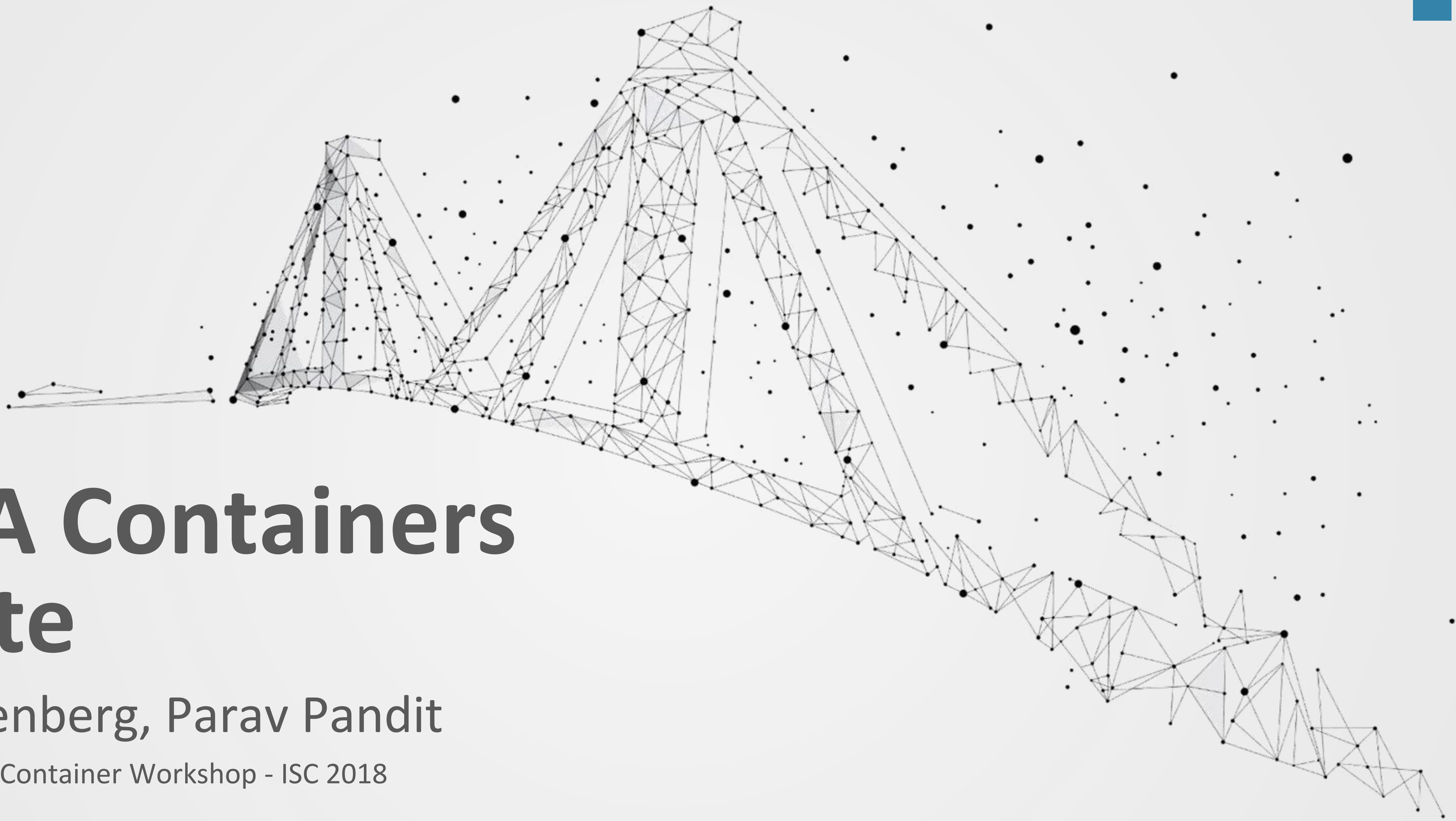


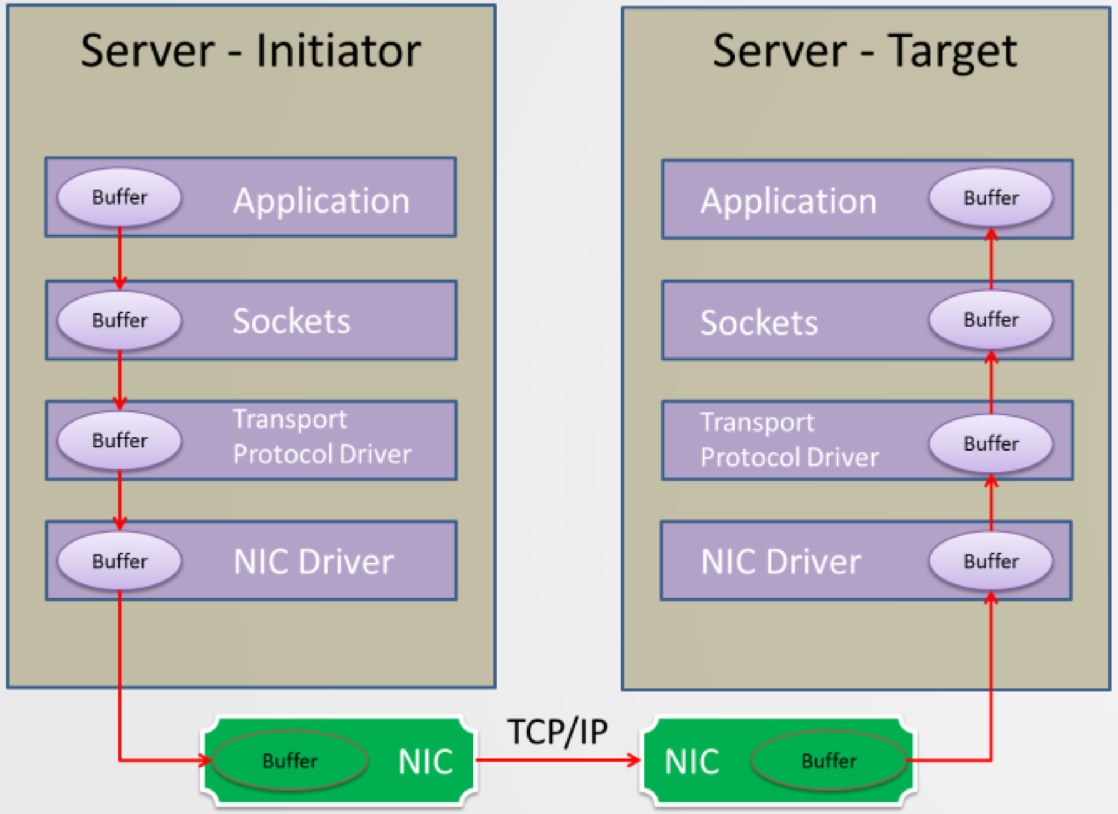
RDMA Containers Update

Dror Goldenberg, Parav Pandit

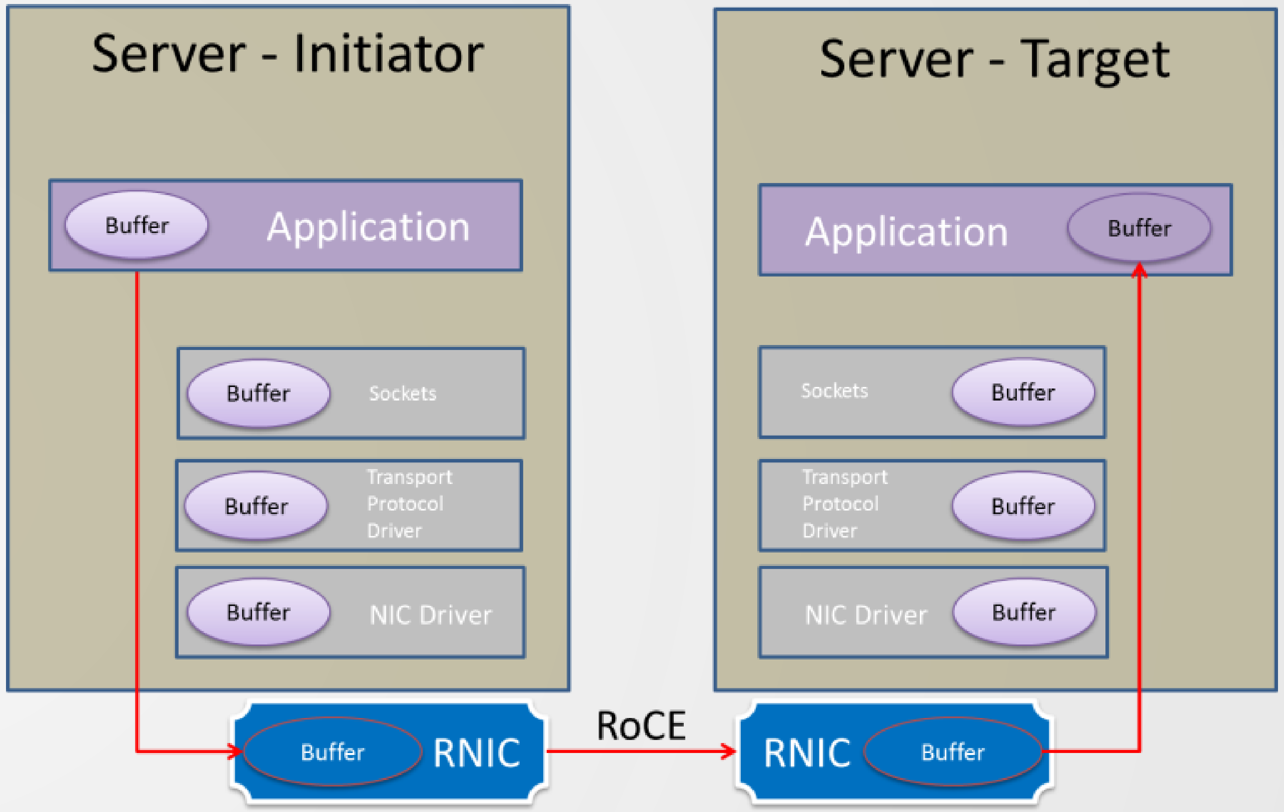
High Performance Container Workshop - ISC 2018

Why RDMA?

TCP/IP



Remote Direct Memory Access (RDMA)



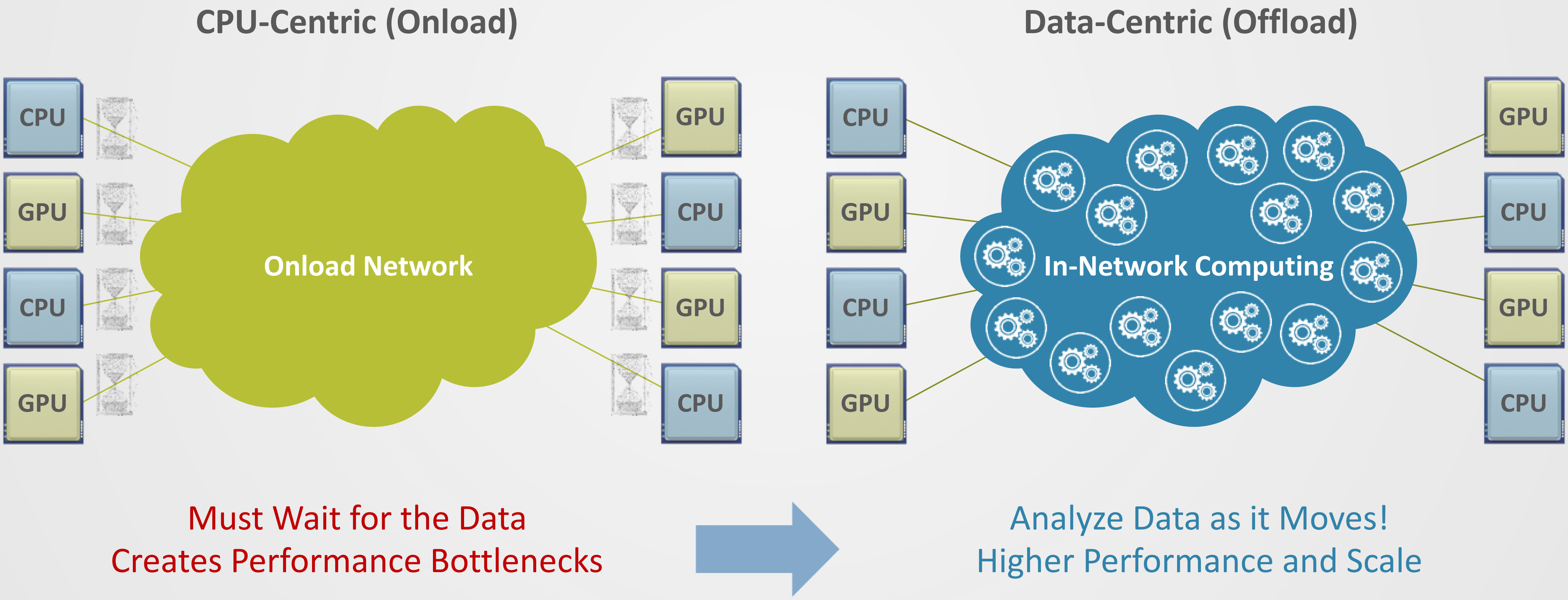
Powers 4 out of 5 top supercomputers
50% better AI performance
10s-100s% better HPC performance

RDMA

2X performance on S2D
10x faster live migration
10x faster messaging
50% faster big data SPARK

The Need for Intelligent and Faster Interconnect

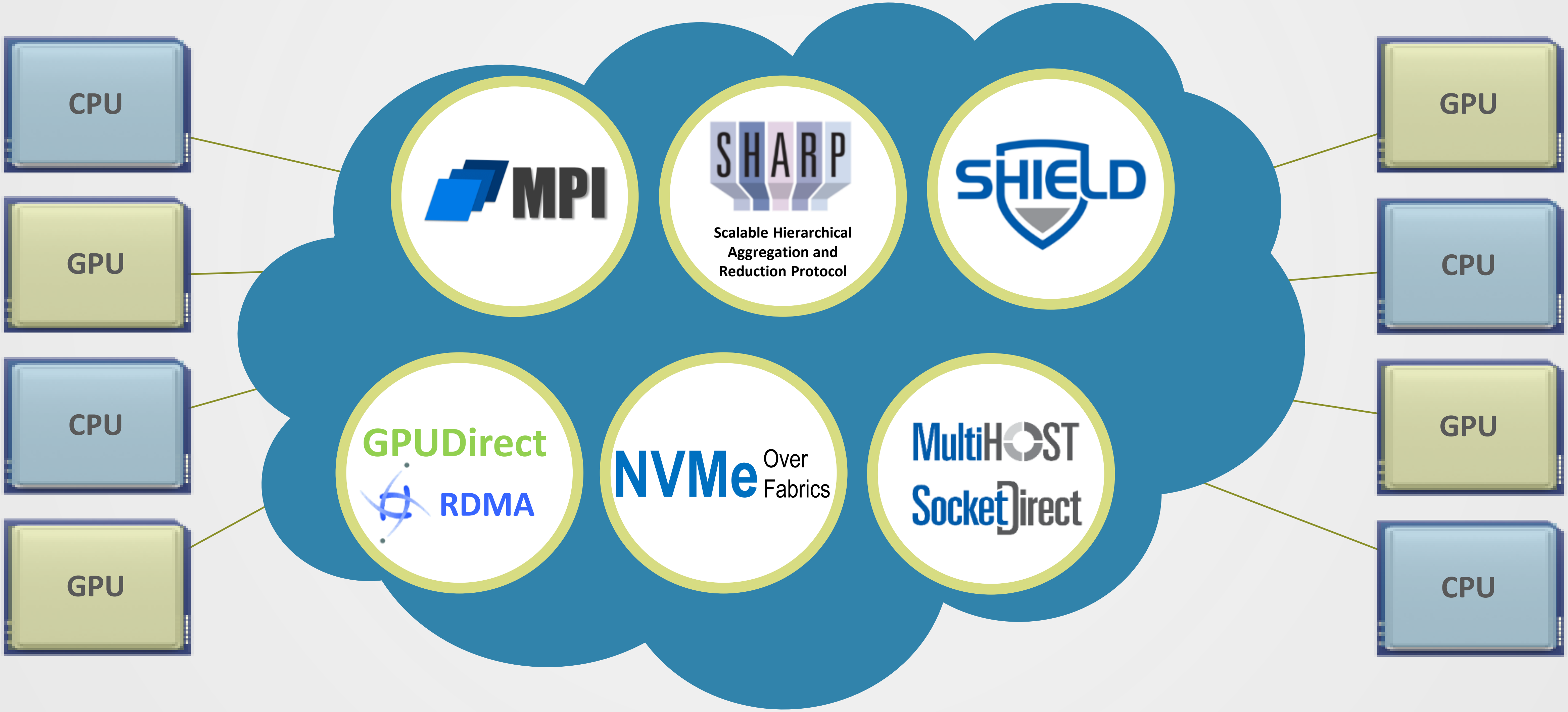
Faster Data Speeds and In-Network Computing
Enable Higher Performance and Scale



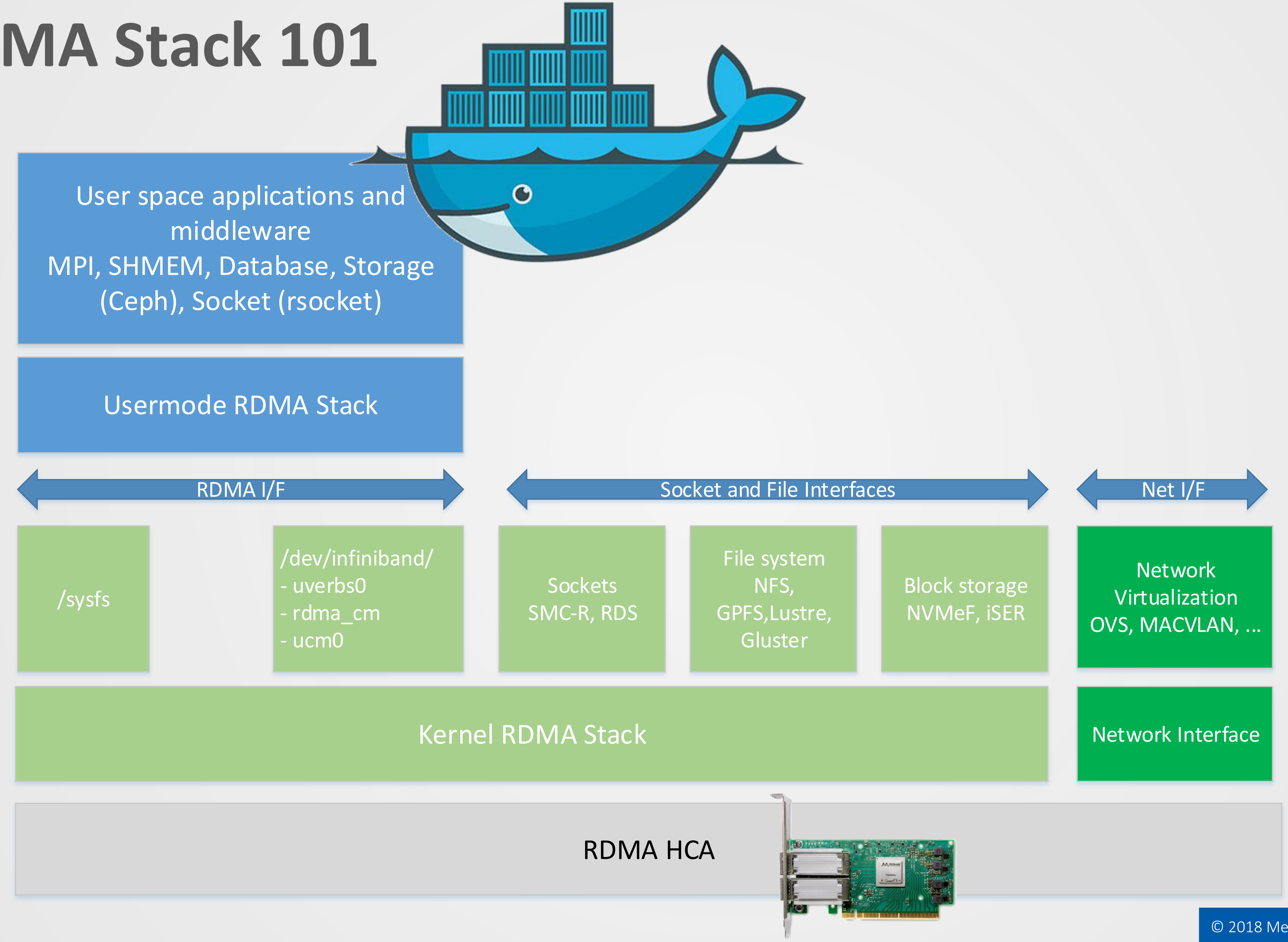
Must Wait for the Data
Creates Performance Bottlenecks

Analyze Data as it Moves!
Higher Performance and Scale

In-Network Computing to Enable Data-Centric Data Centers



RDMA Stack 101



User space applications and middleware
MPI, SHMEM, Database, Storage (Ceph), Socket (rsocket)

Usermode RDMA Stack

RDMA I/F

Socket and File Interfaces

Net I/F

/sysfs

/dev/infiniband/
- uverbs0
- rdma_cm
- ucm0

Sockets
SMC-R, RDS

File system
NFS,
GPFS,Lustre,
Gluster

Block storage
NVMeF, iSER

Network Virtualization
OVS, MACVLAN, …

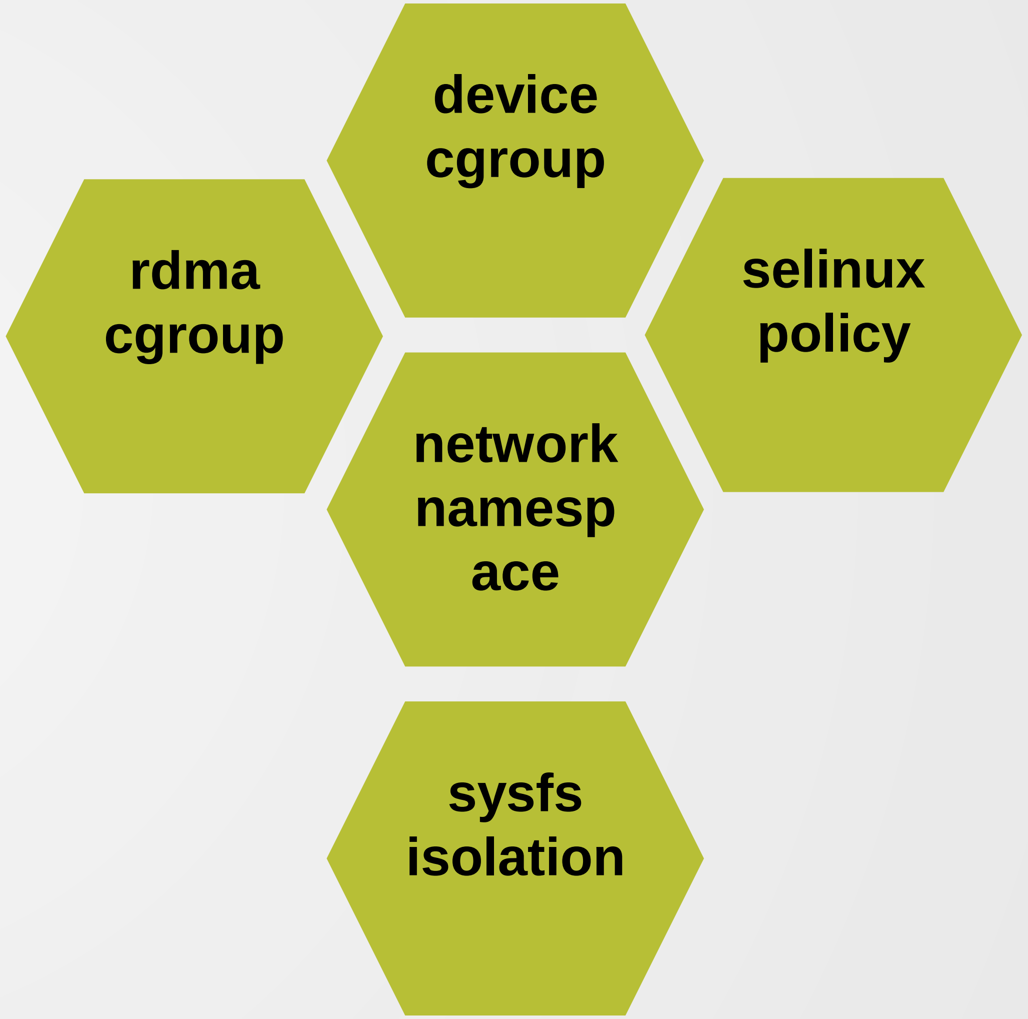
Kernel RDMA Stack

Network Interface

RDMA HCA

Kernel Components for Container Enablement

- Network namespace support
- RDMA cgroup configuration
- Device cgroup configuration
- /sysfs isolation
- SELinux policy enforcement



device cgroup

rdma cgroup

selinux policy

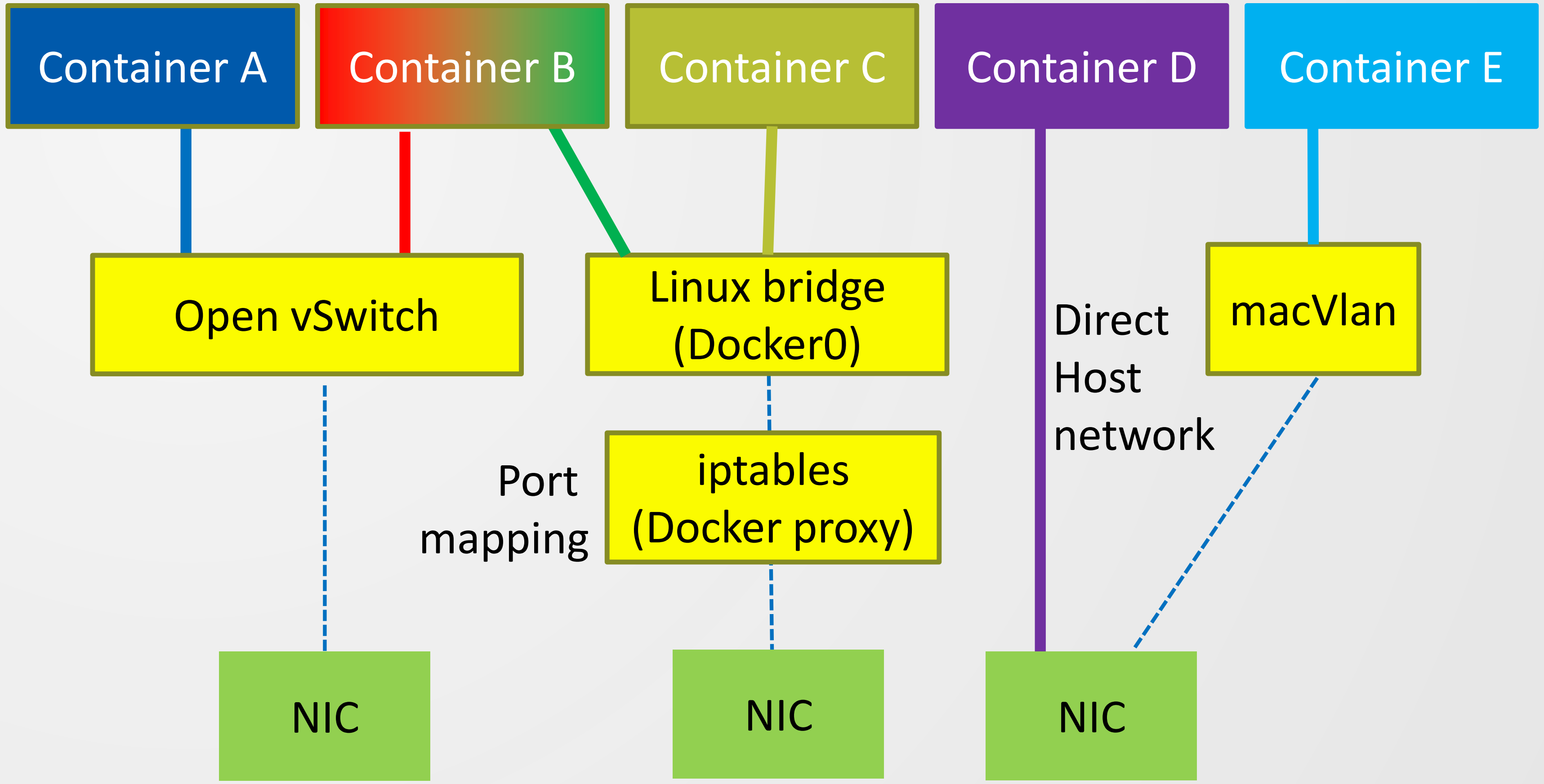
network namesp ace

sysfs isolation

RDMA Network Namespace

- RDMA connections and QPs operate only in caller namespaces
- RDMA underlying network inherit from namespace: IP, MAC, tunnel, InfiniBand L2…

- InfiniBand (kernel 4.9+)
- RoCE (kernel 4.19+)
- Upcoming MOFED 4.4 release



RDMA Control Group

- cgroup - Restricts RDMA resource usage per container
  - hca handles
  - hca objects (AH, CQ, QP, PD, MR, MW, Flows, SRQs…)

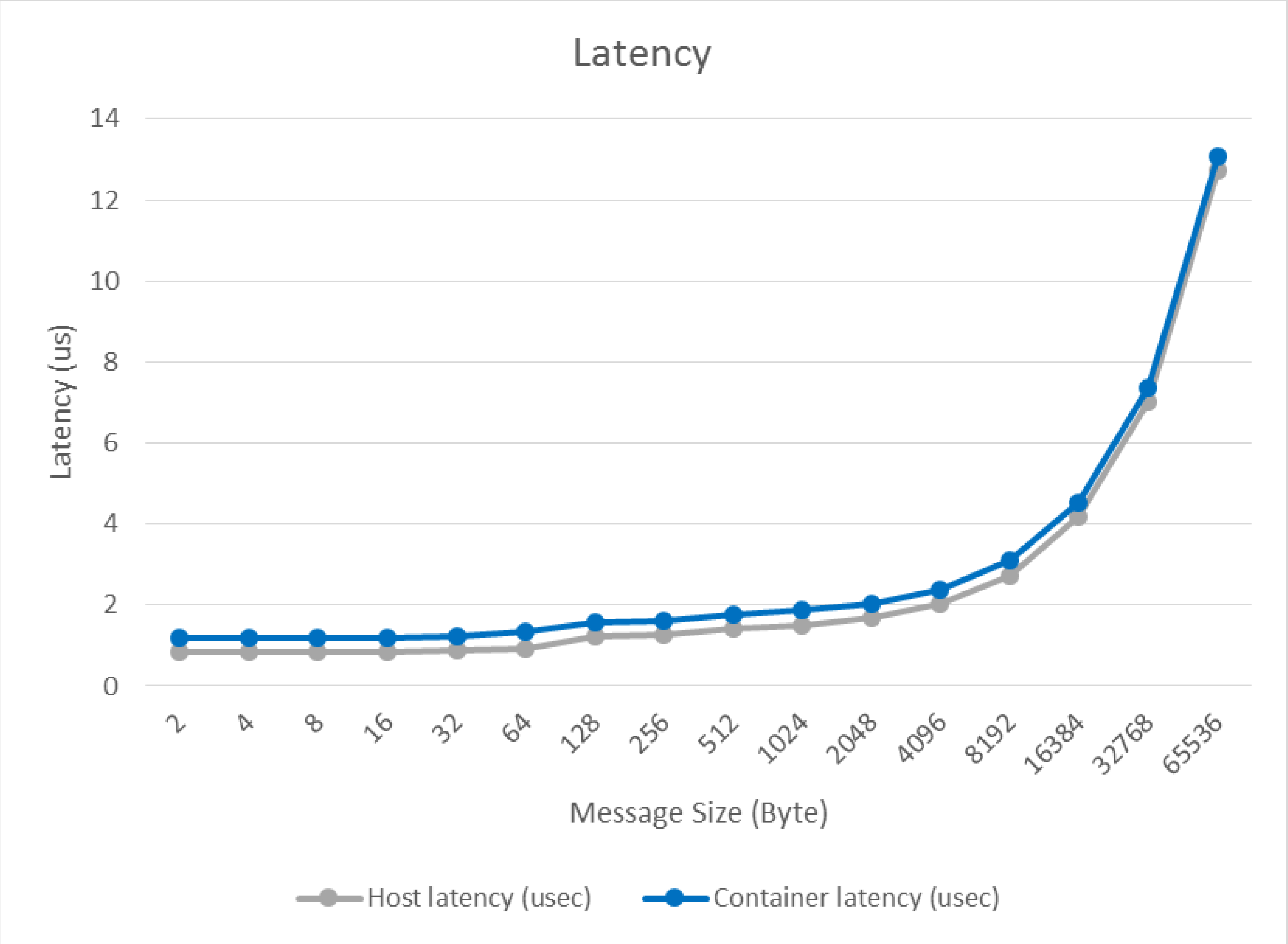
- Kernel
  - Part of kernel from Linux kernel 4.11
- User space
  - Runc spec: https://github.com/opencontainers/runtime-spec
  - containerd/cgroups library https://github.com/containerd/cgroups

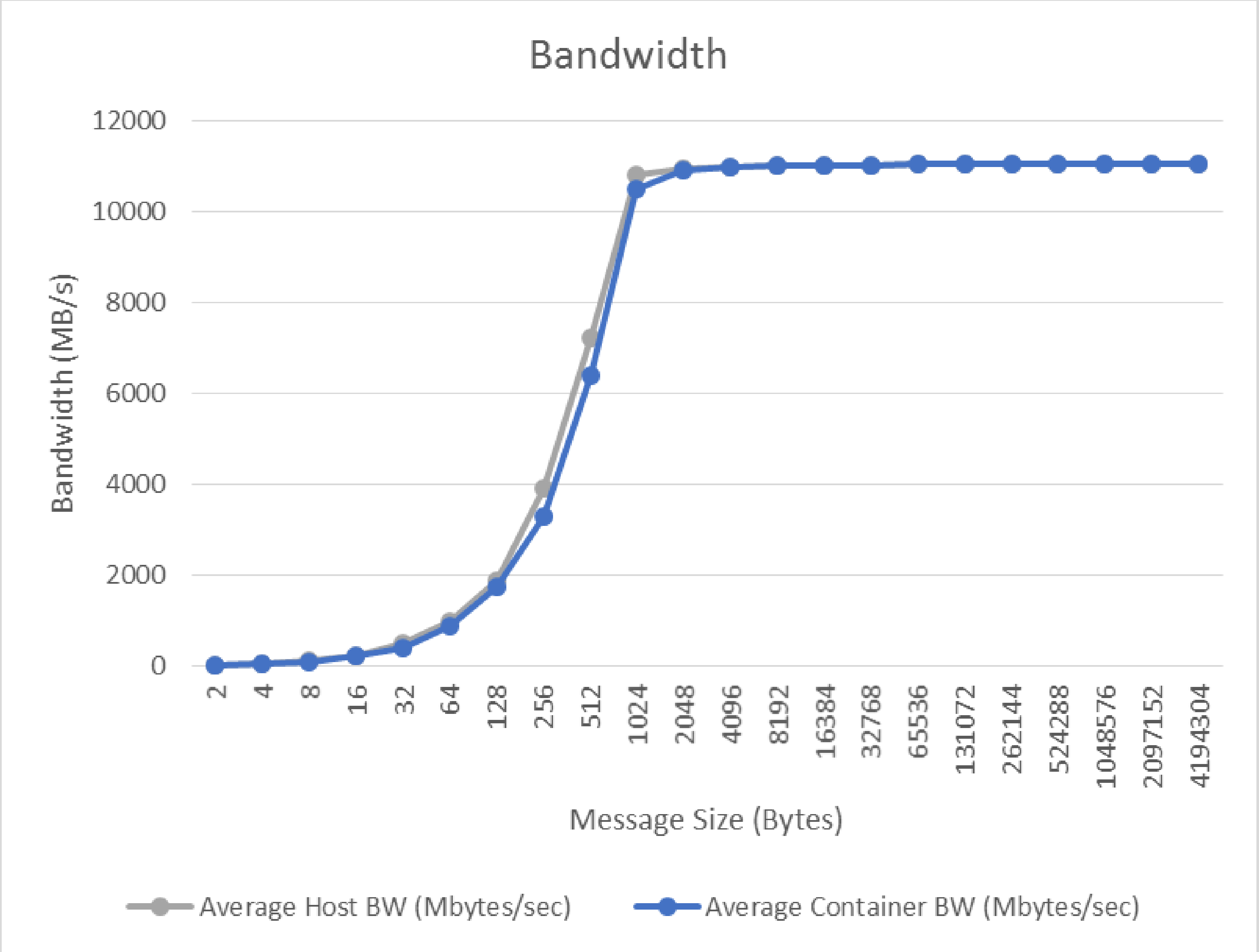
SELinux Policy for InfiniBand

- P_Key policy enforcements per subnet prefix, partition and user context
  - Label individual P_Keys
  - Admin defined policy to allow certain users or application access to labels

- Kernel
  - Initial version starting from Linux kernel 4.13
  - Stable version is 4.15 (IB core)

Container Performance on InfiniBand (SRIOV)





Container performance nearing native performance

Deployment Scenarios

	RoCE MAC VLAN	IB Overlay (Shared Dev)	IB/RoCE SRIOV Legacy	RoCE SRIOV OVS
Native Docker	Supported	Not supported	Supported	WIP
Docker Swarm	Not supported	Supported	Not supported	TBD
Kubernetes	Supported (not tested)	Supported	Supported	TBD

Native Docker: RoCE using macvlan

	RoCE MAC VLAN	IB Overlay (Shared Dev)	IB/RoCE SRIOV Legacy	RoCE SRIOV OVS
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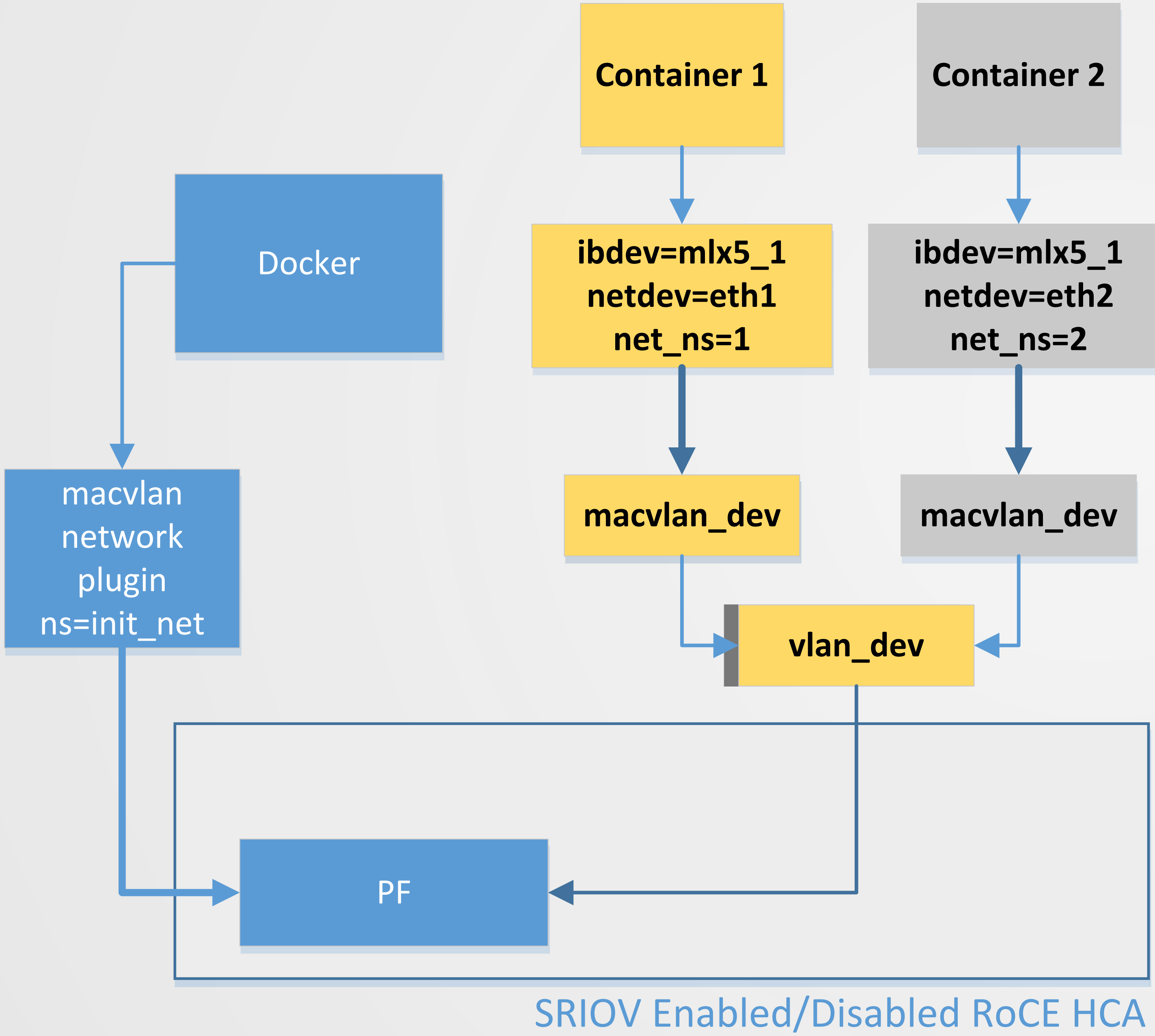

Native Docker: RoCE using macvlan

- Native macvlan Docker driver
- One macvlan netdvice per container
- Single RDMA device shared among multiple containers
- RDMACM and non RDMACM applications are supported for connection management
- Easy to manage, orchestrate and use

- Also useful with two level virtualization - running Docker containers inside a VM with VF mapped to VM
- With combination of VFs and macvlan, large number of containers can be deployed

- Example
  - Create network
    - *docker network create -d macvlan --subnet=192.168.1.0/24 -o parent=ens2f0 network1*

  - Start containers
    - *docker run --cap-add=IPC_LOCK -it --net=network1 --device=/dev/infiniband --device=/dev/infiniband/rdma_cm mellanox/centos_7_4_mofed_4_2_1_2_0_0_60:latest bash*

Docker Swarm: IB using Overlay Networking

	RoCE MAC VLAN	IB Overlay (Shared Dev)	IB/RoCE SRIOV Legacy	RoCE SRIOV OVS
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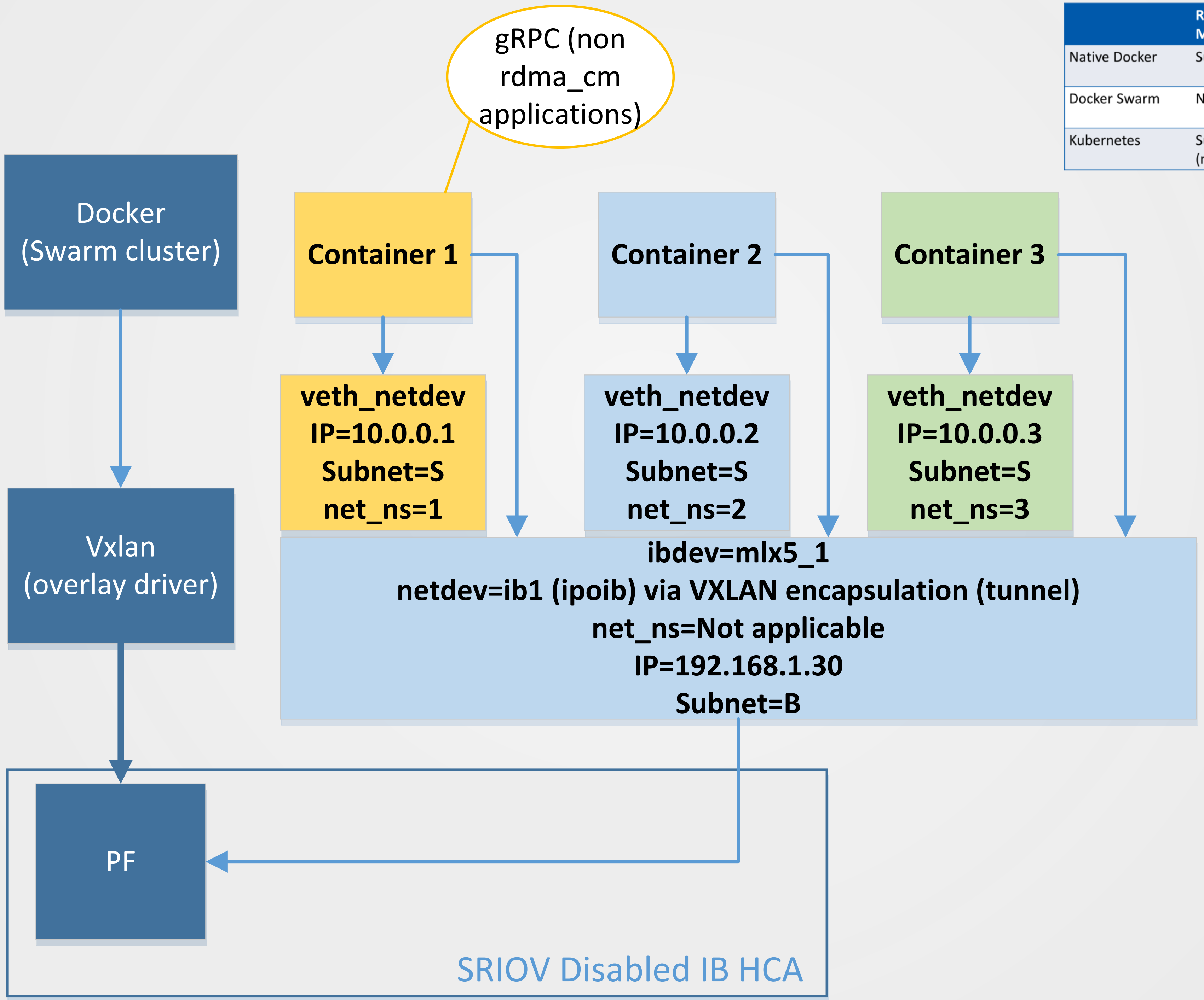
Kubernetes	Supported (not tested)	Supported	Supported	TBD



gRPC (non rdma_cm applications)

Docker (Swarm cluster)

Vxlan (overlay driver)

Container 1

Container 2

Container 3

veth_netdev
IP=10.0.0.1
Subnet=S
net_ns=1

veth_netdev
IP=10.0.0.2
Subnet=S
net_ns=2

veth_netdev
IP=10.0.0.3
Subnet=S
net_ns=3

ibdev=mlx5_1
netdev=ib1 (ipoib) via VXLAN encapsulation (tunnel)
net_ns=Not applicable
IP=192.168.1.30
Subnet=B

PF

SRIOV Disabled IB HCA

Kubernetes Docker: IB using Overlay Networking

	RoCE MAC VLAN	IB Overlay (Shared Dev)	IB/RoCE SRIOV Legacy	RoCE SRIOV OVS
Native Docker	Supported	Not supported	Supported	WIP
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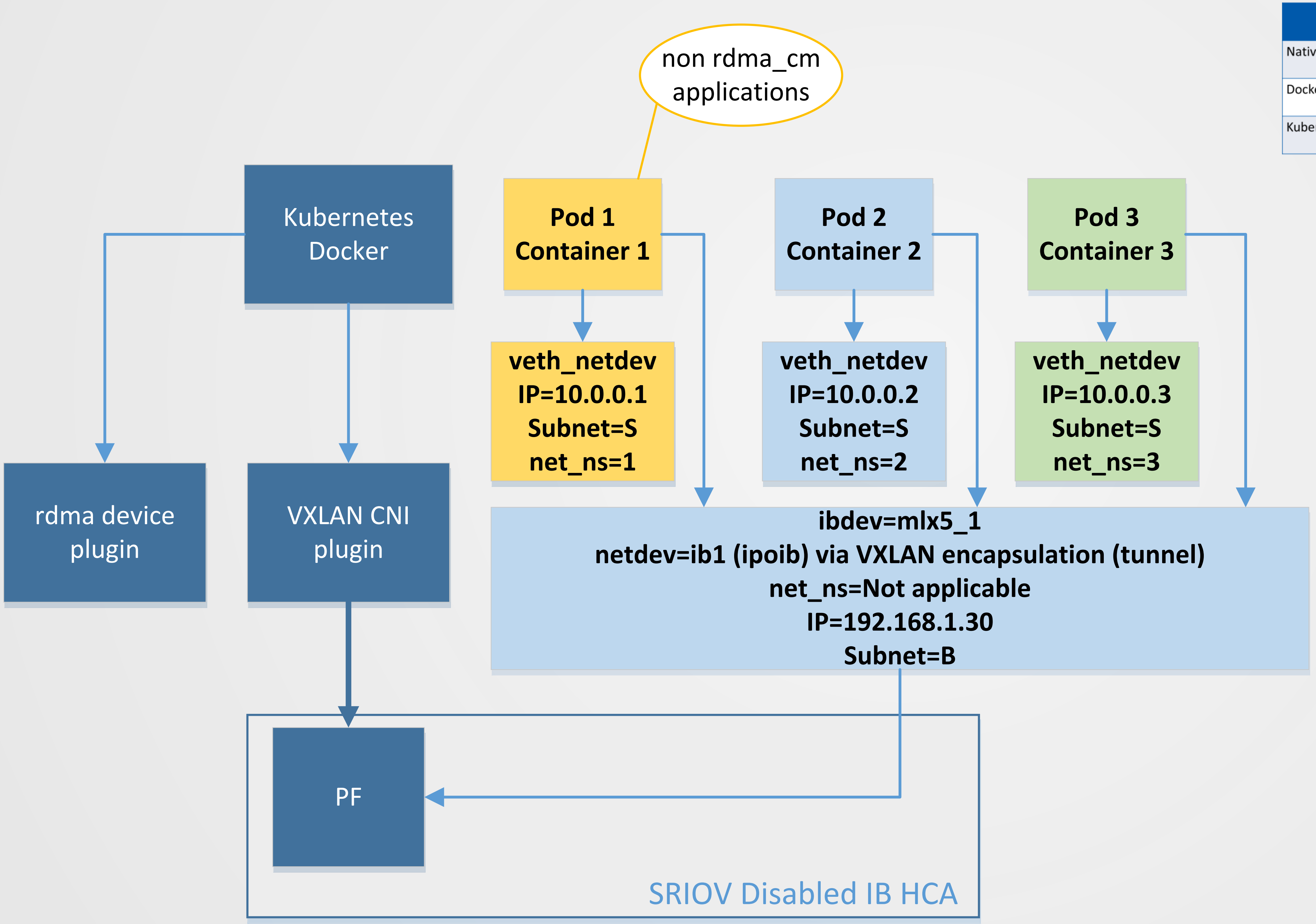
Kubernetes	Supported (not tested)	Supported	Supported	TBD



non rdma_cm applications

Kubernetes Docker

Pod 1 Container 1

Pod 2 Container 2

Pod 3 Container 3

veth_netdev
IP=10.0.0.1
Subnet=S
net_ns=1

veth_netdev
IP=10.0.0.2
Subnet=S
net_ns=2

veth_netdev
IP=10.0.0.3
Subnet=S
net_ns=3

rdma device plugin

VXLAN CNI plugin

ibdev=mlx5_1
netdev=ib1 (ipoib) via VXLAN encapsulation (tunnel)
net_ns=Not applicable
IP=192.168.1.30
Subnet=B

PF

SRIOV Disabled IB HCA

Kubernetes Docker: IB using Overlay Networking

- Networking achieved via VXLAN overlay cni plugin
- IPoIB as parent netdevice
- VXLAN encapsulated packets using IPoIB IP packets

- RDMA device plugin
  - Single RDMA device plugin to share among PODs (containers)

- Large number of PODs per host
- RDMA CM connection manager cannot operate
  - Can be used for applications that have TCP/ssh based connection management

Native Docker: IB/RoCE using SRIOV Networking

	RoCE MAC VLAN	IB Overlay (Shared Dev)	IB/RoCE SRIOV Legacy	RoCE SRIOV OVS
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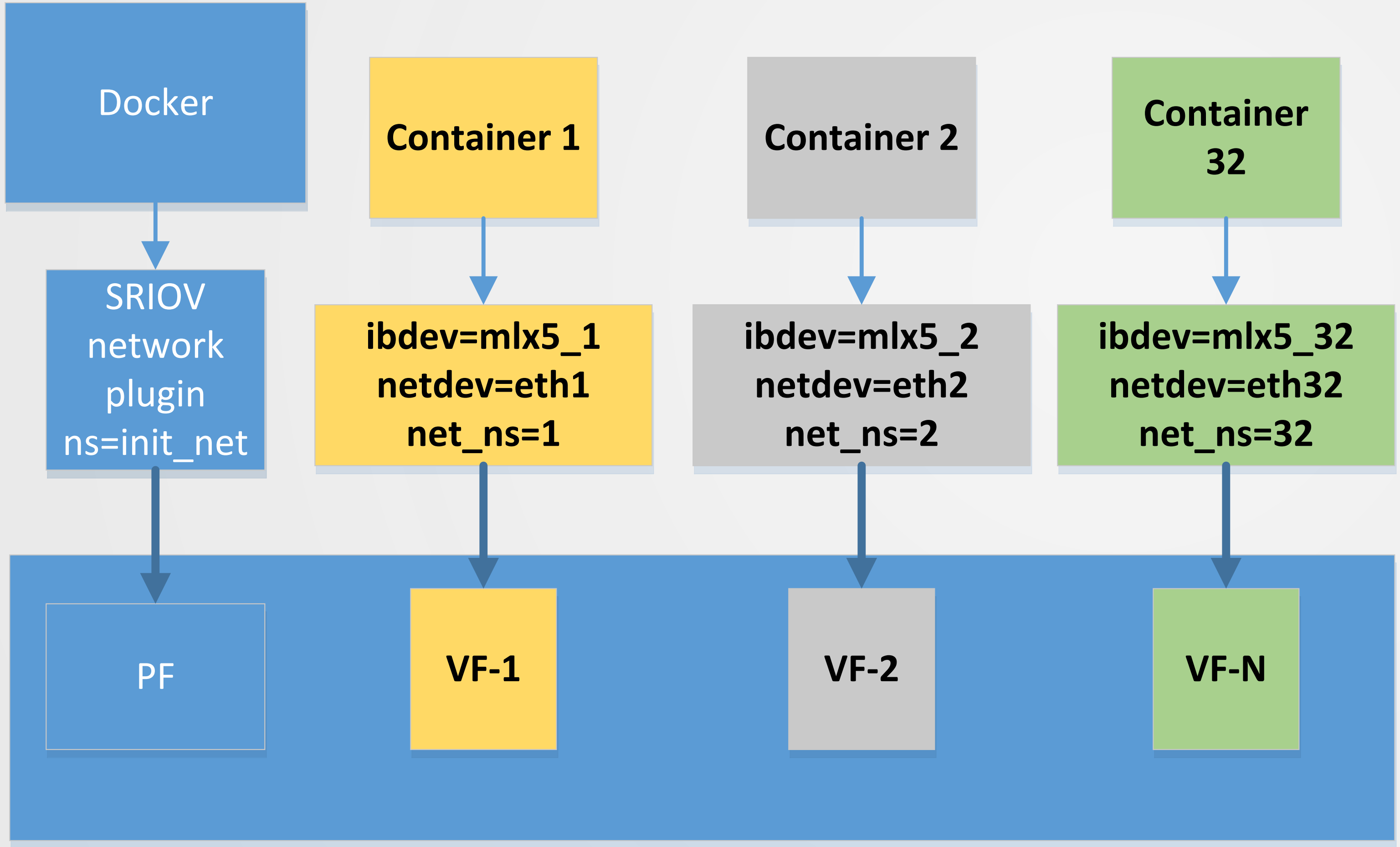

Docker
Container 1
Container 2
Container 32
SRIOV network plugin ns=init_net
ibdev=mlx5_1 netdev=eth1 net_ns=1
ibdev=mlx5_2 netdev=eth2 net_ns=2
ibdev=mlx5_32 netdev=eth32 net_ns=32
PF
VF-1
VF-2
VF-N

IB/RoCE SRIOV Enabled HCA

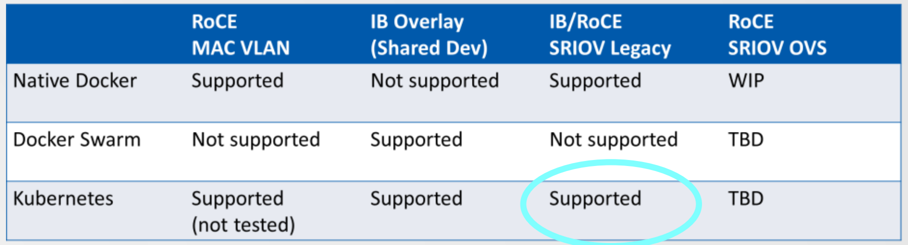
Native Docker: IB/RoCE using SRIOV Networking

- Per Container netdevice and RDMA device
- IB and RoCE link layers supported
  - For InfiniBand, IPoIB netdevice and IB device
  - For Ethernet, Ethernet netdevice and RoCE device
- Applicable for DPDK use-cases
- SR-IOV networking plugin to provision VF for a container
  - VLAN transparent offload
  - VF level rate limiting (BW)
- External docker_rdma_sriov tool for starting containers to provide isolation
  - WIP to eliminate the need for tool

Docker SR-IOV Example

- Example
  - Run SRIOV plugin
    - #docker run -v /run/docker/plugins:/run/docker/plugins -v /etc/docker:/etc/docker --net=host --privileged mellanox/sriov-plugin
  - Get container start tool
    - #docker run --net=host -v /usr/bin:/tmp mellanox/container_tools_install
  - Create network
    - *#docker network create -d sriov --subnet=194.168.1.0/24 -o netdevice=ens2f0 tenant1*
  - Start container
    - *Container1:*
      - *#docker_rdma_sriov run --net=tenant1 -it --ip=192.168.1.9 mellanox/centos_7_4_mofed_4_2_1_2_0_0_60:latest bash*
    - *Container2:*
      - *#docker_rdma_sriov run --net=tenant1 -it --ip=192.168.1.10 mellanox/centos_7_4_mofed_4_2_1_2_0_0_60:latest bash*
- *How to run RDMA application using rdma_cm*
    - *Container-1*
      - *ib_send_bw -R*
    - *Container-2*
      - *ib_send_bw -R <container_1_ip_address>*

Kubernetes Docker: IB/RoCE using SR-IOV Networking



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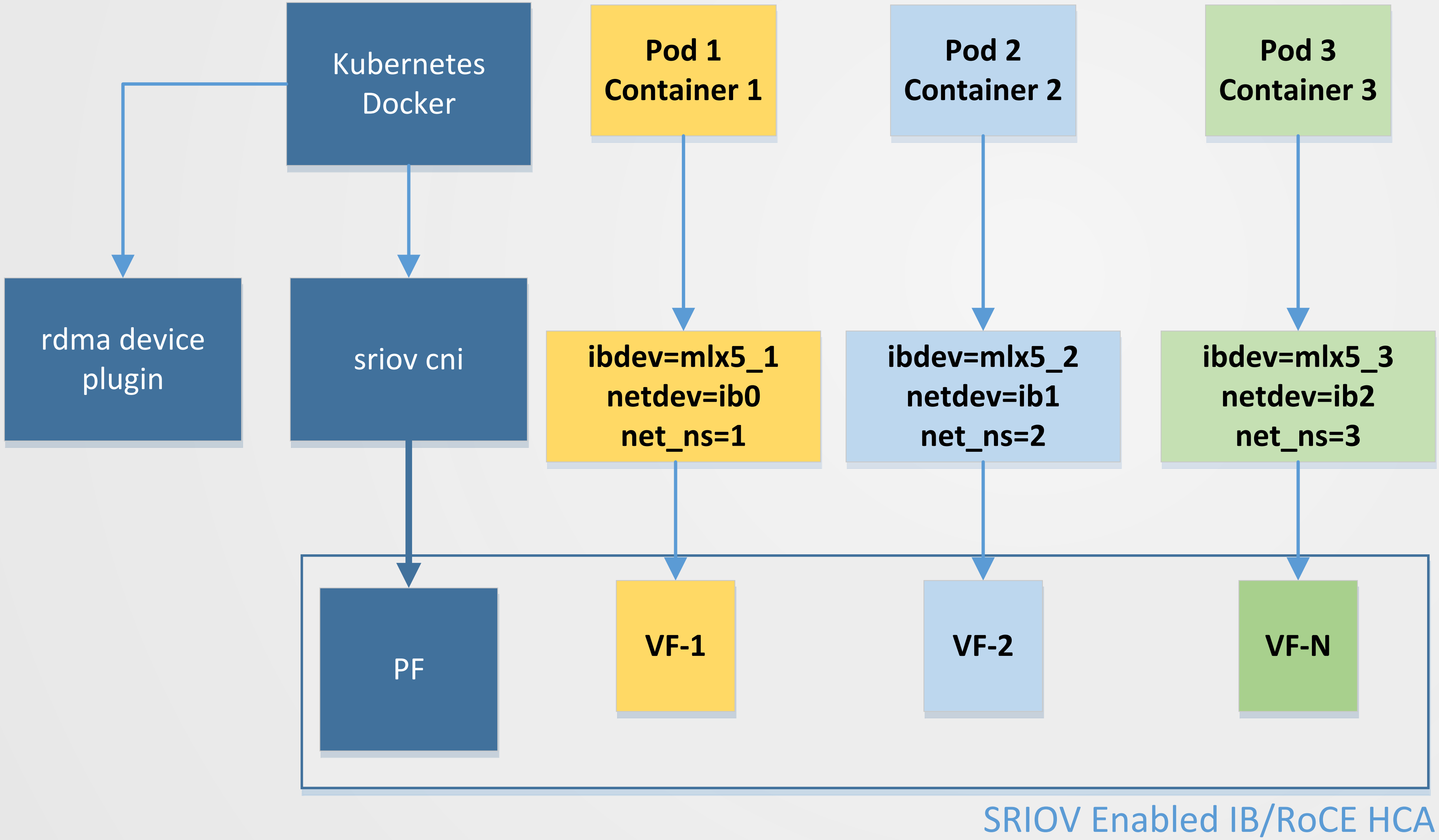

Kubernetes Docker
rdma device plugin
sriov cni
Pod 1 Container 1
Pod 2 Container 2
Pod 3 Container 3
ibdev=mlx5_1 netdev=ib0 net_ns=1
ibdev=mlx5_2 netdev=ib1 net_ns=2
ibdev=mlx5_3 netdev=ib2 net_ns=3
PF
VF-1
VF-2
VF-N
SRIOV Enabled IB/RoCE HCA

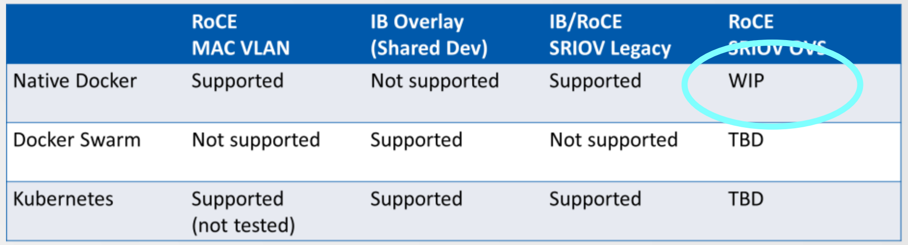
Kubernetes Docker: IB/RoCE using SR-IOV Networking

- Inherits native Docker features

- RDMA device plugin provisions VF
  - Enables SRIOV
  - Configures VF for RDMA and Ethernet
  - Per POD (per container) VF allocation
  - https://hub.docker.com/r/mellanox/k8s-rdma-sriov-dev-plugin/

- RDMA sriov cni
  - Provisions netdevice (IPoIB or Ethernet) for POD
  - https://hub.docker.com/r/mellanox/k8s-sriov-cni-installer/

RoCE VXLAN for Containers



	RoCE MAC VLAN	IB Overlay (Shared Dev)	IB/RoCE SRIOV Legacy	RoCE SRIOV OVS
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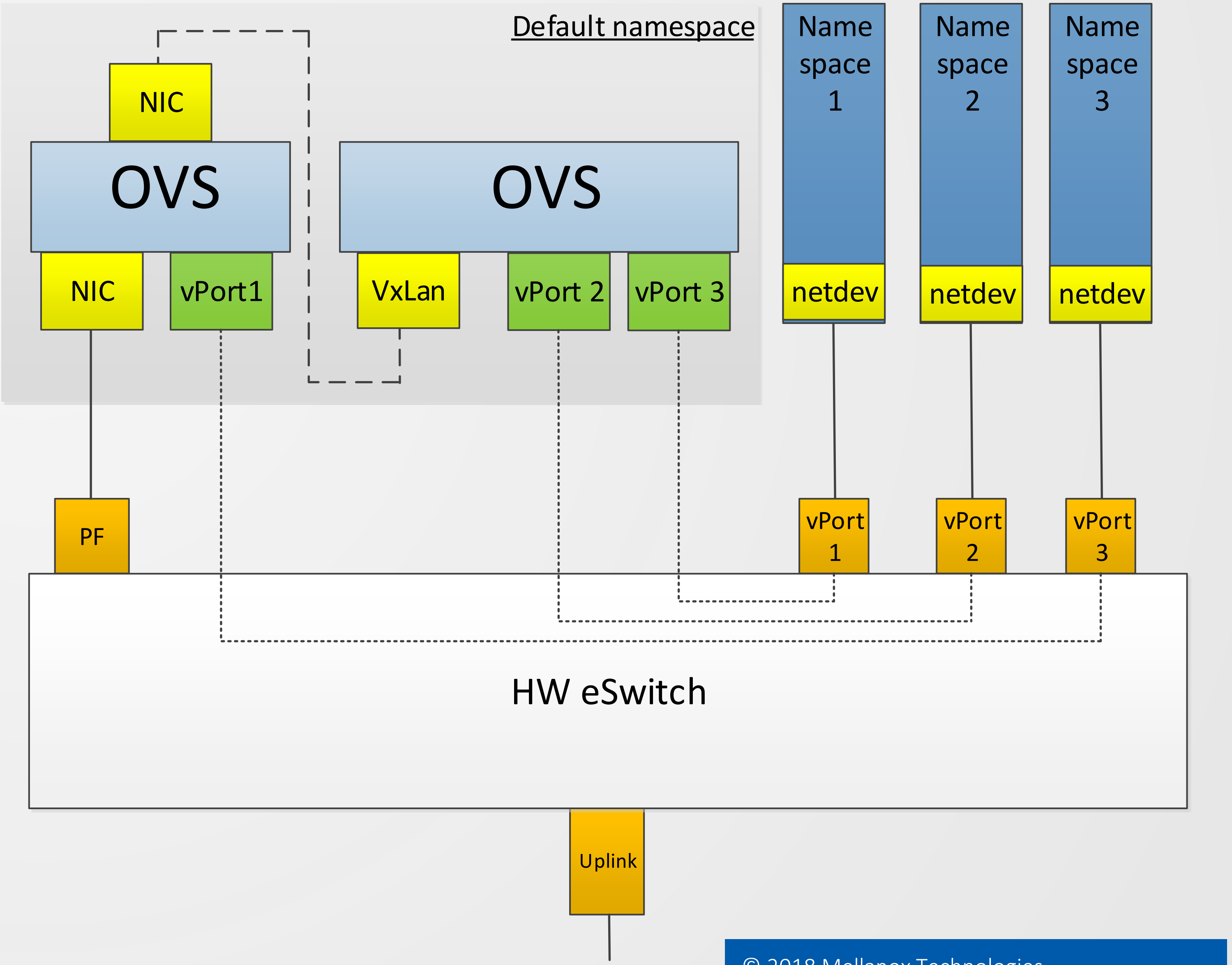
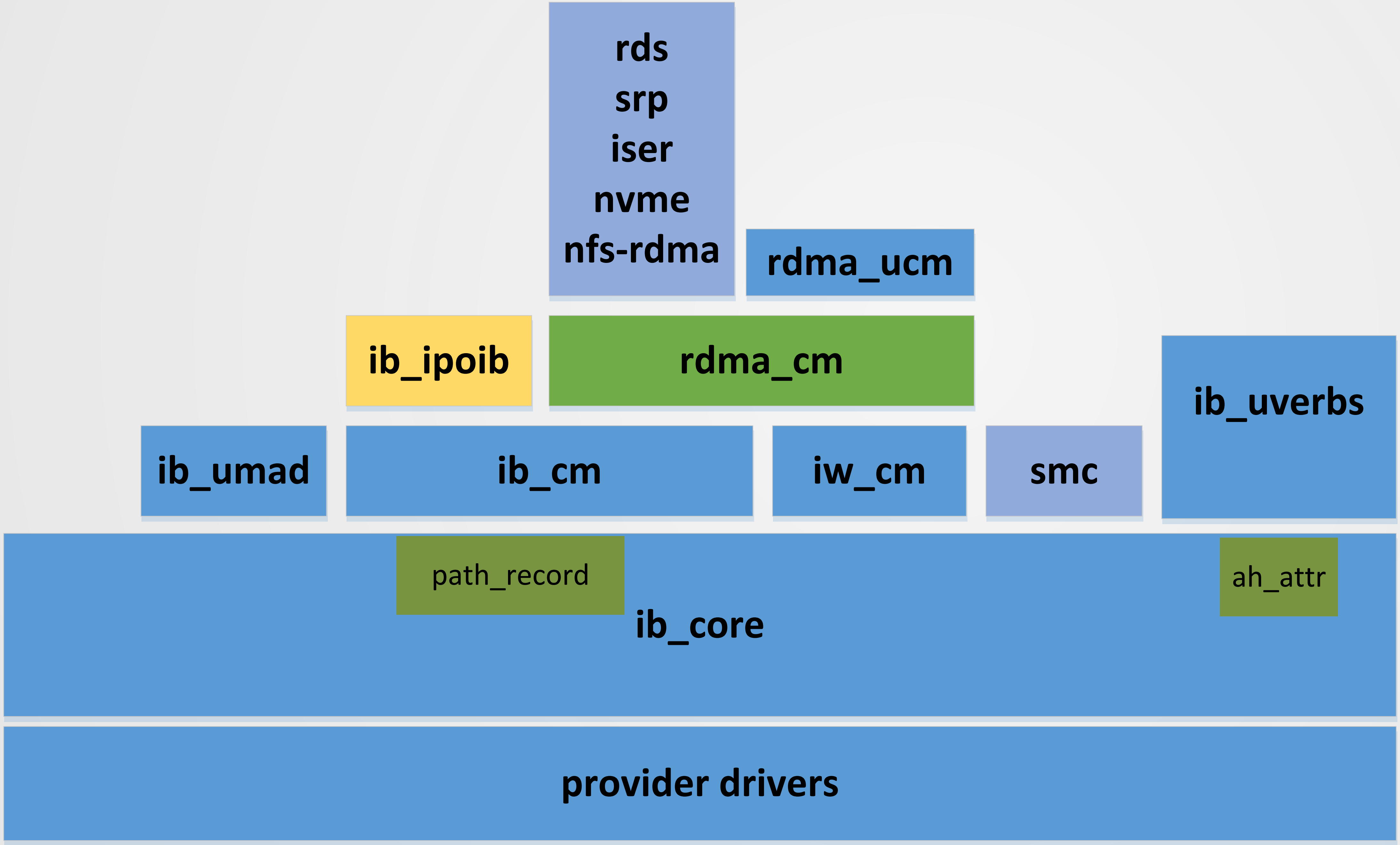
Kubernetes	Supported (not tested)	Supported	Supported	TBD

- OVS is a managed switch that supports VXLAN
- OVS 2.8+ support HW offload
- RoCE & DPDK traffic will be offloaded by eSwitch
- Supported today by assign a VF per container



RDMA Stack View - Net Namespace Enforcement



Challenges and Future Plans

- Per containers rdma statistics/counters
- rdmatool
  - Extension to disable RoCEv1 - scales RoCE containers by 2x
  - Making netlink socket per net_ns for rdmatool
- Orchestration challenge
  - Isolation of character (network) device
  - Isolation of sysfs files, attributes
  - CNI extension?
  - Kubernetes
    - Device plugin and network plugin interaction?
      - Device cgroup configuration
      - RDMA cgroup configuration
      - /sysfs bind mounts
- Net namespace resident IB devices
  - IB device resides in single net namespace
  - Optional mode

Thank You