Using Virtual Functions with DPDK in OpenShift 4

DPDK Summit 2021

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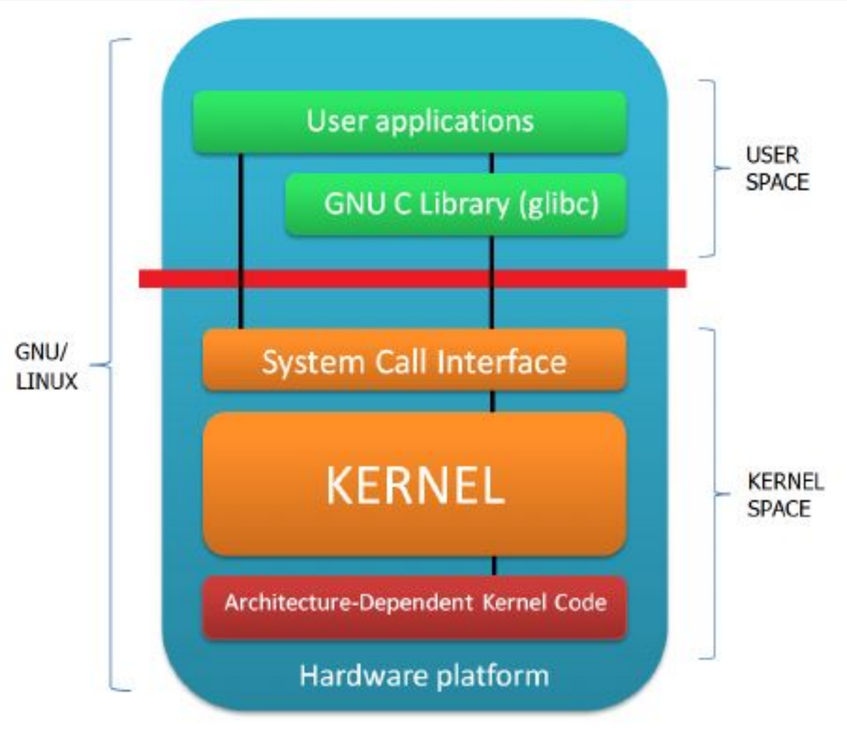
Linux Architecture

- System memory in Linux is divided into two spaces.
- Kernel space is reserved for the highest of trusted functions in a system
- User space is where the “normal” programs reside.

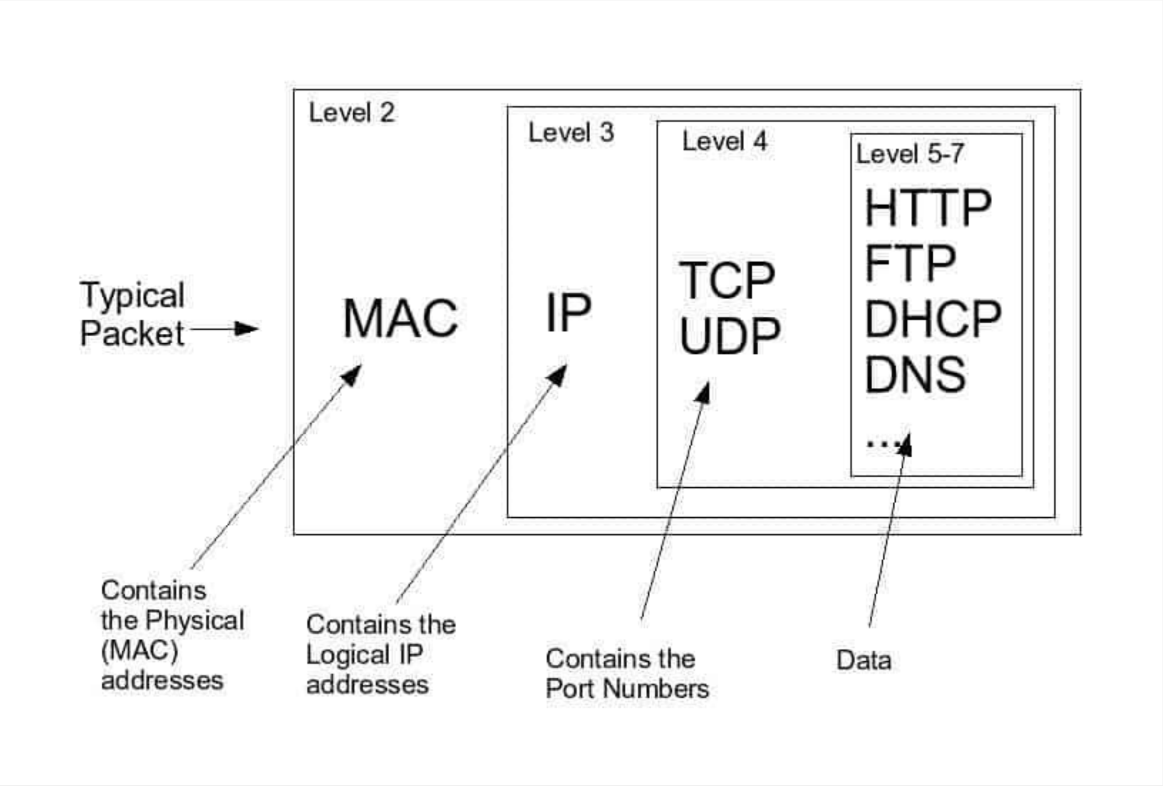


Network Packets Problems

- Network packets are moving inside the Host
- System gets notified of new packet and forward it to an allocated buffer
- Linux uses interrupt notifications handled by the kernel
- Many interrupts created when managing the packet
- More packets have to be processed more resources are consumed
- Poor performance

Network Packets

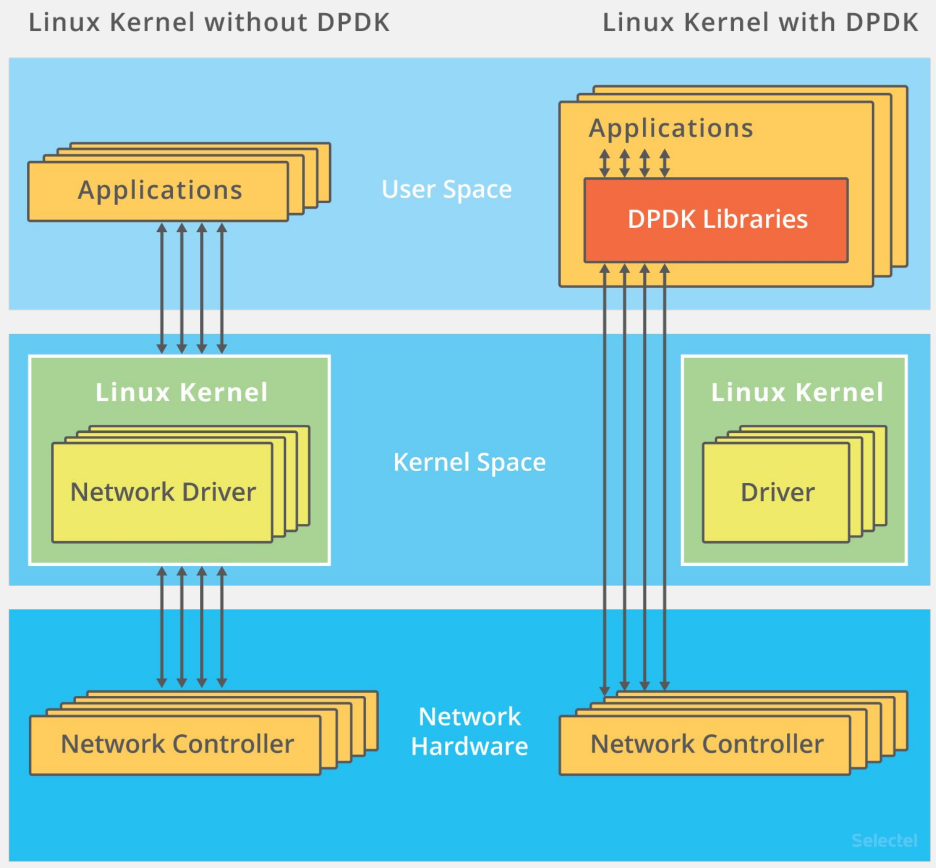
- Don’t want to manage network packet forwarding in Kernel Space
- Obtain high performance in system



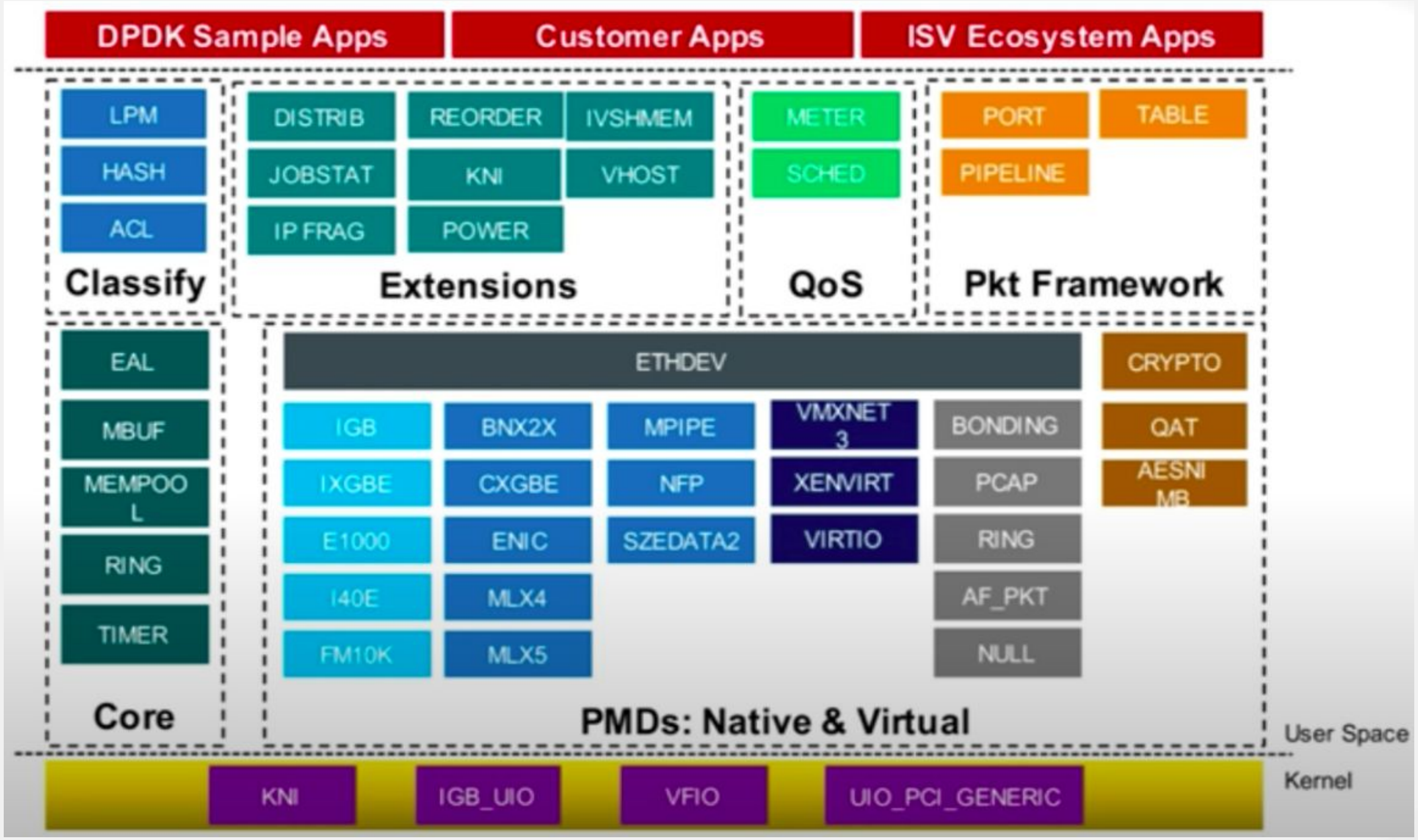
Solution

- Avoid using Kernel Space by using DPDK

DPDK Architecture



DPDK Libraries



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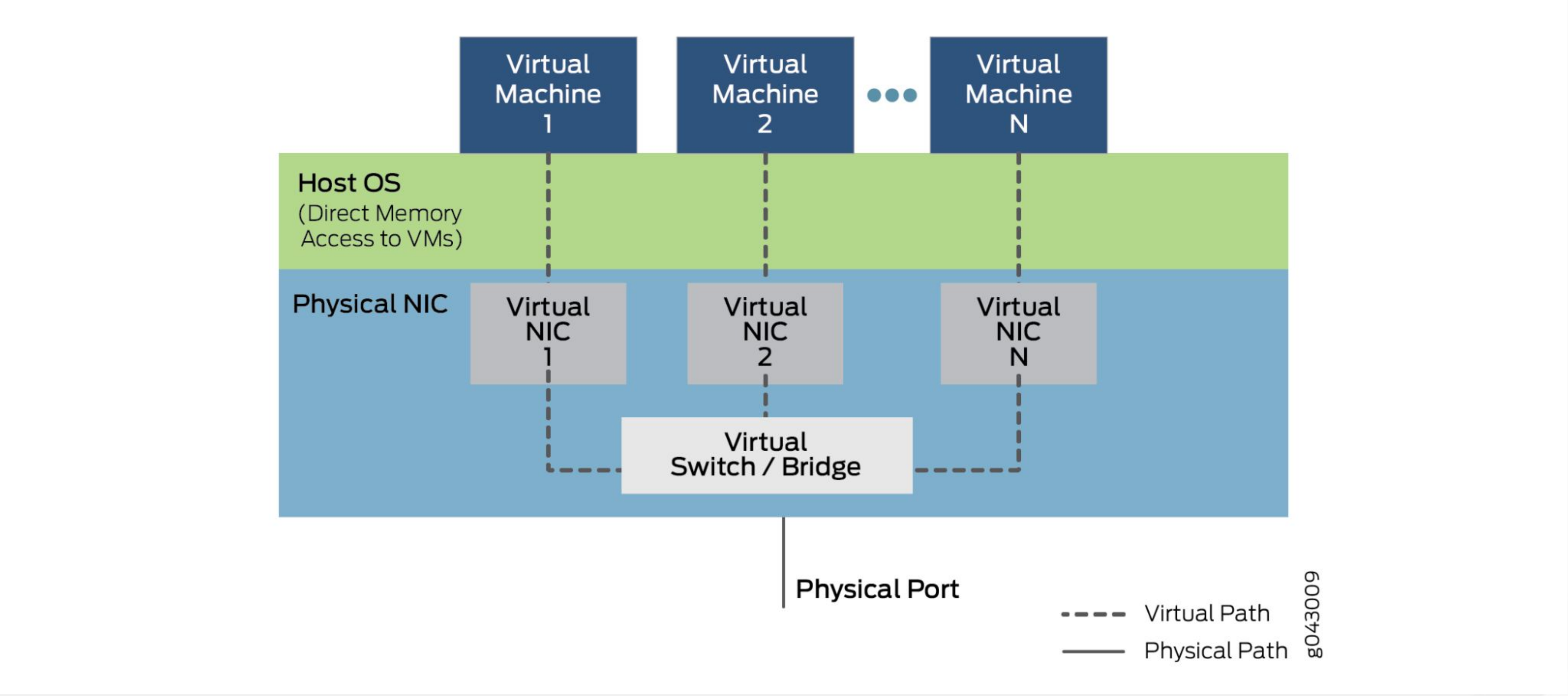
DPDK Benefits

- Reduce uncertainty about latency
- Improve network performance
- Reserve CPU cores that are close to the memory that the process needs
- Cache big pages of memory

Physical NIC and Virtual Functions



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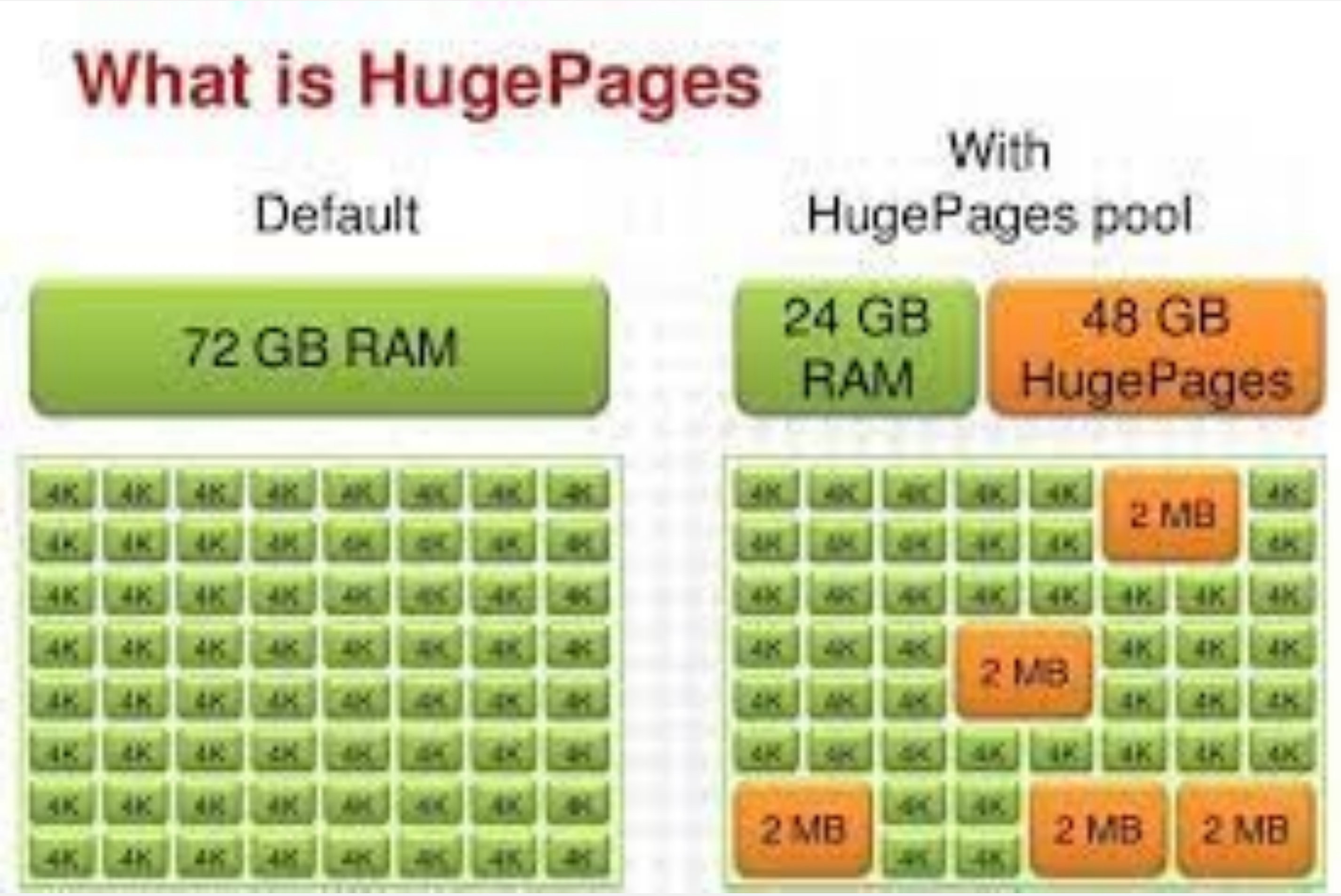
Prerequisites for Using VFs with DPDK

1. Configure SR-IOV
2. Configure HugePages

HugePages

- A huge page is a memory page that is larger than 4Ki
- Two common huge page sizes: 2Mi and 1Gi
- If a huge page pool is allocated, then huge pages need to be allocated.
- Transparent Huge Pages (THP) automates the management of huge pages without application knowledge
- THP leads to performance degradation on nodes with high memory utilization
- Applications in a pod can allocate and consume pre-allocated huge pages.

HugePages



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HugePages Benefits

- Increased performance through increased TLB (Translation Lookaside Buffer) hits
- Pages are locked in memory and never swapped out
- Provides RAM for shared memory structures
- Contiguous pages are preallocated and only used for System shared memory
- Less bookkeeping work for the kernel for virtual memory because of larger page sizes

SR-IOV Network Operator

- Create namespace openshift-sriov-network-operator
- Create label openshift.io/run-level: "1"
- Create Operator Group and bind to that namespace
- Create subscription on the operator

SR-IOV Network Operator

```yaml
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-sriov-network-operator
  labels:
    openshift.io/run-level: "1"
---
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: sriov-network-operators
  namespace: openshift-sriov-network-operator
spec:
  targetNamespaces:
  - openshift-sriov-network-operator
---
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: openshift-sriov-network-operator-subscription
  namespace: openshift-sriov-network-operator
spec:
 channel: "4.4"
 name: sriov-network-operator
 source: redhat-operators
 sourceNamespace: openshift-marketplace
```

SR-IOV Network Operator Namespace

Operator Group and Subscription

Add SR-IOV Labels to Nodes

The SR-IOV Network Node Policy requires this nodeSelector:

```
feature.node.kubernetes.io/network-sriov.capable: "true"
```

Node Feature Discovery Operator

We can install the NFD Operator to automatically label the nodes for us


```yaml
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: nfd
  namespace: openshift-operators
spec:
  channel: "4.4"
  name: nfd
  source: redhat-operators
  sourceNamespace: openshift-marketplace
```

Node Feature Discovery Operator

Node Feature Discovery CRD

```
apiVersion: nfd.openshift.io/v1alpha1
kind: NodeFeatureDiscovery
metadata:
  name: nfd-master-server
  namespace: openshift-operators
spec:
  namespace: openshift-nfd
```

Node Feature Discovery

Validate Node Labels

```
$ oc get node --show-labels
```

Config the SR-IOV Network Devices

- Specify physical NIC and the number of Virtual Functions per NIC
- Not all NICs have the same number of Virtual Functions
- Use Network Node State in SR-IOV Operator to get the VF information

```
oc get sriovnetworknodestate -n openshift-sriov-network-operator
<node name> -o yaml
```


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SR-IOV Network Node State


```
- deviceID: '1572'
  driver: i40e
  mtu: 1500
  name: ens1f0
  pciAddress: '0000:12:00.0'
  totalvfs: 64
  vendor: '8086'
- deviceID: '1572'
  driver: i40e
  mtu: 1500
  name: ens1f1
  pciAddress: '0000:12:00.1'
  totalvfs: 64
  vendor: '8086'
- deviceID: '1572'
  driver: i40e
  mtu: 1500
  name: eno5
  pciAddress: '0000:5d:00.0'
  totalvfs: 64
  vendor: '8086'
```

Review SR-IOV Capable NICs in Web Console

Select Virtual Functions

- Sriov Network Node Policy created by the SR-IOV Operator.
- Set the nicSelector specification in this format

```
<pfname>#<first_vf>-<last_vf>
```

Select Device Type

- netdevice performs the device bind in the kernel space
- vfio-pci binds in the user space

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetworkNodePolicy
metadata:
  name: policy-onboard-dpdk
  namespace: openshift-sriov-network-operator
spec:
  resourceName: onboardDPDK
  nodeSelector:
    feature.node.kubernetes.io/network-sriov.capable: "true"
  mtu: 1500
  numVfs: 64
  nicSelector:
    pfNames: ["eno5#50-59", "eno6#50-59"]
  isRdma: false
  deviceType: vfio-pci
```


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Select Device Type

SR-IOV Network Node Policy

NIC selection is done per Sriov Network Node Policy

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetworkNodePolicy
metadata:
  name: policy-pcie
  namespace: openshift-sriov-network-operator
spec:
  resourceName: pcieSRIOV
  nodeSelector:
    feature.node.kubernetes.io/network-sriov.capable: "true"
  mtu: 1500
  numVfs: 64
  nicSelector:
    pfNames: ["ens1f0#0-49", "ens1f1#0-49"]
  deviceType: netdevice
  isRdma: false
```

SR-IOV Network Attachment

- Define static IPs if you don't have a DHCP server in your network
- Enable the static IP address configuration in the capabilities

```yaml
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetwork
metadata:
  name: sriovnet1
  namespace: openshift-sriov-network-operator
spec:
  ipam: |
    {
      "type": "static",
      "addresses": [
        {
          "address": "192.168.99.0/24",
          "gateway": "192.168.99.1"
        }
      ],
      "dns": {
        "nameservers": ["8.8.8.8"],
        "domain": "test.lablocal",
        "search": ["test.lablocal"]
      }
    }
  vlan: 0
  spoofChk: 'on'
  trust: 'off'
  resourceName: onboardSRIOV
  networkNamespace: test-epa
  capabilities: '{"ips": true}'
```

Create SR-IOV Network

SR-IOV Testing

- Create a couple of pods using the SR-IOV network
- Pods are running on different nodes

```
apiVersion: v1
kind: Pod
metadata:
  name: test-sriov-1
  annotations:
    k8s.v1.cni.cncf.io/networks: '[
        {
                "name": "sriovnet1",
                "ips": ["192.168.99.11/24"]
        }
]'
spec:
  containers:
  - name: example-pod
    command: ["/bin/bash", "-c", "sleep 9000000"]
    image: centos/tools
  nodeName: <node1>
```

```
apiVersion: v1
kind: Pod
metadata:
  name: test-sriov-2
  annotations:
    k8s.v1.cni.cncf.io/networks: '[
        {
                "name": "sriovnet1",
                "ips": ["192.168.99.12/24"]
        }
]'
spec:
  containers:
  - name: example-pod
    command: ["/bin/bash", "-c", "sleep 9000000"]
    image: centos/tools
  nodeName: <node2>
```

SR-IOV Testing

```
$ oc rsh test-sriov-1

sh-4.2# ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN
group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
3: eth0@if179: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1450 qdisc
noqueue state UP group default
    link/ether 0a:58:0a:82:02:14 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.130.2.20/23 brd 10.130.3.255 scope global eth0
       valid_lft forever preferred_lft forever
    inet6 fe80::4b5:27ff:fe7c:6a24/64 scope link
       valid_lft forever preferred_lft forever
135: net1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state
UP group default qlen 1000
    link/ether e2:bd:ea:8c:b0:49 brd ff:ff:ff:ff:ff:ff
    inet 192.168.99.11/24 brd 192.168.99.255 scope global net1
       valid_lft forever preferred_lft forever
    inet6 fe80::e0bd:eaff:fe8c:b049/64 scope link
       valid_lft forever preferred_lft forever

sh-4.2# ping 192.168.99.12
PING 192.168.99.12 (192.168.99.12) 56(84) bytes of data.
64 bytes from 192.168.99.12: icmp_seq=1 ttl=64 time=0.205 ms
64 bytes from 192.168.99.12: icmp_seq=2 ttl=64 time=0.099 ms
```

Jump to one pod and try to ping the other pod.

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SR-IOV Testing

DPDK Configuration

- Intel NICs you should configure the vfio-pci driver
- Mellanox NIC needs to configure netdevice and set isRdma to true

```
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetworkNodePolicy
metadata:
  name: policy-onboard-dpdk
  namespace: openshift-sriov-network-operator
spec:
  resourceName: onboardDPDK
  nodeSelector:
    feature.node.kubernetes.io/network-sriov.capable: "true"
  mtu: 1500
  numVfs: 64
  nicSelector:
    pfNames: ["eno5#50-59", "eno6#50-59"]
  isRdma: false
  deviceType: vfio-pci
```

DPDK SR-IOV Network Configuration


```yaml
apiVersion: sriovnetwork.openshift.io/v1
kind: SriovNetwork
metadata:
  name: dpdknet1
  namespace: openshift-sriov-network-operator
spec:
  ipam: |
    {
      "type": "static",
      "addresses": [
        {
          "address": "192.168.155.0/24",
          "gateway": "192.168.155.1"
        }
      ],
      "dns": {
        "nameservers": ["8.8.8.8"],
        "domain": "testdpdk.lablocal",
        "search": ["testdpdk.lablocal"]
      }
    }
  vlan: 0
  spoofChk: 'on'
  trust: 'off'
  resourceName: onboardDPDK
  networkNamespace: test-epa
  capabilities: '{"ips": true}'
```

DPDK Testing

- Have an Image that uses DPDK
- Create the POD including HugePages configuration and the SR-IOV network definition

DPDK Testing

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: test-dpdk-1
  namespace: test-epa
  annotations:
    k8s.v1.cni.cncf.io/networks: '[
        {
                "name": "dpdknet1",
                "ips": ["192.168.155.12/24"]
        }
]'
```

```yaml
spec:
  containers:
  - name: testpmd
    image: <image>
    securityContext:
     capabilities:
        add: ["IPC_LOCK"]
    volumeMounts:
    - mountPath: /dev/hugepages
      name: hugepage
    resources:
      limits:
        openshift.io/onboardDPDK: "1"
        memory: "1Gi"
        cpu: "4"
        hugepages-1Gi: "4Gi"
      requests:
        openshift.io/onboardDPDK: "1"
        memory: "1Gi"
        cpu: "4"
        hugepages-1Gi: "4Gi"
    command: ["sleep", "infinity"]
  nodeName: worker-epa-1.ocp.172.18.234.152.nip.io
  volumes:
  - name: hugepage
    emptyDir:
      medium: HugePages
```

Conclusion

- We can use the DPDK libraries and attach a network interface (virtual function) directly to the pod.
- DPDK libraries offers to free up the Kernel space from interrupts by processing the work in User space.
- We can leverage Red Hat's DPDK builder image from the Red Hat registry to simplify the application building process.
- The base image allows developers to build applications powered by DPDK with efficiency and quality.

Thank you

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