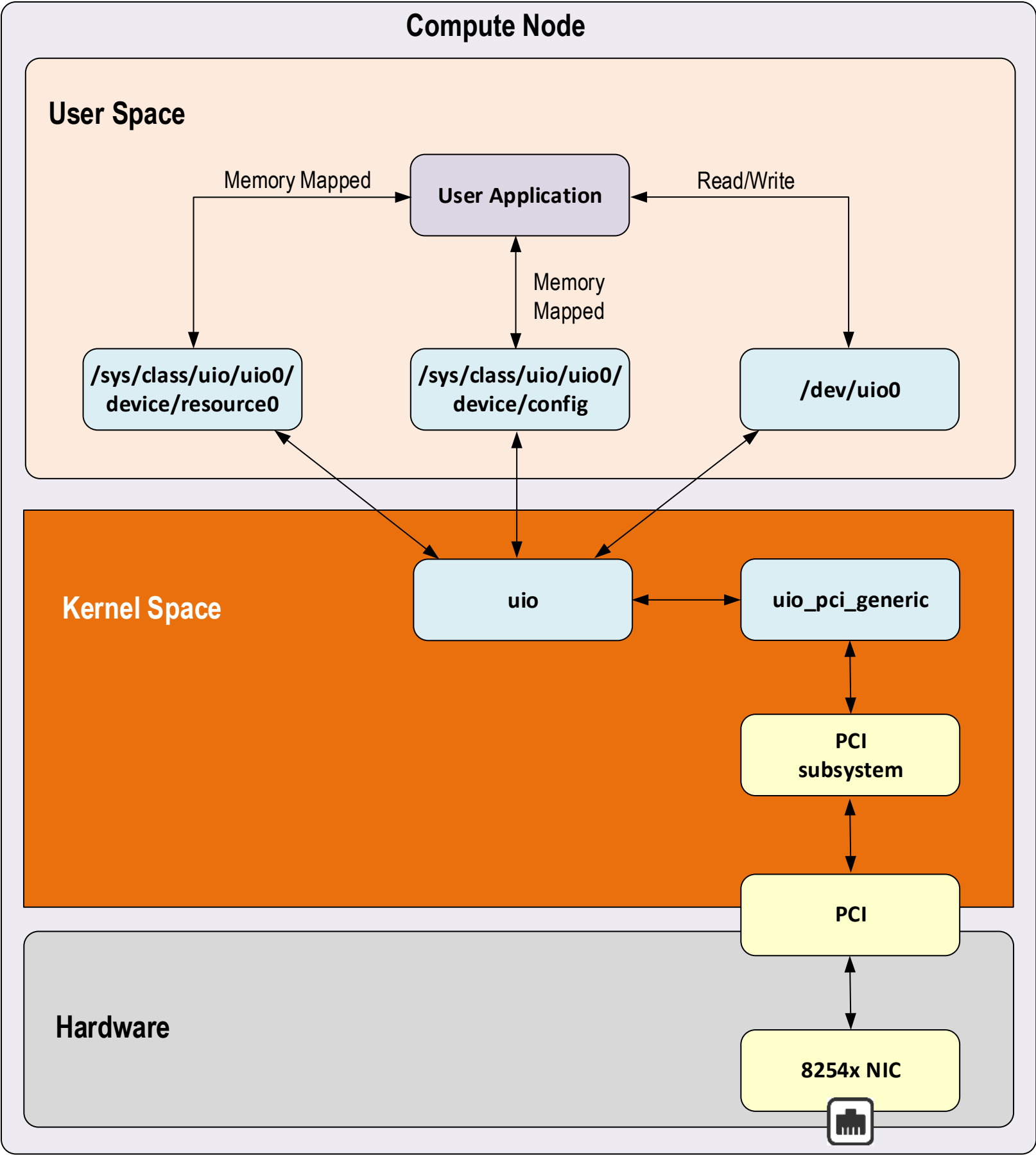
Hardware

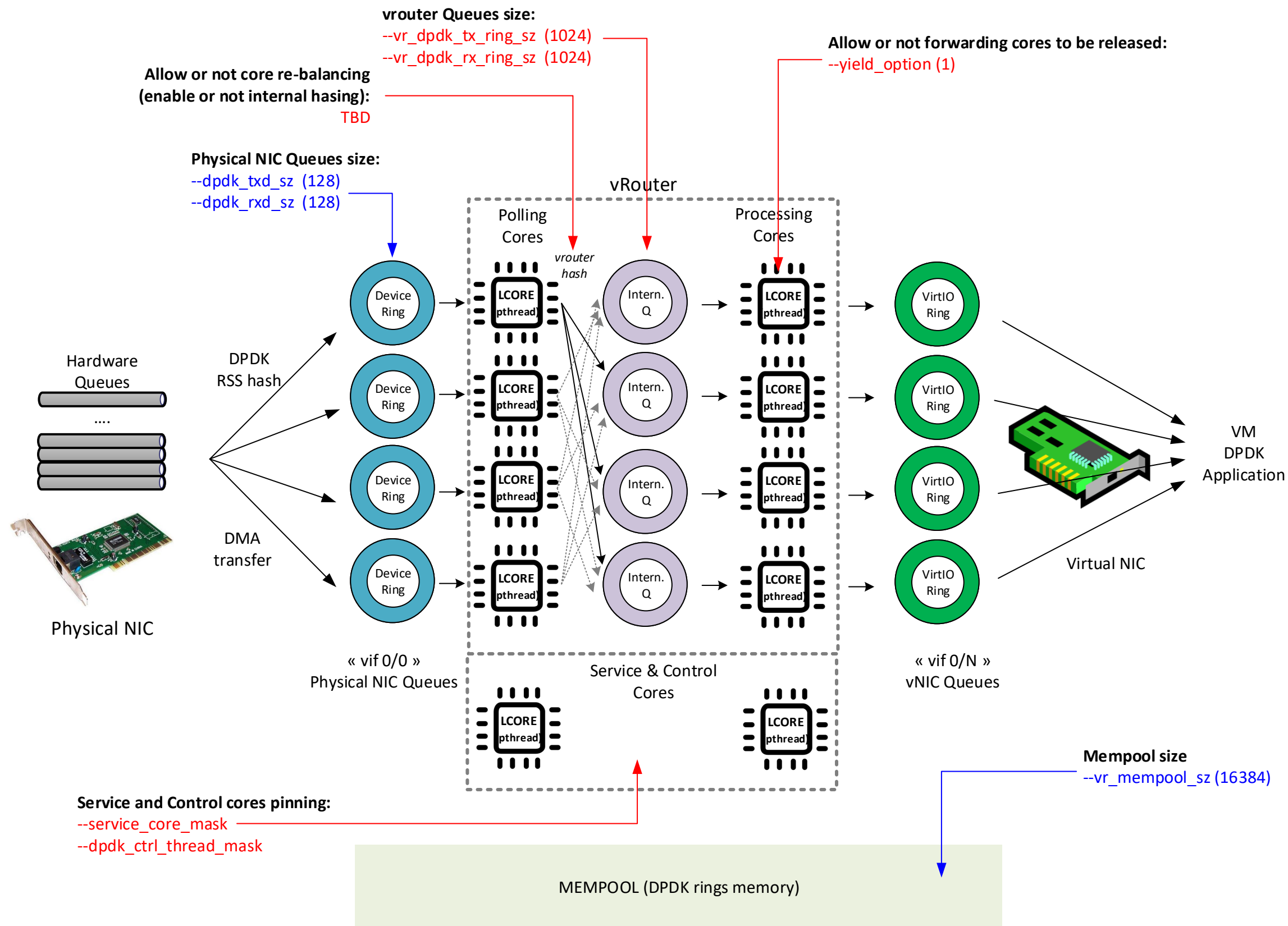


Title: DPDK Library Framework

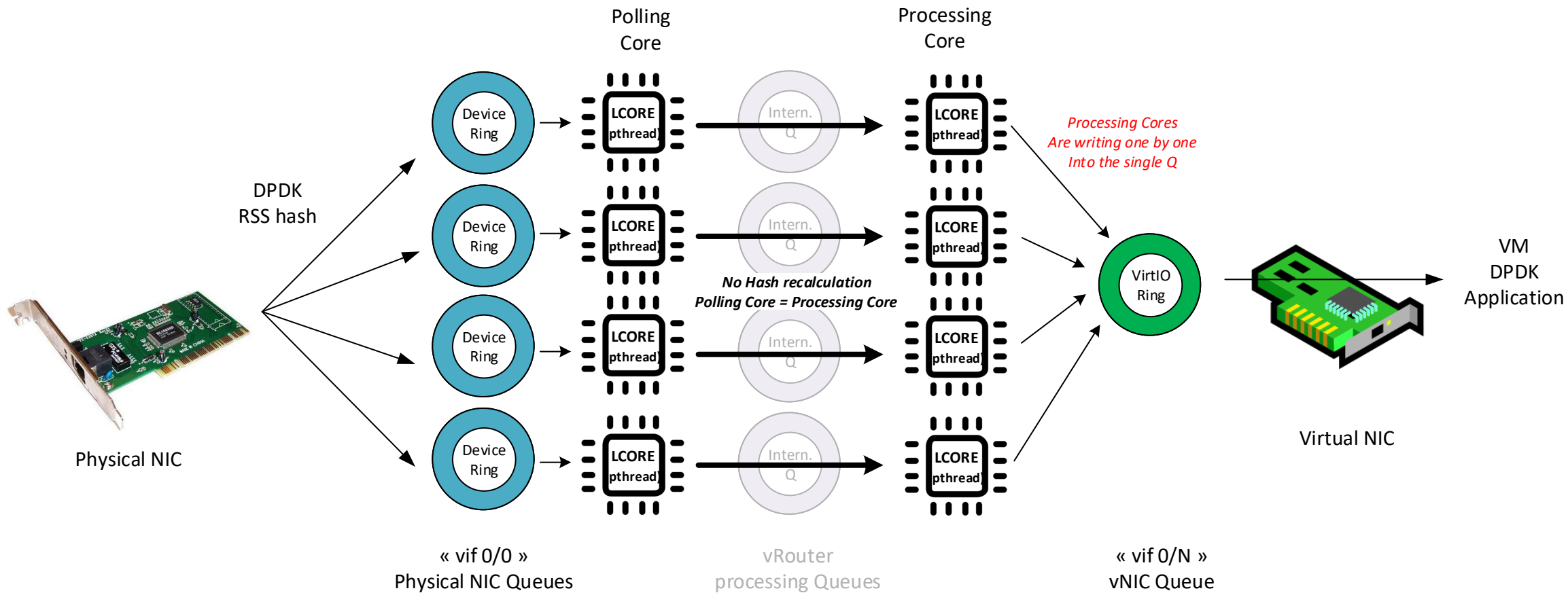
version: 1.0

date: 02/06/2020





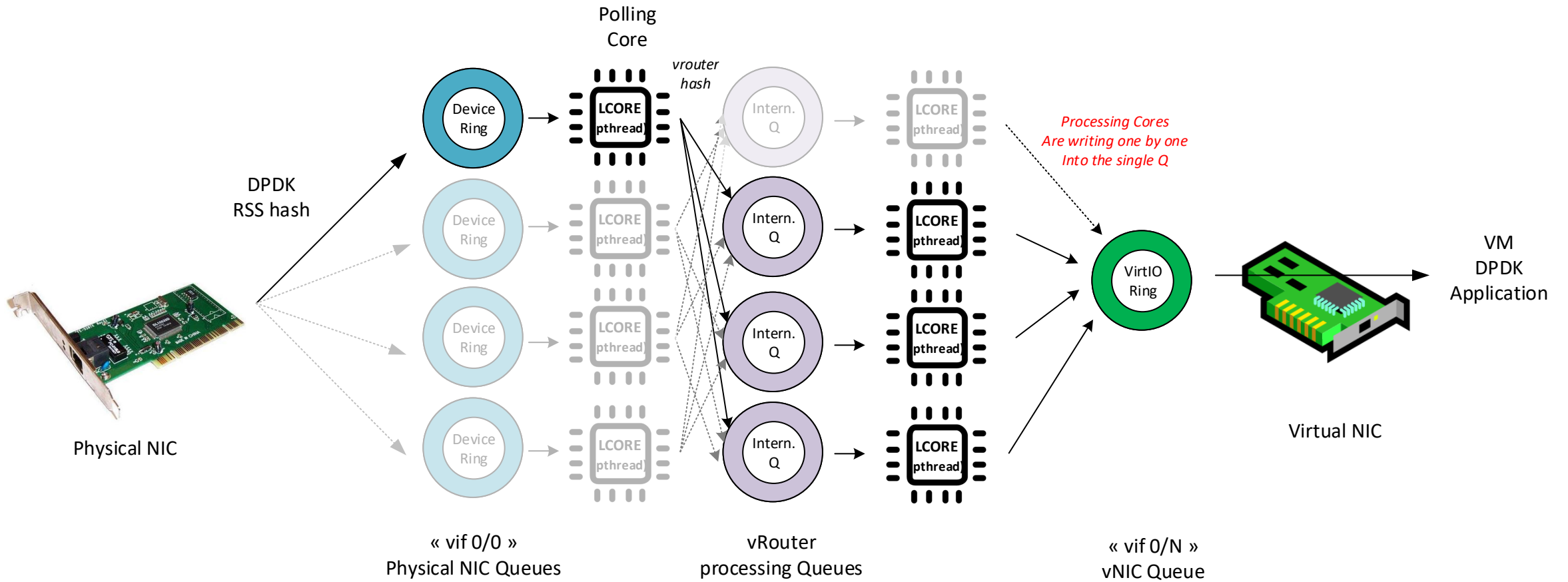
Title: vRouter Architecture	
version: 1.1	date: 22/05/2020



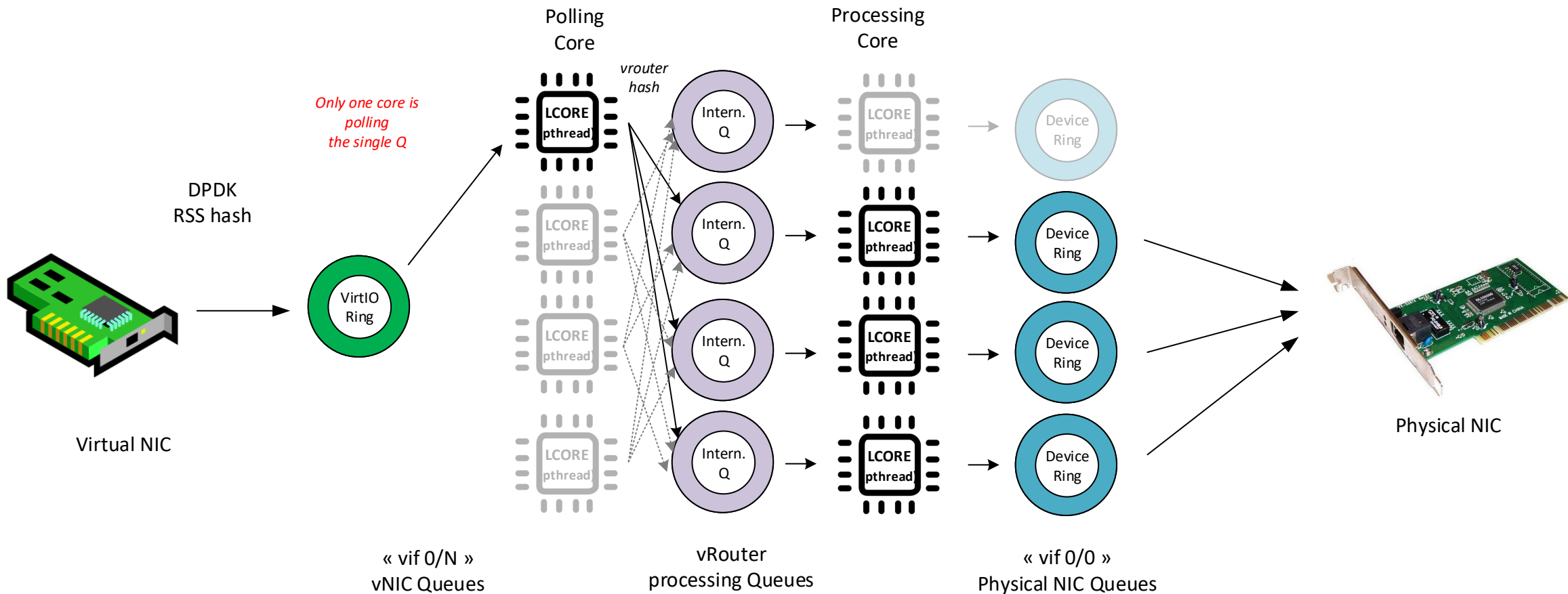
Title: UDP to SingleQ

version: 1.0

date: 25/03/2020



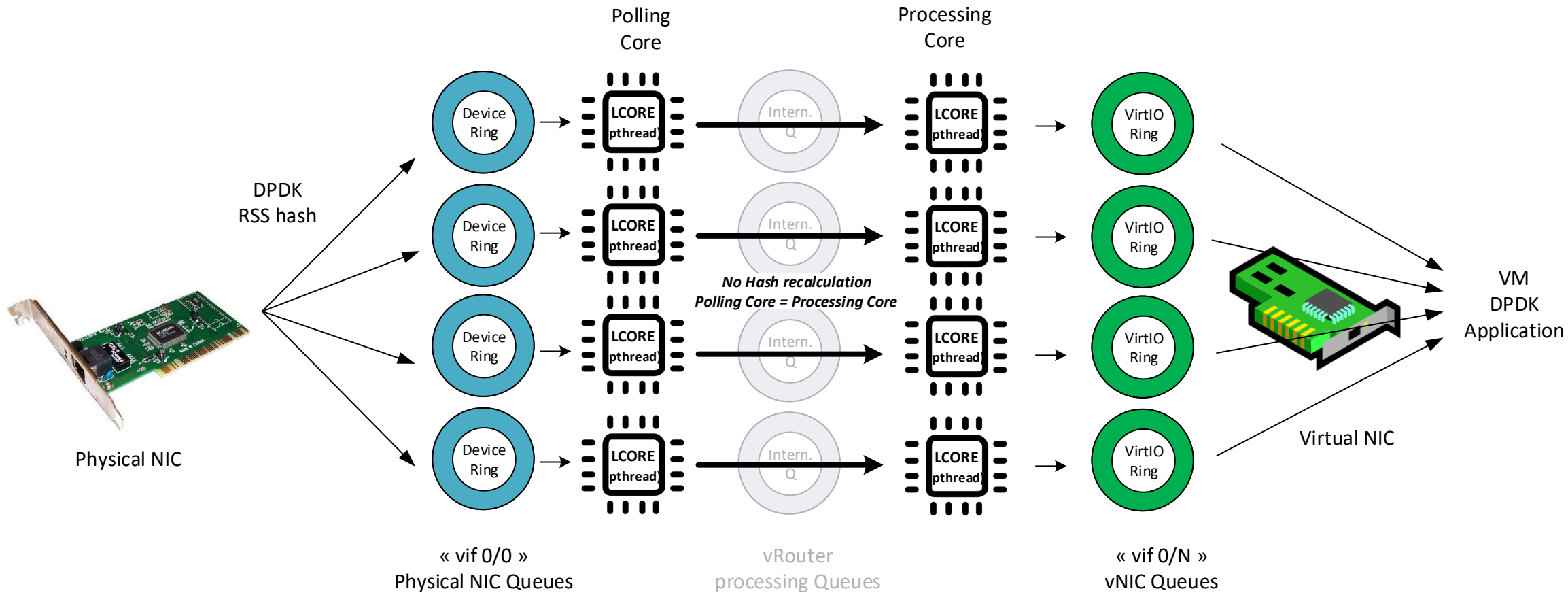
Title: GRE to SingleQ	
version: 1.0	date: 25/03/2020



Title: SingleQ to Underlay

version: 1.0

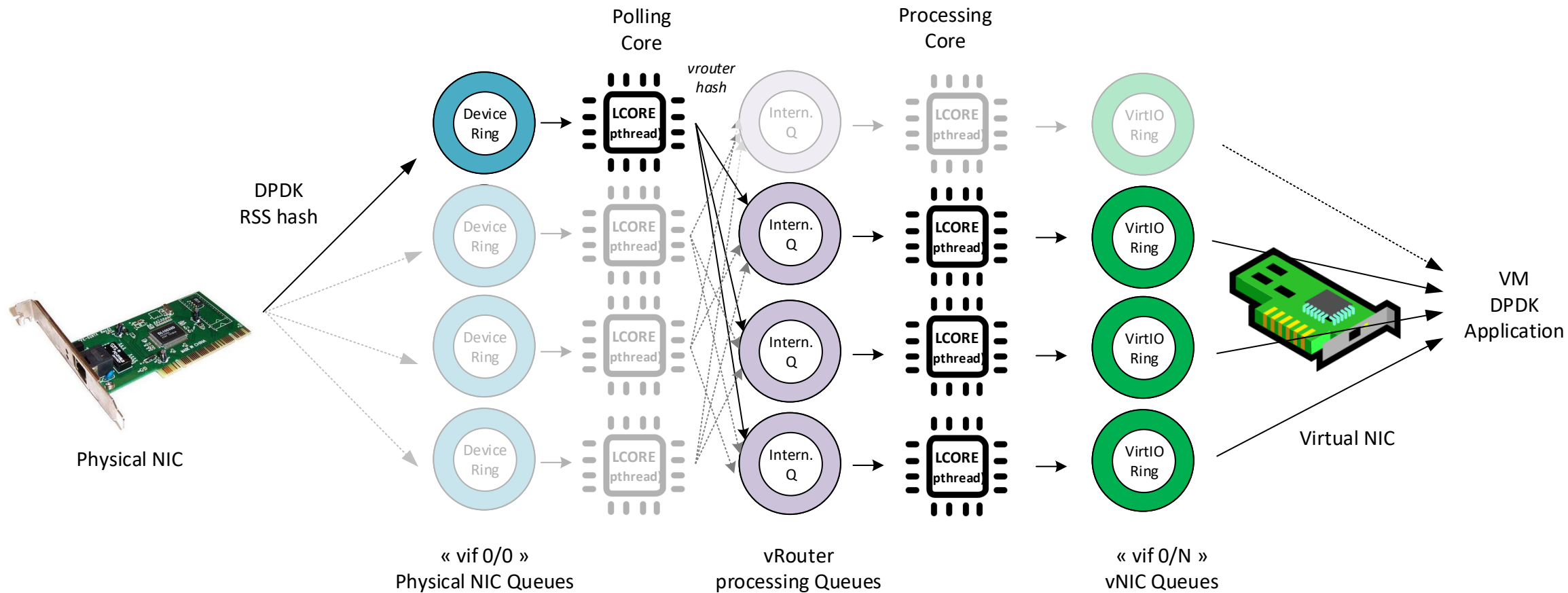
date: 25/03/2020



Title: UDP to MultiQ

version: 1.0

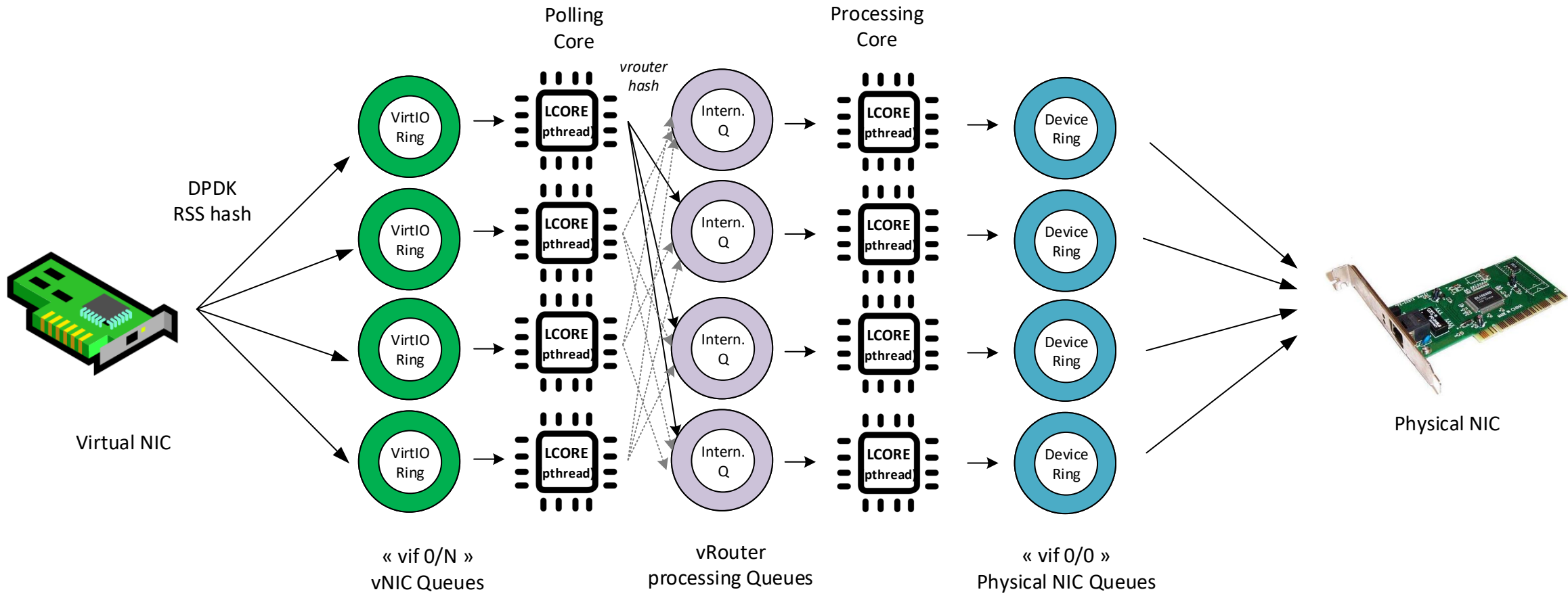
date: 25/03/2020



Title: GRE to MultiQ

version: 1.0

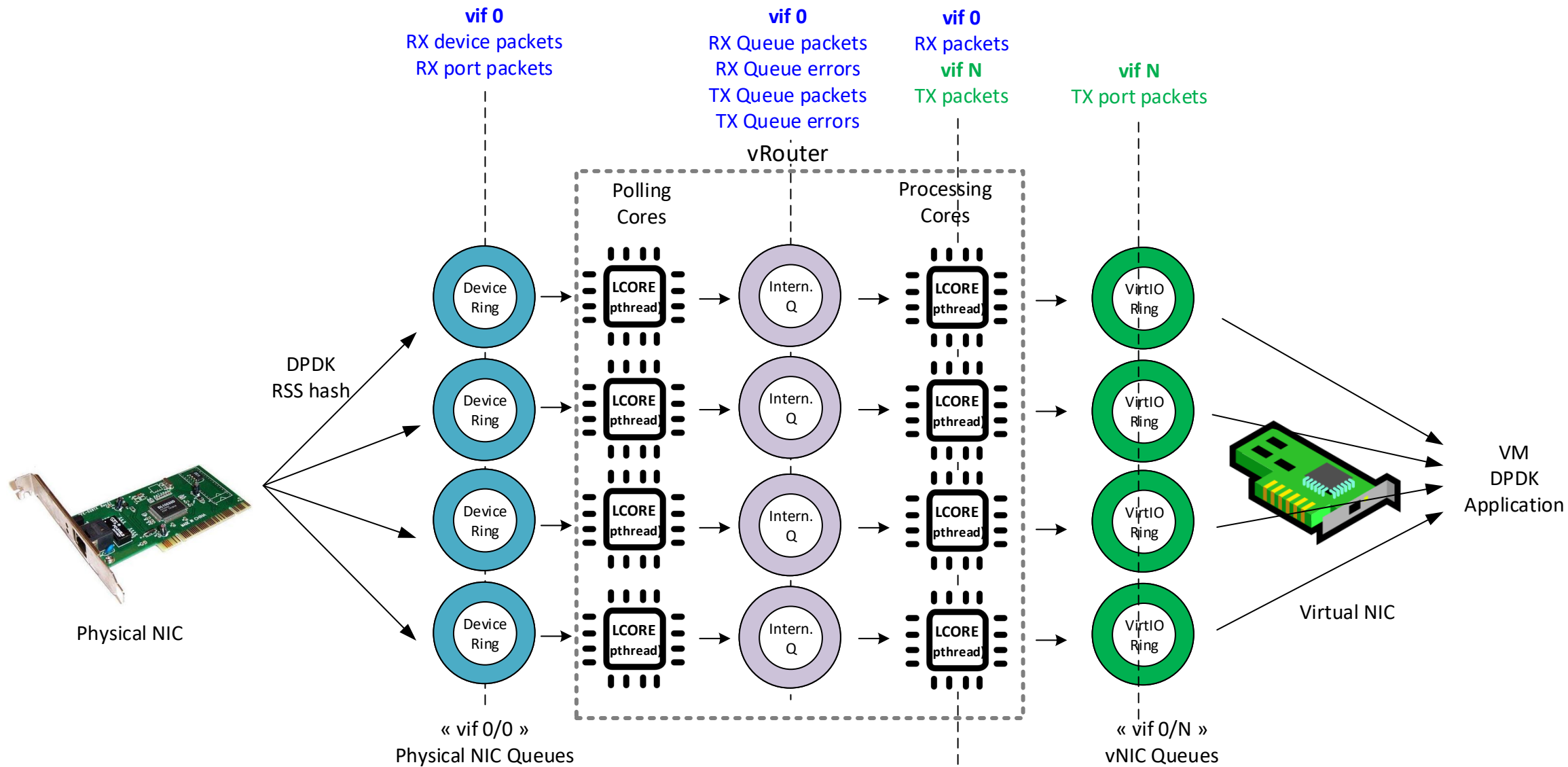
date: 25/03/2020



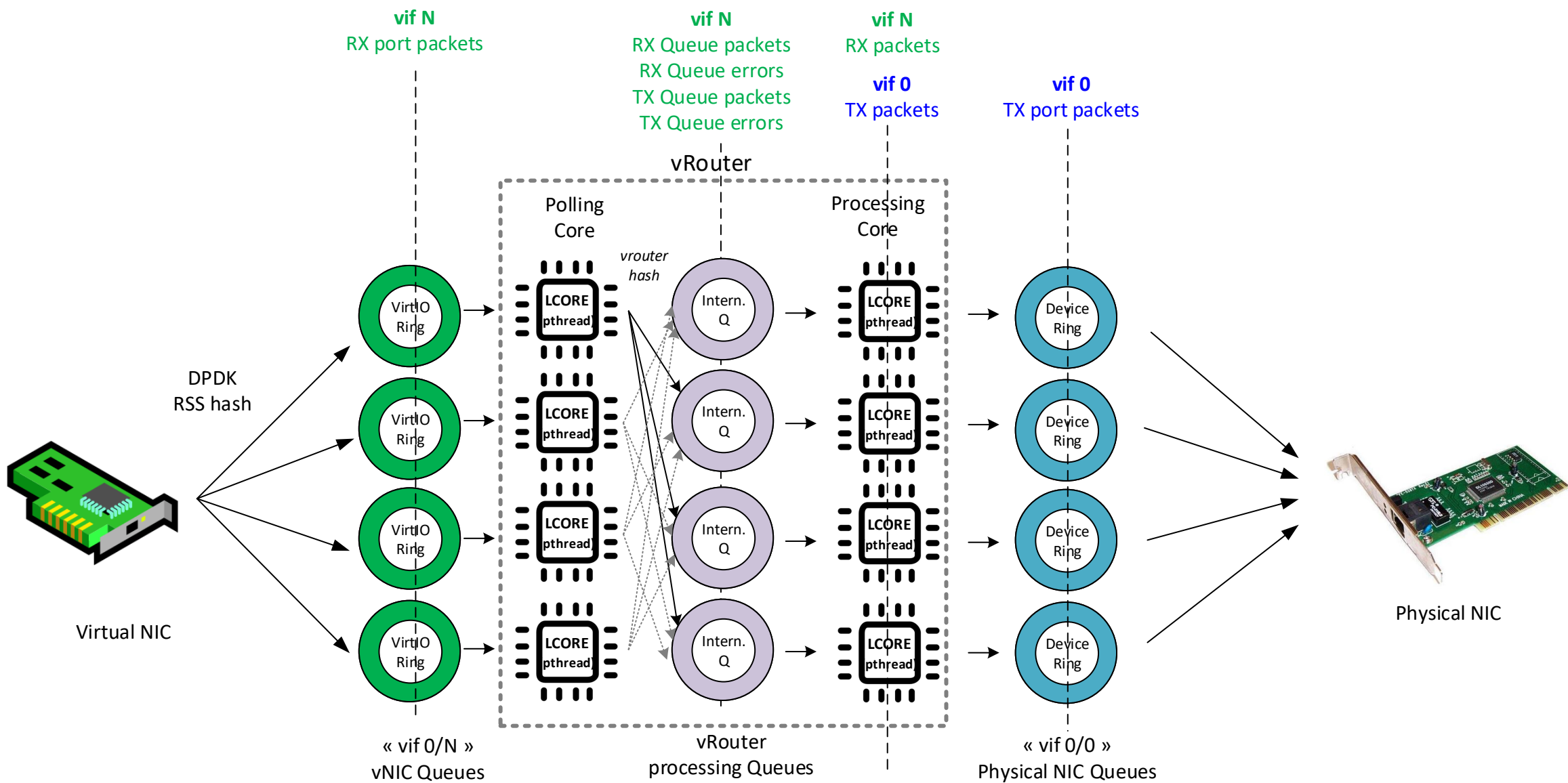
Title: MultiQ to Underlay

version: 1.0

date: 25/03/2020



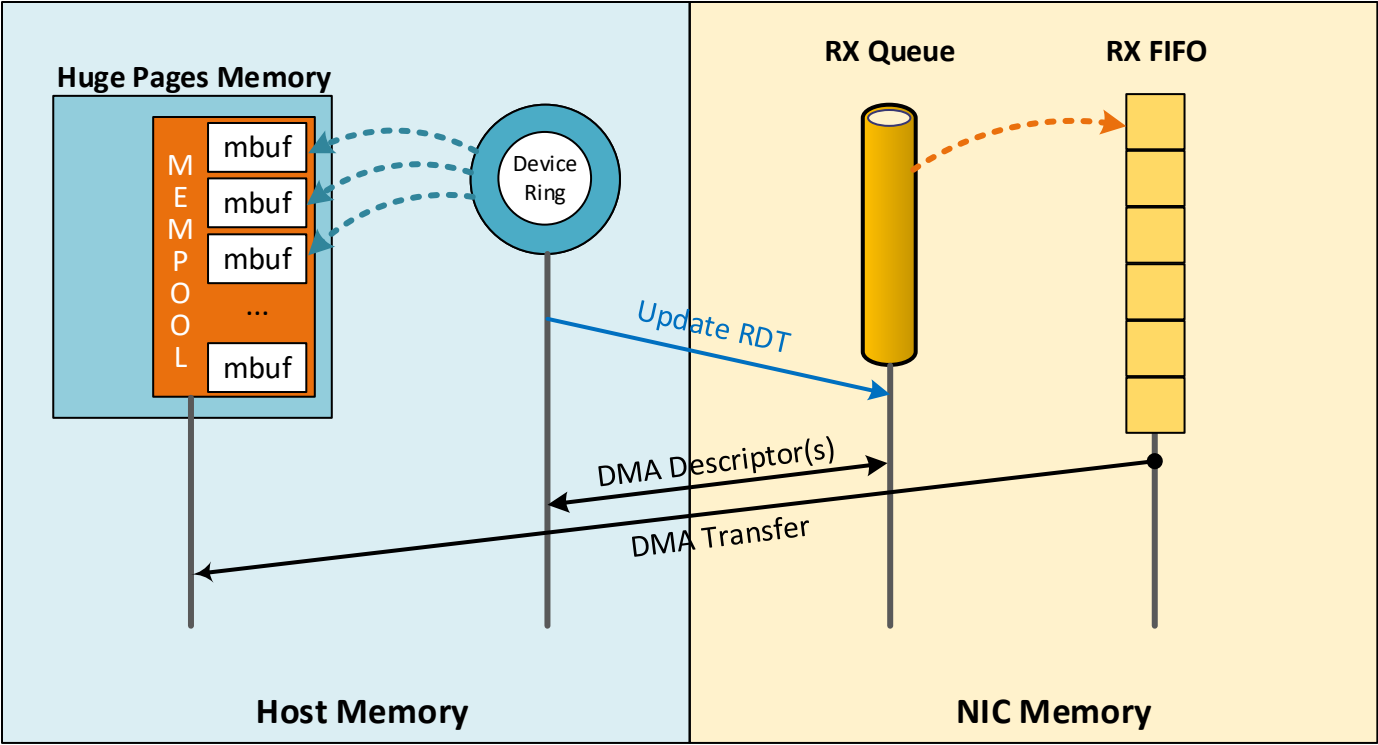
Title: vif counters (phys to virt)	
version: 1.0	date: 25/03/2020



Title: vif counters (virt to phys)

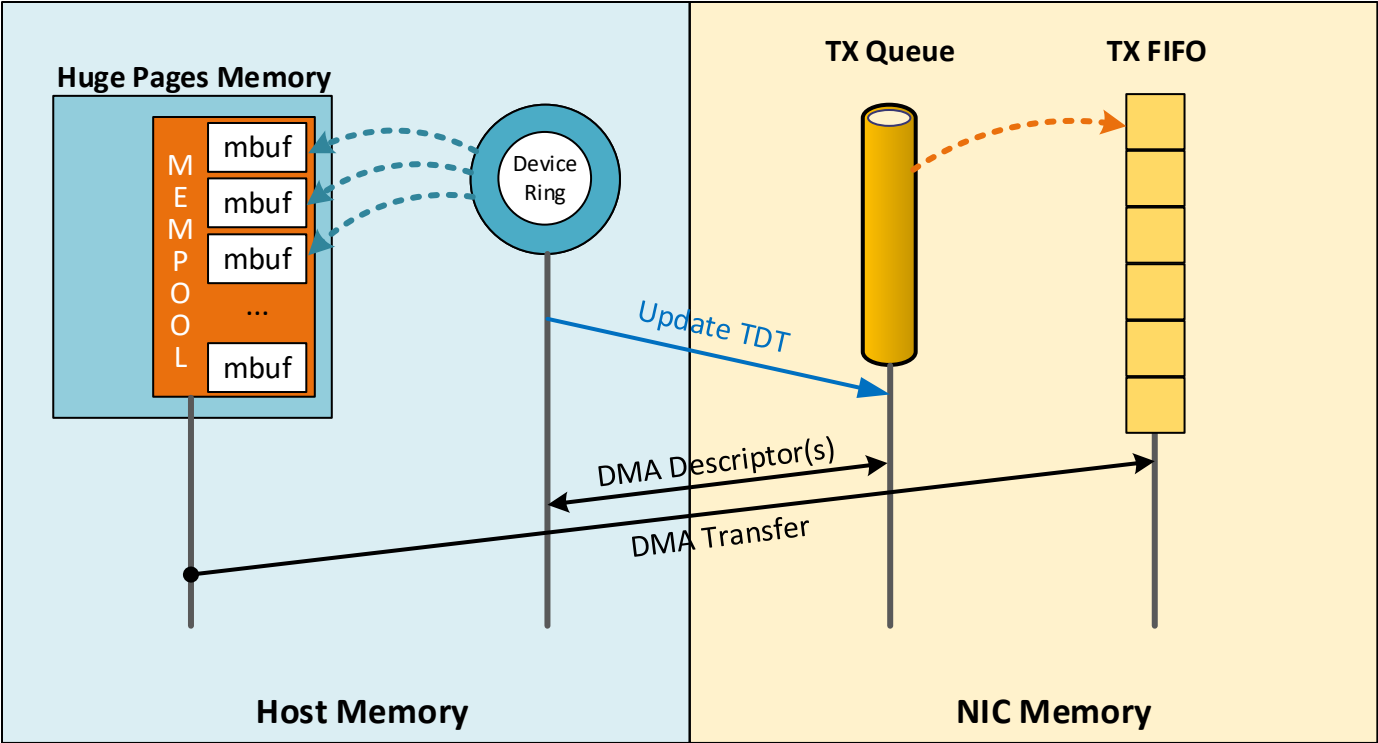
version: 1.0

date: 25/03/2020



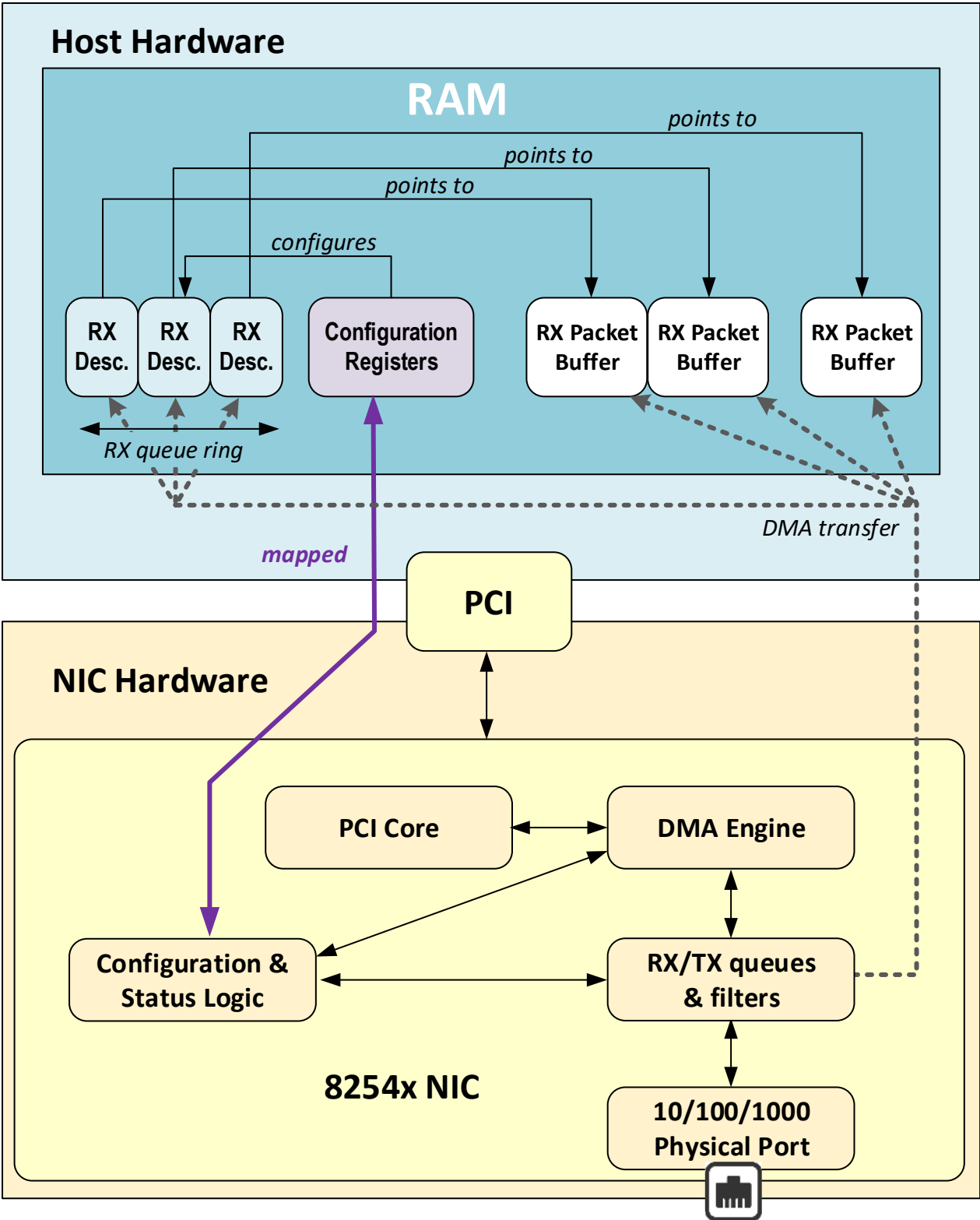
RDT: Receive Descriptor Tail

Title: pNIC incoming packet	
version: 1.0	date: 25/03/2020



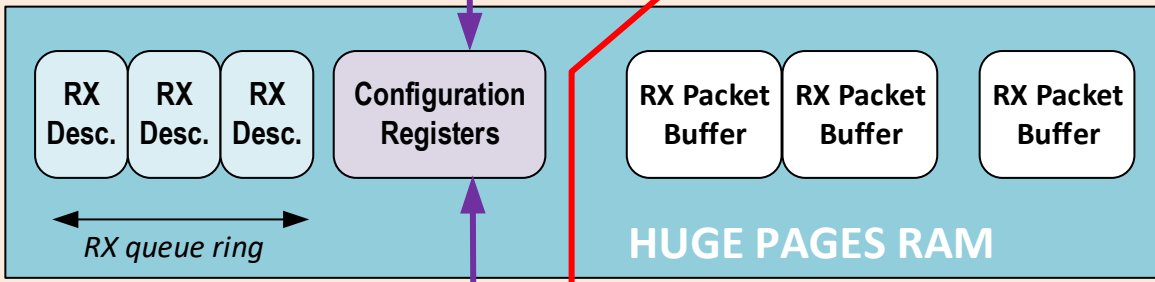
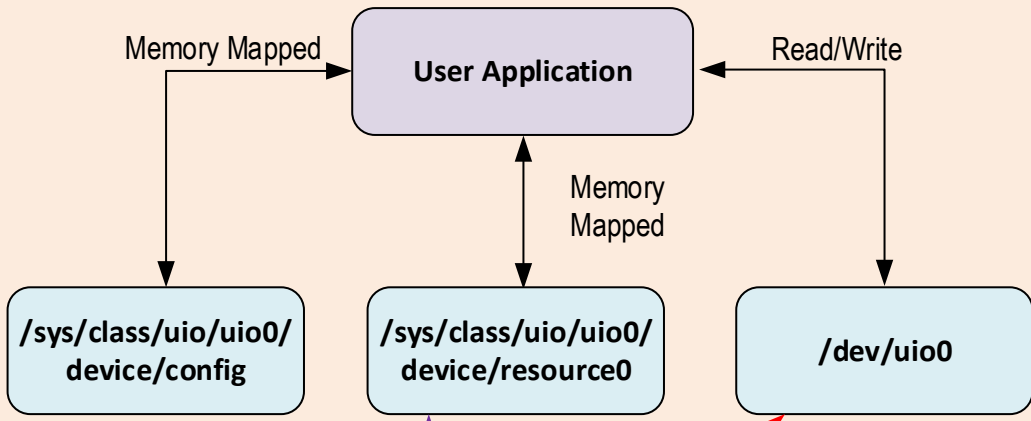
TDT: Transmit Descriptor Tail

Title: pNIC outgoing packet	
version: 1.0	date: 25/03/2020

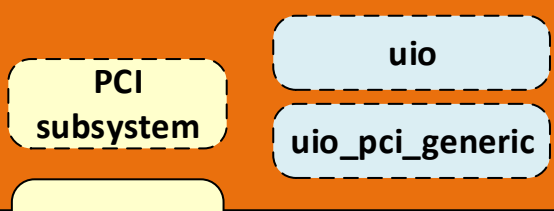


Host Hardware

User Space

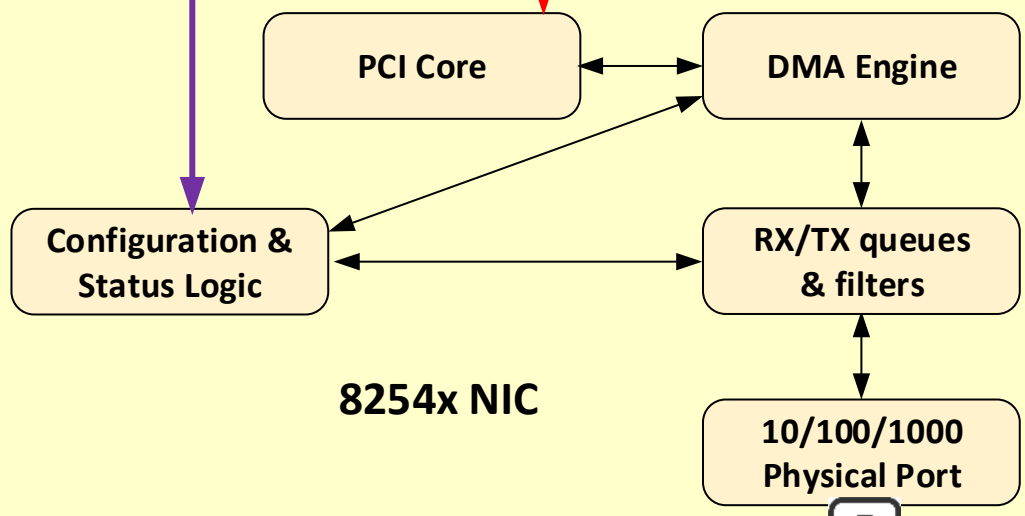


Kernel Space



PCI

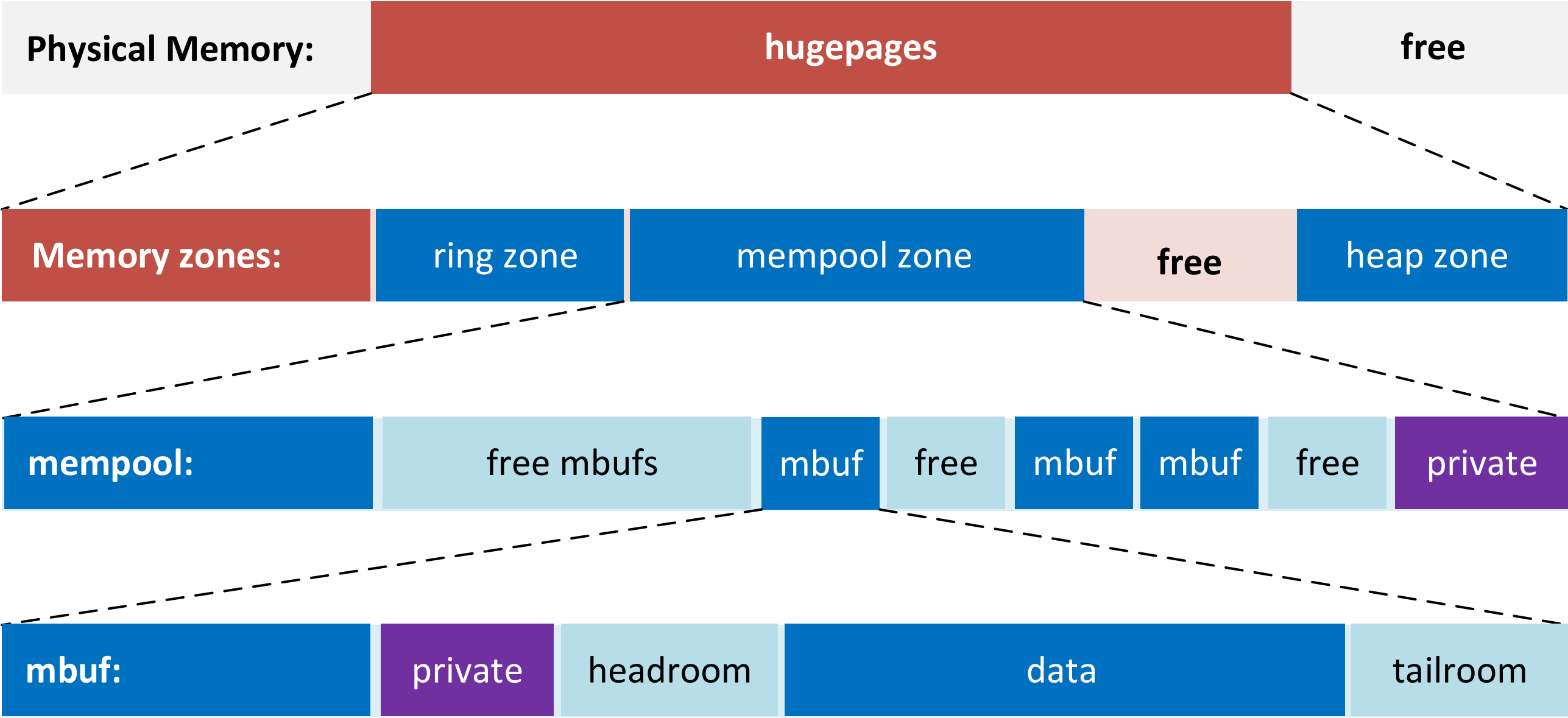
NIC Hardware

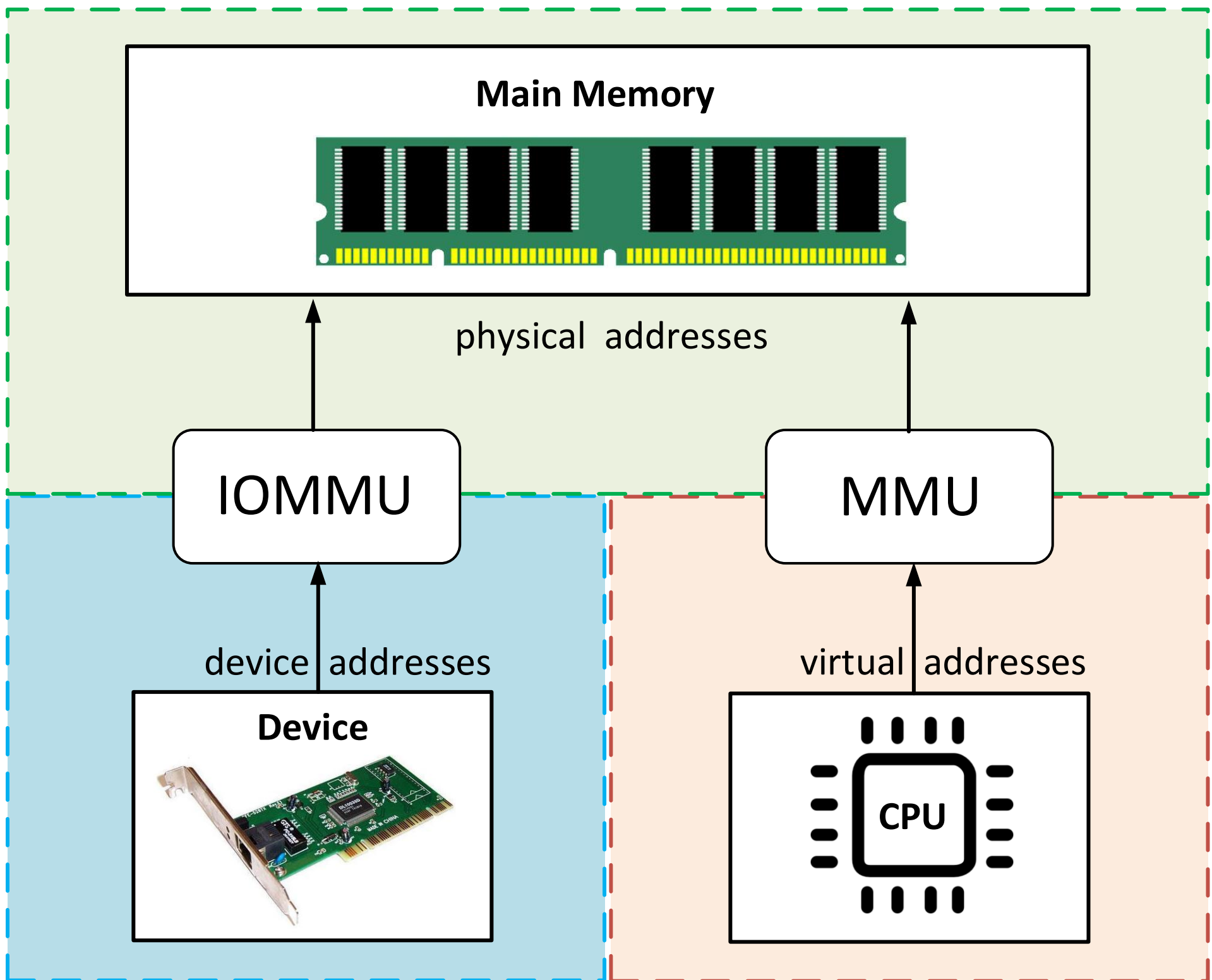


8254x NIC

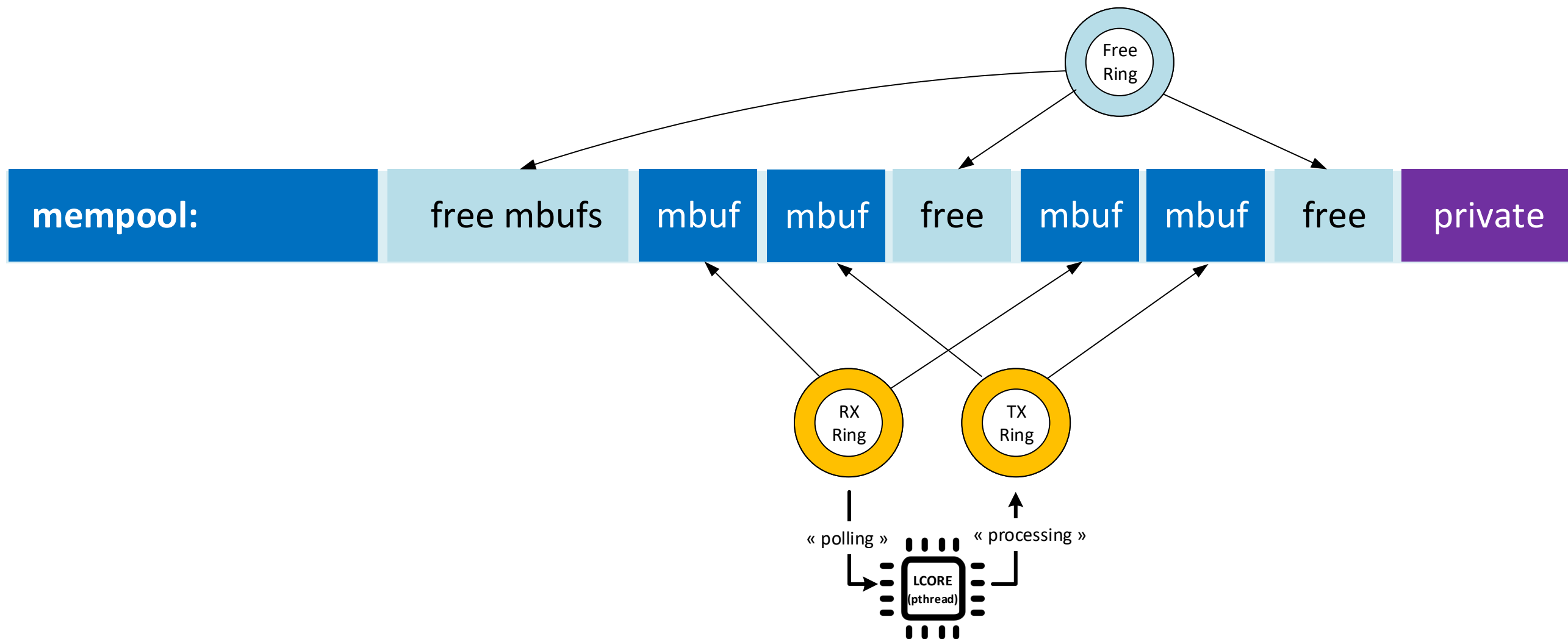
10/100/1000 Physical Port



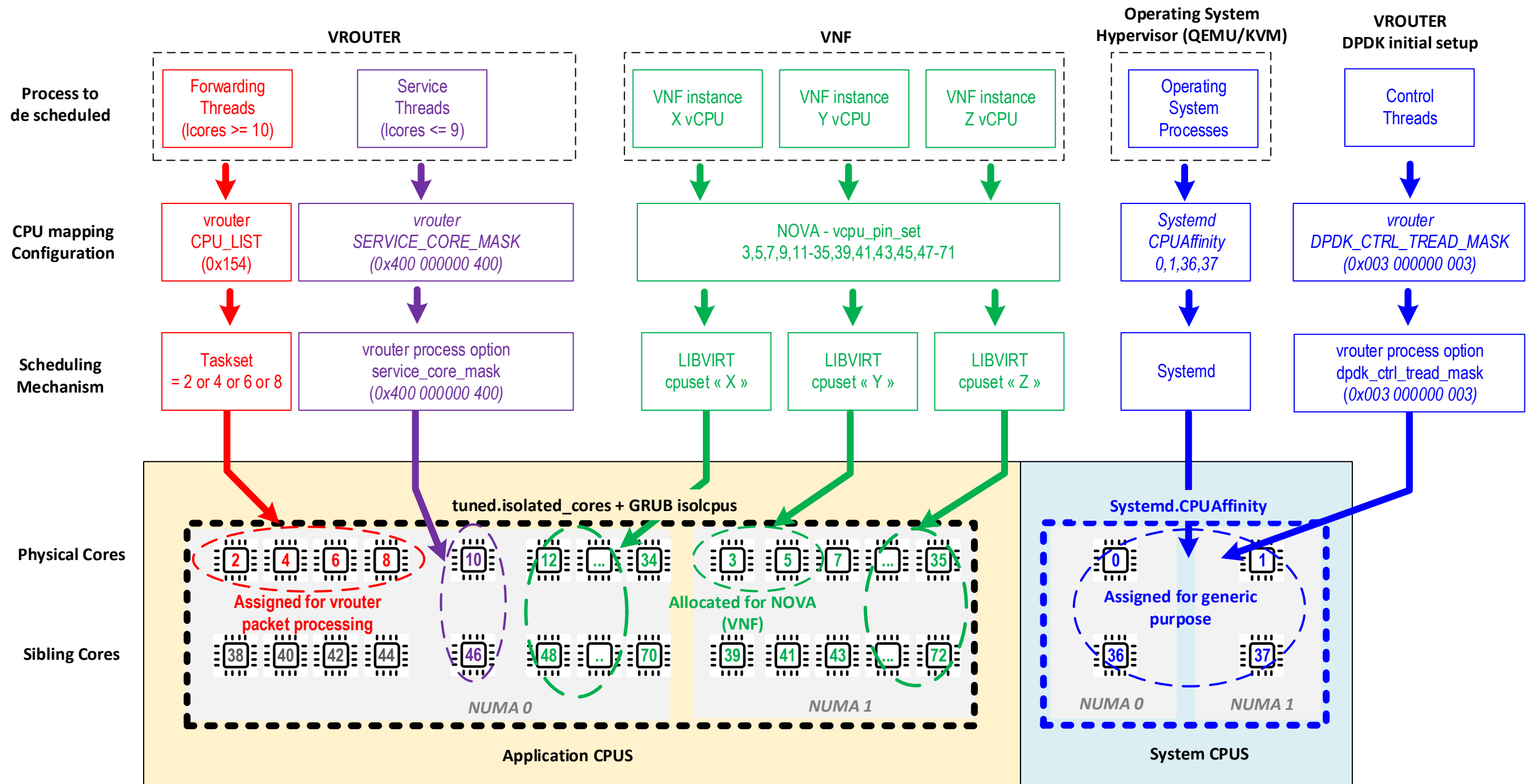




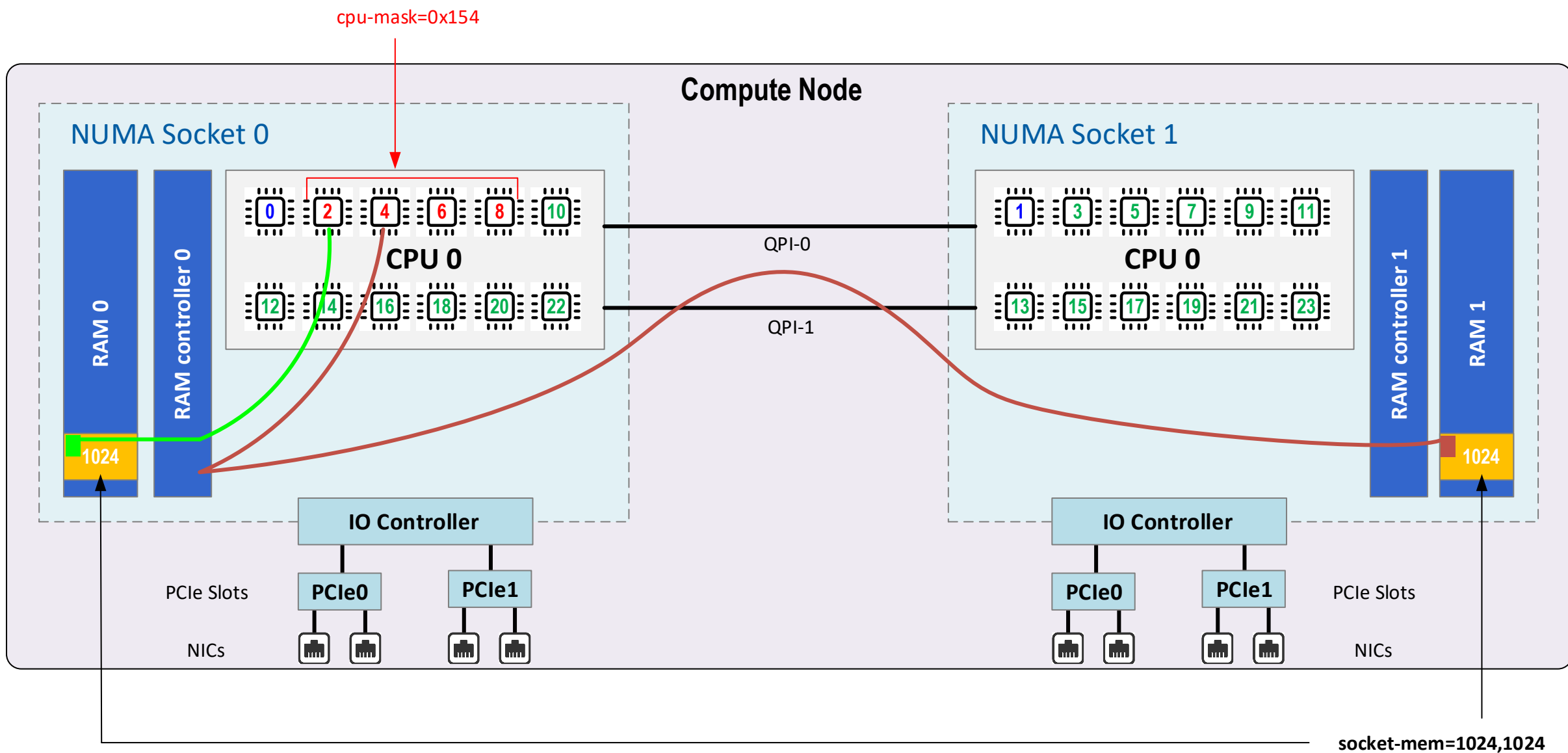
Memory Addressing	
version: 1.0	date: 27/03/2020



Packets Processing and Memory	
version: 1.0	date: 25/03/2020



Title: CPU Pinning	
version: 1.0	date: 25/03/2020



vRouter DPDK PMD allocated CPUs



VM allocated CPUs



Host OS allocated CPUs



vRouter memory access shortest path

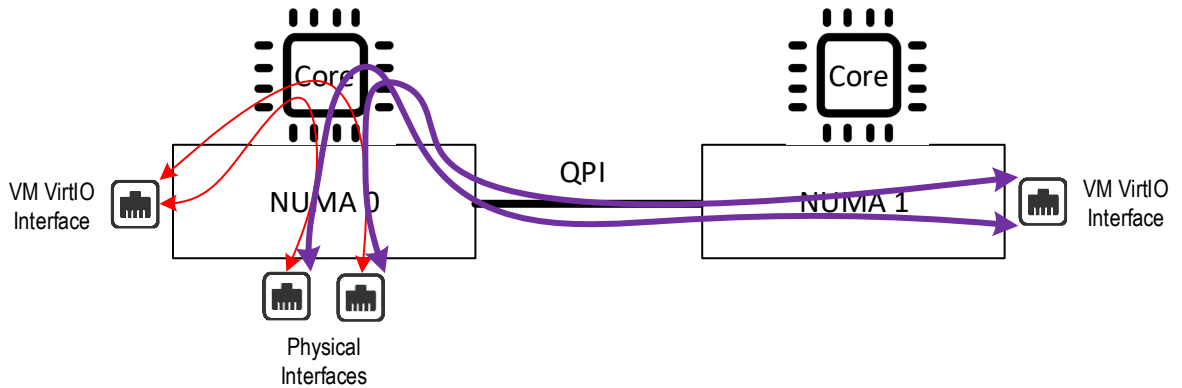
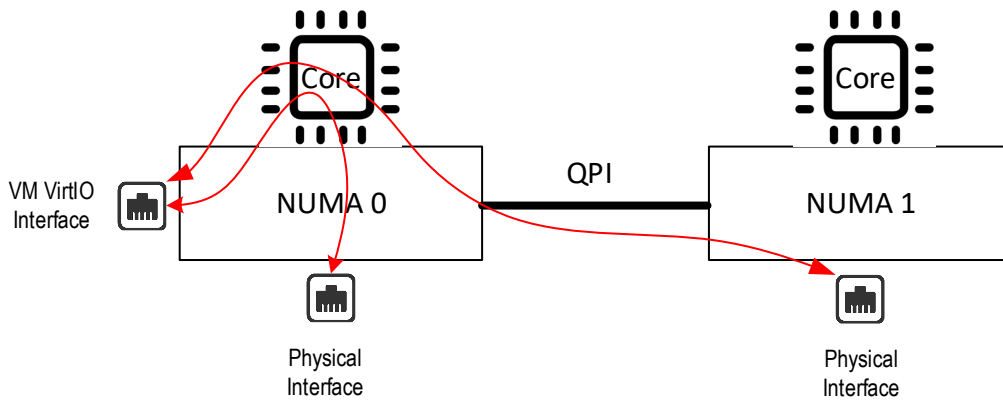


vRouter memory access longer path

Title: vRouter Memory Access and NUMA

version: 1.0

date: 27/03/2020

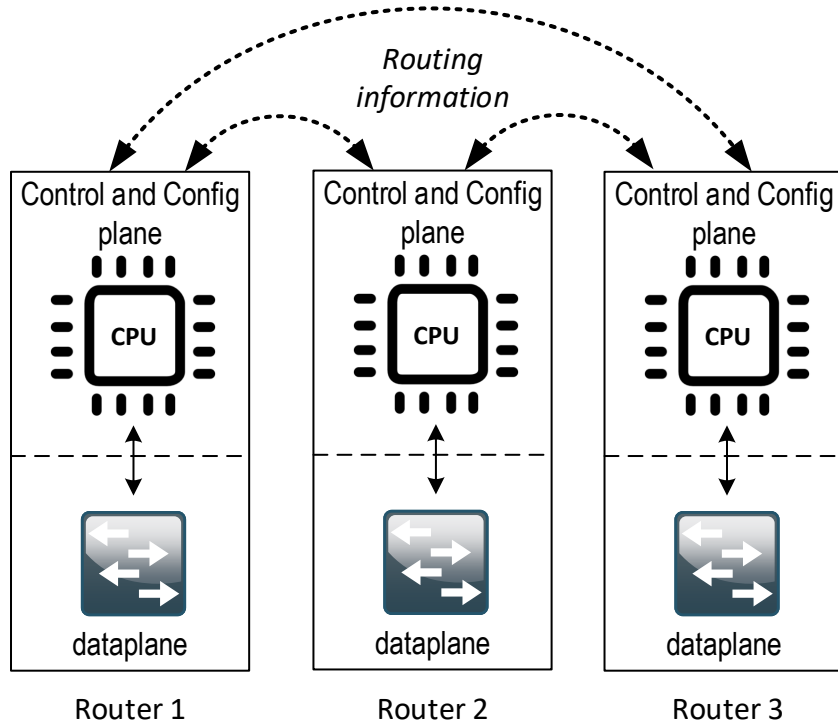


Title: NUMA concern

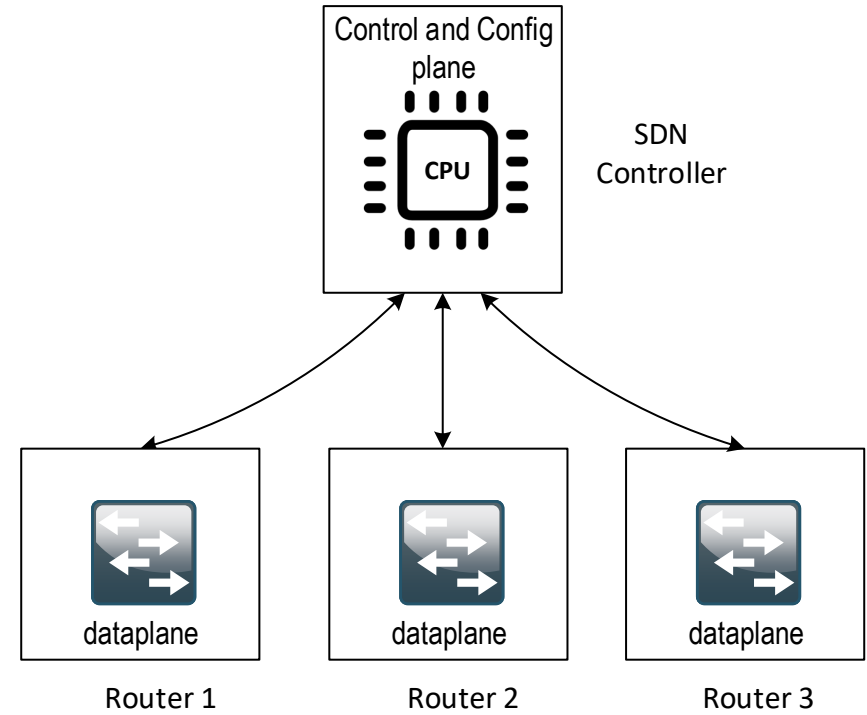
version: 1.0

date: 25/03/2020

Traditional Network Devices



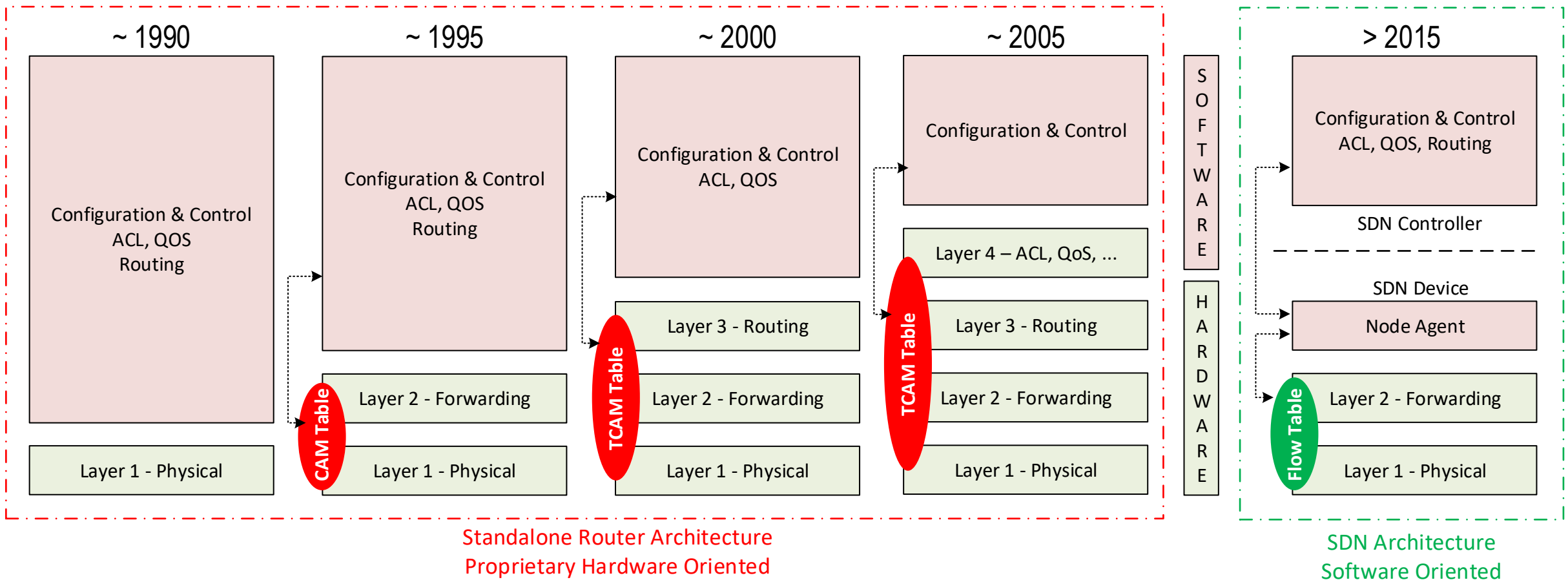
SDN Devices



Title: SDN Overview

version: 1.0

date: 13/04/2020



Title: SDN History	
version: 1.0	date: 13/04/2020

Configuration

Modular Router



Console
Port

Router
Processor Card

OSPF

ISIS

BGP

LDP

RSVP-TE

*Network
Protocols*

RIB

LIB

FIB

LFIB

Switch
Fabric

Line Cards
...

FIB

LFIB

FIB

LFIB

Packets Walk

Control Packets

Traditional Network Node

version: 1.0

date: 13/04/2020

Modular Router

Router Processor Card

Configuration Plane

CLI

SNMP

NetConf

Control Plane

OSPF

ISIS

BGP

LDP

RSVP-TE

Switch
Fabric

Forwarding Plane

TCAM

ASIC

Line Cards
...

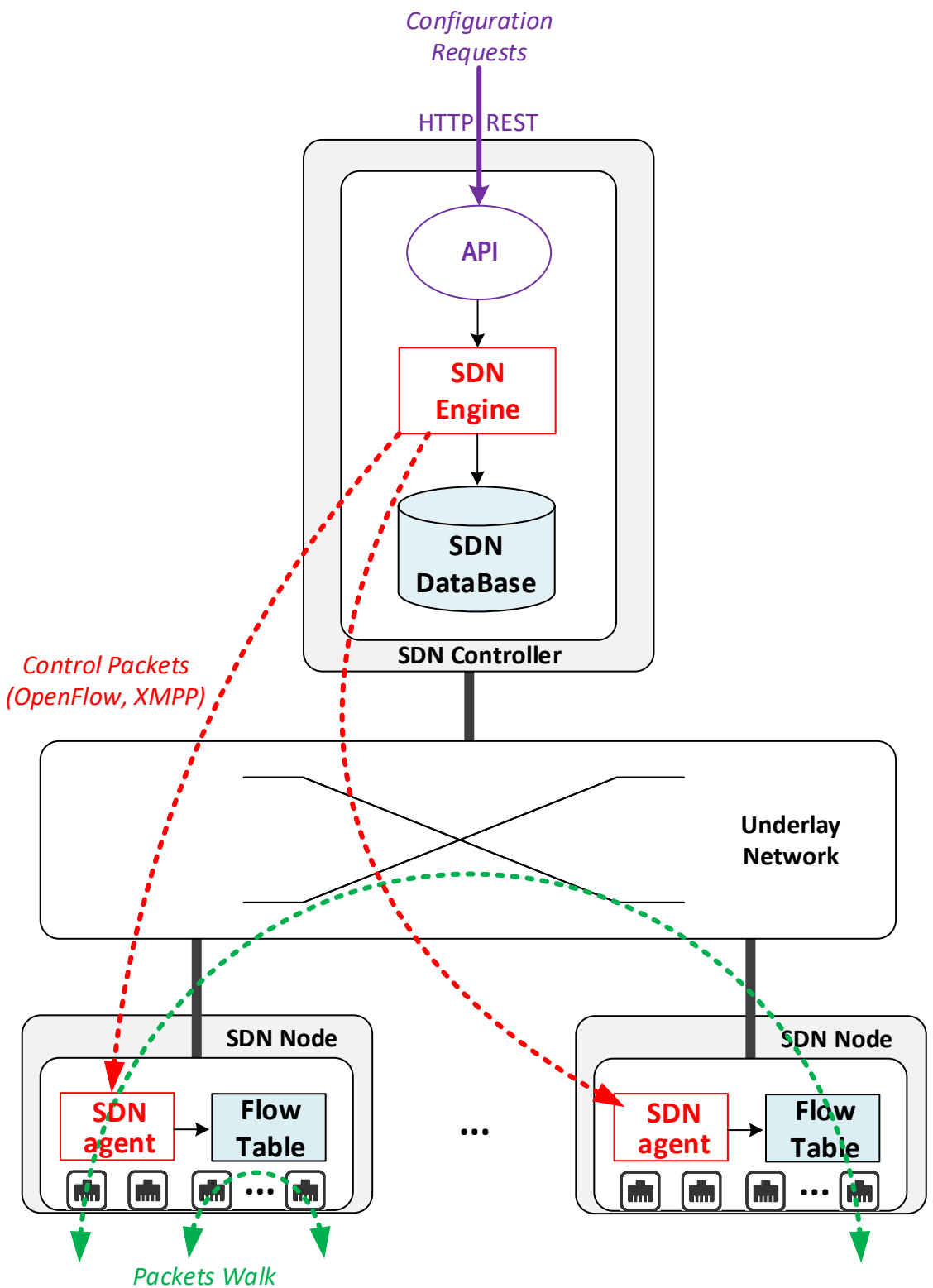
TCAM

ASIC

Traditional Network Planes

version: 1.0

date: 13/04/2020



SDN Detailed Architecture	
version: 1.0	date: 13/04/2020

Admin and Users

OpenStack

Kubernetes

APPLICATION
LAYER

SDN Dashboard
Web GUI
Application

Cloud Network
Interface

Container Network
Interface

CONTROL
LAYER

SDN Controller

Northbound Interfaces

REST
API

Python
API

JAVA
API

SDN Engine

SDN Control
Logic

Routing Info
(flows)

Topology

Statistics

NetFlow

XMPP

NetConf

BGP/LS

PECP

Southbound Interfaces

Underlay
Network

INFRASTRUCTURE
LAYER

SDN Node

SDN
agent

Flow
Table

Packet Engine

Forwarding Plane

...

SDN Node

SDN
agent

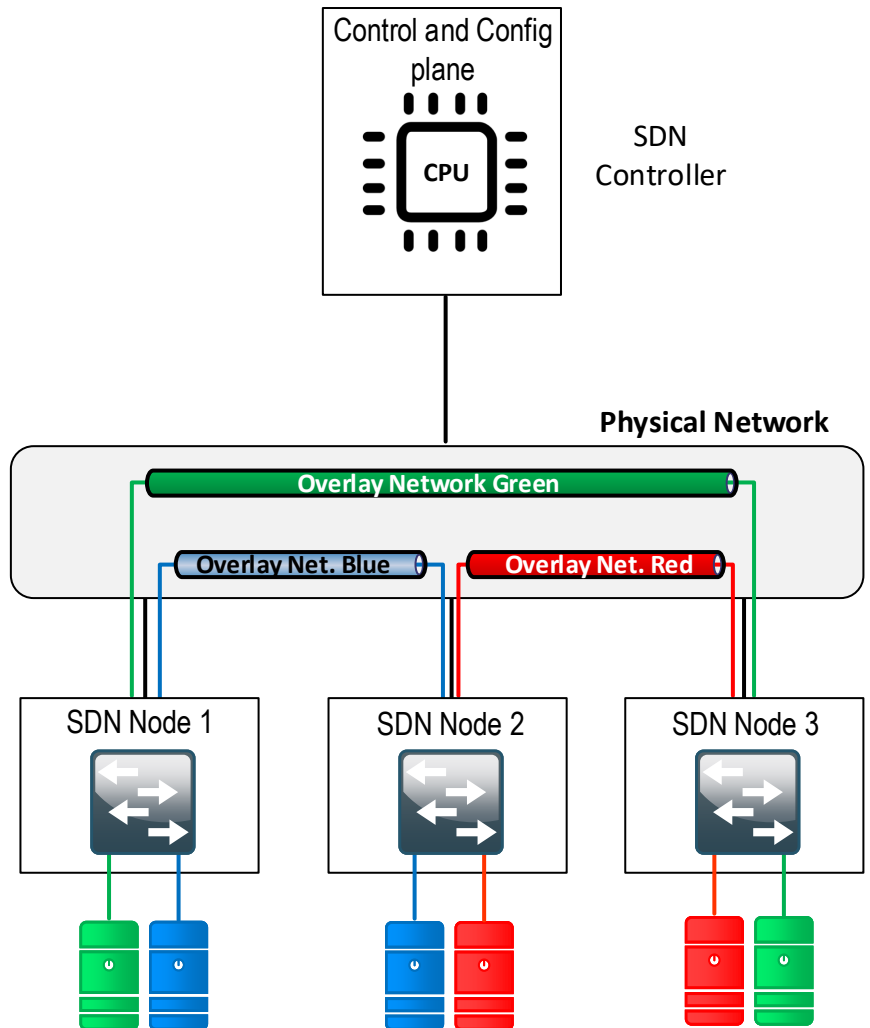
Flow
Table

Packet Engine

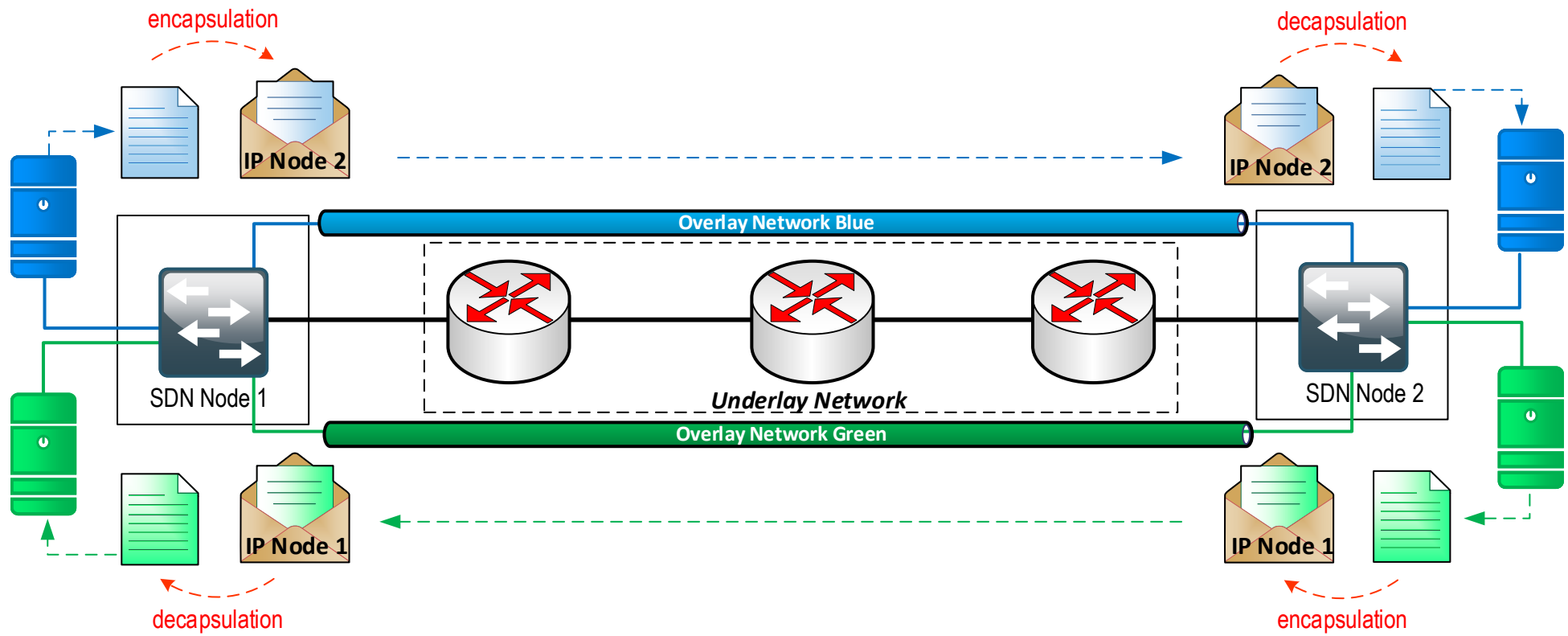
SDN Layers

version: 1.0

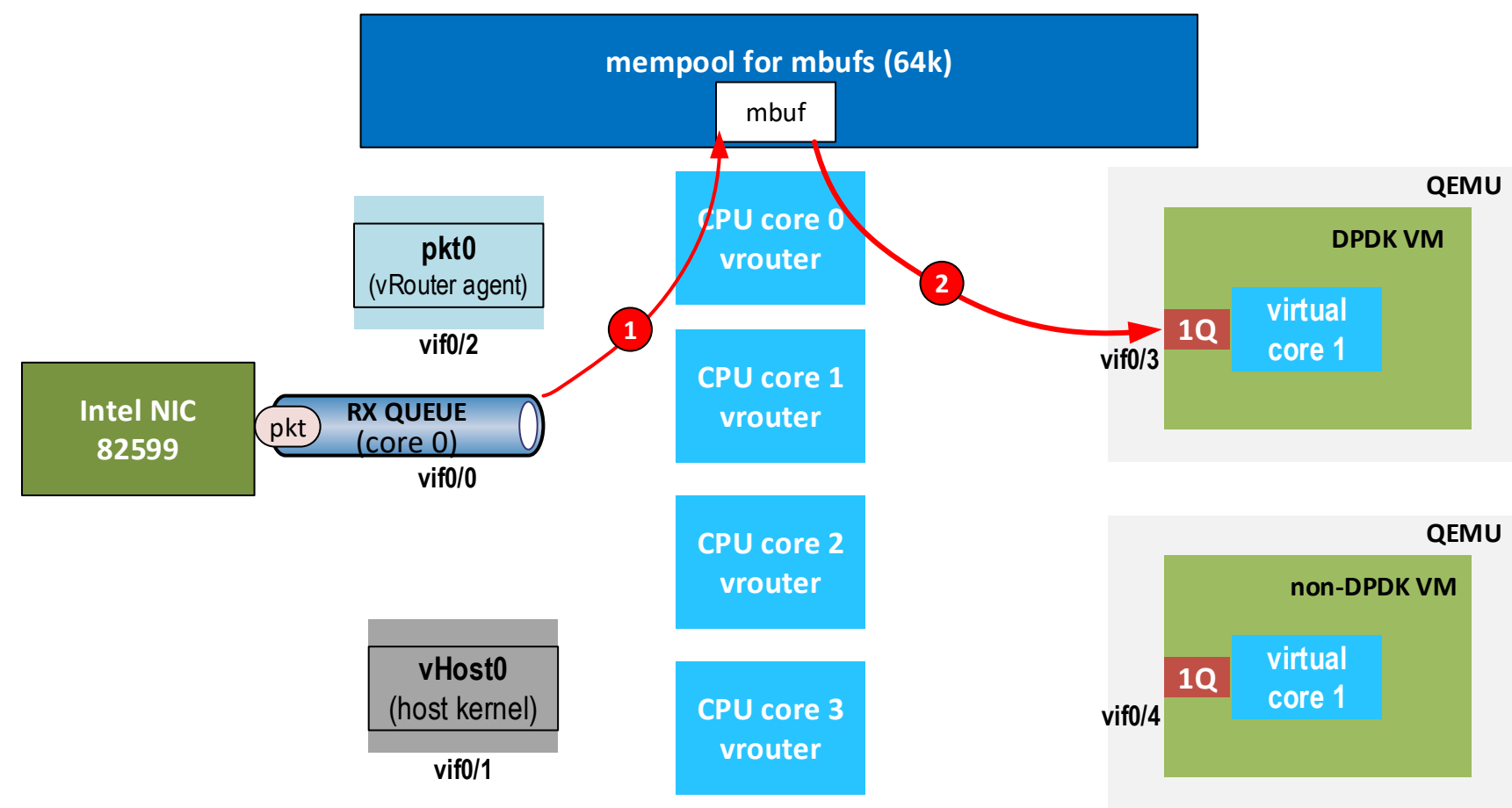
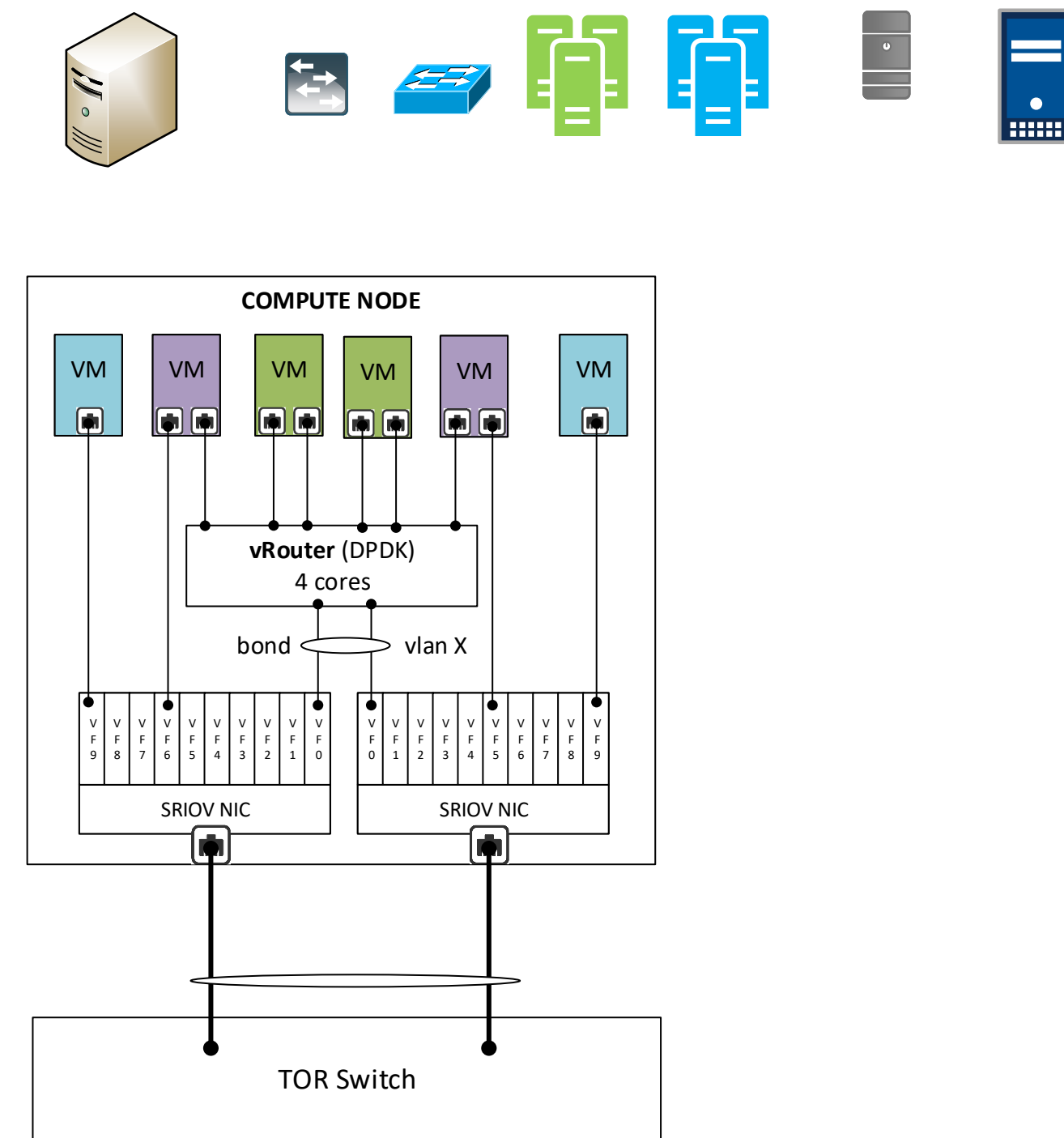
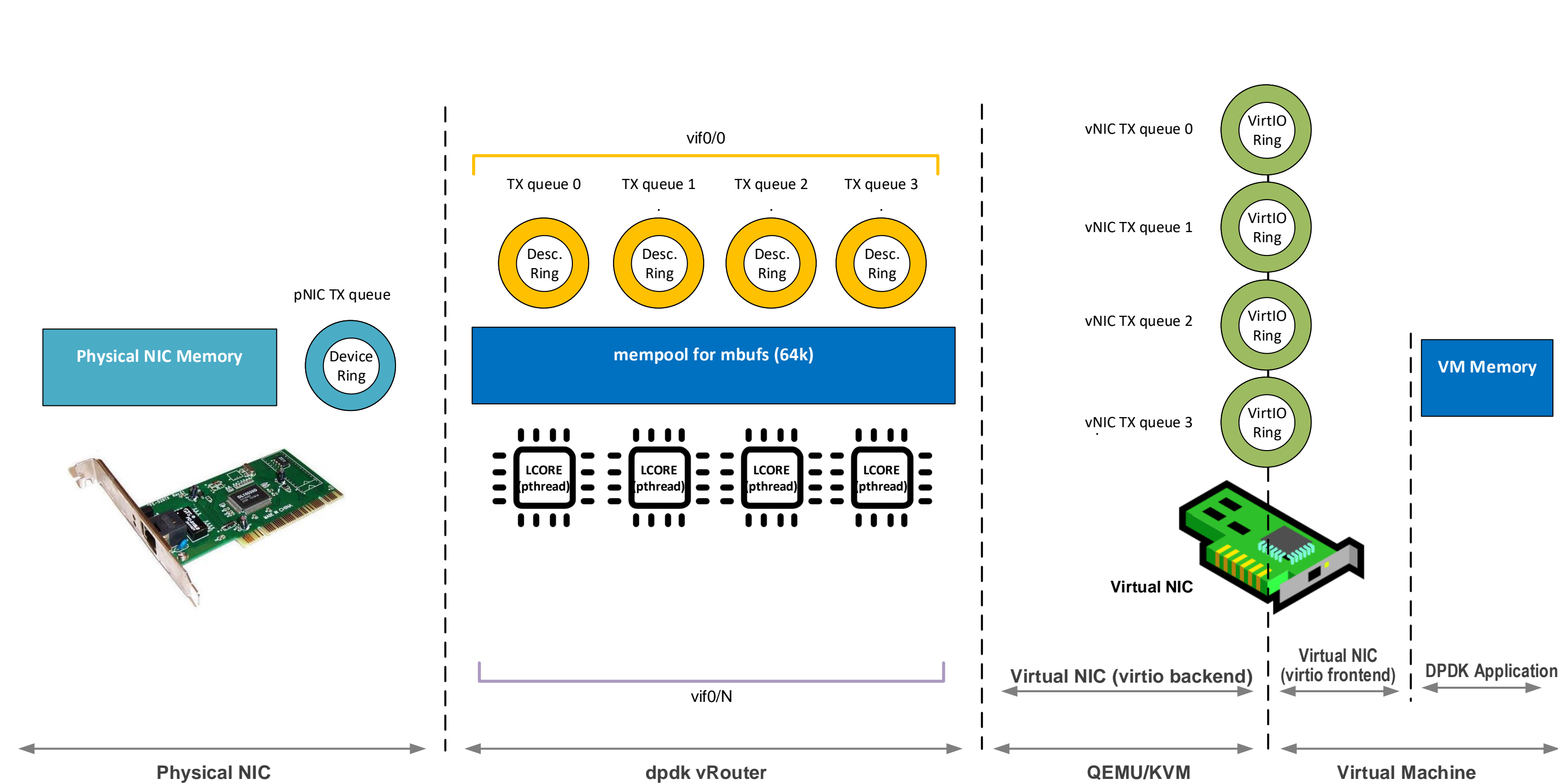
date: 13/04/2020



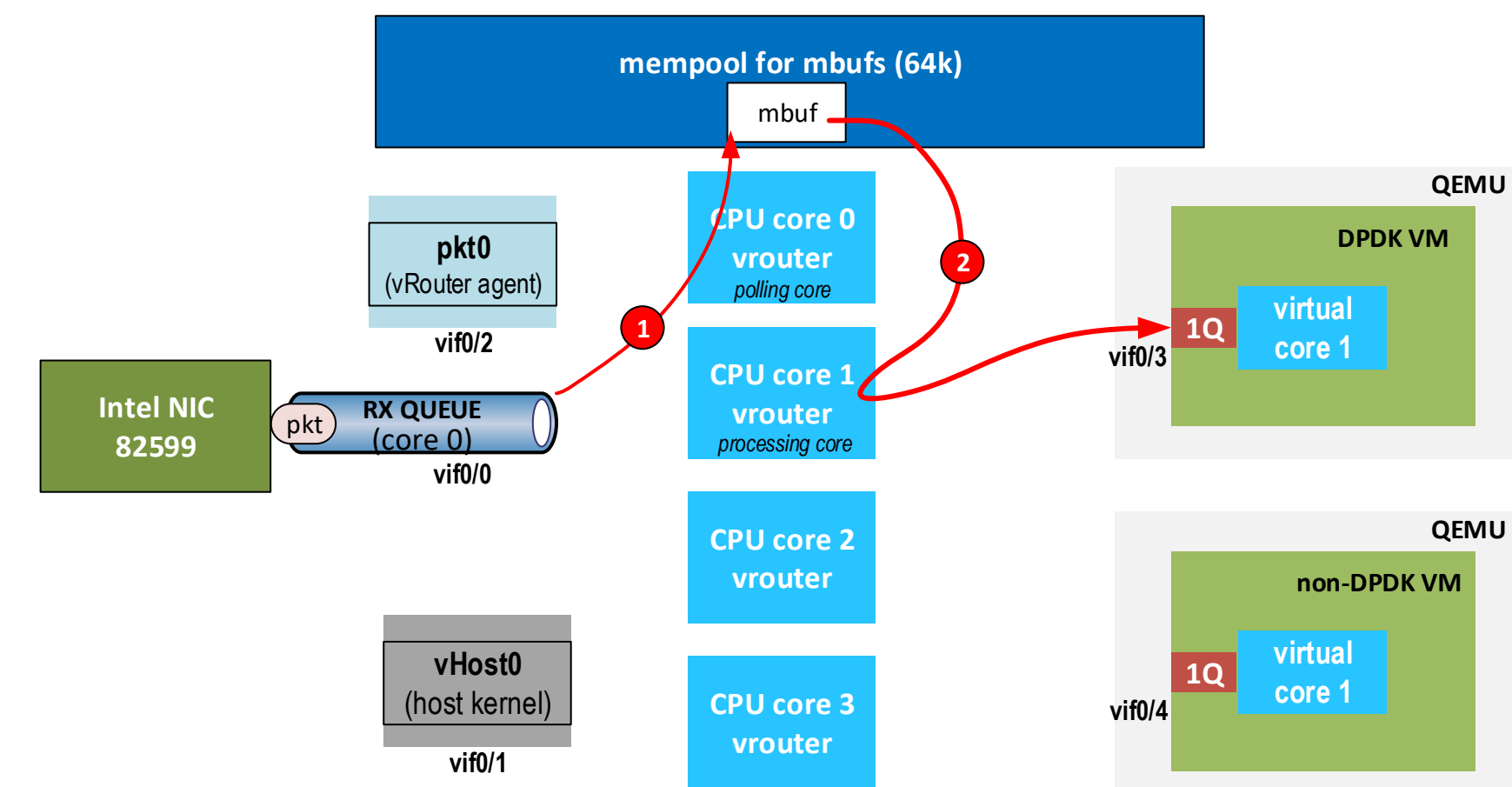
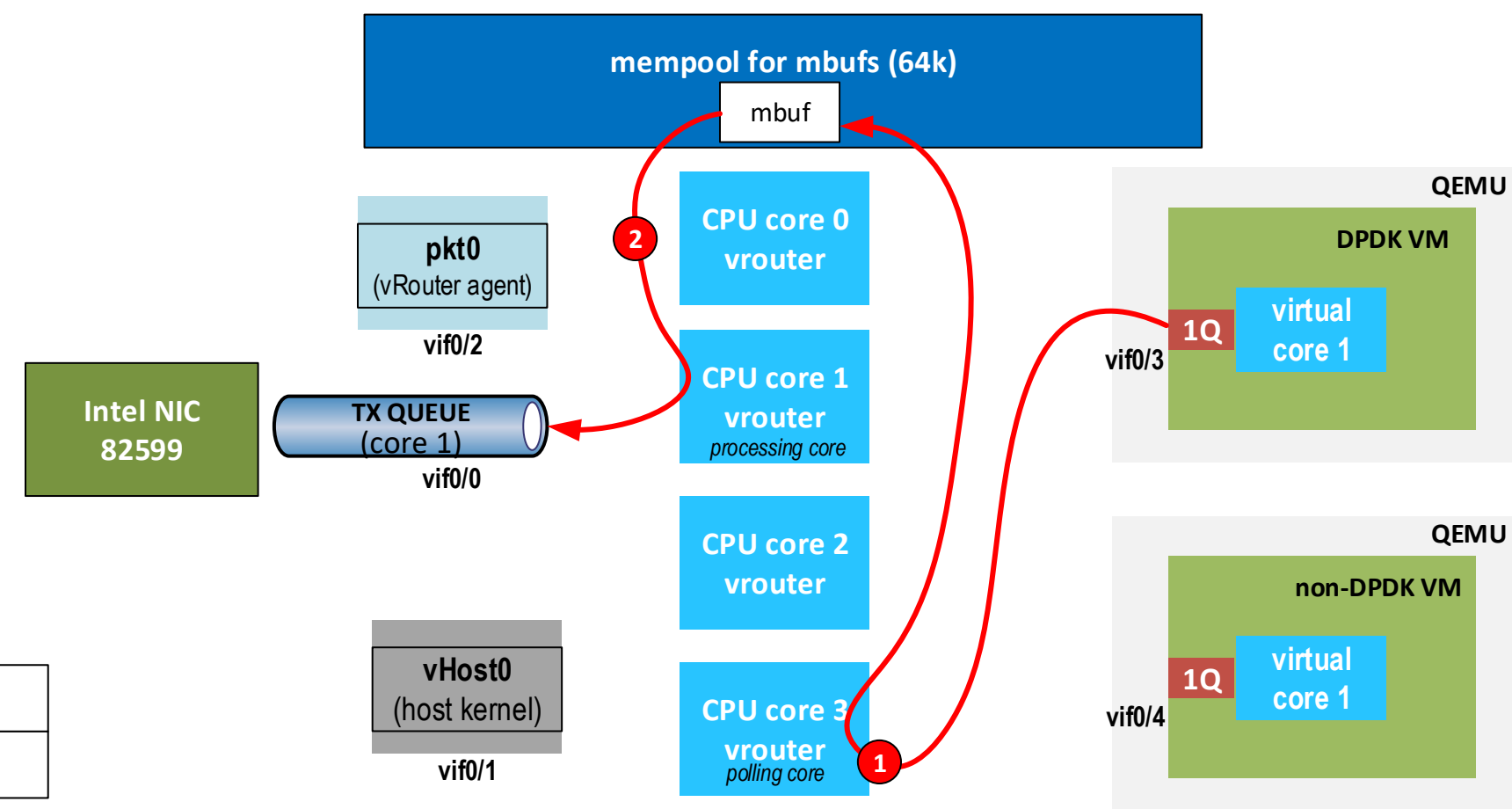
SDN and Overlay	
version: 1.0	date: 13/04/2020



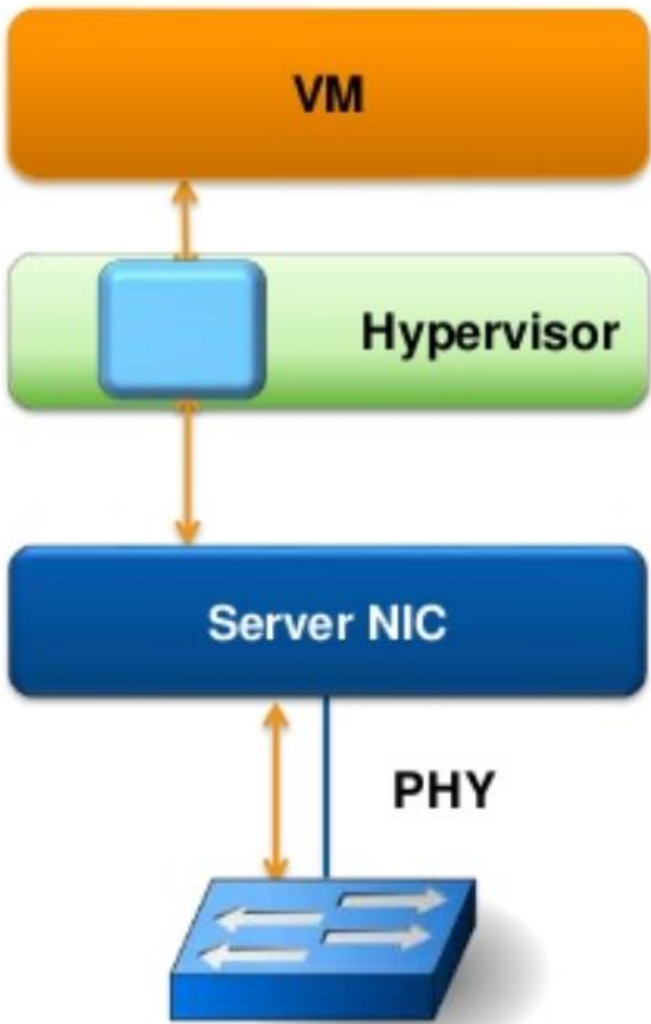
SDN and Encapsulation Principle	
version: 1.0	date: 13/04/2020



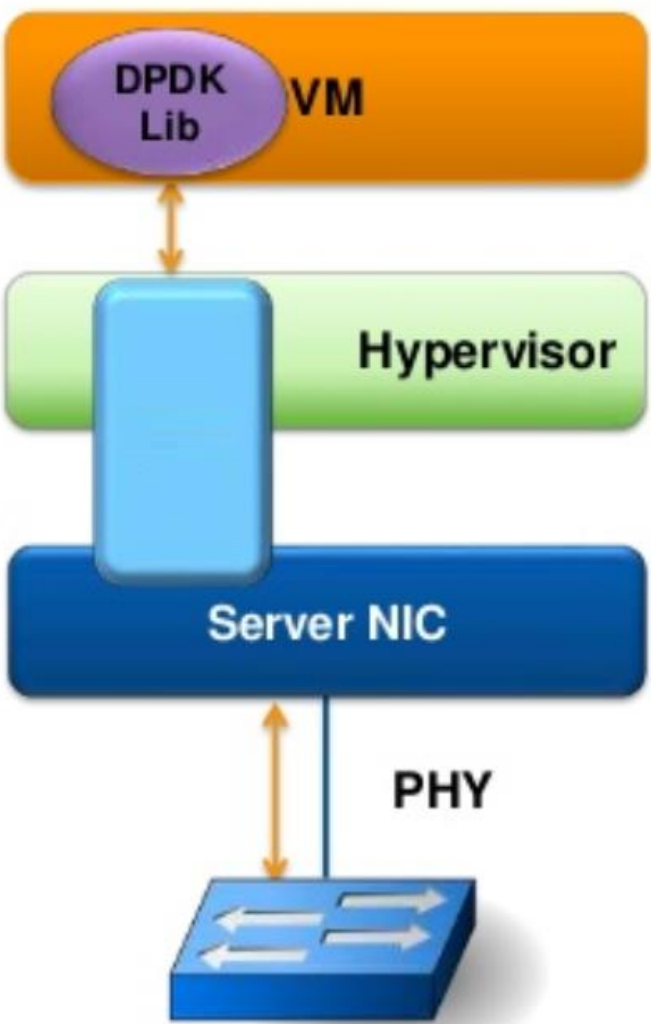
Title: Personal Stuff	
version: 1.0	date: 25/03/2020



KERNEL MODE



DPDK MODE



SRIOV (vrouter bypassed)

