



Cloud Networking (VITMMA02)

Network Virtualization: Overlay Networks

OpenStack Neutron Networking

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OVERLAY NETWORKS

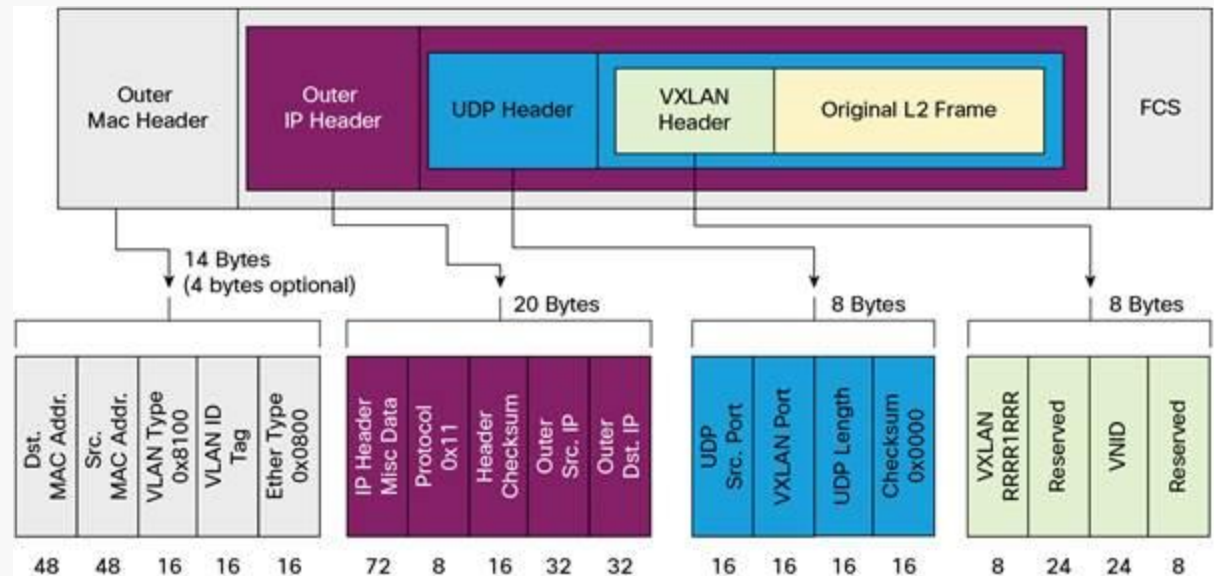


Network Virtualization

- » Support for tenant separation
 - » Virtual Extensible LAN (VXLAN) – RFC 7348
 - » Cisco, VMware
 - » transport of virtual L2 traffic over physical L3 network
 - » Network Virtualization using Generic Routing Encapsulation (NVGRE)
 - » Microsoft, Intel, HP, Dell
 - » Generic Network Virtualization Encapsulation (GENEVE)
 - » superset of VXLAN and NVGRE
 - » Stateless Transport Tunneling (STT)
 - » Nicira ⇔ VMware

VXLAN

- » Original L2 frame of tenant
 - » original MAC address and VLAN tag
- » MAC-in-UDP
- » VXLAN and UDP header
 - » VXLAN network ID (VNID) – identifying the tenant
 - » 24 bit \Rightarrow 16 million tenant
- » physical network: IP routing (Layer3)

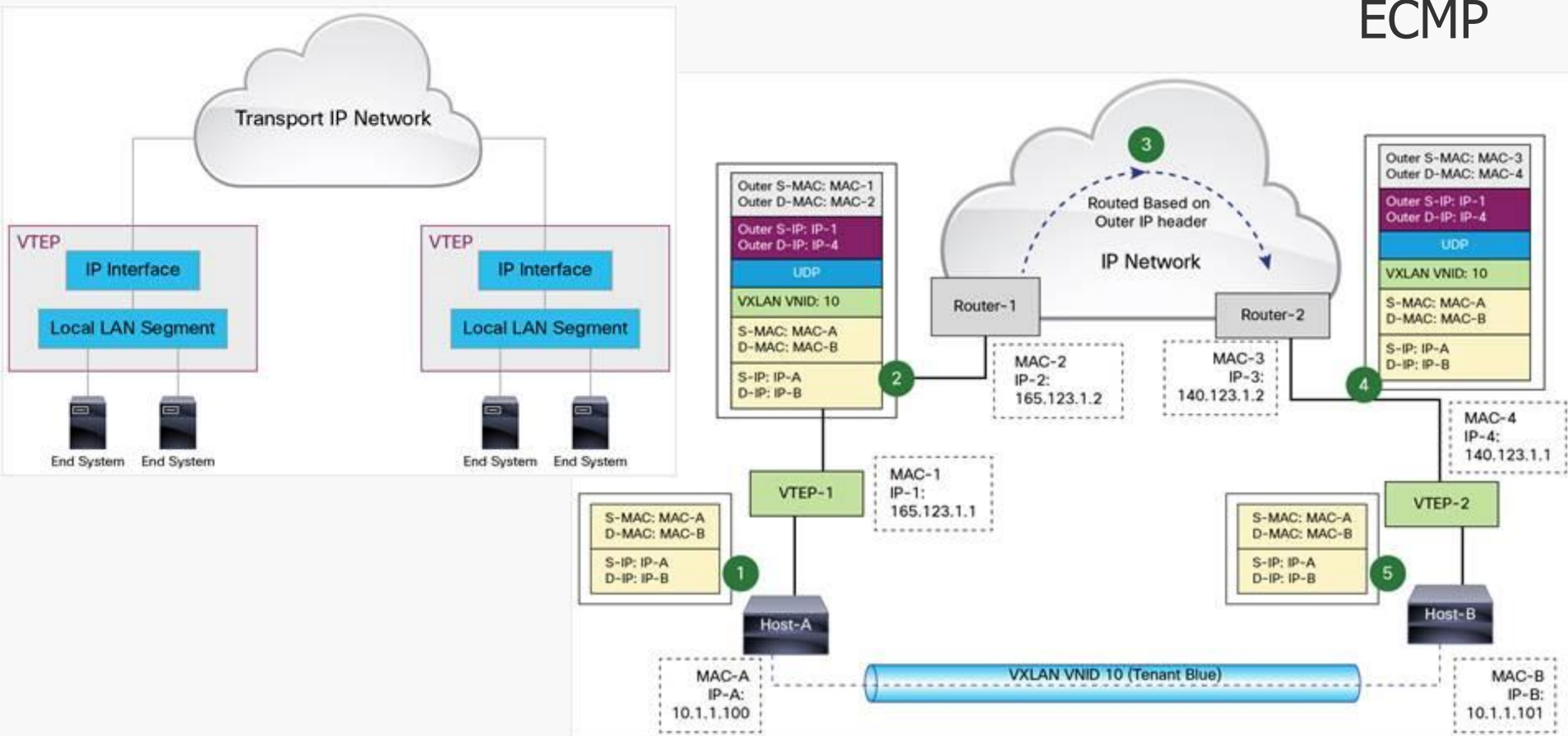




VXLAN

- » VXLAN Tunnel End Point (VTEP)
- » MAC-to-VTEP tables by learning (IP multicast)
 - » all VTEP of a VNI in a multicast group

ECMP





NVGRE

- » is very similar to VXLAN
- » basis: Generic Routing Encapsulation (GRE)
 - » generic header
 - » can encapsulate a wide variety of network layer protocols
 - » point-to-point links over an Internet Protocol network
- » NVGRE
 - » GRE header
 - »


```

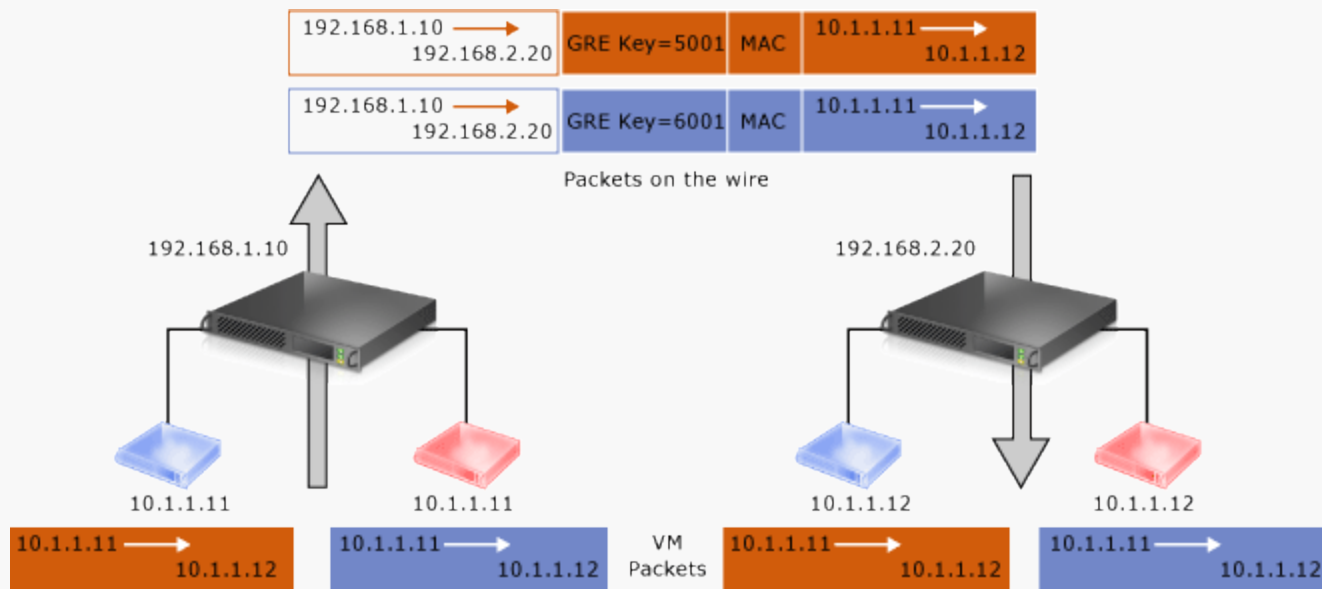
              +-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
              |0| |1|0|   Reserved0   | Ver |   Protocol Type 0x6558   |
              +-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
              |
              |           Virtual Subnet ID (VSID)           |   FlowID   |
              +-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
              
```

 - » Virtual Subnet Identifier (VSID) 24 bit \Rightarrow 16 million tenant
 - » FlowID: optional, unique flow identifier
 - » for ECMP hashing
 - » no inner VLAN tag (or it is removed)
 - » encoded into VSID or multiple VSIDs for the same tenant



NVGRE

- » Network Virtual Endpoint (NVE)
 - » forwarding to the destination based on VSID and DMAC
- » not specified in the Internet draft
 - » dissemination of addressing information
 - » restoring VLAN information

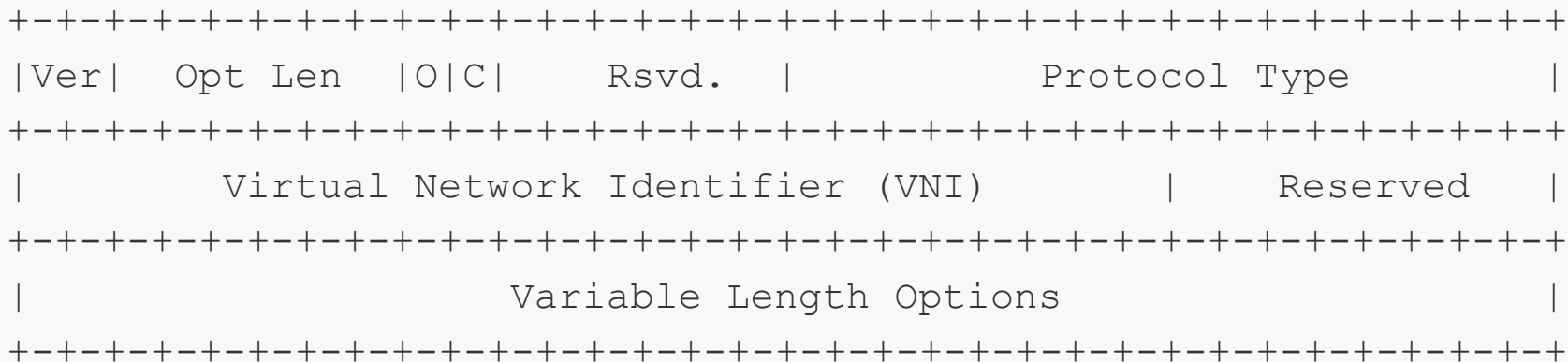




Generic Network Virtualization Encapsulation

- » MAC-in-UDP over IPv4/IPv6
- » universal, extensible
- » specifies only the encapsulation format
- » optional fields
 - » variable field lengths, flexibility

» Geneve header:





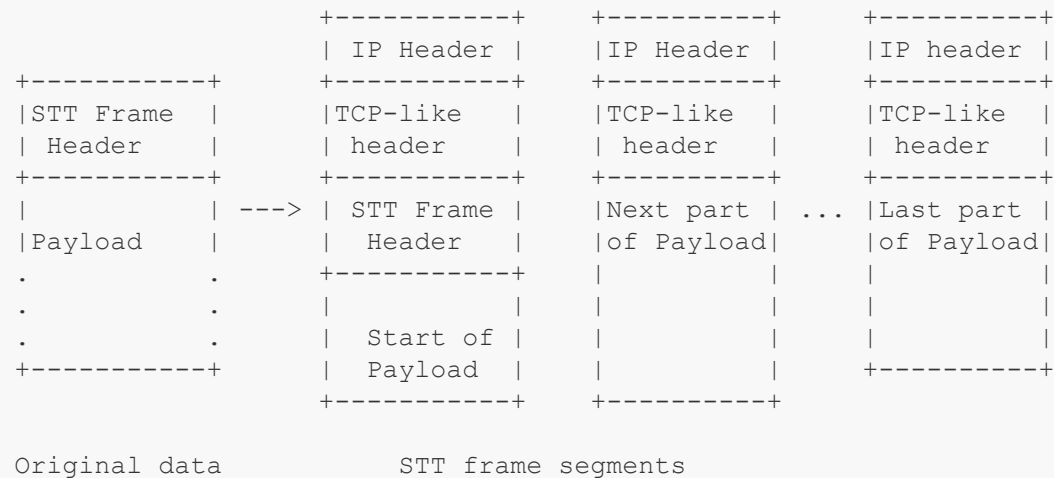
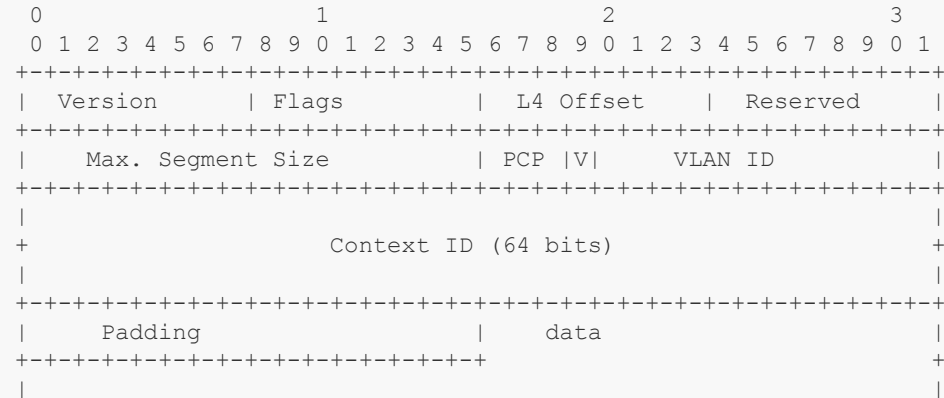
Location of Tunnel Endpoint

- » Inside hypervisor/vSwitch
 - » most common
 - » closest to the VMs
 - » consumes CPU resources
 - » TCP segmentation offload (TSO), checksum offload support for non-encapsulated packets
- » NIC
 - » offload support for tunneling
- » ToR switch
 - » VMs are unknown
 - » has to identify VM based on inner MAC to assign VNI/VSID



Stateless Transport Tunneling (STT)

- » primary goal: communication between vSwitches
- » more complex than the others
- » max. 64 kbyte Ethernet frames
 - » maximum transmission unit (MTU)
 - » using TCP segmentation offload on NIC
- » STT header
 - » 64 bit Context ID field
- » TCP-like/IP/Eth header before the segments
 - » reassembling the original data based on this





Comparison

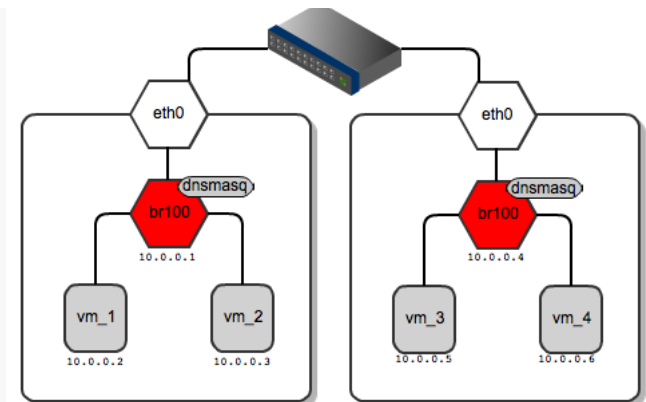
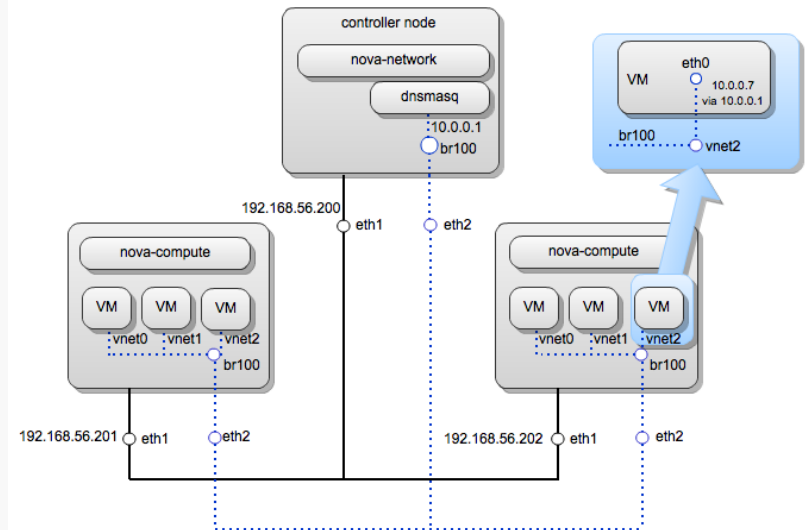
	VXLAN	NVGRE	STT
Extra bytes	50 (VLAN: +4)	42 (VLAN: +4)	First segment: 76 Others: 58 (VLAN: +4)
Protocol	UDP	GRE	TCP
Tenant separation	24 bit VNID	24 bit VSID	64 bit Context ID
ECMP flow differentiation (inner \Rightarrow outer flow)	Source UDP port	VSID + FlowID (8bit)	Source TCP port



OPENSTACK NEUTRON

OpenStack network architecture

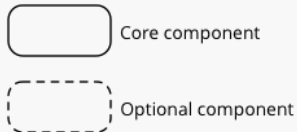
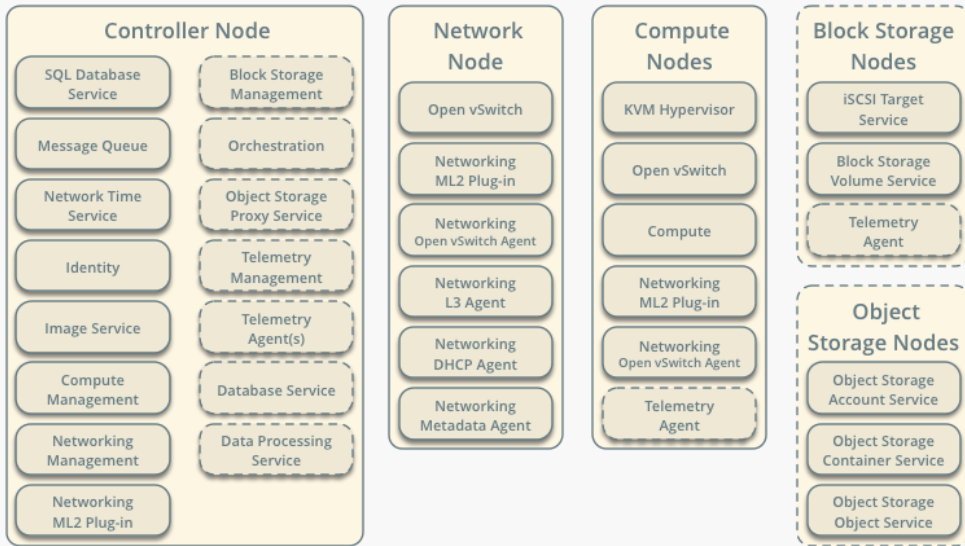
- » „Networking in OpenStack is a complex, multifaceted challenge.“ /OpenStack Operations Guide/
- » Network as a Service
- » functions
 - » IP addressing
 - » static, DHCP
 - » floating IP
 - » virtual networks
 - » flat, VLAN
 - » self-service
- » alternatives
 - » Nova networking / Neutron
 - » single-host / multi-host
- » Neutron
 - » plug-in architecture
 - » SDN/OpenFlow



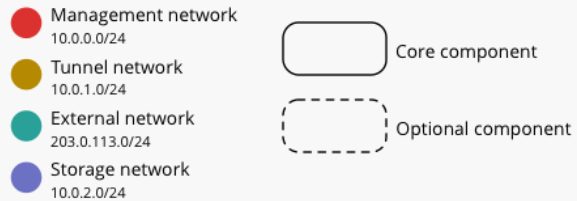
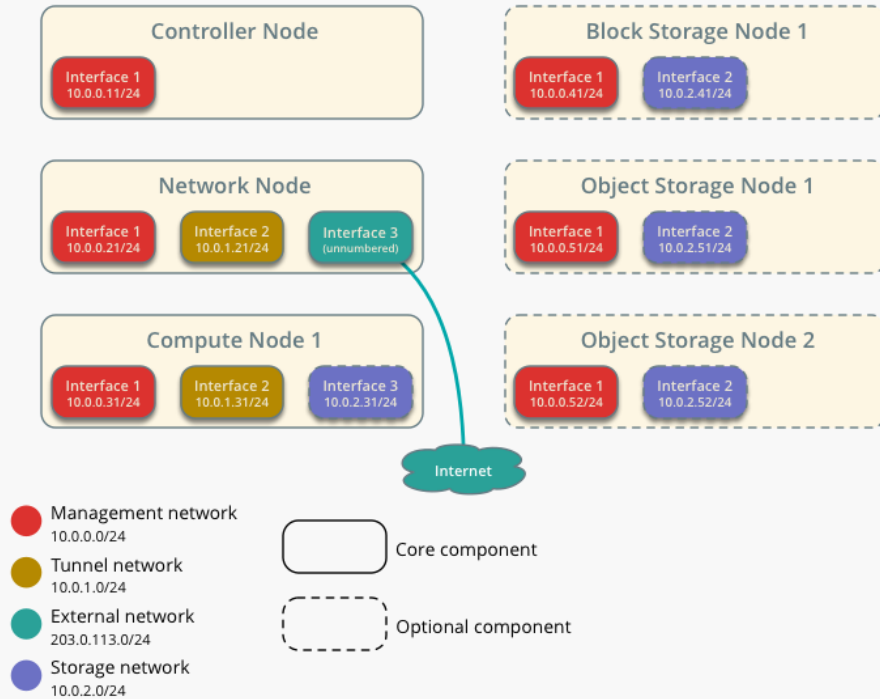


Neutron network

Minimal Architecture Example - Service Layout
OpenStack Networking (neutron)



Minimal Architecture Example - Network Layout
OpenStack Networking (neutron)





Nova and Neutron Network

» Nova

- » basic networking functions
 - » network address translation (NAT), DHCP, DNS
- » only support L2 bridge networking
 - » allows virtual interfaces to connect to the outside network through the physical interface
- » limited scalability
 - » VLAN, DNS&DHCP (dnsmasq)

» Neutron

- » network abstraction
- » L2/L3 network, self-service
 - » e.g. more LAN segments for a web service
- » Load Balancing, Virtual IP, VPN, firewall
- » overlay VLAN tunneling
- » Distributed Virtual Router (from Juno)

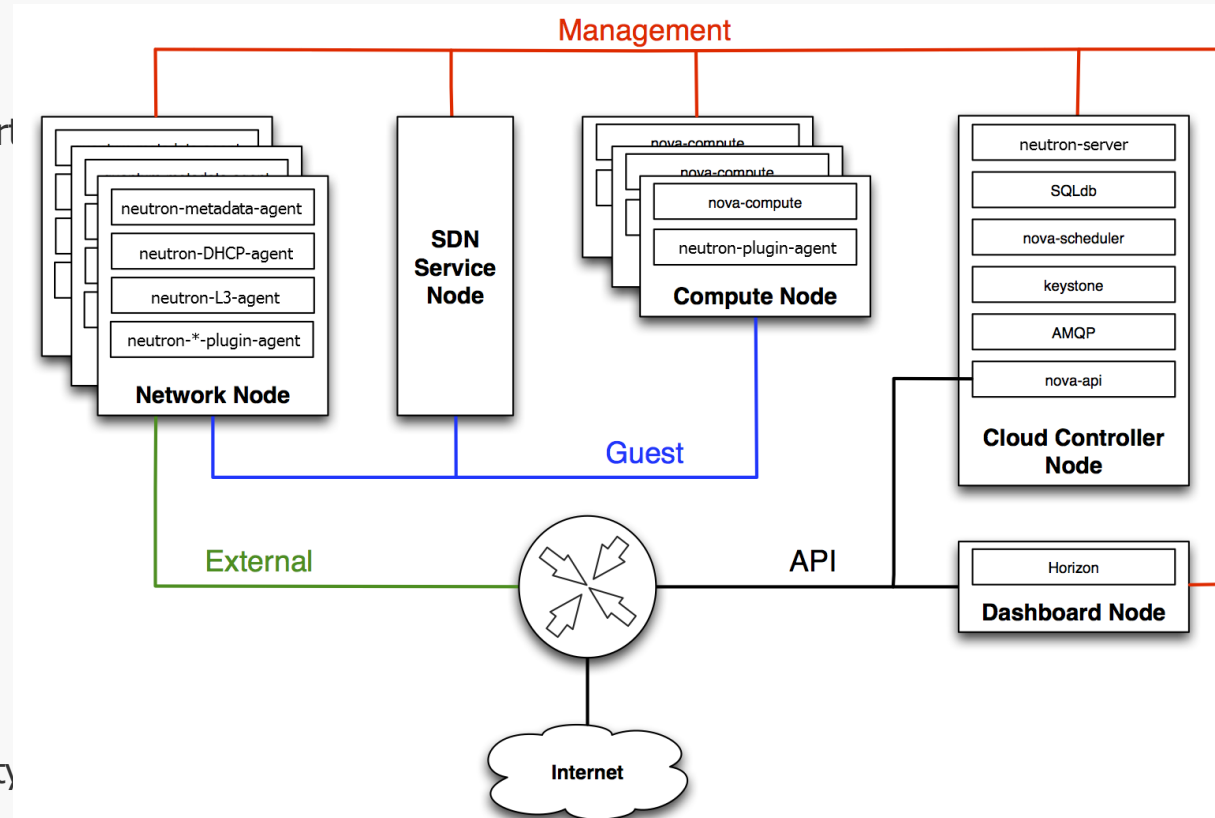


Neutron network abstraction

- » External /physical/ network, e.g. Internet
- » Internal networks to connect VMs
 - » virtual: network, subnetwork, router
 - » floating IP from external network address space for reaching a VM from outside
- » Security groups
 - » firewall rules
 - » assigned to the VM
- » Open vSwitch
 - » core plugin
 - » br-int (integration bridge)
 - » connected to VMs
 - » br-ex
 - » connected to external network

Neutron components

- » server + plugin + agent architecture
 - » neutron-server
 - » on controller node
 - » handling API requests
 - » network model and port IP address setup
 - » plugin – extensions: neutron-***-plugin
 - » on network node
 - » plugin-agent: neutron-***-agent
 - » on compute node
 - » managing the local vswitch
 - » general agents
 - » DHCP: neutron-dhcp-agent
 - » L3 agent: neutron-l3-agent
 - » L3/NAT functionality towards the external network
 - » implementation: Linux IP stack and iptables





Modular Layer 2 (ML2) plugin

- » Managing different L2 network technologies in uniform way
- » Operates with openvswitch, linuxbridge and Hyper-V L2 agents
- » Type drivers for different network types
 - » Flat
 - » Local (DevStack single box)
 - » VLAN
 - » GRE
 - » VXLAN

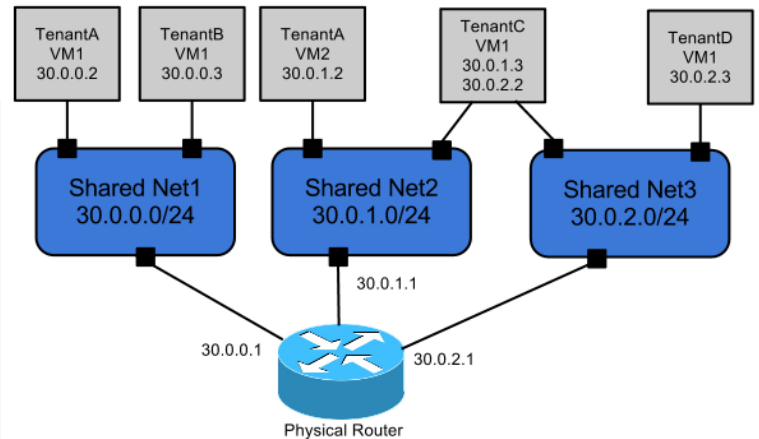
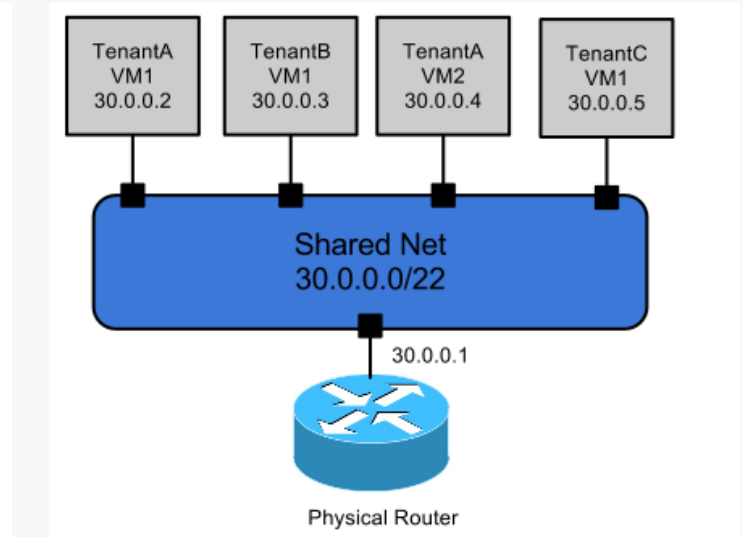
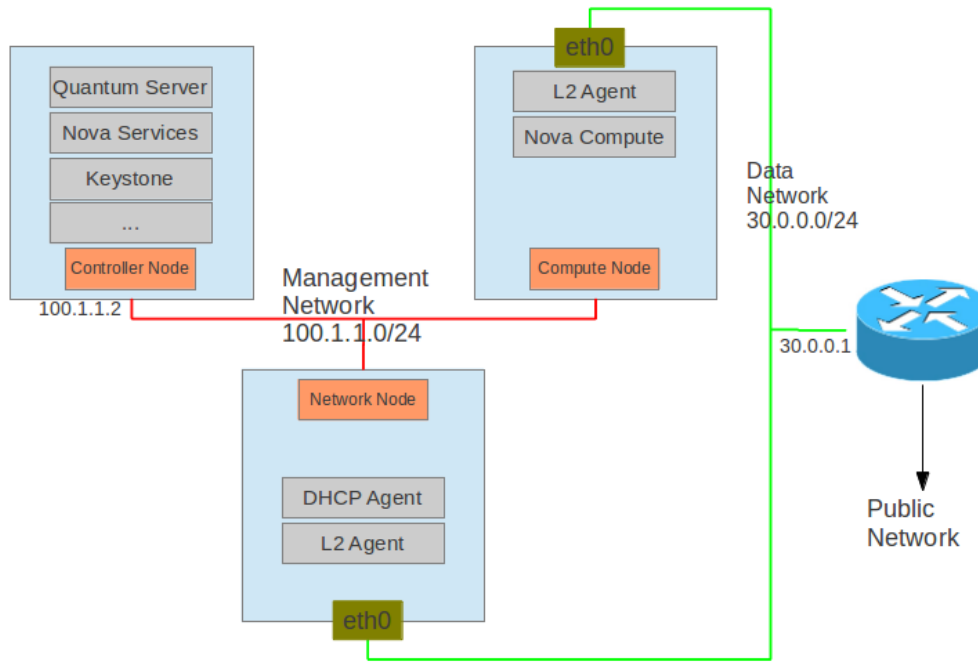


Network namespaces

- » kernel level namespaces, not only for networking
 - » file system, process, user, etc.
- » isolated Layer2 networks with overlapping IP addresses
- » separating virtual interfaces, routers
- » e.g. dhcp-agent and l3-agent runs in different namespaces
- » In practice
 - » `ip netns`
 - » lists available network namespaces
 - » `ip netns exec <namespace> <command>`
 - » e.g. `ip netns exec qdhcp-e521f9d0-a1bd-4ff4-bc81-78a60dd88fe5 ip a`

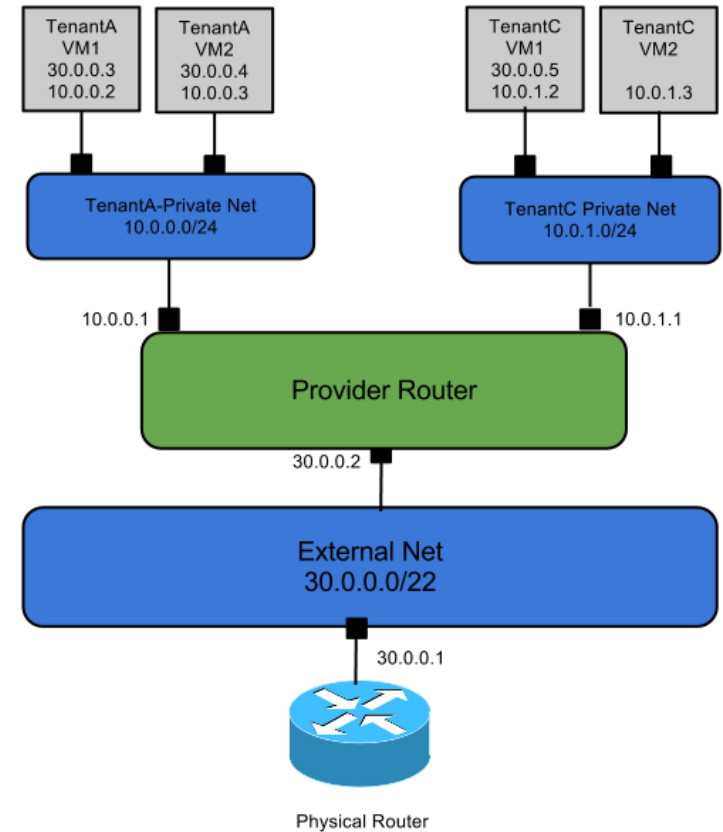
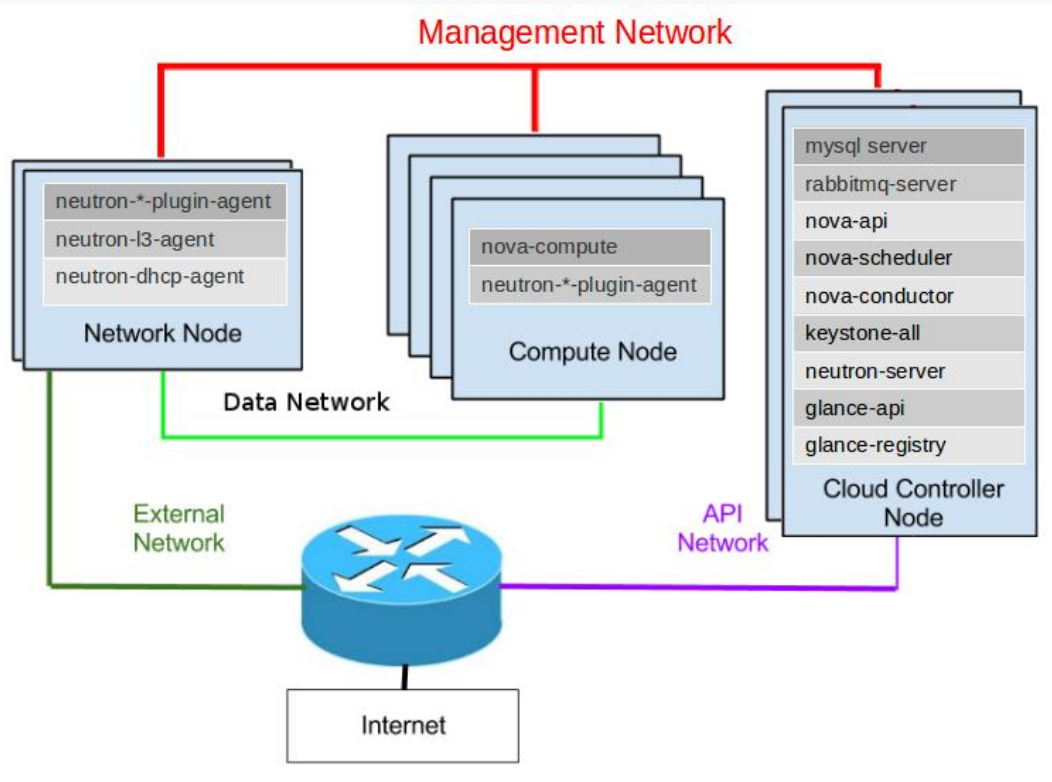


Neutron: single/multiple flat network



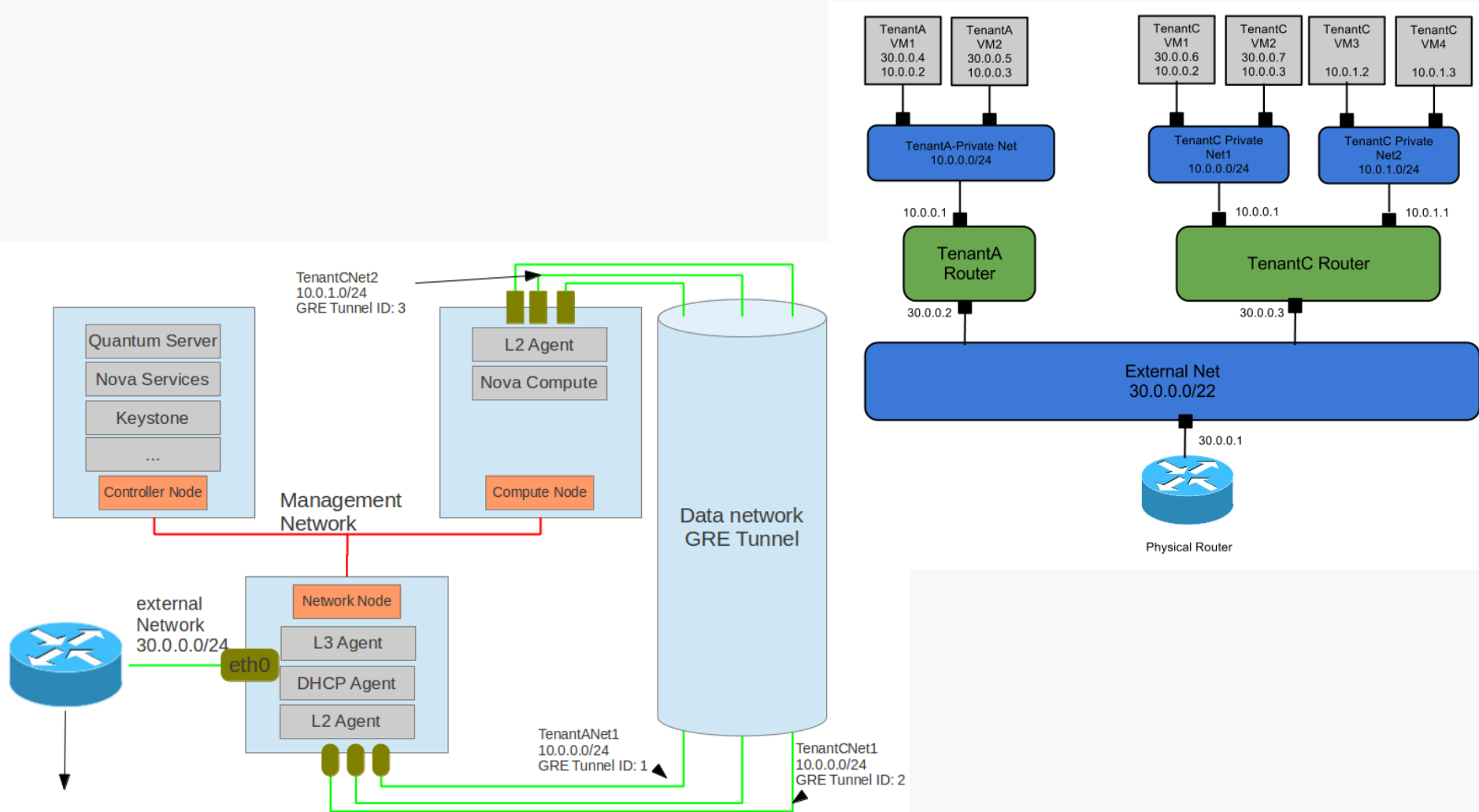


Neutron: provider router





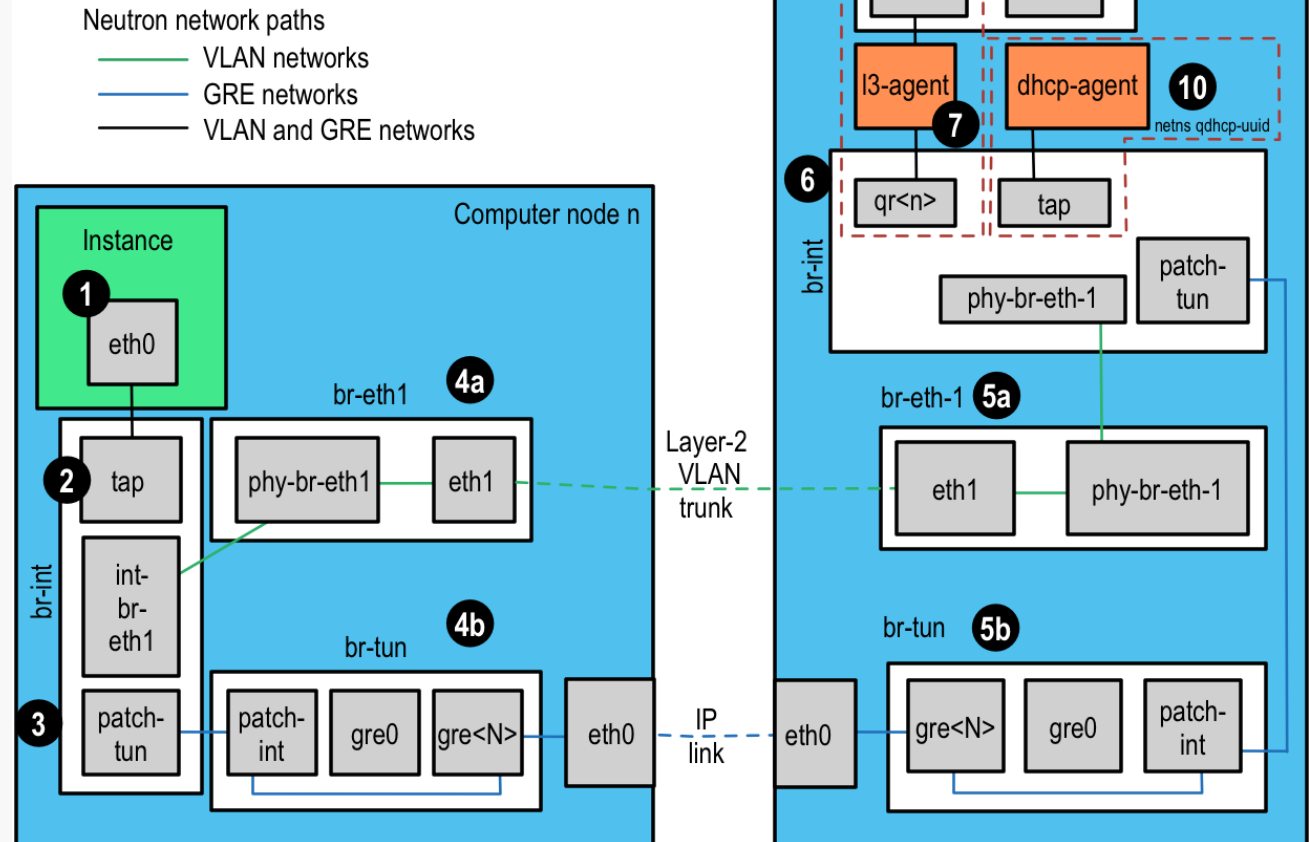
Neutron: tenant routers





Path of a packet

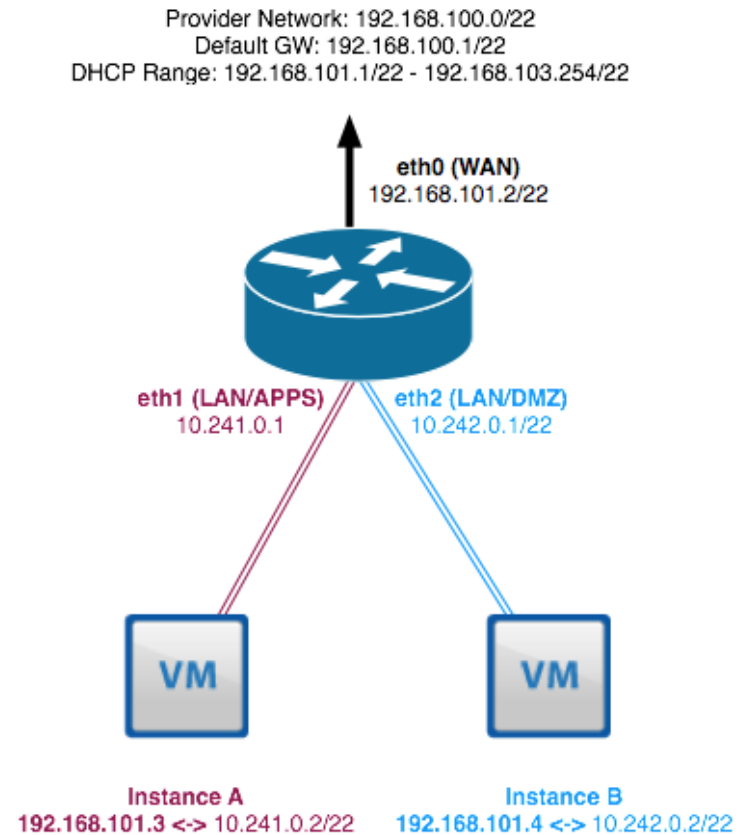
- » Test Access Point (TAP) device
- » int-br: integration bridge
- » br-eth1: VLAN internal/external tag translation
- » veth: between int-br-eth1 and phy-br-eth1



Floating IP

- » Neutron router
 - » gateway for VMs
 - » iptables/NAT rules in the namespace of router
 - » nova network: in hypervisor
 - » floating IP addresses allocated from the public network address range

Diagram 1.1 - Logical Neutron Router



- Diagram 1.1 -

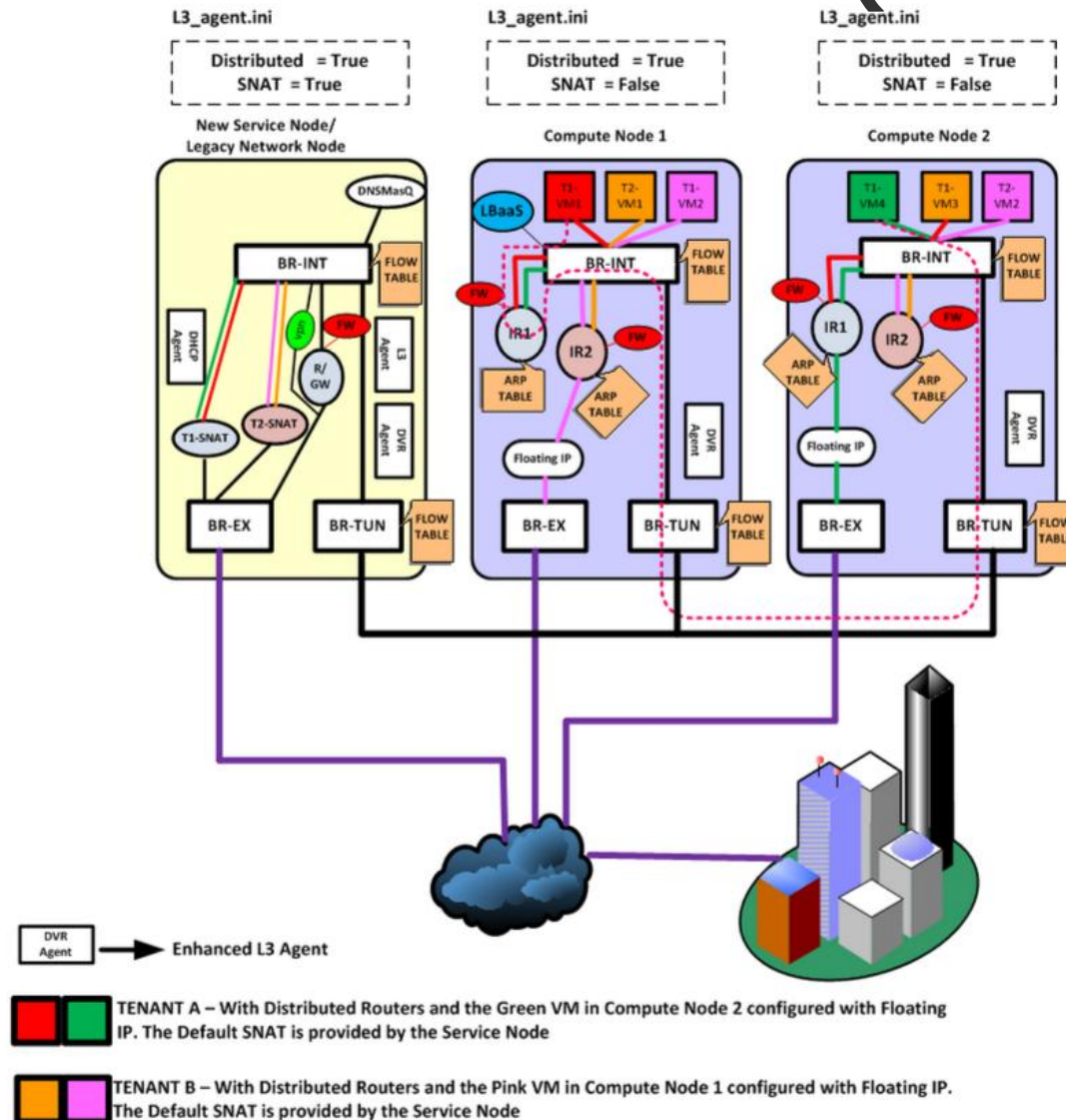
eth0 is connected to a PROVIDER network.
eth1 is connected to a TENANT network.
eth2 is connected to a TENANT network.

Floating IPs are assigned from the DHCP range of the PROVIDER network:

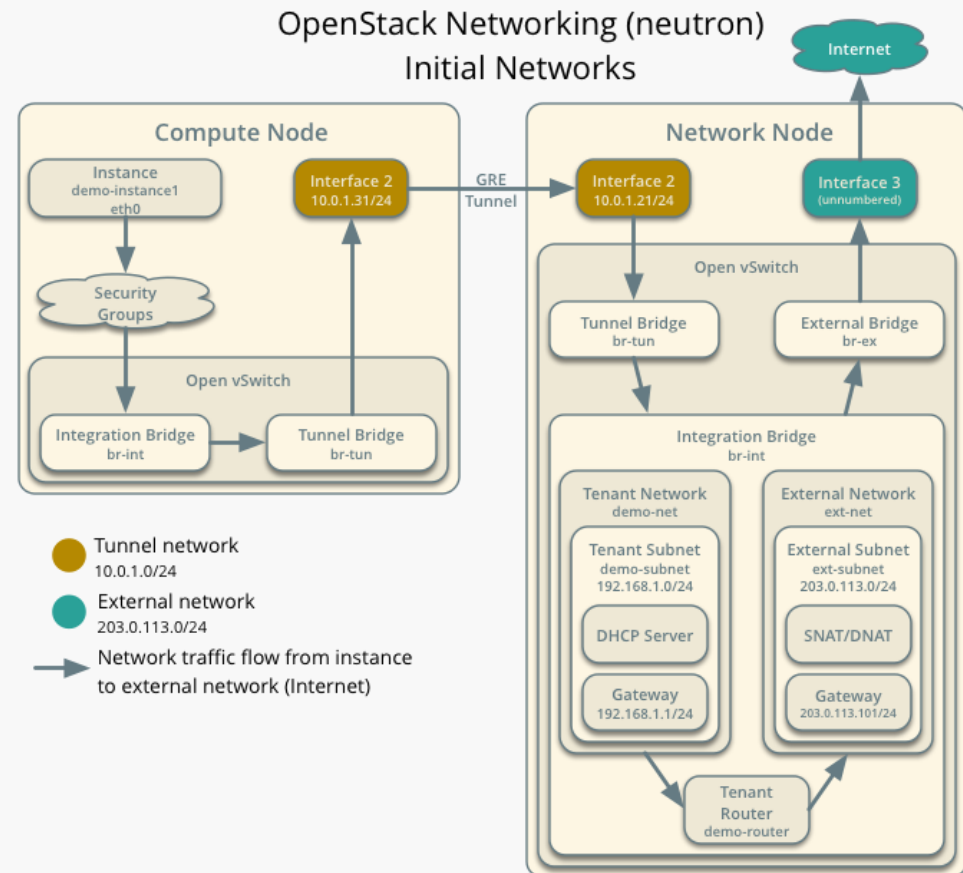
DHCP Range: 192.168.101.1/22 - 192.168.103.254/22



Distributed Virtual Router (DVR)



Virtual network configuration



» Open vSwitch

» setup by ovs-dpctl / OpenFlow

» e.g. mapping VM MAC address and hypervisor transport IP address



References

- » Overlay Virtual Networking Explained, Ivan Pepelnjak, NIL Data Communications, 2011.
- » <http://docs.openstack.org>
- » <https://developer.rackspace.com/blog/neutron-networking-l3-agent/>
- » https://www.rdoproject.org/Networking_in_too_much_detail