
KubeCon
CloudNativeCon
Europe 2025
LONDON BUS

Uncharted Waters: Dynamic Resource Allocation for Networking

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Agenda

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Problem & Motivation

Multi-network status quo

Intro to DRA

DRA in the Context of Networking

Existing KEPs
- Multi-Network
- Scheduling Use Case

Demo

Problem

Kubernetes is Opinionated

Each Pod Gets One Interface

All Pods are Interconnected
- No NAT !
- Micro-Segmentation via Network Policies

Motivation

What if …

- You don’t want the cluster Default Network ?
- You want *more* than one Interface ?

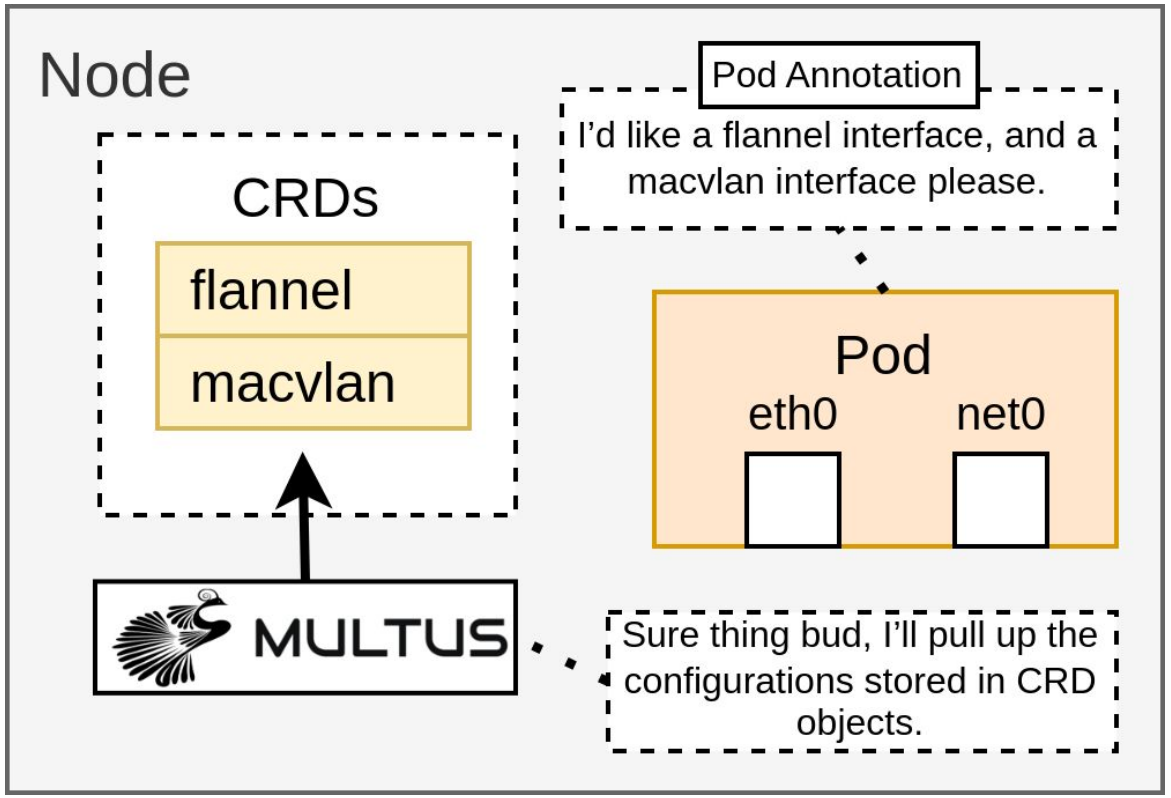
The Current Status Quo

Network Plumbing Working Group / Multus CNI

CNI JSON inside YAML and "out-of-tree"

```
kind: Pod
metadata:
  name: pod1
  annotations:
    k8s.cni.cncf.io/networks : '{"name":
"media-net", "interface": "net0"}'
spec:
   [...]
```

```
kind: NetworkAttachmentDefinition
[...]
spec:
  conf: '{
  "type": "bridge",
  "name": "media-net",
  "ipam": {"type": "static"}
 }'
```



KEP-3698: Bringing Multi-Network “In Tree”

Network Plumbing Working Group / Multus CNI

CNI JSON inside YAML and "out-of-tree"

```
kind: Pod
metadata:
  name: pod1
  annotations:
    k8s.cni.cncf.io/networks : '{"name":
"media-net", "interface": "net0"}'
spec:
   [...]
```

```
kind: NetworkAttachmentDefinition
[...]
spec:
  conf: '{
  "type": "bridge",
  "name": "media-net",
  "ipam": {"type": "static"}
 }’
```

K8s Native Multi-networking / PodNetwork

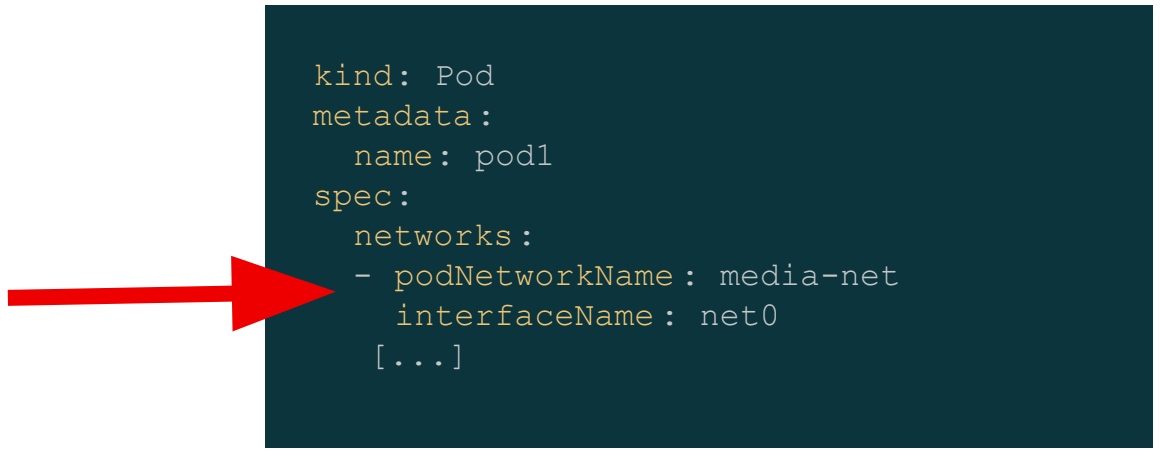
All YAML and all "in tree"

```
kind: Pod
metadata:
  name: pod1
spec:
  networks:
  - podNetworkName: media-net
    interfaceName: net0
   [...]
```

```
apiVersion: v1
kind: PodNetwork
metadata:
  name: media-net
spec:
  provider:
"myprovider.io/application"
```

Can’t Touch This !

“Do *Not* Touch the Pod Object Specification”



```yaml
kind: Pod
metadata:
  name: pod1
spec:
  networks:
  - podNetworkName: media-net
    interfaceName: net0
   [...]
```

The Current Status Quo - Device Plugins

	Device Plugins
Introduced in…	K8s 1.8 (alpha)
Resource Model	Extended Resources: `vendor.com/device=X`
Sharing across pods?	❌ No (one pod per device)
Per node daemon required?	✅ Yes (device plugin on each node)

Multi-Network Decomposed

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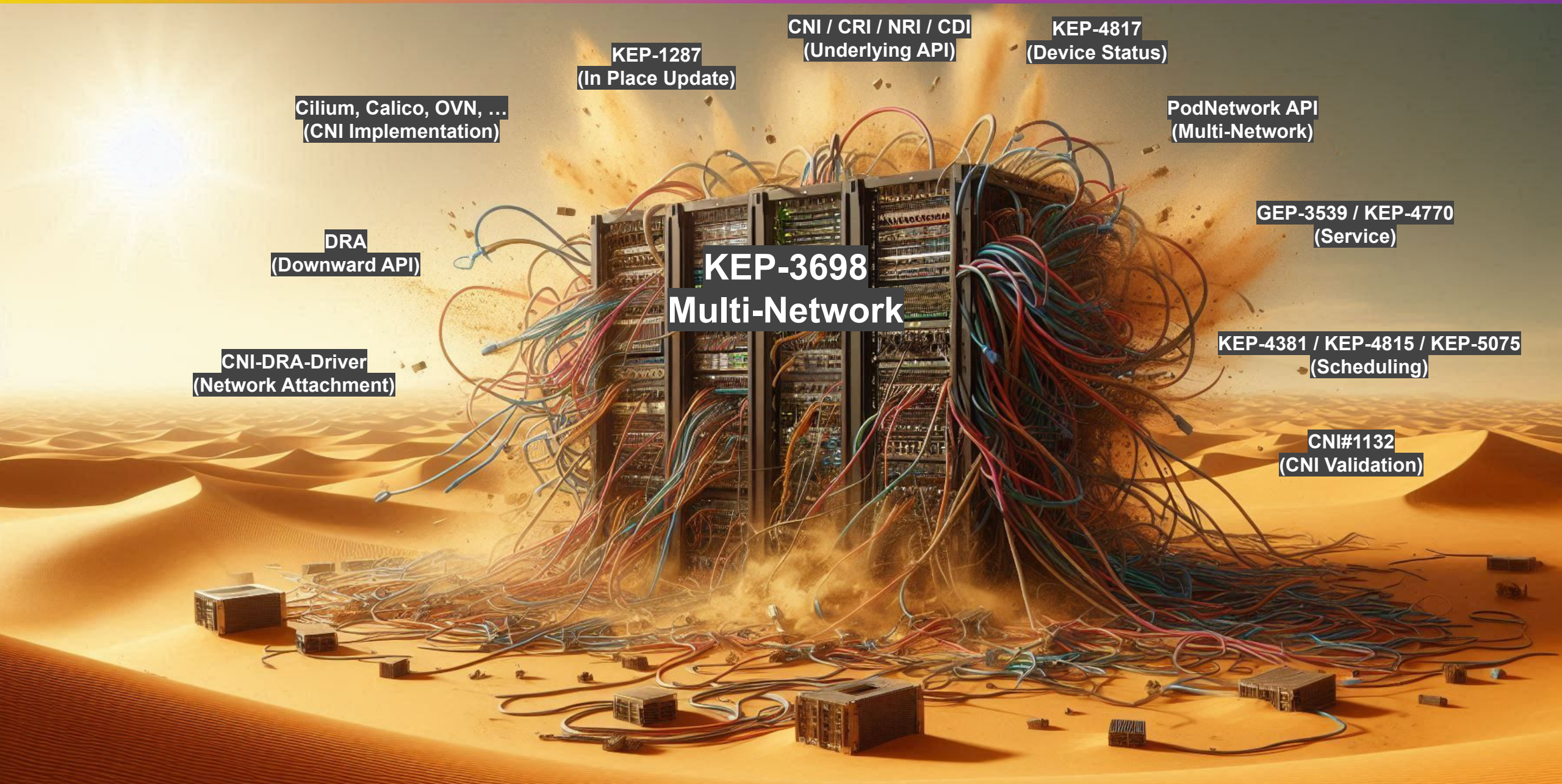
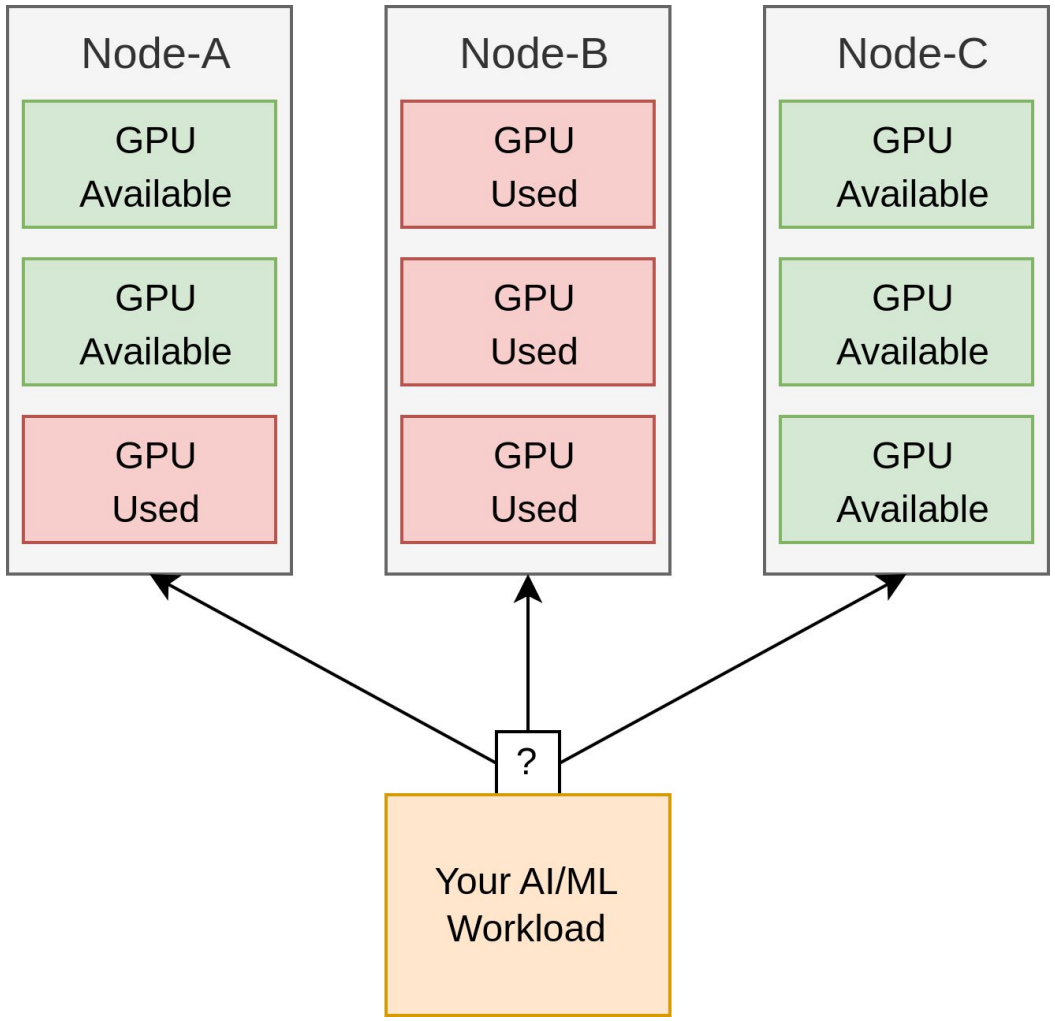


What is DRA

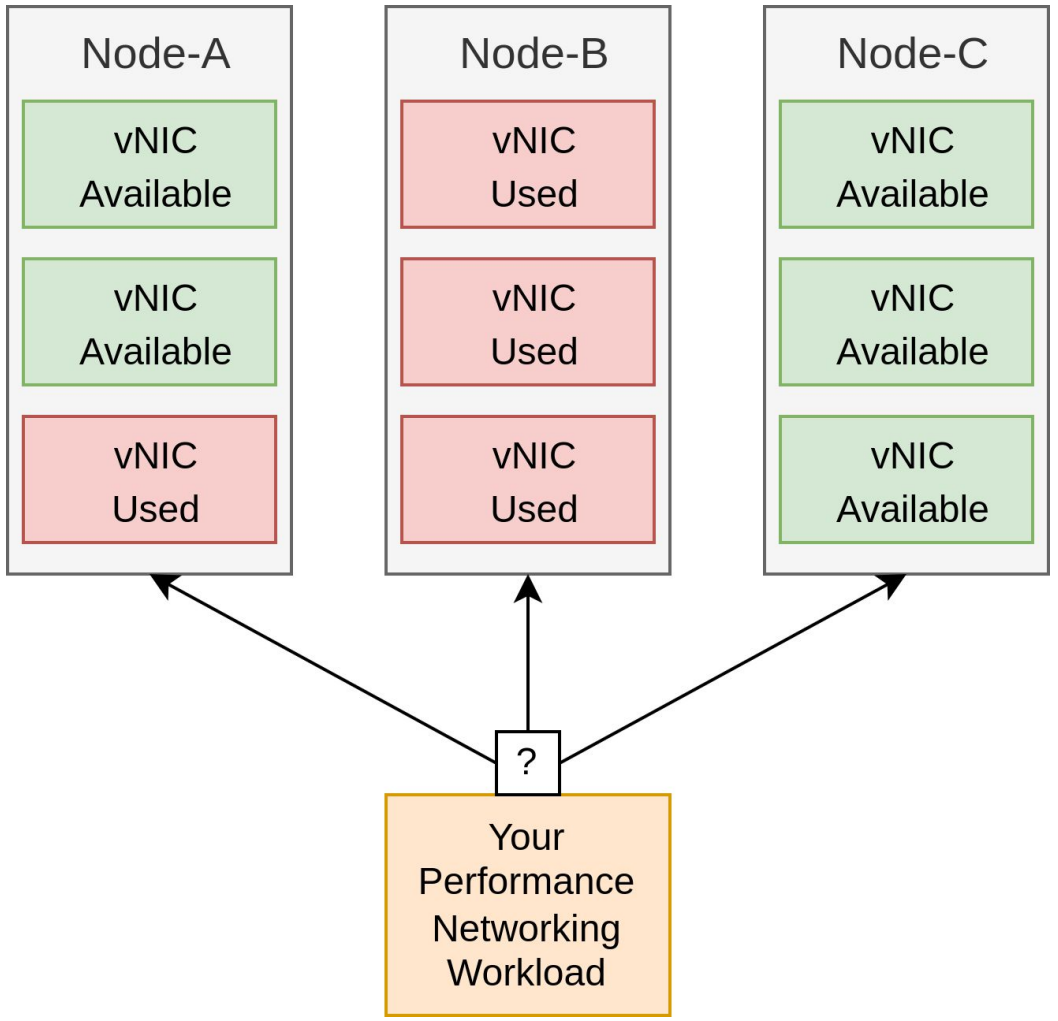
“an API for requesting and sharing resources between pods and containers inside a pod” - K8s.io

Currently beta in 1.32



Generalizing DRA

… an API for requesting and sharing ***network interfaces*** between pods and containers



Scheduling

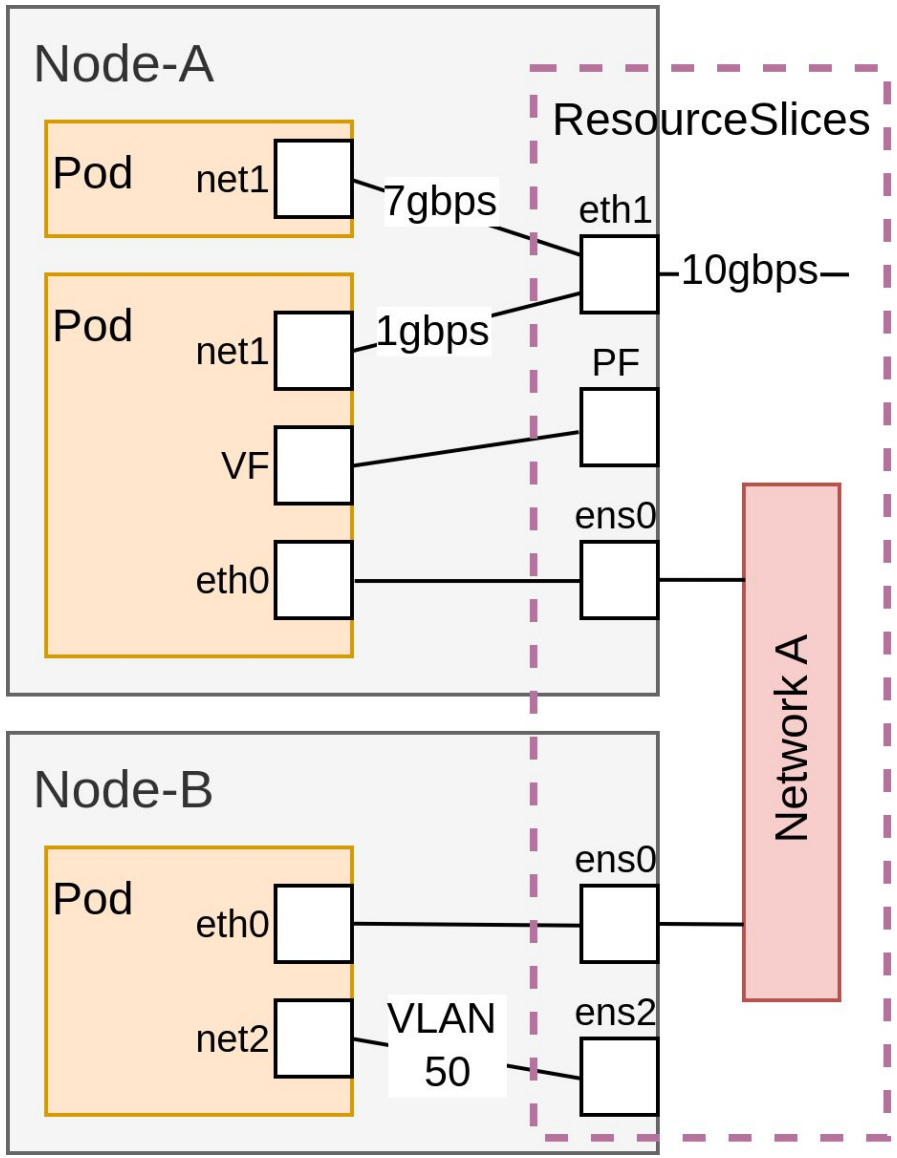
ResourceSlice Lists What is Available

Pod Requests Requirements

Schedule Pods Based on Their Needs

Non-Uniform Clusters

KEP-5075 - Consumable Capacity

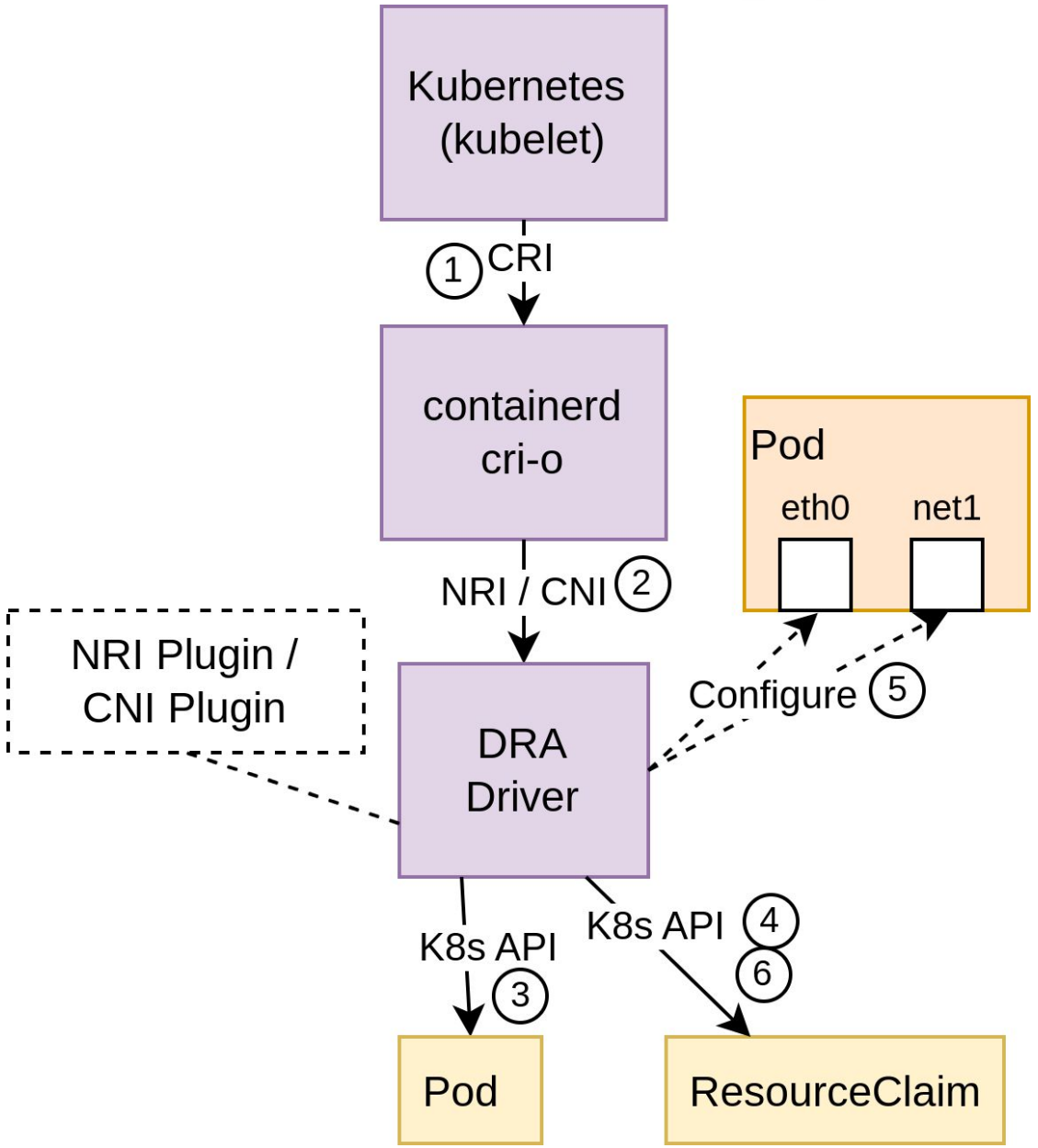


Network Interface Workflow Configuration

Node Resource Interface (NRI)

Hook into Pod Lifecycle Events

1. RunPodSandbox
2. RunPodSandbox (NRI) / CNI ADD
3. Get Pod
4. Get Pod's ResourceClaims
5. Configure Pod's Network Interfaces
6. Set ResourceClaims Status



Device Status

KEP-4817 - ResourceClaim Device Status

Responsibility on the DRA-Driver

1. Network Services
2. Troubleshooting

1 Pod per ResourceClaim

Alpha in 1.32 and Beta in 1.33

```yaml
apiVersion: resource.k8s.io/v1beta1
kind: ResourceClaim
metadata:
  name: macvlan-eth0
spec:
  ...
status:
  ...
  devices:
  - conditions: []
    device: macvlan-eth0
    driver: cni.dra.driver
    pool: kind-worker
    data:
      cniVersion: 1.0.0
      interfaces:
      - mac: 00:01:ec:f9:12:3b
        name: net1
        sandbox: /var/run/netns/cni-d36910c7
      ips:
      - address: 10.10.1.2/24
        gateway: 10.10.1.1
        interface: 0
    networkData:
      ips:
      - 10.10.1.2/24
      hardwareAddress: 00:01:ec:f9:12:3b
      interfaceName: net1
```

Demo - MACVLAN on Non-Uniform Cluster

Check the Environment

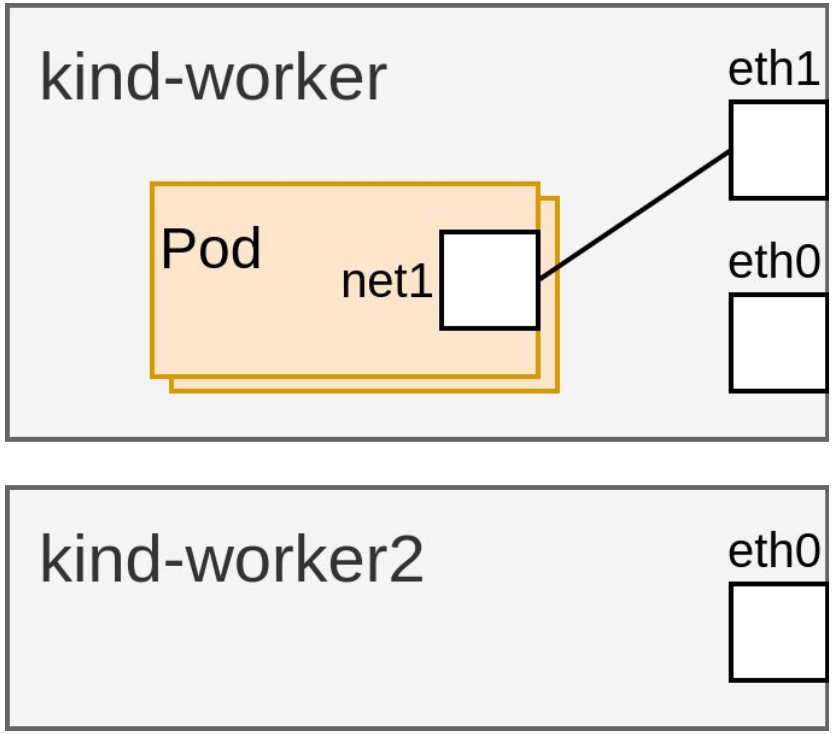
List Resources Available (ResourceSlices)

Request Resources from Pods (15 replicas)

- **MACVLAN on Top of eth1 Only Available on Kind-Worker**

Verify Resources Allocated

Inspect Acquired Resource



Demo - Environment (Cluster)

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```
~$ kubectl get pods --all-namespaces -o wide
NAMESPACE            NAME                                       READY   STATUS    RESTARTS   AGE   IP           NODE
default              cni-dra-driver-57m2k                       1/1     Running   0          24s   172.18.0.2   kind-worker2
default              cni-dra-driver-wldbs                       1/1     Running   0          24s   172.18.0.4   kind-control-plane
default              cni-dra-driver-zjm9x                       1/1     Running   0          24s   172.18.0.3   kind-worker
kube-system          coredns-668d6bf9bc-cb27b                   1/1     Running   0          30m   10.244.0.2   kind-control-plane
kube-system          coredns-668d6bf9bc-rsvfn                   1/1     Running   0          30m   10.244.0.4   kind-control-plane
kube-system          etcd-kind-control-plane                    1/1     Running   0          31m   172.18.0.4   kind-control-plane
kube-system          install-cni-plugins-bghjt                  1/1     Running   0          24s   172.18.0.4   kind-control-plane
kube-system          install-cni-plugins-jvrl8                  1/1     Running   0          24s   172.18.0.3   kind-worker
kube-system          install-cni-plugins-vstlp                  1/1     Running   0          24s   172.18.0.2   kind-worker2
kube-system          kindnet-2k2mj                              1/1     Running   0          30m   172.18.0.3   kind-worker
kube-system          kindnet-bbssj                              1/1     Running   0          30m   172.18.0.4   kind-control-plane
kube-system          kindnet-f6zx9                              1/1     Running   0          30m   172.18.0.2   kind-worker2
kube-system          kube-apiserver-kind-control-plane          1/1     Running   0          31m   172.18.0.4   kind-control-plane
kube-system          kube-controller-manager-kind-control-plane 1/1     Running   0          31m   172.18.0.4   kind-control-plane
kube-system          kube-proxy-hgls4                           1/1     Running   0          30m   172.18.0.2   kind-worker2
kube-system          kube-proxy-j49fc                           1/1     Running   0          30m   172.18.0.3   kind-worker
kube-system          kube-proxy-lbfhl                           1/1     Running   0          30m   172.18.0.4   kind-control-plane
kube-system          kube-scheduler-kind-control-plane          1/1     Running   0          31m   172.18.0.4   kind-control-plane
local-path-storage   local-path-provisioner-58cc7856b6-x774j    1/1     Running   0          30m   10.244.0.3   kind-control-plane
~$ docker exec -it kind-worker ip -br link show
lo               UNKNOWN        00:00:00:00:00:00 <LOOPBACK,UP,LOWER_UP>
eth0@if45        UP             c6:6f:2a:06:54:3f <BROADCAST,MULTICAST,UP,LOWER_UP>
kube-ipvs0       DOWN           46:ad:01:b5:0a:b2 <BROADCAST,NOARP>
eth1@eth0        DOWN           02:a9:d4:b9:b0:17 <BROADCAST,MULTICAST>
~$ docker exec -it kind-worker2 ip -br link show
lo               UNKNOWN        00:00:00:00:00:00 <LOOPBACK,UP,LOWER_UP>
eth0@if44        UP             ce:05:77:12:ae:e1 <BROADCAST,MULTICAST,UP,LOWER_UP>
kube-ipvs0       DOWN           96:7f:36:af:46:4b <BROADCAST,NOARP>
```

https://github.com/kubernetes-sigs/cni-dra-driver/pull/3

https://asciinema.org/a/707514

Demo - Environment (ResourceSlices)

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```
~$ kubectl get resourceslice
NAME                          NODE          DRIVER                          POOL          AGE
kind-worker-cni-dra-driver    kind-worker   cni.dra.networking.x-k8s.io     kind-worker   38s
kind-worker2-cni-dra-driver   kind-worke2   cni.dra.networking.x-k8s.io     kind-worker   38s
```

```
~$ kubectl get resourceslice
kind-worker-cni-dra-driver -o yaml
apiVersion: resource.k8s.io/v1beta1
kind: ResourceSlice
metadata:
  name: kind-worker-cni-dra-driver
spec:
  devices:
  - basic:
      attributes:
        name:
          string: eth0
    name: eth0
  - basic:
      attributes:
        name:
          string: eth1
    name: eth1
  driver: cni.dra.networking.x-k8s.io
  nodeName: kind-worker
  pool:
    generation: 0
    name: kind-worker
    resourceSliceCount: 1
```

```
~$ kubectl get resourceslice kind-worker2-cni-dra-driver -o
yaml
apiVersion: resource.k8s.io/v1beta1
kind: ResourceSlice
metadata:
  name: kind-worker2-cni-dra-driver
spec:
  devices:
  - basic:
      attributes:
        name:
          string: eth0
    name: eth0
  driver: cni.dra.networking.x-k8s.io
  nodeName: kind-worke2
  pool:
    generation: 0
    name: kind-worker
    resourceSliceCount: 1
```

https://github.com/kubernetes-sigs/cni-dra-driver/pull/3

https://asciinema.org/a/707514

Demo (ResourceClaimTemplate + Deployment)

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```
~$ kubectl get resourceclaimtemplate macvlan-eth1-attachment -o yaml
apiVersion: resource.k8s.io/v1beta1
kind: ResourceClaimTemplate
metadata:
  name: macvlan-eth1-attachment
  namespace: default
spec:
  spec:
    devices:
      config:
      - opaque:
          driver: cni.dra.networking.x-k8s.io
          parameters:
            apiVersion: cni.networking.x-k8s.io/v1alpha1
            config:
              cniVersion: 1.0.0
              name: macvlan-eth1
              plugins:
              - ipam:
                  ranges:
                  - - subnet: 10.10.1.0/24
                  type: host-local
                master: eth1
                mode: bridge
                type: macvlan
            ifName: net1
            kind: CNI
        requests:
        - macvlan-eth1
      requests:
      - adminAccess: true
        allocationMode: ExactCount
        count: 1
        deviceClassName: cni.networking.x-k8s.io
        name: macvlan-eth1
        selectors:
        - cel:
            expression: device.driver == "cni.dra.networking.x-k8s.io"
        - cel:
            expression: device.attributes["cni.dra.networking.x-k8s.io"].name == "eth1"
```

https://github.com/kubernetes-sigs/cni-dra-driver/pull/3

```
~$ kubectl apply -f deployment-template.yaml
resourceclaimtemplate.resource.k8s.io/macvlan-eth1-attachment created
deployment.apps/demo-application created


~$ kubectl get deployment demo-application -o yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  generation: 1
  labels:
    app: demo-application
  name: demo-application
  namespace: default
spec:
  replicas: 15
  selector:
    matchLabels:
      app: demo-application
  template:
    metadata:
      labels:
        app: demo-application
    spec:
      containers:
      - command:
        - sleep
        - infinity
        image: alpine:latest
        imagePullPolicy: IfNotPresent
        name: alpine
      resourceClaims:
      - name: macvlan-eth1-attachment
        resourceClaimTemplateName: macvlan-eth1-attachment
status:
  availableReplicas: 15
  readyReplicas: 15
  replicas: 15
  updatedReplicas: 15
```

https://asciinema.org/a/707514

Demo (ResourceClaims)

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```
~$ kubectl get resourceclaim
NAME                                                        STATE                AGE
demo-application-c86fd78c5-2lxjq-macvlan-eth1-attachment-kvnjg   allocated,reserved   27s
demo-application-c86fd78c5-65gj7-macvlan-eth1-attachment-q2q7c   allocated,reserved   27s
demo-application-c86fd78c5-672rj-macvlan-eth1-attachment-lmx5g   allocated,reserved   27s
demo-application-c86fd78c5-9msd5-macvlan-eth1-attachment-6xkdq   allocated,reserved   27s
demo-application-c86fd78c5-blzln-macvlan-eth1-attachment-h4rcg   allocated,reserved   27s
demo-application-c86fd78c5-bsndz-macvlan-eth1-attachment-vfq55   allocated,reserved   27s
demo-application-c86fd78c5-d8q26-macvlan-eth1-attachment-btlbh   allocated,reserved   27s
demo-application-c86fd78c5-dwzrt-macvlan-eth1-attachment-5h6nr   allocated,reserved   27s
demo-application-c86fd78c5-fv8sg-macvlan-eth1-attachment-n5f5h   allocated,reserved   27s
demo-application-c86fd78c5-gqs4d-macvlan-eth1-attachment-wcsx9   allocated,reserved   27s
demo-application-c86fd78c5-kbdrm-macvlan-eth1-attachment-fnn5b   allocated,reserved   27s
demo-application-c86fd78c5-mm84g-macvlan-eth1-attachment-4sgx8   allocated,reserved   27s
demo-application-c86fd78c5-nnbxr-macvlan-eth1-attachment-slqxq   allocated,reserved   27s
demo-application-c86fd78c5-qbmwg-macvlan-eth1-attachment-7t9fw   allocated,reserved   27s
demo-application-c86fd78c5-zl248-macvlan-eth1-attachment-4vxzq   allocated,reserved   27s
```

https://github.com/kubernetes-sigs/cni-dra-driver/pull/3

https://asciinema.org/a/707514

Demo (ResourceClaim)

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```
~$ kubectl get resourceclaim -o yaml demo-application-c86fd78c5-2lxjq-macvlan-eth1-attachment-kvnjg
apiVersion: resource.k8s.io/v1beta1
kind: ResourceClaim
metadata:
  annotations:
    resource.kubernetes.io/pod-claim-name: macvlan-eth1-attachment
  generateName: demo-application-c86fd78c5-2lxjq-macvlan-eth1-attachment-
  name: demo-application-c86fd78c5-2lxjq-macvlan-eth1-attachment-kvnjg
  namespace: default
  ownerReferences:
  - apiVersion: v1
    blockOwnerDeletion: true
    controller: true
    kind: Pod
    name: demo-application-c86fd78c5-2lxjq
    uid: a2735b69-92de-4ac1-8461-725323ddefb7
  resourceVersion: "3618"
  uid: 80067ad8-ba85-4230-bc4a-ee3e1e1c4a2b
[...]
```

```
[...]
spec:
  devices:
    config:
    - opaque:
        driver: cni.dra.networking.x-k8s.io
        parameters:
          apiVersion: cni.networking.x-k8s.io/v1alpha1
          config:
            cniVersion: 1.0.0
            name: macvlan-eth1
            plugins:
            - ipam:
                ranges:
                - - subnet: 10.10.1.0/24
                type: host-local
              master: eth1
              mode: bridge
              type: macvlan
            ifName: net1
            kind: CNI
      requests:
      - macvlan-eth1
    requests:
    - adminAccess: true
      allocationMode: ExactCount
      count: 1
      deviceClassName: cni.networking.x-k8s.io
      name: macvlan-eth1
      selectors:
      - cel:
          expression: device.driver == "cni.dra.networking.x-k8s.io"
      - cel:
          expression: device.attributes["cni.dra.networking.x-k8s.io"].name == "eth1"
[...]
```

https://github.com/kubernetes-sigs/cni-dra-driver/pull/3

https://asciinema.org/a/707514

Demo (ResourceClaim Status)

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```
[...]
status:
  allocation:
    devices:
      config:
      - opaque:
          driver: cni.dra.networking.x-k8s.io
          parameters:
            apiVersion: cni.networking.x-k8s.io/v1alpha1
            config:
              cniVersion: 1.0.0
              name: macvlan-eth1
              plugins:
              - ipam:
                  ranges:
                  - - subnet: 10.10.1.0/24
                  type: host-local
                master: eth1
                mode: bridge
                type: macvlan
              ifName: net1
              kind: CNI
        requests:
        - macvlan-eth1
        source: FromClaim
      results:
      - adminAccess: true
        device: eth1
        driver: cni.dra.networking.x-k8s.io
        pool: kind-worker
        request: macvlan-eth1
    nodeSelector:
      nodeSelectorTerms:
      - matchFields:
        - key: metadata.name
          operator: In
          values:
          - kind-worker
[...]
```

```
[...]
  devices:
  - conditions: null
    data:
      cniVersion: 1.0.0
      interfaces:
      - mac: 8e:18:6b:cb:d3:c5
        name: net1
        sandbox: /var/run/netns/cni-ed50d613-a4a9-1b5b-c422-3e620dc17878
      ips:
      - address: 10.10.1.16/24
        gateway: 10.10.1.1
        interface: 0
    device: eth1
    driver: cni.dra.networking.x-k8s.io
    networkData:
      hardwareAddress: 8e:18:6b:cb:d3:c5
      interfaceName: net1
      ips:
      - 10.10.1.16/24
    pool: kind-worker
  reservedFor:
  - name: demo-application-c86fd78c5-2lxjq
    resource: pods
    uid: a2735b69-92de-4ac1-8461-725323ddefb7
```

https://github.com/kubernetes-sigs/cni-dra-driver/pull/3

https://asciinema.org/a/707514

Demo (Pods + Network Interfaces)

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```
~$ kubectl get pods -o wide
NAME                                READY   STATUS    RESTARTS   AGE    IP             NODE                 NOMINATED NODE   READINESS GATES
cni-dra-driver-57m2k                1/1     Running   0          105s   172.18.0.2     kind-worker2         <none>           <none>
cni-dra-driver-wldbs                1/1     Running   0          105s   172.18.0.4     kind-control-plane   <none>           <none>
cni-dra-driver-zjm9x                1/1     Running   0          105s   172.18.0.3     kind-worker          <none>           <none>
demo-application-c86fd78c5-2lxjq    1/1     Running   0          47s    10.244.2.16    kind-worker          <none>           <none>
demo-application-c86fd78c5-65gj7    1/1     Running   0          47s    10.244.2.9     kind-worker          <none>           <none>
demo-application-c86fd78c5-672rj    1/1     Running   0          47s    10.244.2.8     kind-worker          <none>           <none>
demo-application-c86fd78c5-9msd5    1/1     Running   0          47s    10.244.2.10    kind-worker          <none>           <none>
demo-application-c86fd78c5-blzln    1/1     Running   0          47s    10.244.2.11    kind-worker          <none>           <none>
demo-application-c86fd78c5-bsndz    1/1     Running   0          47s    10.244.2.4     kind-worker          <none>           <none>
demo-application-c86fd78c5-d8q26    1/1     Running   0          47s    10.244.2.14    kind-worker          <none>           <none>
demo-application-c86fd78c5-dwzrt    1/1     Running   0          47s    10.244.2.15    kind-worker          <none>           <none>
demo-application-c86fd78c5-fv8sg    1/1     Running   0          47s    10.244.2.13    kind-worker          <none>           <none>
demo-application-c86fd78c5-gqs4d    1/1     Running   0          47s    10.244.2.12    kind-worker          <none>           <none>
demo-application-c86fd78c5-kbdrm    1/1     Running   0          47s    10.244.2.2     kind-worker          <none>           <none>
demo-application-c86fd78c5-mm84g    1/1     Running   0          47s    10.244.2.6     kind-worker          <none>           <none>
demo-application-c86fd78c5-nnbxr    1/1     Running   0          47s    10.244.2.5     kind-worker          <none>           <none>
demo-application-c86fd78c5-qbmwg    1/1     Running   0          47s    10.244.2.7     kind-worker          <none>           <none>
demo-application-c86fd78c5-zl248    1/1     Running   0          47s    10.244.2.3     kind-worker          <none>           <none>
~$ kubectl exec -it demo-application-c86fd78c5-2lxjq -- ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN 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
2: eth0@if19: <BROADCAST,MULTICAST,UP,LOWER_UP,M-DOWN> mtu 1500 qdisc noqueue state UP
    link/ether 9a:a4:24:47:f2:01 brd ff:ff:ff:ff:ff:ff
    inet 10.244.2.16/24 brd 10.244.2.255 scope global eth0
       valid_lft forever preferred_lft forever
    inet6 fe80::98a4:24ff:fe47:f201/64 scope link
       valid_lft forever preferred_lft forever
3: net1@eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP
    link/ether 8e:18:6b:cb:d3:c5 brd ff:ff:ff:ff:ff:ff
    inet 10.10.1.16/24 brd 10.10.1.255 scope global net1
       valid_lft forever preferred_lft forever
    inet6 fe80::8c18:6bff:fecb:d3c5/64 scope link
       valid_lft forever preferred_lft forever
```

https://github.com/kubernetes-sigs/cni-dra-driver/pull/3

https://asciinema.org/a/707514

Get Involved!

KubeCon CloudNativeCon Europe 2025

CNI

- Weekly Meeting (Monday)
- https://github.com/containernetworking/meeting-notes

WG Device Management

- Every Two Weeks (Tuesday)
- https://docs.google.com/document/d/1qxI87VqGtgN7EAJlqVfxx86HGKEAc2A3SKru8nJHNkQ

Multi-Network

- Every Week (Wednesday)
- https://github.com/kubernetes-sigs/multi-network

K8S Network Plumbing WG

- Every Two Weeks (Thursday)
- https://github.com/k8snetworkplumbingwg

Conclusions

- DRA Allows Users to Request Arbitrary Resources for Pods
- Network Interfaces Can Be Considered as a Resource
- DRA's Upcoming "Consumable Capacity" Enables Unique New Use Cases
  - Scheduling / Resource Sharing

Thank You!