深入理解 OpenStack 中的网络实现

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v0.3: 2014-03-10

添加 GRE 模式下对流表规则分析；

添加 GRE 模式下的 answer 文件。

v0.2: 2014-03-06

修正图表引用错误；

添加对 GRE 模式下流表细节分析。

v0.1: 2014-02-20

开始整体结构。

1.1 概述

1.1.1 术语

bridge：网桥，Linux 中用于表示一个能连接不同网络设备的虚拟设备，linux 中传统实现的网桥类似一个 hub 设备，而 ovs 管理的网桥一般类似交换机。

br-int：bridge-integration，综合网桥，常用于表示实现主要内部网络功能的网桥。

br-ex：bridge-external，外部网桥，通常表示负责跟外部网络通信的网桥。

GRE：General Routing Encapsulation，一种通过封装来实现隧道的方式。在 openstack 中一般是基于 L3 的 gre，即 original pkt/GRE/IP/Ethernet

VETH：虚拟 ethernet 接口，通常以 pair 的方式出现，一端发出的网包，会被另一端接收，可以形成两个网桥之间的通道。

qvb：Quantum veth, Linux Bridge-side

qvo：Quantum veth, OVS-side

TAP 设备：模拟一个二层的网络设备，可以接受和发送二层网包。

TUN 设备：模拟一个三层的网络设备，可以接受和发送三层网包。

iptables：Linux 上常见的实现安全策略的防火墙软件。

Vlan：虚拟 lan，同一个物理 lan 下用标签实现隔离，可用标号为 1-4094。

namespace：用来实现隔离的一套机制，不同 namespace 之间彼此不可见。

1.2 概念

Neutron 管理下面的实体：

- 网络： 隔离的 L2 域，可以是虚拟、逻辑或交换，同一个网络中的主机彼此 L2 可见。
- 子网： IP 地址快，其中每个虚拟机有一个 IP，同一个子网的主机彼此 L3 可见。
- 端口： 网络上虚拟、逻辑或交换端口。

所有这些实体都是虚拟的，拥有自动生成的唯一标示 id，支持 CRUD 功能，并在数据库中跟踪记录状态。

1.2.1 网络

隔离的 L2 广播域，一般是创建它的用户所有。用户可以拥有多个网络。网络是最基础的，子网和端口都需要关联到网络上。网络的属性如所示。

1.2.2 子网

子网代表了一组分配了 IP 的虚拟机。每个子网必须有一个 CIDR 和关联到一个网络。IP 可以从 CIDR 或者用户指定池中选取。

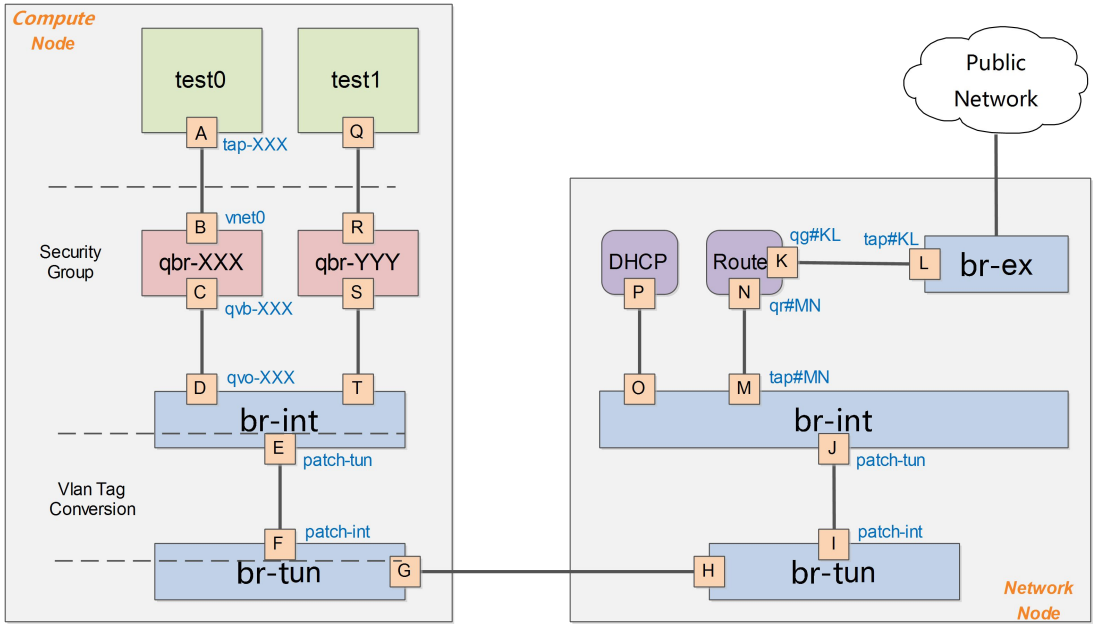
子网可能会有一个网关、一组 DNS 和主机路由。

1.2.3 端口

逻辑网络交换机上的一个虚拟交换口。虚拟机挂载他们的网卡到这些端口上。逻辑口往往定义了挂载到它上面的网卡的 MAC 地址和 IP 地址。当端口有 IP 的时候，意味着它属于某个子网。

1.3 GRE 模式

图表 1 给出了在 OpenStack 中网络实现的一个简化的架构示意。OpenStack 中网络实现包括 vlan 和 gre 两种模式，此处以 gre 模式为例。



图表 1 网络基本架构

在 OpenStack 中，所有网络有关的逻辑管理均在 Network 节点中实现，例如 DNS、DHCP 以及路由等。Compute 节点上只需要对所部属的虚拟机提供基本的网络功能支持，包括隔离不同租户的虚拟机和进行一些基本的安全策略管理（即 security group）。

1.3.1 Compute 节点

以图表 1 为例，Compute 节点上包括两台虚拟机 test0 和 test1，分别经过一个网桥（如 qbr-XXX）连接到 br-int 网桥上。br-int 网桥再经过 br-tun 网桥（物理网络是 GRE 实现）连接到物理主机外部网络。

对于物理网络通过 vlan 来隔离的情况，一般会存在一个 br-eth 网桥。

1.3.1.1 qbr

在 test0 中，虚拟机的网卡实际上连接到了物理机的一个 TAP 设备（即 A，常见名称如 tap-XXX）上，A 则进一步通过 VETH pair（A-B）连接到网桥 qbr-XXX 的端口 vnet0（端口 B）上，之后再通过 VETH pair（C-D）连到 br-int 网桥上。一般 C 的名字格式为 qvb-XXX，而 D 的名字格式为 qvo-XXX。注意它们的名称除了前缀外，后面的 id 都是一样的，表示位于同一个虚拟机网络到物理机网络的连接上。

之所以 TAP 设备 A 没有直接连接到网桥 br-int 上，是因为 OpenStack 需要单独在一个网桥上通过 iptables 实现 security group 的安全策略功能。目前 openvswitch 并不支持应用 iptables 规则的 Tap 设备。

因为 qbr 的存在主要是为了实现 security group 功能，有时候也被称为 firewall bridge。详见1.3.1.4。

1.3.1.2 br-int

一个典型的 br-int 的端口如下所示：

```
# ovs-vsctl show
Bridge br-int
    Port "qvo-XXX"
        tag: 1
        Interface "qvo-XXX"
    Port patch-tun
        Interface patch-tun
            type: patch
            options: {peer=patch-int}
    Port br-int
        Interface br-int
            type: internal
```

其中 br-int 为内部端口。

端口 patch-tun（即端口 E，端口号为 1）连接到 br-tun 上，实现到外部网络的隧道。

端口 qvo-XXX（即端口 D，端口号为 2）带有 tag1，说明这个口是一个 1 号 vlan 的 access 端口。虚拟机发出的从该端口到达 br-int 的网包将被自动带上 vlan tag 1，而其他带有 vlan tag 1 的网包则可以在去掉 vlan tag 后从该端口发出（具体请查询 vlan access 端口）。这个 vlan tag 是用来实现不同网络相互隔离的，比如租户创建一个网络（neutron net-create），则会被分配一

个唯一的 vlan tag。

br-int 在 GRE 模式中作为一个 NORMAL 交换机使用，因此有效规则只有一条正常转发。如果两个在同一主机上的 vm 属于同一个 tenant 的（同一个 vlan tag），则它们之间的通信只需要经过 br-int 即可。

```
# ovs-ofctl dump-flows br-int
NXST_FLOW reply (xid=0x4):
 cookie=0x0, duration=10727.864s, table=0, n_packets=198, n_bytes=17288, idle_age=13,
priority=1 actions=NORMAL
```

1.3.1.3 br-tun

一个典型的 br-tun 上的端口类似：

```
Bridge br-tun
        Port patch-int
            Interface patch-int
                type: patch
                options: {peer=patch-tun}
        Port "gre-1"
            Interface "gre-1"
                type: gre
                options: {in_key=flow, local_ip="10.0.0.101", out_key=flow,
remote_ip="10.0.0.100"}
        Port br-tun
            Interface br-tun
                type: internal
```

其中 patch-int（即端口 F，端口号为 1）是连接到 br-int 上的 veth pair 的端口，gre-1 口（即端口 G，端口号为 2）对应 vm 到外面的隧道。

gre-1 端口是虚拟 gre 端口，当网包发送到这个端口的时候，会经过内核封包，然后从 10.0.0.101 发送到 10.0.0.100，即从本地的物理网卡（10.0.0.101）发出。

br-tun 将带有 vlan tag 的 vm 跟外部通信的流量转换到对应的 gre 隧道，这上面要实现主要的转换逻辑，规则要复杂，一般通过多张表来实现。

典型的转发规则为：

```
# ovs-ofctl dump-flows br-tun
NXST_FLOW reply (xid=0x4):
 cookie=0x0, duration=10970.064s, table=0, n_packets=189, n_bytes=16232, idle_age=16,
priority=1,in_port=1 actions=resubmit(,1)
 cookie=0x0, duration=10906.954s, table=0, n_packets=29, n_bytes=5736, idle_age=16,
priority=1,in_port=2 actions=resubmit(,2)
 cookie=0x0, duration=10969.922s, table=0, n_packets=3, n_bytes=230, idle_age=10962,
priority=0 actions=drop
```

```
 cookie=0x0, duration=10969.777s, table=1, n_packets=26, n_bytes=5266, idle_age=16,
priority=0,dl_dst=00:00:00:00:00:00/01:00:00:00:00:00 actions=resubmit(,20)
 cookie=0x0, duration=10969.631s, table=1, n_packets=163, n_bytes=10966, idle_age=21,
priority=0,dl_dst=01:00:00:00:00:00/01:00:00:00:00:00 actions=resubmit(,21)
 cookie=0x0, duration=688.456s, table=2, n_packets=29, n_bytes=5736, idle_age=16,
priority=1,tun_id=0x1 actions=mod_vlan_vid:1,resubmit(,10)
 cookie=0x0, duration=10969.488s, table=2, n_packets=0, n_bytes=0, idle_age=10969,
priority=0 actions=drop
 cookie=0x0, duration=10969.343s, table=3, n_packets=0, n_bytes=0, idle_age=10969,
priority=0 actions=drop
 cookie=0x0, duration=10969.2s, table=10, n_packets=29, n_bytes=5736, idle_age=16,
priority=1
actions=learn(table=20,hard_timeout=300,priority=1,NXM_OF_VLAN_TCI[0..11],NXM_OF_ETH
_DST[]=NXM_OF_ETH_SRC[],load:0->NXM_OF_VLAN_TCI[],load:NXM_NX_TUN_ID[]->NXM_NX
_TUN_ID[],output:NXM_OF_IN_PORT[]),output:1
 cookie=0x0, duration=682.603s, table=20, n_packets=26, n_bytes=5266, hard_timeout=300,
idle_age=16, hard_age=16, priority=1,vlan_tci=0x0001/0x0fff,dl_dst=fa:16:3e:32:0d:db
actions=load:0->NXM_OF_VLAN_TCI[],load:0x1->NXM_NX_TUN_ID[],output:2
 cookie=0x0, duration=10969.057s, table=20, n_packets=0, n_bytes=0, idle_age=10969,
priority=0 actions=resubmit(,21)
 cookie=0x0, duration=688.6s, table=21, n_packets=161, n_bytes=10818, idle_age=21,
priority=1,dl_vlan=1 actions=strip_vlan,set_tunnel:0x1,output:2
 cookie=0x0, duration=10968.912s, table=21, n_packets=2, n_bytes=148, idle_age=689,
priority=0 actions=drop
```

其中，表 0 中有 3 条规则：从端口 1（即 patch-int）来的，扔到表 1，从端口 2（即 gre-1）来的，扔到表 2。

```
cookie=0x0, duration=10970.064s, table=0, n_packets=189, n_bytes=16232, idle_age=16,
priority=1,in_port=1 actions=resubmit(,1)
 cookie=0x0, duration=10906.954s, table=0, n_packets=29, n_bytes=5736, idle_age=16,
priority=1,in_port=2 actions=resubmit(,2)
 cookie=0x0, duration=10969.922s, table=0, n_packets=3, n_bytes=230, idle_age=10962,
priority=0 actions=drop
```

表 1 有 2 条规则：如果是单播（00:00:00:00:00:00/01:00:00:00:00:00），则扔到表 20；如果是多播等（01:00:00:00:00:00/01:00:00:00:00:00），则扔到表 21。

```
cookie=0x0, duration=10969.777s, table=1, n_packets=26, n_bytes=5266, idle_age=16,
priority=0,dl_dst=00:00:00:00:00:00/01:00:00:00:00:00 actions=resubmit(,20)
 cookie=0x0, duration=10969.631s, table=1, n_packets=163, n_bytes=10966, idle_age=21,
priority=0,dl_dst=01:00:00:00:00:00/01:00:00:00:00:00 actions=resubmit(,21)
```

表 2 有 2 条规则：如果是 tunnel 1 的网包，则修改其 vlan id 为 1，并扔到表 10；非 tunnel 1 的网包，则丢弃。

```
cookie=0x0, duration=688.456s, table=2, n_packets=29, n_bytes=5736, idle_age=16, priority=1,tun_id=0x1 actions=mod_vlan_vid:1,resubmit(,10)
 cookie=0x0, duration=10969.488s, table=2, n_packets=0, n_bytes=0, idle_age=10969, priority=0 actions=drop
```

表 3 只有 1 条规则：丢弃。

表 10 有一条规则，基于 learn 行动来创建反向（从 gre 端口抵达，且目标是到 vm 的网包）的规则。learn 行动并非标准的 openflow 行动，是 openvswitch 自身的扩展行动，这个行动可以根据流内容动态来修改流表内容。这条规则首先创建了一条新的流（该流对应 vm 从 br-tun 的 gre 端口发出的规则）：其中 table=20 表示规则添加在表 20；NXM_OF_VLAN_TCI[0..11]表示匹配包自带的 vlan id；NXM_OF_ETH_DST[]=NXM_OF_ETH_SRC[]表示 L2 目标地址需要匹配包的 L2 源地址；load:0->NXM_OF_VLAN_TCI[]，去掉 vlan，load:NXM_NX_TUN_ID[]->NXM_NX_TUN_ID[]，添加 tunnel 号为原始 tunnel 号；output:NXM_OF_IN_PORT[]，发出端口为原始包抵达的端口。最后规则将匹配的网包从端口 1（即 patch-int）发出。

```
cookie=0x0, duration=10969.2s, table=10, n_packets=29, n_bytes=5736, idle_age=16, priority=1
actions=learn(table=20,hard_timeout=300,priority=1,NXM_OF_VLAN_TCI[0..11],NXM_OF_ETH_DST[]=NXM_OF_ETH_SRC[],load:0->NXM_OF_VLAN_TCI[],load:NXM_NX_TUN_ID[]->NXM_NX_TUN_ID[],output:NXM_OF_IN_PORT[]),output:1
```

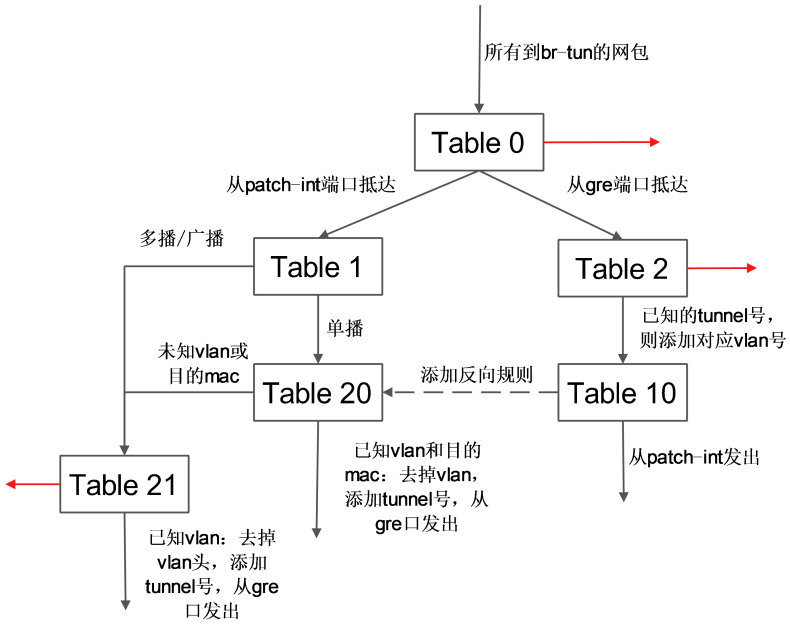
表 20 中有两条规则，其中第一条即表 10 中规则利用 learn 行动创建的流表项，第 2 条提交其他流到表 21。

```
cookie=0x0, duration=682.603s, table=20, n_packets=26, n_bytes=5266, hard_timeout=300, idle_age=16, hard_age=16, priority=1,vlan_tci=0x0001/0x0fff,dl_dst=fa:16:3e:32:0d:db actions=load:0->NXM_OF_VLAN_TCI[],load:0x1->NXM_NX_TUN_ID[],output:2
 cookie=0x0, duration=10969.057s, table=20, n_packets=0, n_bytes=0, idle_age=10969, priority=0 actions=resubmit(,21)
```

表 21 有 2 条规则，第一条是匹配所有目标 vlan 为 1 的网包，去掉 vlan，然后从端口 2（gre 端口）发出。第二条是丢弃。

```
 cookie=0x0, duration=688.6s, table=21, n_packets=161, n_bytes=10818, idle_age=21, priority=1,dl_vlan=1 actions=strip_vlan,set_tunnel:0x1,output:2
 cookie=0x0, duration=10968.912s, table=21, n_packets=2, n_bytes=148, idle_age=689, priority=0 actions=drop
```

这些规则所组成的整体转发逻辑如图表 2 所示。



图表 2 Compute 节点 br-tun 的转发逻辑

1.3.1.4 Security group 实现

Security group 的实现，目前是放在 qbr***这样的 Linux 传统 bridge 上的，是基于 iptables 服务。例如查找 qbr-XXX 上相关的 iptables 规则。

```
# iptables -S | grep tap-XXX
-A quantum-openvswi-FORWARD -m physdev --physdev-out tap-XXX --physdev-is-bridged -j quantum-openvswi-sg-chain
-A quantum-openvswi-FORWARD -m physdev --physdev-in tap-XXX --physdev-is-bridged -j quantum-openvswi-sg-chain
-A quantum-openvswi-INPUT -m physdev --physdev-in tap-XXX --physdev-is-bridged -j quantum-openvswi-o7c7ae61e-0
-A quantum-openvswi-sg-chain -m physdev --physdev-out tap-XXX --physdev-is-bridged -j quantum-openvswi-i7c7ae61e-0
-A quantum-openvswi-sg-chain -m physdev --physdev-in tap-XXX --physdev-is-bridged -j quantum-openvswi-o7c7ae61e-0
```

可以看出，进出 tap-XXX 口的 FORWARD 链上的流量都被扔到了 quantum-openvswi-sg-chain 这个链，quantum-openvswi-sg-chain 上是 security group 具体的实现（两条规则，访问虚拟机的流量扔给 quantum-openvswi-i7c7ae61e-0；从虚拟机出来的扔给 quantum-openvswi-o7c7ae61e-0）。

INPUT 链上的流量被扔到了 quantum-openvswi-o7c7ae61e-0 链。

quantum-openvswi-o7c7ae61e-0 链负责从虚拟机出来的流量的处理，上面的默认规则有：

```
-A quantum-openvswi-o7c7ae61e-0 -m mac ! --mac-source FA:16:3E:03:00:E7 -j DROP
-A quantum-openvswi-o7c7ae61e-0 -p udp -m udp --sport 68 --dport 67 -j RETURN
```

```
-A quantum-openvswi-o7c7ae61e-0 ! -s 10.1.0.2/32 -j DROP
-A quantum-openvswi-o7c7ae61e-0 -p udp -m udp --sport 67 --dport 68 -j DROP
-A quantum-openvswi-o7c7ae61e-0 -m state --state INVALID -j DROP
-A quantum-openvswi-o7c7ae61e-0 -m state --state RELATED,ESTABLISHED -j RETURN
-A quantum-openvswi-o7c7ae61e-0 -j RETURN
-A quantum-openvswi-o7c7ae61e-0 -j quantum-openvswi-sg-fallback
```

第 1、3 条是仅允许指定的源 mac 和源 IP 的流量。

第 2 条是对于 DHCP 请求，返回到上层链。

第 3 条是禁止虚拟机往外发送 DHCP 的响应。

其他条是处理失败状态和默认行为。

quantum-openvswi-i7c7ae61e-0 这条链管理要访问虚拟机的入口流量，在通过命令：

```
# neutron security-group-rule-create --protocol tcp \
  --port-range-min 22 --port-range-max 22 --direction ingress default
```

打开对虚拟机的 ssh 访问之后，默认的规则包括：

```
-A quantum-openvswi-i7c7ae61e-0 -m state --state INVALID -j DROP
-A quantum-openvswi-i7c7ae61e-0 -m state --state RELATED,ESTABLISHED -j RETURN
-A quantum-openvswi-i7c7ae61e-0 -p icmp -j RETURN
-A quantum-openvswi-i7c7ae61e-0 -p tcp -m tcp --dport 22 -j RETURN
-A quantum-openvswi-i7c7ae61e-0 -p tcp -m tcp --dport 80 -j RETURN
-A quantum-openvswi-i7c7ae61e-0 -s 10.1.0.3/32 -p udp -m udp --sport 67 --dport 68 -j
RETURN
-A quantum-openvswi-i7c7ae61e-0 -j quantum-openvswi-sg-fallback
```

这些规则默认允许访问虚拟机的 22 和 80 端口，允许 DHCP 应答从 DHCP 服务器 10.1.0.3 这个地址返回。

1.3.2 Network 节点

1.3.2.1 br-tun

```
Bridge br-tun
        Port br-tun
            Interface br-tun
                type: internal
        Port patch-int
            Interface patch-int
                type: patch
                options: {peer=patch-tun}
        Port "gre-2"
            Interface "gre-2"
                type: gre
```

```
                options:        {in_key=flow,        local_ip="10.0.0.100",        out_key=flow,
remote_ip="10.0.0.101"}
```

Compute 节点上发往 GRE 隧道的网包最终抵达 Network 节点上的 br-tun，该网桥的规则包括：

```
# ovs-ofctl dump-flows br-tun
NXST_FLOW reply (xid=0x4):
cookie=0x0, duration=19596.862s, table=0, n_packets=344, n_bytes=66762, idle_age=4,
priority=1,in_port=1 actions=resubmit(,1)
 cookie=0x0, duration=19537.588s, table=0, n_packets=625, n_bytes=125972, idle_age=4,
priority=1,in_port=2 actions=resubmit(,2)
 cookie=0x0, duration=19596.602s, table=0, n_packets=2, n_bytes=140, idle_age=19590,
priority=0 actions=drop
 cookie=0x0, duration=19596.343s, table=1, n_packets=323, n_bytes=65252, idle_age=4,
priority=0,dl_dst=00:00:00:00:00:00/01:00:00:00:00:00 actions=resubmit(,20)
 cookie=0x0, duration=19596.082s, table=1, n_packets=21, n_bytes=1510, idle_age=5027,
priority=0,dl_dst=01:00:00:00:00:00/01:00:00:00:00:00 actions=resubmit(,21)
 cookie=0x0, duration=9356.289s, table=2, n_packets=625, n_bytes=125972, idle_age=4,
priority=1,tun_id=0x1 actions=mod_vlan_vid:1,resubmit(,10)
 cookie=0x0, duration=19595.821s, table=2, n_packets=0, n_bytes=0, idle_age=19595,
priority=0 actions=drop
 cookie=0x0, duration=19595.554s, table=3, n_packets=0, n_bytes=0, idle_age=19595,
priority=0 actions=drop
 cookie=0x0, duration=19595.292s, table=10, n_packets=625, n_bytes=125972, idle_age=4,
priority=1
actions=learn(table=20,hard_timeout=300,priority=1,NXM_OF_VLAN_TCI[0..11],NXM_OF_ETH
_DST[]=NXM_OF_ETH_SRC[],load:0->NXM_OF_VLAN_TCI[],load:NXM_NX_TUN_ID[]->NXM_NX
_TUN_ID[],output:NXM_OF_IN_PORT[]),output:1
 cookie=0x0,      duration=9314.338s,      table=20,      n_packets=323,      n_bytes=65252,
hard_timeout=300,                idle_age=4,                hard_age=3,
priority=1,vlan_tci=0x0001/0x0fff,dl_dst=fa:16:3e:cb:11:f6
actions=load:0->NXM_OF_VLAN_TCI[],load:0x1->NXM_NX_TUN_ID[],output:2
 cookie=0x0, duration=19595.026s, table=20, n_packets=0, n_bytes=0, idle_age=19595,
priority=0 actions=resubmit(,21)
 cookie=0x0, duration=9356.592s, table=21, n_packets=9, n_bytes=586, idle_age=5027,
priority=1,dl_vlan=1 actions=strip_vlan,set_tunnel:0x1,output:2
 cookie=0x0, duration=19594.759s, table=21, n_packets=12, n_bytes=924, idle_age=5057,
priority=0 actions=drop
```

这些规则跟 Compute 节点上 br-tun 的规则相似，完成 tunnel 跟 vlan 之间的转换。

1.3.2.2 br-int

```
Bridge br-int
        Port "qr-ff19a58b-3d"
            tag: 1
            Interface "qr-ff19a58b-3d"
                type: internal
        Port br-int
            Interface br-int
                type: internal
        Port patch-tun
            Interface patch-tun
                type: patch
                options: {peer=patch-int}
        Port "tap4385f950-8b"
            tag: 1
            Interface "tap4385f950-8b"
                type: internal
```

该集成网桥上挂载了很多进程来提供网络服务，包括路由器、DHCP 服务器等。这些进程不同的租户可能都需要，彼此的地址空间可能冲突，也可能跟物理网络的地址空间冲突，因此都运行在独立的网络名字空间中。

规则跟 computer 节点的 br-int 规则一致，表现为一个正常交换机。

```
# ovs-ofctl dump-flows br-int
NXST_FLOW reply (xid=0x4):
 cookie=0x0, duration=18198.244s, table=0, n_packets=849, n_bytes=164654, idle_age=43,
priority=1 actions=NORMAL
```

1.3.2.3 网络名字空间

在 linux 中，网络名字空间可以被认为是隔离的拥有单独网络栈（网卡、路由转发表、iptables）的环境。网络名字空间经常用来隔离网络设备和服务，只有拥有同样网络名字空间的设备，才能看到彼此。

可以用 ip netns list 命令来查看已经存在的名字空间。

```
# ip netns
qdhcp-88b1609c-68e0-49ca-a658-f1edff54a264
qrouter-2d214fde-293c-4d64-8062-797f80ae2d8f
```

qdhcp 开头的名字空间是 dhcp 服务器使用的，qrouter 开头的则是 router 服务使用的。

可以通过 ip netns exec namespaceid command 来在指定的网络名字空间中执行网络命令，例如

```
# ip netns exec qdhcp-88b1609c-68e0-49ca-a658-f1edff54a264 ip addr
71: ns-f14c598d-98: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state
UP qlen 1000
    link/ether fa:16:3e:10:2f:03 brd ff:ff:ff:ff:ff:ff
    inet 10.1.0.3/24 brd 10.1.0.255 scope global ns-f14c598d-98
    inet6 fe80::f816:3eff:fe10:2f03/64 scope link
        valid_lft forever preferred_lft forever
```

可以看到，dhcp 服务的网络名字空间中只有一个网络接口“ns-f14c598d-98”，它连接到 br-int 的 tapf14c598d-98 接口上。

1.3.2.4 dhcp 服务

dhcp 服务是通过 dnsmasq 进程（轻量级服务器，可以提供 dns、dhcp、tftp 等服务）来实现的，该进程绑定到 dhcp 名字空间中的 br-int 的接口上。可以查看相关的进程。

```
# ps -fe | grep 88b1609c-68e0-49ca-a658-f1edff54a264
nobody    23195     1  0 Oct26 ?        00:00:00 dnsmasq --no-hosts --no-resolv
--strict-order --bind-interfaces --interface=ns-f14c598d-98 --except-interface=lo
--pid-file=/var/lib/quantum/dhcp/88b1609c-68e0-49ca-a658-f1edff54a264/pid
--dhcp-hostsfile=/var/lib/quantum/dhcp/88b1609c-68e0-49ca-a658-f1edff54a264/host
--dhcp-optsfile=/var/lib/quantum/dhcp/88b1609c-68e0-49ca-a658-f1edff54a264/opts
--dhcp-script=/usr/bin/quantum-dhcp-agent-dnsmasq-lease-update --leasefile-ro
--dhcp-range=tag0,10.1.0.0,static,120s --conf-file= --domain=openstacklocal
root      23196 23195  0 Oct26 ?        00:00:00 dnsmasq --no-hosts --no-resolv
--strict-order --bind-interfaces --interface=ns-f14c598d-98 --except-interface=lo
--pid-file=/var/lib/quantum/dhcp/88b1609c-68e0-49ca-a658-f1edff54a264/pid
--dhcp-hostsfile=/var/lib/quantum/dhcp/88b1609c-68e0-49ca-a658-f1edff54a264/host
--dhcp-optsfile=/var/lib/quantum/dhcp/88b1609c-68e0-49ca-a658-f1edff54a264/opts
--dhcp-script=/usr/bin/quantum-dhcp-agent-dnsmasq-lease-update --leasefile-ro
--dhcp-range=tag0,10.1.0.0,static,120s --conf-file= --domain=openstacklocal
```

1.3.2.5 router 服务

首先，什么是 router，router 是提供跨 subnet 的互联功能的。比如用户的内部网络中主机想要访问外部互联网的地址，就需要 router 来转发（因此，所有跟外部网络的流量都必须经过 router）。目前 router 的实现是通过 iptables 进行的。

同样的，router 服务也运行在自己的名字空间中，可以通过如下命令查看：

```
# ip netns exec qrouter-2d214fde-293c-4d64-8062-797f80ae2d8f ip addr
66: qg-d48b49e0-aa: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
state UP qlen 1000
    link/ether fa:16:3e:5c:a2:ac brd ff:ff:ff:ff:ff:ff
    inet 172.24.4.227/28 brd 172.24.4.239 scope global qg-d48b49e0-aa
```

```
    inet 172.24.4.228/32 brd 172.24.4.228 scope global qg-d48b49e0-aa
    inet6 fe80::f816:3eff:fe5c:a2ac/64 scope link
        valid_lft forever preferred_lft forever
68: qr-c2d7dd02-56: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state
UP qlen 1000
    link/ether fa:16:3e:ea:64:6e brd ff:ff:ff:ff:ff:ff
    inet 10.1.0.1/24 brd 10.1.0.255 scope global qr-c2d7dd02-56
    inet6 fe80::f816:3eff:feea:646e/64 scope link
        valid_lft forever preferred_lft forever
```

可以看出，该名字空间中包括两个网络接口。

第一个接口 qg-d48b49e0-aa（即 K）是外部接口（qg=q gateway），将路由器的网关指向默认网关（通过 router-gateway-set 命令指定），这个接口连接到 br-ex 上的 tapd48b49e0-aa（即 L）。

第二个接口 qr-c2d7dd02-56（即 N，qr=q bridge）跟 br-int 上的 tapc2d7dd02-56 口（即 M）相连，将 router 进程连接到集成网桥上。

查看该名字空间中的路由表：

```
# ip netns exec qrouter-2d214fde-293c-4d64-8062-797f80ae2d8f ip route
172.24.4.224/28 dev qg-d48b49e0-aa  proto kernel  scope link  src 172.24.4.227
10.1.0.0/24 dev qr-c2d7dd02-56  proto kernel  scope link  src 10.1.0.1
default via 172.24.4.225 dev qg-d48b49e0-aa
```

其中，第一条规则是将到 172.24.4.224/28 段的访问都从网卡 qg-d48b49e0-aa（即 K）发出。

第二条规则是将到 10.1.0.0/24 段的访问都从网卡 qr-c2d7dd02-56（即 N）发出。

最后一条是默认路由，所有的通过 qg-d48b49e0-aa 网卡（即 K）发出。

floating ip 服务同样在路由器名字空间中实现，例如如果绑定了外部的 floating ip 172.24.4.228 到某个虚拟机 10.1.0.2，则 nat 表中规则为：

```
# ip netns exec qrouter-2d214fde-293c-4d64-8062-797f80ae2d8f iptables -t nat -S
-P PREROUTING ACCEPT
-P POSTROUTING ACCEPT
-P OUTPUT ACCEPT
-N quantum-l3-agent-OUTPUT
-N quantum-l3-agent-POSTROUTING
-N quantum-l3-agent-PREROUTING
-N quantum-l3-agent-float-snat
-N quantum-l3-agent-snat
-N quantum-postrouting-bottom
-A PREROUTING -j quantum-l3-agent-PREROUTING
-A POSTROUTING -j quantum-l3-agent-POSTROUTING
-A POSTROUTING -j quantum-postrouting-bottom
-A OUTPUT -j quantum-l3-agent-OUTPUT
-A quantum-l3-agent-OUTPUT -d 172.24.4.228/32 -j DNAT --to-destination 10.1.0.2
-A quantum-l3-agent-POSTROUTING ! -i qg-d48b49e0-aa ! -o qg-d48b49e0-aa -m conntrack !
--ctstate DNAT -j ACCEPT
```

```
-A quantum-l3-agent-PREROUTING -d 169.254.169.254/32 -p tcp -m tcp --dport 80 -j REDIRECT
--to-ports 9697
-A quantum-l3-agent-PREROUTING -d 172.24.4.228/32 -j DNAT --to-destination 10.1.0.2
-A quantum-l3-agent-float-snat -s 10.1.0.2/32 -j SNAT --to-source 172.24.4.228
-A quantum-l3-agent-snat -j quantum-l3-agent-float-snat
-A quantum-l3-agent-snat -s 10.1.0.0/24 -j SNAT --to-source 172.24.4.227
-A quantum-postrouting-bottom -j quantum-l3-agent-snat
```

其中 SNAT 和 DNAT 规则完成外部 floating ip 到内部 ip 的映射：

```
-A quantum-l3-agent-OUTPUT -d 172.24.4.228/32 -j DNAT --to-destination 10.1.0.2
-A quantum-l3-agent-PREROUTING -d 172.24.4.228/32 -j DNAT --to-destination 10.1.0.2
-A quantum-l3-agent-float-snat -s 10.1.0.2/32 -j SNAT --to-source 172.24.4.228
```

另外有一条 SNAT 规则把所有其他的内部 IP 出来的流量都映射到外部 IP 172.24.4.227。这样即使在内部虚拟机没有外部 IP 的情况下，也可以发起对外网的访问。

```
-A quantum-l3-agent-snat -s 10.1.0.0/24 -j SNAT --to-source 172.24.4.227
```

1.3.2.6 br-ex

```
Bridge br-ex
        Port "eth1"
            Interface "eth1"
        Port br-ex
            Interface br-ex
                type: internal
        Port "qg-1c3627de-1b"
            Interface "qg-1c3627de-1b"
                type: internal
```

br-ex 上直接连接到外部物理网络，一般情况下网关在物理网络中已经存在，则直接转发即可。

```
# ovs-ofctl dump-flows br-ex
NXST_FLOW reply (xid=0x4):
 cookie=0x0, duration=23431.091s, table=0, n_packets=893539, n_bytes=504805376,
idle_age=0, priority=0 actions=NORMAL
```

如果对外部网络的网关地址配置到了 br-ex（即 br-ex 作为一个网关）：

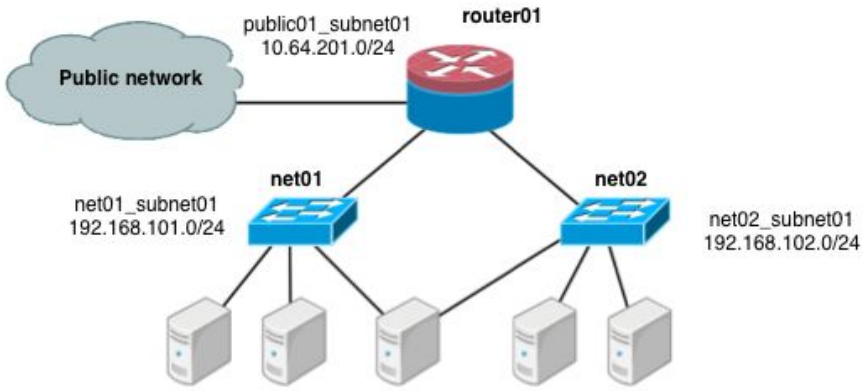
```
# ip addr add 172.24.4.225/28 dev br-ex
```

需要将内部虚拟机发出的流量进行 SNAT，之后发出。

```
# iptables -A FORWARD -d 172.24.4.224/28 -j ACCEPT
# iptables -A FORWARD -s 172.24.4.224/28 -j ACCEPT
# iptables -t nat -I POSTROUTING 1 -s 172.24.4.224/28 -j MASQUERADE
```

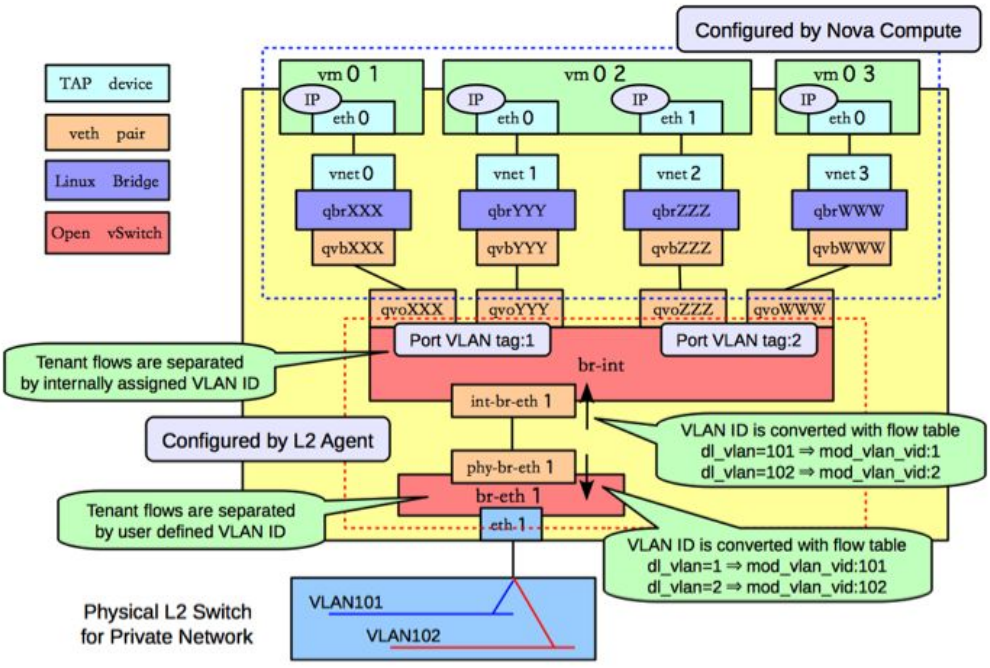
1.4 VLAN 模式

下面进行一些细节的补充讨论，以 Vlan 作为物理网络隔离的实现。假如要实现同一个租户下两个子网，如图表 2 所示：



图表 3 同一个租户的两个子网

1.4.1 Compute 节点



图表 4 Compute 节点网络示意

查看网桥信息：

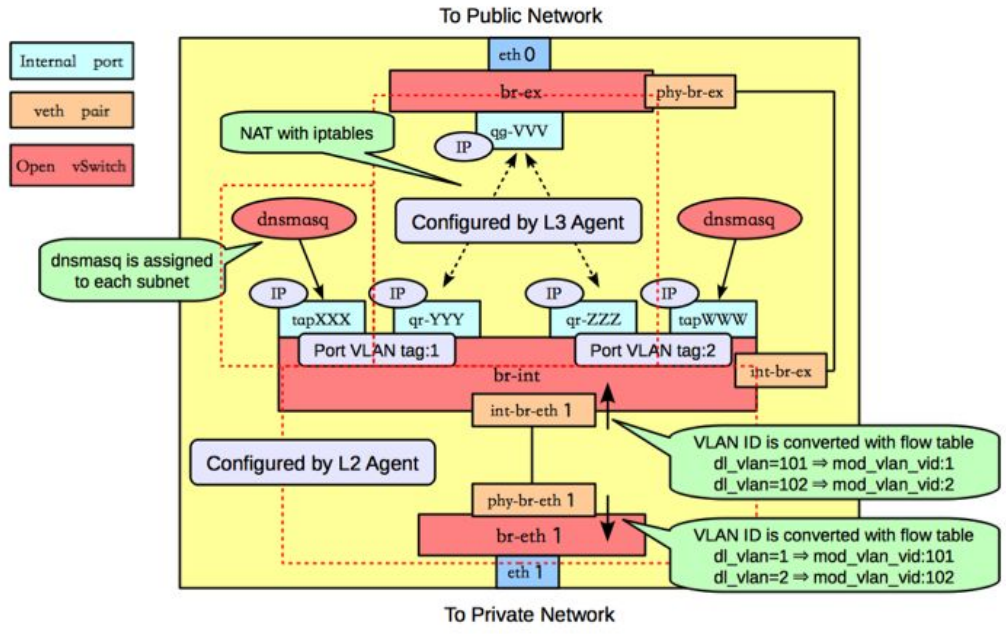
```
[root@Compute ~]# ovs-vsctl show
f1ec36f2-10f5-4b7d-8fb1-2cff7882f3d5
    Bridge "br-eth1"
        Port "phy-br-eth1"
```

```
            Interface "phy-br-eth1"
        Port "eth1"
            Interface "eth1"
        Port "br-eth1"
            Interface "br-eth1"
                type: internal
    Bridge br-int
        Port br-int
            Interface br-int
                type: internal
        Port "int-br-eth1"
            Interface "int-br-eth1"
```

类似 GRE 模式下，其中，qbr 负责实现安全策略，br-int 负责租户隔离，br-eth1 负责跟计算节点外的网络通信。

br-int 和 br-eth1 分别对从端口 int-br-eth1 和 phy-br-eth1 上到达的网包进行 vlan tag 的处理。此处有两个网，分别带有两个 vlan tag（内部 tag1 对应外部 tag101，内部 tag2 对应外部 tag102）。

1.4.2 Network 节点



图表 5 Network 节点网络示意

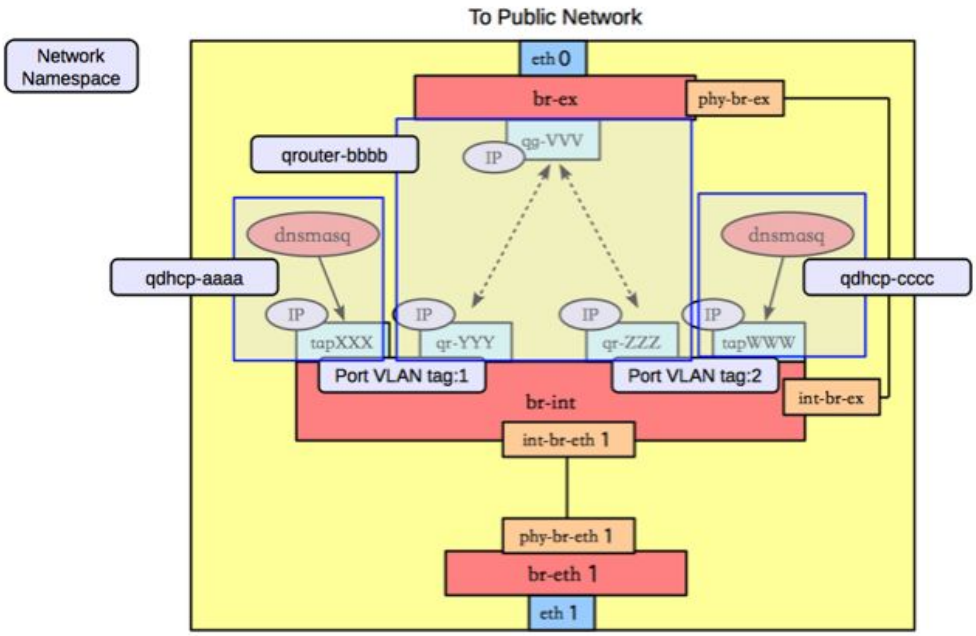
类似 GRE 模式下，br-eth1 收到到达的网包，int-br-eth1 和 phy-br-eth1 上分别进行 vlan 转换，保证到达 br-int 上的网包都是带有内部 vlan tag，到达 br-eth1 上的都是带有外部 vlan tag。

同样的，dnsmasq 负责提供 DHCP 服务，绑定到某个特定的名字空间上，每个需要 DHCP 服务的租户网络有自己专属隔离的 DHCP 服务（图中的 tapXXX 和 tapWWW 上各自监听了一个

dnsmasq）。

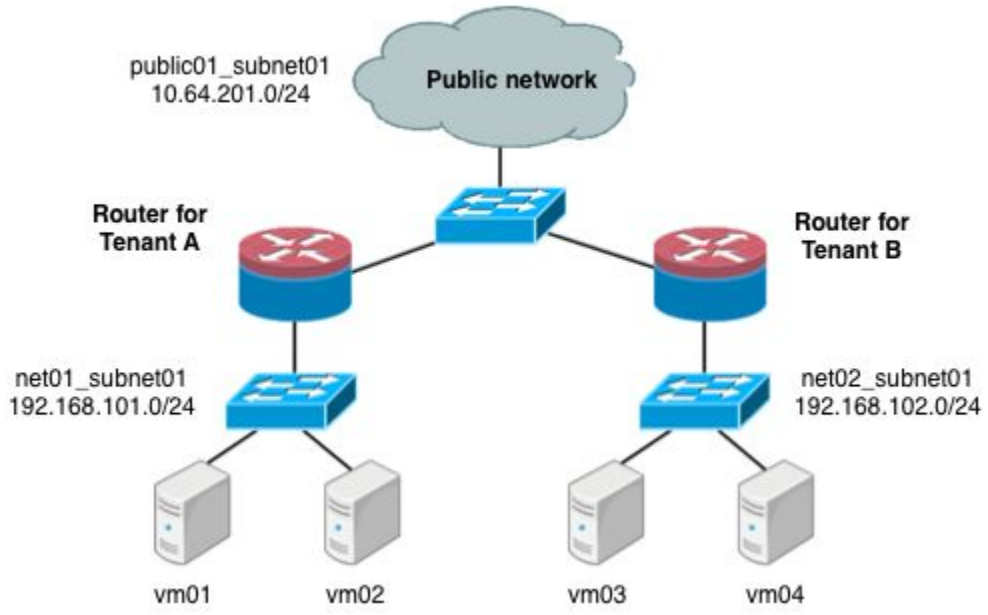
路由是 L3 agent 来实现，每个子网在 br-int 上有一个端口（qr-YYY 和 qr-ZZZ，已配置 IP，分别是各自内部子网的网关），L3 agent 绑定到上面。要访问外部的公共网络，需要通过 L3 agent 发出，而不是经过 int-br-ex 到 phy-br-ex（实际上并没有网包从这个 veth pair 传输）。如果要使用外部可见的 floating IP，L3 agent 仍然需要通过 iptables 来进行 NAT。

每个 L3 agent 或 dnsmasq 都在各自独立的名字空间中，如图表 5 所示，其中同一租户的两个子网都使用了同一个路由器。



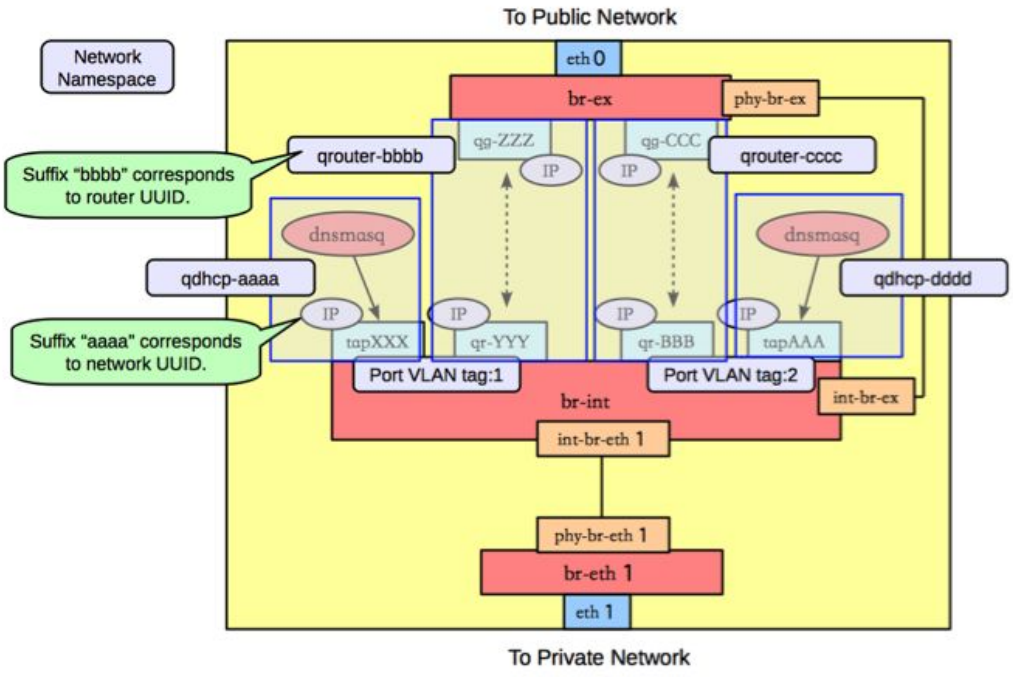
图表 6 每个网络功能进程都在自己的名字空间中

对于子网使用不同路由器的情况，多个路由器会在自己独立的名字空间中。例如要实现两个租户的两个子网的情况，如图表 6 所示。



图表 7 两个租户的两个子网的结构

这种情况下，网络节点上的名字空间如图表 7 所示。



图表 8 两个租户两个子网情况下的名字空间

1.5 参考

[1] http://openstack.redhat.com/Networking_in_too_much_detail

[2] http://masimum.inf.um.es/fjrm/2013/12/26/the-journey-of-a-packet-within-an-openstack-cloud/
[3] http://packetpushers.net/openstack-quantum-network-implementation-in-linux/
[4] http://masimum.inf.um.es/fjrm/2013/12/26/the-journey-of-a-packet-within-an-openstack-cloud/
[5] http://blog.scottlowe.org/2013/09/04/introducing-linux-network-namespaces/
[6] http://assafmuller.wordpress.com/2013/10/14/gre-tunnels-in-openstack-neutron/

1.6 附：安装配置

本文中示例以 havana 版本为例。

控制节点和计算节点分开，均为双网卡，eth0 为 openstack 内部数据网，eth1 为 openstack 管理网（同时为外部控制网）。

控制节点为 CentOS 6.5，计算节点为 Redhat。

安装利用 redhat 的 rdo。

1.6.1 RDO answer 文件-GRE 模式

```
[general]

# Path to a Public key to install on servers. If a usable key has not
# been installed on the remote servers the user will be prompted for a
# password and this key will be installed so the password will not be
# required again
CONFIG_SSH_KEY=/root/.ssh/id_rsa.pub

# Set to 'y' if you would like Packstack to install MySQL
CONFIG_MYSQL_INSTALL=y

# Set to 'y' if you would like Packstack to install OpenStack Image
# Service (Glance)
CONFIG_GLANCE_INSTALL=y

# Set to 'y' if you would like Packstack to install OpenStack Block
# Storage (Cinder)
CONFIG_CINDER_INSTALL=y

# Set to 'y' if you would like Packstack to install OpenStack Compute
# (Nova)
CONFIG_NOVA_INSTALL=y

# Set to 'y' if you would like Packstack to install OpenStack
# Networking (Neutron)
```

```
CONFIG_NEUTRON_INSTALL=y

# Set to 'y' if you would like Packstack to install OpenStack
# Dashboard (Horizon)
CONFIG_HORIZON_INSTALL=y

# Set to 'y' if you would like Packstack to install OpenStack Object
# Storage (Swift)
CONFIG_SWIFT_INSTALL=n

# Set to 'y' if you would like Packstack to install OpenStack
# Metering (Ceilometer)
CONFIG_CEILOMETER_INSTALL=y

# Set to 'y' if you would like Packstack to install OpenStack
# Orchestration (Heat)
CONFIG_HEAT_INSTALL=y

# Set to 'y' if you would like Packstack to install the OpenStack
# Client packages. An admin "rc" file will also be installed
CONFIG_CLIENT_INSTALL=y

# Comma separated list of NTP servers. Leave plain if Packstack
# should not install ntpd on instances.
CONFIG_NTP_SERVERS=pool.ntp.org

# Set to 'y' if you would like Packstack to install Nagios to monitor
# OpenStack hosts
CONFIG_NAGIOS_INSTALL=n

# Comma separated list of servers to be excluded from installation in
# case you are running Packstack the second time with the same answer
# file and don't want Packstack to touch these servers. Leave plain if
# you don't need to exclude any server.
EXCLUDE_SERVERS=

# Set to 'y' if you want to run OpenStack services in debug mode.
# Otherwise set to 'n'.
CONFIG_DEBUG_MODE=n

# The IP address of the server on which to install MySQL
```

```
CONFIG_MYSQL_HOST=9.186.105.154

# Username for the MySQL admin user
CONFIG_MYSQL_USER=root

# Password for the MySQL admin user
CONFIG_MYSQL_PW=root

# The IP address of the server on which to install the QPID service
CONFIG_QPID_HOST=9.186.105.154

# Enable SSL for the QPID service
CONFIG_QPID_ENABLE_SSL=n

# Enable Authentication for the QPID service
CONFIG_QPID_ENABLE_AUTH=n

# The password for the NSS certificate database of the QPID service
CONFIG_QPID_NSS_CERTDB_PW=4afeb1315f9341ec994ccfb5c0ace171

# The port in which the QPID service listens to SSL connections
CONFIG_QPID_SSL_PORT=5671

# The filename of the certificate that the QPID service is going to
# use
CONFIG_QPID_SSL_CERT_FILE=/etc/pki/tls/certs/qpid_selfcert.pem

# The filename of the private key that the QPID service is going to
# use
CONFIG_QPID_SSL_KEY_FILE=/etc/pki/tls/private/qpid_selfkey.pem

# Auto Generates self signed SSL certificate and key
CONFIG_QPID_SSL_SELF_SIGNED=y

# User for qpid authentication
CONFIG_QPID_AUTH_USER=qpid_user

# Password for user authentication
CONFIG_QPID_AUTH_PASSWORD=19f1540f541d402e

# The IP address of the server on which to install Keystone
```

```
CONFIG_KEYSTONE_HOST=9.186.105.154

# The password to use for the Keystone to access DB
CONFIG_KEYSTONE_DB_PW=0a9fbe8bcfc14091

# The token to use for the Keystone service api
CONFIG_KEYSTONE_ADMIN_TOKEN=bfab1155f8944cb49dc0d745fa52ec51

# The password to use for the Keystone admin user
CONFIG_KEYSTONE_ADMIN_PW=admin

# The password to use for the Keystone demo user
CONFIG_KEYSTONE_DEMO_PW=a93b7421f3ae4b18

# Kestone token format. Use either UUID or PKI
CONFIG_KEYSTONE_TOKEN_FORMAT=PKI

# The IP address of the server on which to install Glance
CONFIG_GLANCE_HOST=9.186.105.154

# The password to use for the Glance to access DB
CONFIG_GLANCE_DB_PW=78c3cc98e8a94fef

# The password to use for the Glance to authenticate with Keystone
CONFIG_GLANCE_KS_PW=e47ccb960cb74c4c

# The IP address of the server on which to install Cinder
CONFIG_CINDER_HOST=9.186.105.154

# The password to use for the Cinder to access DB
CONFIG_CINDER_DB_PW=0042879961db474e

# The password to use for the Cinder to authenticate with Keystone
CONFIG_CINDER_KS_PW=ac0b3965e2a34e4f

# The Cinder backend to use, valid options are: lvm, gluster, nfs
CONFIG_CINDER_BACKEND=lvm

# Create Cinder's volumes group. This should only be done for testing
# on a proof-of-concept installation of Cinder.    This will create a
# file-backed volume group and is not suitable for production usage.
```

```
CONFIG_CINDER_VOLUMES_CREATE=y

# Cinder's volumes group size. Note that actual volume size will be
# extended with 3% more space for VG metadata.
CONFIG_CINDER_VOLUMES_SIZE=20G

# A single or comma separated list of gluster volume shares to mount,
# eg: ip-address:/vol-name, domain:/vol-name
CONFIG_CINDER_GLUSTER_MOUNTS=

# A single or comma seprated list of NFS exports to mount, eg: ip-
# address:/export-name
CONFIG_CINDER_NFS_MOUNTS=

# The IP address of the server on which to install the Nova API
# service
CONFIG_NOVA_API_HOST=9.186.105.154

# The IP address of the server on which to install the Nova Cert
# service
CONFIG_NOVA_CERT_HOST=9.186.105.154

# The IP address of the server on which to install the Nova VNC proxy
CONFIG_NOVA_VNCPROXY_HOST=9.186.105.154

# A comma separated list of IP addresses on which to install the Nova
# Compute services
CONFIG_NOVA_COMPUTE_HOSTS=9.186.105.240

# The IP address of the server on which to install the Nova Conductor
# service
CONFIG_NOVA_CONDUCTOR_HOST=9.186.105.154

# The password to use for the Nova to access DB
CONFIG_NOVA_DB_PW=622b61c95e334c36

# The password to use for the Nova to authenticate with Keystone
CONFIG_NOVA_KS_PW=0573f5812091497a

# The IP address of the server on which to install the Nova Scheduler
# service
```

```
CONFIG_NOVA_SCHED_HOST=9.186.105.154

# The overcommitment ratio for virtual to physical CPUs. Set to 1.0
# to disable CPU overcommitment
CONFIG_NOVA_SCHED_CPU_ALLOC_RATIO=16.0

# The overcommitment ratio for virtual to physical RAM. Set to 1.0 to
# disable RAM overcommitment
CONFIG_NOVA_SCHED_RAM_ALLOC_RATIO=1.5

# Private interface for Flat DHCP on the Nova compute servers
CONFIG_NOVA_COMPUTE_PRIVIF=eth0

# The list of IP addresses of the server on which to install the Nova
# Network service
CONFIG_NOVA_NETWORK_HOSTS=9.186.105.154

# Nova network manager
CONFIG_NOVA_NETWORK_MANAGER=nova.network.manager.FlatDHCPManager

# Public interface on the Nova network server
CONFIG_NOVA_NETWORK_PUBIF=eth1

# Private interface for network manager on the Nova network server
CONFIG_NOVA_NETWORK_PRIVIF=eth0

# IP Range for network manager
CONFIG_NOVA_NETWORK_FIXEDRANGE=192.168.32.0/22

# IP Range for Floating IP's
CONFIG_NOVA_NETWORK_FLOATRANGE=10.3.4.0/22

# Name of the default floating pool to which the specified floating
# ranges are added to
CONFIG_NOVA_NETWORK_DEFAULTFLOATINGPOOL=nova

# Automatically assign a floating IP to new instances
CONFIG_NOVA_NETWORK_AUTOASSIGNFLOATINGIP=n

# First VLAN for private networks
CONFIG_NOVA_NETWORK_VLAN_START=100
```

```
# Number of networks to support
CONFIG_NOVA_NETWORK_NUMBER=1

# Number of addresses in each private subnet
CONFIG_NOVA_NETWORK_SIZE=255

# The IP addresses of the server on which to install the Neutron
# server
CONFIG_NEUTRON_SERVER_HOST=9.186.105.154

# The password to use for Neutron to authenticate with Keystone
CONFIG_NEUTRON_KS_PW=906aae1c5727416b

# The password to use for Neutron to access DB
CONFIG_NEUTRON_DB_PW=4ef2c9f1292c4feb

# A comma separated list of IP addresses on which to install Neutron
# L3 agent
CONFIG_NEUTRON_L3_HOSTS=9.186.105.154

# The name of the bridge that the Neutron L3 agent will use for
# external traffic, or 'provider' if using provider networks
CONFIG_NEUTRON_L3_EXT_BRIDGE=br-ex

# A comma separated list of IP addresses on which to install Neutron
# DHCP agent
CONFIG_NEUTRON_DHCP_HOSTS=9.186.105.154

# A comma separated list of IP addresses on which to install Neutron
# LBaaS agent
CONFIG_NEUTRON_LBAAS_HOSTS=

# The name of the L2 plugin to be used with Neutron
CONFIG_NEUTRON_L2_PLUGIN=openvswitch

# A comma separated list of IP addresses on which to install Neutron
# metadata agent
CONFIG_NEUTRON_METADATA_HOSTS=9.186.105.154

# A comma separated list of IP addresses on which to install Neutron
```

```
# metadata agent
CONFIG_NEUTRON_METADATA_PW=31620943f151436c

# A comma separated list of network type driver entrypoints to be
# loaded from the neutron.ml2.type_drivers namespace.
CONFIG_NEUTRON_ML2_TYPE_DRIVERS=local

# A comma separated ordered list of network_types to allocate as
# tenant networks. The value 'local' is only useful for single-box
# testing but provides no connectivity between hosts.
CONFIG_NEUTRON_ML2_TENANT_NETWORK_TYPES=local

# A comma separated ordered list of networking mechanism driver
# entrypoints to be loaded from the neutron.ml2.mechanism_drivers
# namespace.
CONFIG_NEUTRON_ML2_MECHANISM_DRIVERS=openvswitch

# A comma separated     list of physical_network names with which flat
# networks can be created. Use * to allow flat networks with arbitrary
# physical_network names.
CONFIG_NEUTRON_ML2_FLAT_NETWORKS=*

# A comma separated list of <physical_network>:<vlan_min>:<vlan_max>
# or <physical_network> specifying physical_network names usable for
# VLAN provider and tenant networks, as well as ranges of VLAN tags on
# each available for allocation to tenant networks.
CONFIG_NEUTRON_ML2_VLAN_RANGES=

# A comma separated list of <tun_min>:<tun_max> tuples enumerating
# ranges of GRE tunnel IDs that are available for tenant network
# allocation. Should be an array with tun_max +1 - tun_min > 1000000
CONFIG_NEUTRON_ML2_TUNNEL_ID_RANGES=

# Multicast group for VXLAN. If unset, disables VXLAN enable sending
# allocate broadcast traffic to this multicast group. When left
# unconfigured, will disable multicast VXLAN mode. Should be an
# Multicast IP (v4 or v6) address.
CONFIG_NEUTRON_ML2_VXLAN_GROUP=

# A comma separated list of <vni_min>:<vni_max> tuples enumerating
# ranges of VXLAN VNI IDs that are available for tenant network
```

```
# allocation. Min value is 0 and Max value is 16777215.
CONFIG_NEUTRON_ML2_VNI_RANGES=

# The name of the L2 agent to be used with Neutron
CONFIG_NEUTRON_L2_AGENT=openvswitch

# The type of network to allocate for tenant networks (eg. vlan,
# local)
CONFIG_NEUTRON_LB_TENANT_NETWORK_TYPE=local

# A comma separated list of VLAN ranges for the Neutron linuxbridge
# plugin (eg. physnet1:1:4094,physnet2,physnet3:3000:3999)
CONFIG_NEUTRON_LB_VLAN_RANGES=

# A comma separated list of interface mappings for the Neutron
# linuxbridge plugin (eg. physnet1:br-eth1,physnet2:br-eth2,physnet3
# :br-eth3)
CONFIG_NEUTRON_LB_INTERFACE_MAPPINGS=

# Type of network to allocate for tenant networks (eg. vlan, local,
# gre, vxlan)
CONFIG_NEUTRON_OVS_TENANT_NETWORK_TYPE=gre

# A comma separated list of VLAN ranges for the Neutron openvswitch
# plugin (eg. physnet1:1:4094,physnet2,physnet3:3000:3999)
CONFIG_NEUTRON_OVS_VLAN_RANGES=

# A comma separated list of bridge mappings for the Neutron
# openvswitch plugin (eg. physnet1:br-eth1,physnet2:br-eth2,physnet3
# :br-eth3)
CONFIG_NEUTRON_OVS_BRIDGE_MAPPINGS=

# A comma separated list of colon-separated OVS bridge:interface
# pairs. The interface will be added to the associated bridge.
CONFIG_NEUTRON_OVS_BRIDGE_IFACES=

# A comma separated list of tunnel ranges for the Neutron openvswitch
# plugin (eg. 1:1000)
CONFIG_NEUTRON_OVS_TUNNEL_RANGES=1:1000

# The interface for the OVS tunnel. Packstack will override the IP
```

```
# address used for tunnels on this hypervisor to the IP found on the
# specified interface. (eg. eth1)
CONFIG_NEUTRON_OVS_TUNNEL_IF=eth0

# VXLAN UDP port
CONFIG_NEUTRON_OVS_VXLAN_UDP_PORT=4789

# The IP address of the server on which to install the OpenStack
# client packages. An admin "rc" file will also be installed
CONFIG_OSCLIENT_HOST=9.186.105.154

# The IP address of the server on which to install Horizon
CONFIG_HORIZON_HOST=9.186.105.154

# To set up Horizon communication over https set this to "y"
CONFIG_HORIZON_SSL=n

# PEM encoded certificate to be used for ssl on the https server,
# leave blank if one should be generated, this certificate should not
# require a passphrase
CONFIG_SSL_CERT=

# Keyfile corresponding to the certificate if one was entered
CONFIG_SSL_KEY=

# The IP address on which to install the Swift proxy service
# (currently only single proxy is supported)
CONFIG_SWIFT_PROXY_HOSTS=9.186.105.154

# The password to use for the Swift to authenticate with Keystone
CONFIG_SWIFT_KS_PW=85f42ee1d9604761

# A comma separated list of IP addresses on which to install the
# Swift Storage services, each entry should take the format
# <ipaddress>[/dev], for example 127.0.0.1/vdb will install /dev/vdb
# on 127.0.0.1 as a swift storage device(packstack does not create the
# filesystem, you must do this first), if /dev is omitted Packstack
# will create a loopback device for a test setup
CONFIG_SWIFT_STORAGE_HOSTS=9.186.105.154

# Number of swift storage zones, this number MUST be no bigger than
```

```
# the number of storage devices configured
CONFIG_SWIFT_STORAGE_ZONES=1

# Number of swift storage replicas, this number MUST be no bigger
# than the number of storage zones configured
CONFIG_SWIFT_STORAGE_REPLICAS=1

# FileSystem type for storage nodes
CONFIG_SWIFT_STORAGE_FSTYPE=ext4

# Shared secret for Swift
CONFIG_SWIFT_HASH=dcd782d154134ed5

# Size of the swift loopback file storage device
CONFIG_SWIFT_STORAGE_SIZE=2G

# Whether to provision for demo usage and testing
CONFIG_PROVISION_DEMO=n

# The CIDR network address for the floating IP subnet
CONFIG_PROVISION_DEMO_FLOATRANGE=172.24.4.224/28

# Whether to configure tempest for testing
CONFIG_PROVISION_TEMPEST=n

# The uri of the tempest git repository to use
CONFIG_PROVISION_TEMPEST_REPO_URI=https://github.com/openstack/tempest.git

# The revision of the tempest git repository to use
CONFIG_PROVISION_TEMPEST_REPO_REVISION=stable/havana

# Whether to configure the ovs external bridge in an all-in-one
# deployment
CONFIG_PROVISION_ALL_IN_ONE_OVS_BRIDGE=n

# The IP address of the server on which to install Heat service
CONFIG_HEAT_HOST=9.186.105.154

# The password used by Heat user to authenticate against MySQL
CONFIG_HEAT_DB_PW=db67579b56ea4bcd
```

```
# The password to use for the Heat to authenticate with Keystone
CONFIG_HEAT_KS_PW=0ecab082910c4fab

# Set to 'y' if you would like Packstack to install Heat CloudWatch
# API
CONFIG_HEAT_CLOUDWATCH_INSTALL=n

# Set to 'y' if you would like Packstack to install Heat
# CloudFormation API
CONFIG_HEAT_CFN_INSTALL=n

# The IP address of the server on which to install Heat CloudWatch
# API service
CONFIG_HEAT_CLOUDWATCH_HOST=9.186.105.154

# The IP address of the server on which to install Heat
# CloudFormation API service
CONFIG_HEAT_CFN_HOST=9.186.105.154

# The IP address of the server on which to install Ceilometer
CONFIG_CEILOMETER_HOST=9.186.105.154

# Secret key for signing metering messages.
CONFIG_CEILOMETER_SECRET=339bb60f1d79431d

# The password to use for Ceilometer to authenticate with Keystone
CONFIG_CEILOMETER_KS_PW=9364b11a6575405f

# The IP address of the server on which to install the Nagios server
CONFIG_NAGIOS_HOST=9.186.105.154

# The password of the nagiosadmin user on the Nagios server
CONFIG_NAGIOS_PW=593a5048a8ed4bb8

# To subscribe each server to EPEL enter "y"
CONFIG_USE_EPEL=n

# A comma separated list of URLs to any additional yum repositories
# to install
CONFIG_REPO=
```

```
# To subscribe each server with Red Hat subscription manager, include
# this with CONFIG_RH_PW
CONFIG_RH_USER=

# To subscribe each server with Red Hat subscription manager, include
# this with CONFIG_RH_USER
CONFIG_RH_PW=

# To subscribe each server to Red Hat Enterprise Linux 6 Server Beta
# channel (only needed for Preview versions of RHOS) enter "y"
CONFIG_RH_BETA_REPO=n

# To subscribe each server with RHN Satellite,fill Satellite's URL
# here. Note that either satellite's username/password or activation
# key has to be provided
CONFIG_SATELLITE_URL=

# Username to access RHN Satellite
CONFIG_SATELLITE_USER=

# Password to access RHN Satellite
CONFIG_SATELLITE_PW=

# Activation key for subscription to RHN Satellite
CONFIG_SATELLITE_AKEY=

# Specify a path or URL to a SSL CA certificate to use
CONFIG_SATELLITE_CACERT=

# If required specify the profile name that should be used as an
# identifier for the system in RHN Satellite
CONFIG_SATELLITE_PROFILE=

# Comma separated list of flags passed to rhnreg_ks. Valid flags are:
# novirtinfo, norhnsd, nopackages
CONFIG_SATELLITE_FLAGS=

# Specify a HTTP proxy to use with RHN Satellite
CONFIG_SATELLITE_PROXY=

# Specify a username to use with an authenticated HTTP proxy
```

```
CONFIG_SATELLITE_PROXY_USER=

# Specify a password to use with an authenticated HTTP proxy.
CONFIG_SATELLITE_PROXY_PW=
```