How to Bring your Virtual Machine VNF to Container World?

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The Motivation is...

Containerized app brings more agility/efficiency/flexibility than virtualized app...

So what about NFV?
Is It Easy to Make a VNF Container?

- Physical Router
  - Console
  - Mgmt Interface
  - Kernel (modified)

- Virtualized Router
  - Console
  - Mgmt Interface
  - Kernel (modified)

- Containerized Router
  - Console
  - Mgmt Interface
  - Generic Kernel
CNF = Container Network Function? or Cloud Native Network Function?

From https://www.cncf.io/about/charter/, cloud native systems should be:

(a) **Container packaged**.
(b) Dynamically managed.
(c) Micro-services oriented.
Agenda:

- Network Device Functions for Containers
  - Data Plane
  - User Interface
  - Orchestration
- Open Source Projects for Container Network Functions
Network Device Functions for Containers VNF?

Orchestration
  - Deploy

User Interface
  - Configuration & Operation
  - Telemetry

Control Plane

Data Plane
  - Multiple networks in Kubernetes
  - SR-IOV
Data Plane (Multiple Networks in Kubernetes)

The Kubernetes Pod always have **one** interface to connect Kubernetes networks.

But sometimes VNFs want to use multiple interfaces

- To serve L2 network functions (e.g. vCPE use-case)
- To isolate networks from other Pod/Users
Data Plane (Multiple Networks in Kubernetes)

There are two working groups in K8s community, under network-SIG:

- Network Plumbing WG ([meeting agenda/info](#))
- Network Service Mesh WG ([meeting agenda/info](#))
Data Plane (Multiple Networks in Kubernetes)

<<<<<< They have talk/tutorial in ONS!!! >>>>>>>

- Network Plumbing WG
  - Tutorial: "Tutorial: NFV features in Kubernetes" at G102 (right now!)
- Network Service Mesh WG
  - Talk: “Network Service Mesh: An Attempt to Reimagine NFV in a Cloud-Native Fashion” Tomorrow (Sep 26, 14:30 - 15:00, G106/7)
Multiple Interface in Kubernetes

The Core Concept is....

Pod

All traffic goes through eth0
- (Liveness and Readiness) Probes
- Communication between API and Pod
- User Traffic

k8servers (api, kubelet so on)
Multiple Interface in Kubernetes (cont'd)

The Core Concept is....

- Kubernetes servers (api, kubelet so on)
- (Liveness and Readiness) Probes
- Communication between API and Pod

another network

Pod
- net0
- eth0

User Traffic

default network
Data Plane (Multiple Networks in Kubernetes)

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- **Network Plumbing WG**
- **Network Service Mesh WG**
Data Plane (Multiple networks in Kubernetes)

Network Plumbing WG

- Making de-facto standard document/specs
  - [Kubernetes Network Custom Resource Definition De-facto Standard Version 1](https://example.com)
  - V2 currently under development...
- Implement [multus-cni](https://example.com) as its reference implementation
  - meta-plugin to multiplex network CNI plugins
Multiple Interface in Kubernetes (cont'd)

multus-cni example

Kubernetes servers (api, kubelet so on)

Network attachments

Pod

kind: Pod
... (snip)...
annotations:

k8s.v1.cni.cncf.io/networks: foobar

CNI config with vlan plugin

apiVersion: "k8s.cni.cncf.io/v1"
kind: NetworkAttachmentDefinition
metadata:
  name: foobar
spec:
  config: '{ "type": "vlan", (snip) }'

another network

vlan

default network

eth0

net0
Data Plane (Multiple Networks in Kubernetes)

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Data Plane (Multiple networks in Kubernetes)

Network Service Mesh WG

• Provide network service (L2, L3 and others) into Kubernetes from scratch
• Interacts with Device Plugin API (DPAPI) without CNI
  • Provide a brand new network framework in Kubernetes
• Implementation: github.com/ligato/networkservicemesh
Network Device Functions for Containers VNF?

- Orchestration
- User Interface
- Control Plane
- Data Plane

- Deploy
- Configuration & Operation
- Telemetry
- Multiple networks in Kubernetes
- SR-IOV and userspace
SR-IOV

- [https://github.com/hustcat/sriov-cni](https://github.com/hustcat/sriov-cni)
  - without any resource management...
- [https://github.com/intel/sriov-network-device-plugin](https://github.com/intel/sriov-network-device-plugin)
  - CNI plugin + device plugin for resource management
- Network Service Mesh
  - device plugin only
SR-IOV

- [https://github.com/intel/sriov-network-device-plugin](https://github.com/intel/sriov-network-device-plugin)
  - resource management with Device Plugin API (DPAPI)
    - Step 1) Before the pod launch, Device Plugin allocates VFs
    - Step 2) Its CNI plugin configures VF, given from Device Plugin
  - Mainly discuss at
    - [k8s/resource-management working group](https://github.com/zshi-redhat/virt-network-device-plugin)
    - network plumbing working group

Note: [https://github.com/zshi-redhat/virt-network-device-plugin](https://github.com/zshi-redhat/virt-network-device-plugin) provides SR-IOV emulation with virtio_net for PoC/Demo
Userspace

https://github.com/intel/userspace-cni-network-plugin (active)

- In very early development phase
- Create virtual interface (other than veth)
- Connect to virtual switch
  - OvS-DPDK (vhostuser interface)
  - VPP (memif interface)

LT@ONS: Bringing User Space Networking to CNI - Billy McFall, Red Hat
(Sep 26, 15:10 - 15:20, G109)
Network Device Functions for Containers VNF?

- **Orchestration**
  - Deploy

- **User Interface**
  - Configuration & Operation
  - Telemetry

- **Control Plane**

- **Data Plane**
  - Multiple networks in Kubernetes
  - SR-IOV and userspace
Configuration and Operation: Gap

Strongly related to its lifecycle:

- Container
  - Stateless
  - Read once, no changed (delete and launch again if config is changed)
- Network device
  - STATEFUL! (only config also the network protocol, tcp)
  - Changed on-demand
Configuration and Operation (cont’d)

Infra in Kubernetes:

- **Custom Resources** (CRD)
- **Admission Controllers/Dynamic Admission Control**
- (skipped: Overlay Mount Filesystem, provide ARG in Pod...)

Infra in Networking:

- RESTCONF/NETCONF/YANG for modeling
- gRPC/ssh/http for transport
Custom Resources:

- Create Original ‘Resource’ object in Kubernetes
- User can create/modify through k8s API
- multus-cni uses custom resources as following:

```yaml
apiVersion: "k8s.cni.cncf.io/v1"
kind: NetworkAttachmentDefinition
metadata:
  name: foobar
...
```

Annotations:

```yaml
k8s.v1.cni.cncf.io/networks: foobar
```
Configuration... (cont’d) - Infra in Kubernetes

Admission Controllers/Dynamic Admission Control:

- Intercepts requests for Kubernetes API (to create custom resource, for example) after auth, before its persisted
- ValidatingAdmissionWebhook is used to hook the request and do validation
Configuration and Operation (cont’d)

Infra in Kubernetes:

- Custom Resources
- Admission Controllers/Dynamic Admission Control
  (skipped: Overlay Mount Filesystem, provide ARG in Pod...)

Infra in Networking:

- RESTCONF/NETCONF/YANG for modeling
- gRPC/ssh/http for transport
Configuration... in Networking

- IETF netmod WG: NETCONF, RESTCONF/YANG
  - IETF netmod WG provides data models in YANG
  - NETCONF/RESTCONF uses ssh/http(s)/TLS/SOAP/TLS for transport
- OpenConfig: NETCONF, RESTCONF, gRPC/YANG
  - OpenConfig provides common data models in YANG
  - OpenConfig also defines gNMI (gRPC Network Management Interface)
Configuration and Operation (cont’d)

Talk: Beyond the Command Line: Programming Network Devices with gRPC and OpenConfig

(Day3, September 27, 16:45 - 17:15, G106/107)
Network Device Functions for Containers VNF?

- Orchestration
- User Interface
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- Data Plane

Deploy

- Configuration & Operation
  - Telemetry

Multiple networks in Kubernetes
- SR-IOV and userspace
Telemetry

Infra in Container:
• http/https (for Prometheus)

Infra in Networking:
• YANG-PUSH in IETF netconf wg
• gNMI, Streaming Telemetry in OpenConfig
• VES(VNF Event Stream) in OPNFV
• and so on (vendor specific way and yeah, we have SNMP!)
Telemetry

Additional consideration in case of container environment:

• Should we provide all information for each container?
  • Some info is host specific, not container specific.
• Is container telemetry suitable for Telco?
  • Prometheus exporter (TLS with nginx)
  • Prometheus exporter consumes TCP ports....
Network Device Functions for Containers VNF?

- **Orchestration**
- **User Interface**
- **Control Plane**
- **Data Plane**

- **Deploy**
- **Configuration & Operation**
- **Telemetry**
- **Multiple networks in Kubernetes**
- **SR-IOV and userspace**
Deploy

Kubernetes and its community provide the following tools:

- **Helm**
- **Operator Framework**
Deploy

**Helm**

- Package manager for Kubernetes
- Package, 'charts', provides several Kubernetes resources
  - Pod
  - Configmap
  - Service
  - Deployment
Deploy

**Operator Framework**

- Framework to manage Kubernetes native applications
  - can be used for deployment as well as automation
  - e.g: etcd-operators, prometheus-operators
- Operator creates custom resource to manage applications
- Each operators has associated 'operator pod'
  - to watch custom resource objects and
  - to keep apps based on its custom resources (e.g. # of replica)
Deploy **Operator Framework** (in case of etcd-operator)

```yaml
apiVersion: "etcd.database.coreos.com/v1beta2"
kind: EtcdCluster
metadata:
  name: example-etcd-cluster
  .... (snip)
spec:
  size: 3
```

- operator Pod:
- check CRD object
- watch pod and change it as CRD's spec
- Kubernetes api-server
- etcd pod1
- etcd pod2
- etcd pod3
Open Source Projects for Container VNF

Container VNF:
- Container4NFV project in OPNFV
- Metaswitch's Clearwarter docker integration
- Metaswitch's Clearwater Kubernetes integration by Intel

Cloud native VNF:
- Clover in OPNFV
Wrap-up:

- Network Device Functions for Containers
  - Data Plane
  - User Interface
  - Orchestration
- Open Source Projects for Container Network Functions
Thank you! Questions?

Slides available at https://onseu18.sched.com/

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