The Notorious M.T.U.

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Objectives

- Learn about MTU in physical networks
- Learn about nuances of virtual networks that impact MTU
- Review confusing MTU options and workarounds/hacks in releases prior to Mitaka
- Apply MTU knowledge to reveal issues in OpenStack (neutron and nova) including several common deployment cases
- Learn about MTU solution in Mitaka

What is MTU?

- Largest network layer (3) data unit that underlying data link layer (2) can pass between transmitter and receiver
    - Commonly, the largest IP packet that can fit into available Ethernet frame
    - Layer 3 must dynamically adjust to changes at layer 2
- Typically 1500 bytes for 802.3 (Ethernet), although many devices support “jumbo frames” up to approximately 9000 bytes
- Provider/carrier network devices often support over 9000 bytes to account for overhead from MPLS, 802.1ad (Q-in-Q), etc.

IP Path MTU Discovery (PMTUD)

- Automatically determines the smallest MTU of network segments between transmitter and receiver
- Operates at IP layer using ICMP
  - Routers (3), not switches (2), handle MTU changes between segments
  - ICMP must pass freely between endpoints!

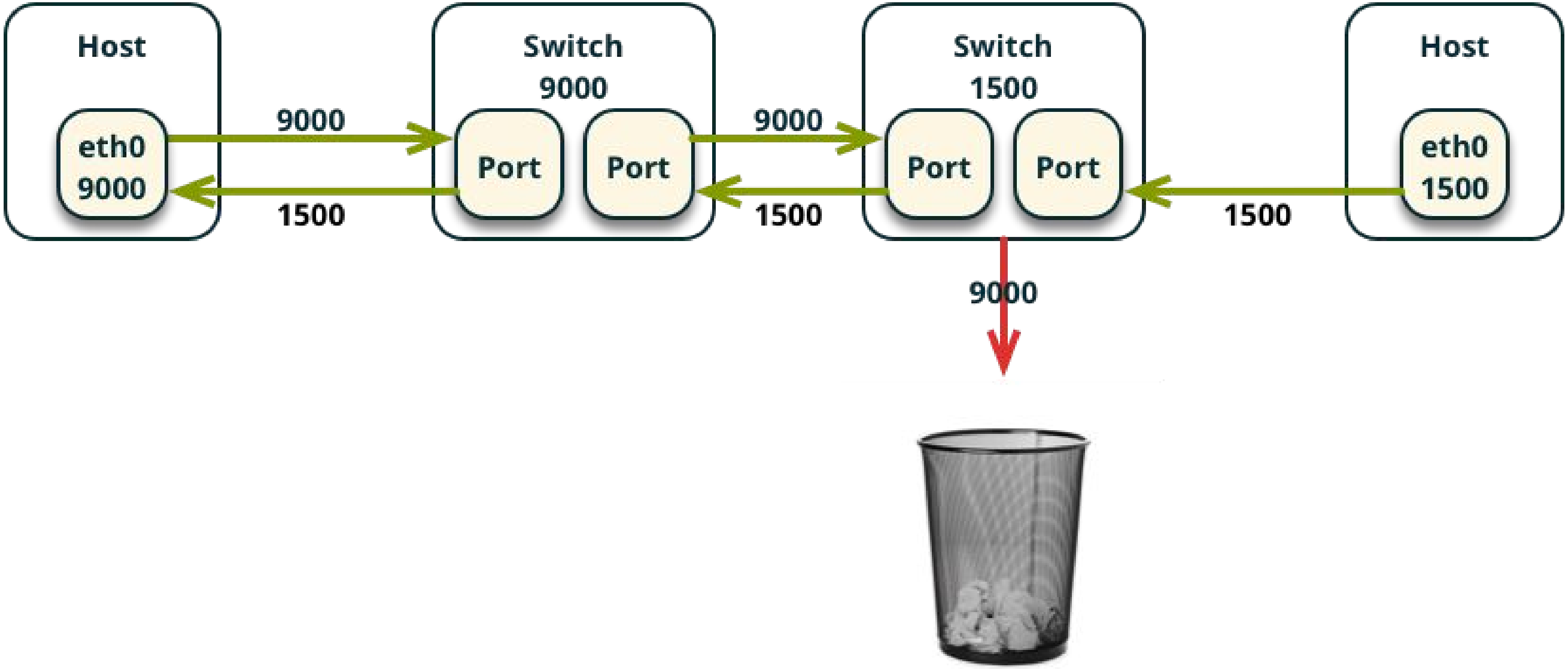
IP PMTUD - IPv4

- IPv4 supports fragmentation, but it can impact performance
- Operation
  - Transmitter generates a packet using the MTU of the underlying network interface and sets “Don’t Fragment” (DF) bit
  - If a segment between transmitter and receiver contains a smaller MTU, the router prior to that segment returns an ICMP “Fragmentation Needed” (Type 3, Code 4) message to the sender that contains the smaller MTU value
  - Operating system tracks MTU value for the receiver
  - Transmitter generates packet again using the smaller MTU and sets DF bit
  - Cycle repeats until the transmitter discovers the smallest MTU value between transmitter and receiver

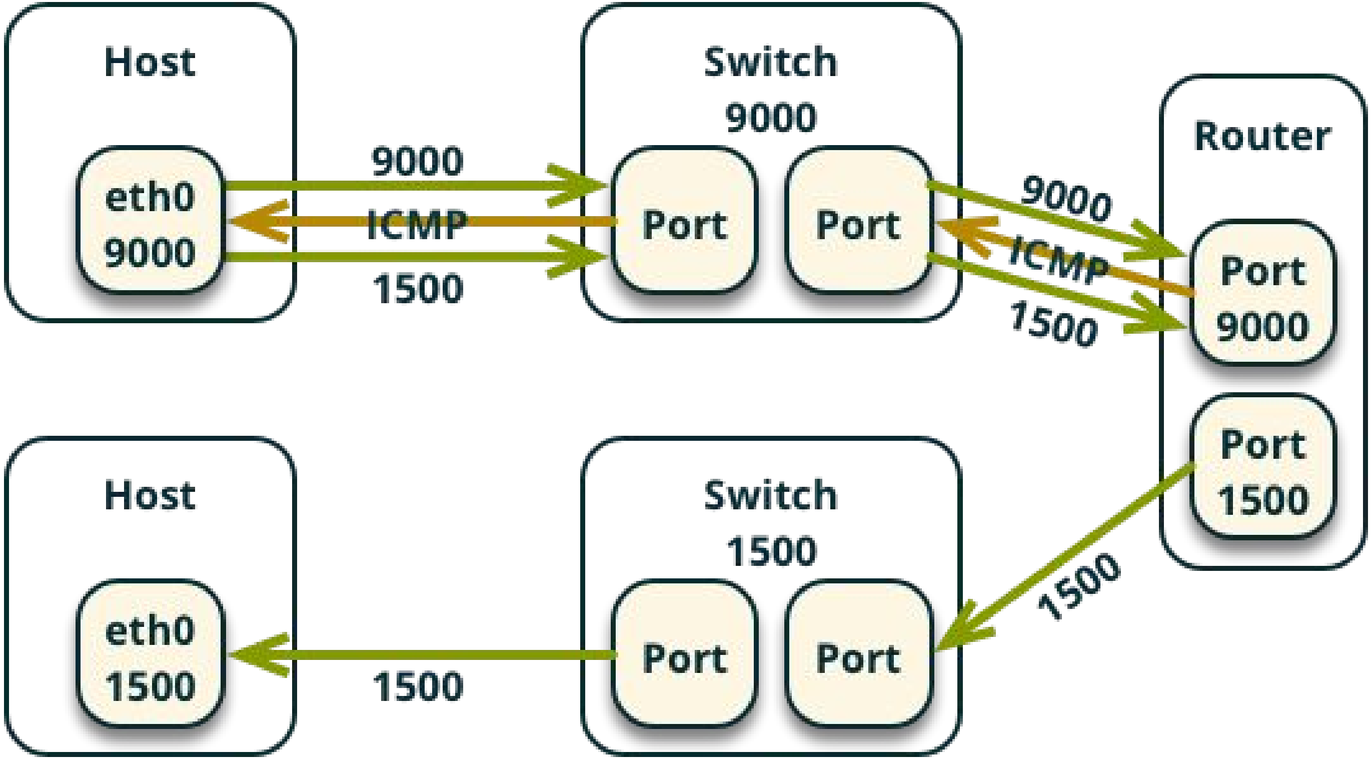
IP PMTUD - IPv6

- IPv6 does not support fragmentation
- Operation
  - Transmitter generates a packet using the MTU of the underlying network interface
  - If a segment between transmitter and receiver contains a smaller MTU, the router prior to that segment returns an ICMP “Packet Too Big” (Type 2) message to the sender that contains the smaller MTU value
  - Operating system tracks MTU value for the receiver
  - Transmitter generates packet again using the smaller MTU
  - Cycle repeats until the transmitter discovers the smallest MTU value between transmitter and receiver

MTU changes at layer 2 = bad



MTU changes at layer 3 = good



Virtual networks and MTU

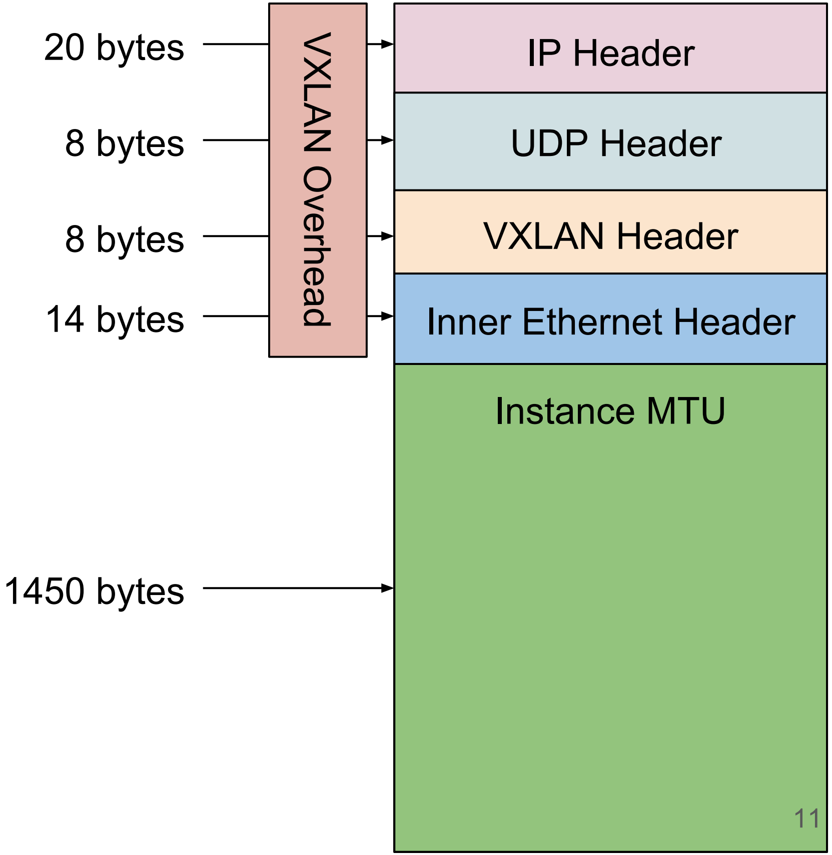
- Flat
  - Uses IEEE 802.3 (Ethernet)
  - Each flat network requires a unique physical network
  - Instance (VM) network interface can use underlying physical network MTU
- VLAN
  - Uses IEEE 802.1q (Ethernet with VLAN tagging)
    - Adds 32-bit field to Ethernet header containing a 12-bit VLAN ID and some other information
    - Effectively adds 4 bytes to Ethernet frame
    - Does not impact payload size
    - Multiple logical networks, each using a unique VLAN ID, can share a physical network
  - Instance (VM) network interface can use underlying physical network MTU

Virtual networks and MTU

- Overlay
    - Uses an encapsulation protocol such as VXLAN or GRE to pass arbitrary 802.3 Ethernet frames or IP packets via IP (and sometimes TCP/UDP)
    - Outer (native) IP headers, sometimes TCP/UDP headers, and protocol metadata create overhead that consumes a portion of the outer IP packet, thus reducing space available to devices using the overlay network
    - Instance (VM) network interface must use underlying physical network MTU minus the overhead

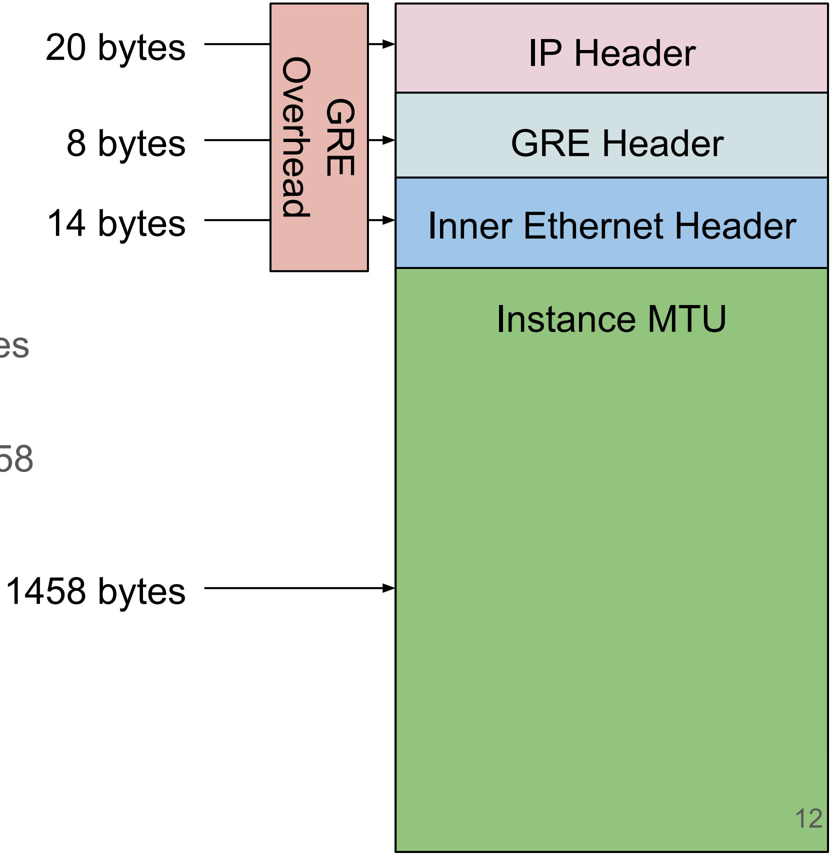
VXLAN protocol

- Uses UDP
- Encapsulates inner 802.3 Ethernet frame
- Calculate overhead for IPv4 using 1500-byte MTU
    - Subtract outer IP header (20 bytes) = 1480 bytes
    - Subtract UDP header (8 bytes) = 1472 bytes
    - Subtract VXLAN header (8 bytes) = 1464 bytes
    - Subtract inner 802.3 Ethernet header (14 bytes) = 1450 bytes for IP available to device using overlay network



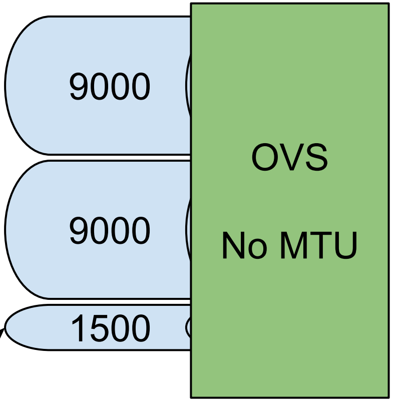
GRE protocol

- Uses unique transport protocol (47)
- Encapsulates inner 802.3 Ethernet frame
- Calculate overhead for IPv4 using 1500-byte MTU
  - Subtract outer IP header (20 bytes) = 1480 bytes
  - Subtract GRE header (8 bytes) = 1472 bytes
  - Subtract inner Ethernet header (14 bytes) = 1458 bytes for IP available to device using overlay network

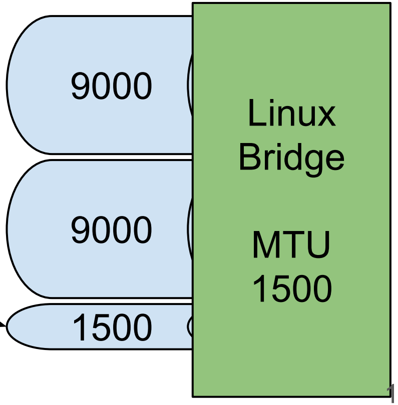


Interesting observations

- Linux
  - Automatically configures tunnel network interface MTU by subtracting overlay protocol overhead from the underlying physical network interface MTU
  - Automatically configures bridge network interface MTU to use the lowest MTU of all ports (devices) on the bridge
  - Permits ends of virtual Ethernet (veth) pairs to use different MTUs
- Open vSwitch
  - Internally uses arbitrarily large MTU
  - Ignores MTU of bridge interface on host



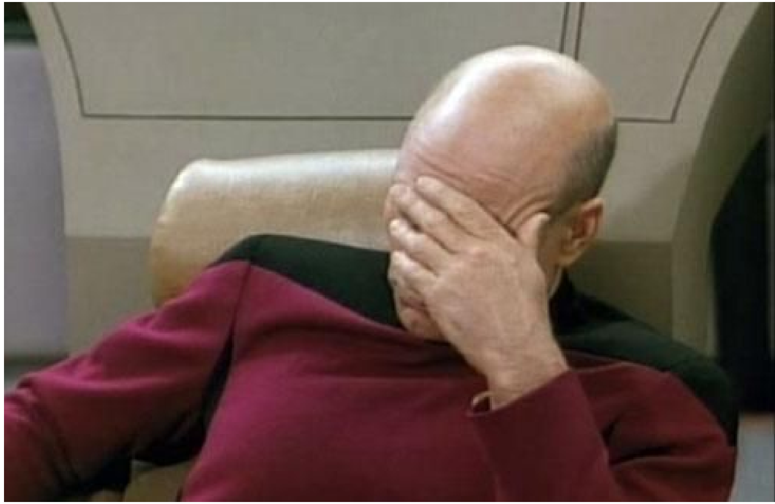
Silently discards packets larger than 1500 to this interface



Forces downgrade of entire bridge

OpenStack MTU problems

- Neutron lacks obvious and consistent support for MTUs larger than 1500 bytes
- By default, nova creates security group bridges and interfaces using a 1500-byte MTU
- Features claiming to address MTU involve confusing and often useless options
  - advertise_mtu (neutron core)
  - physical_network_mtus (ML2 plug-in)
  - path_mtu (ML2 plug-in)
  - segment_mtu (ML2 plug-in)
  - veth_mtu (Open vSwitch agent)
  - network_device_mtu (neutron and nova core)
- Only some plug-ins support the MTU API extension
- Documentation… what documentation?



OpenStack MTU hacks

- Folsom to Juno
  - [Environment] Implement MTU larger than 1500 bytes on underlying physical network while leaving virtual network components at 1500 bytes to account for overlay protocol overhead
    - Instances on any network can use 1500 bytes
  - [Neutron] Manually configure Dnsmasq to provide a smaller MTU that accounts for overlay protocol overhead
    - Also reduces MTU for instances on flat and VLAN networks
  - [Neutron/Nova] Attempt to use the **`network_device_mtu`** option to configure MTU of virtual network components
    - Implementation varies by release, plug-in/agent, network types, and combination of other options
  - [Neutron] For the Open vSwitch plug-in/agent with veth interfaces, attempt to use the **`veth_mtu`** option

OpenStack MTU hacks

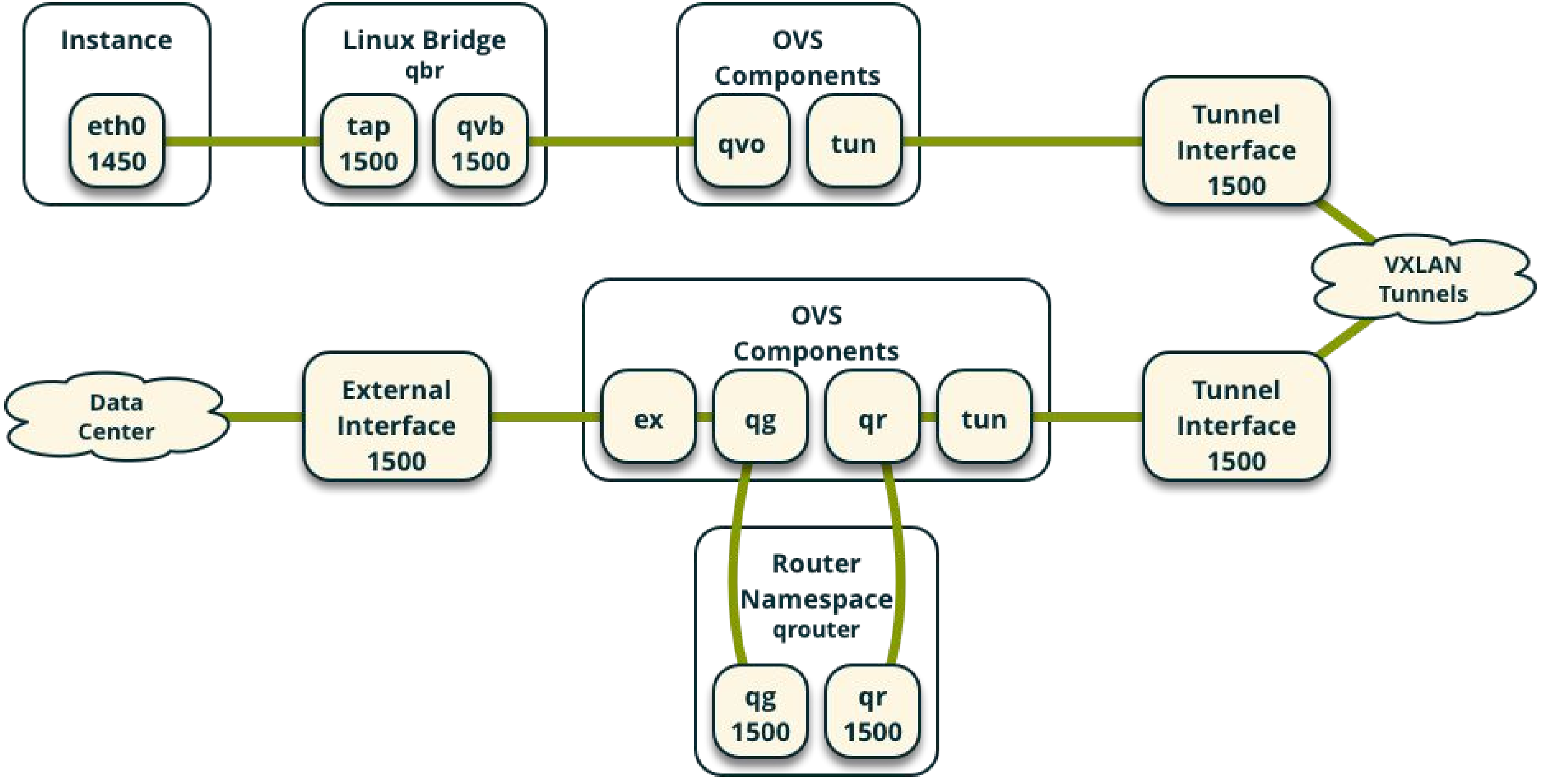
- Kilo and Liberty
  - [Neutron+ML2] Configure Dnsmasq to provide a smaller MTU that accounts for overlay protocol overhead
    - Combination of **`path_mtu`** and **`advertise_mtu`** options
    - Only impacts instances on overlay networks
  - [ML2] Attempt to use variety of additional options that configure MTU for some but not all virtual network components
    - **`segment_mtu`**
    - **`physical_network_mtus`**
  - [Neutron/Nova] Attempt to use the **`network_device_mtu`** option with or without additional options

Common use cases

- Assume proper configuration of underlying physical network
- Assume use of Liberty
- Assume VXLAN overlay networks with IPv4 endpoints
  - 50 bytes of overhead
- Cases 1-4 only use **`path_mtu`** and **`advertise_mtu`** options, if available, to configure instance network interface MTU
- Cases 5-6 also use the **`network_device_mtu`** option

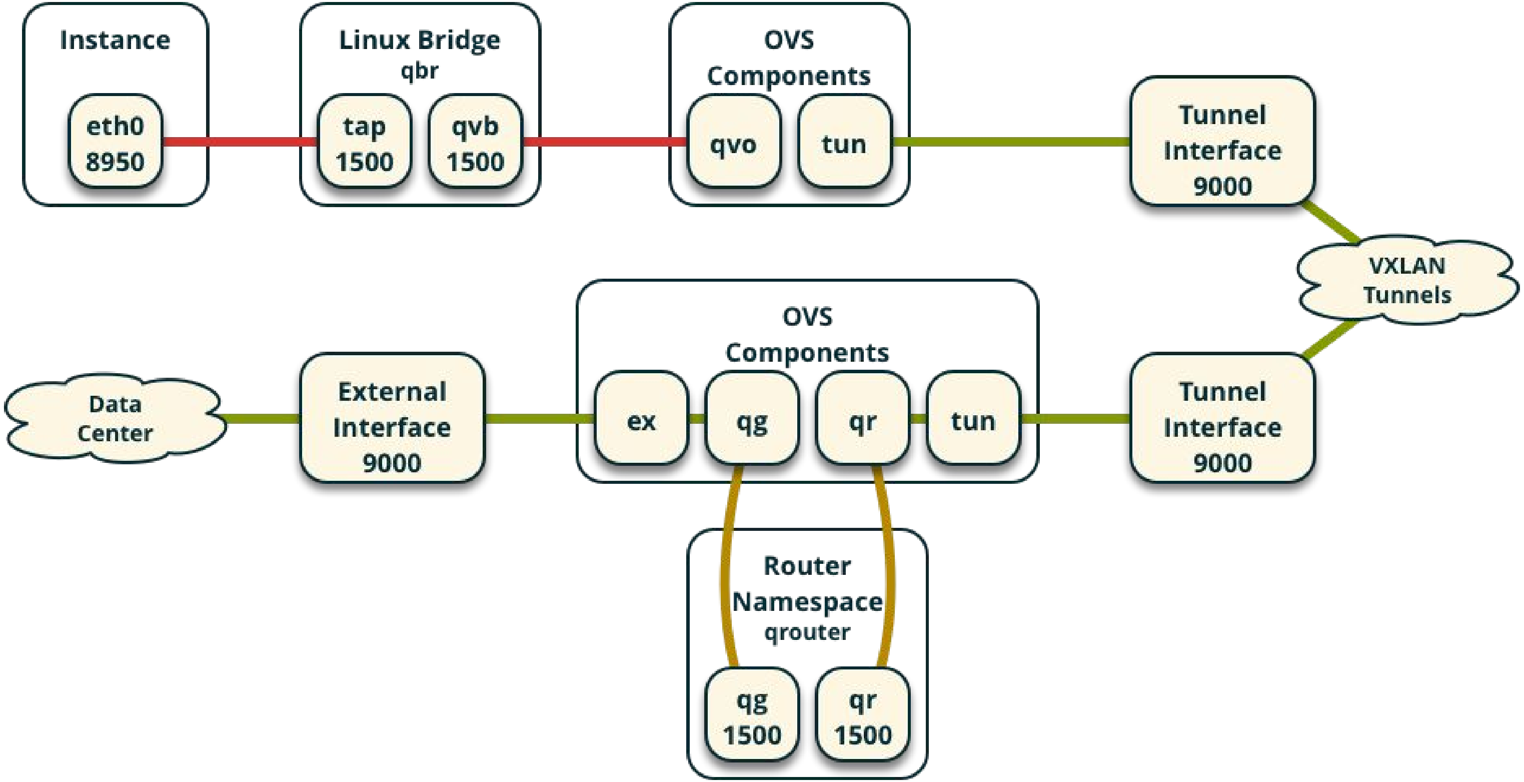
Case 1: Open vSwitch agent with 1500-byte MTU

```
advertise_mtu = true and path_mtu = 1500
```



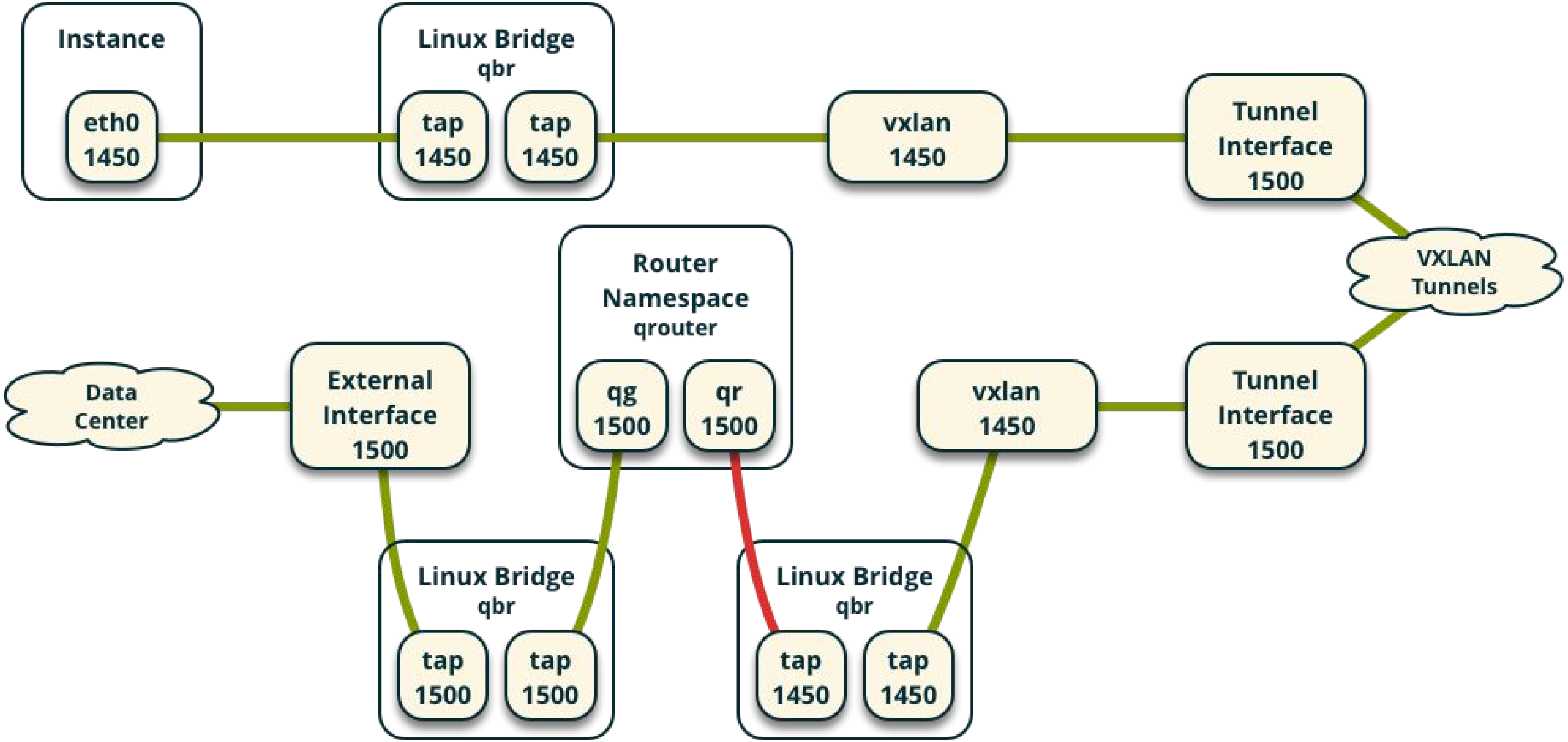
Case 2: Open vSwitch agent with 9000-byte MTU

`advertise_mtu = true and path_mtu = 9000`



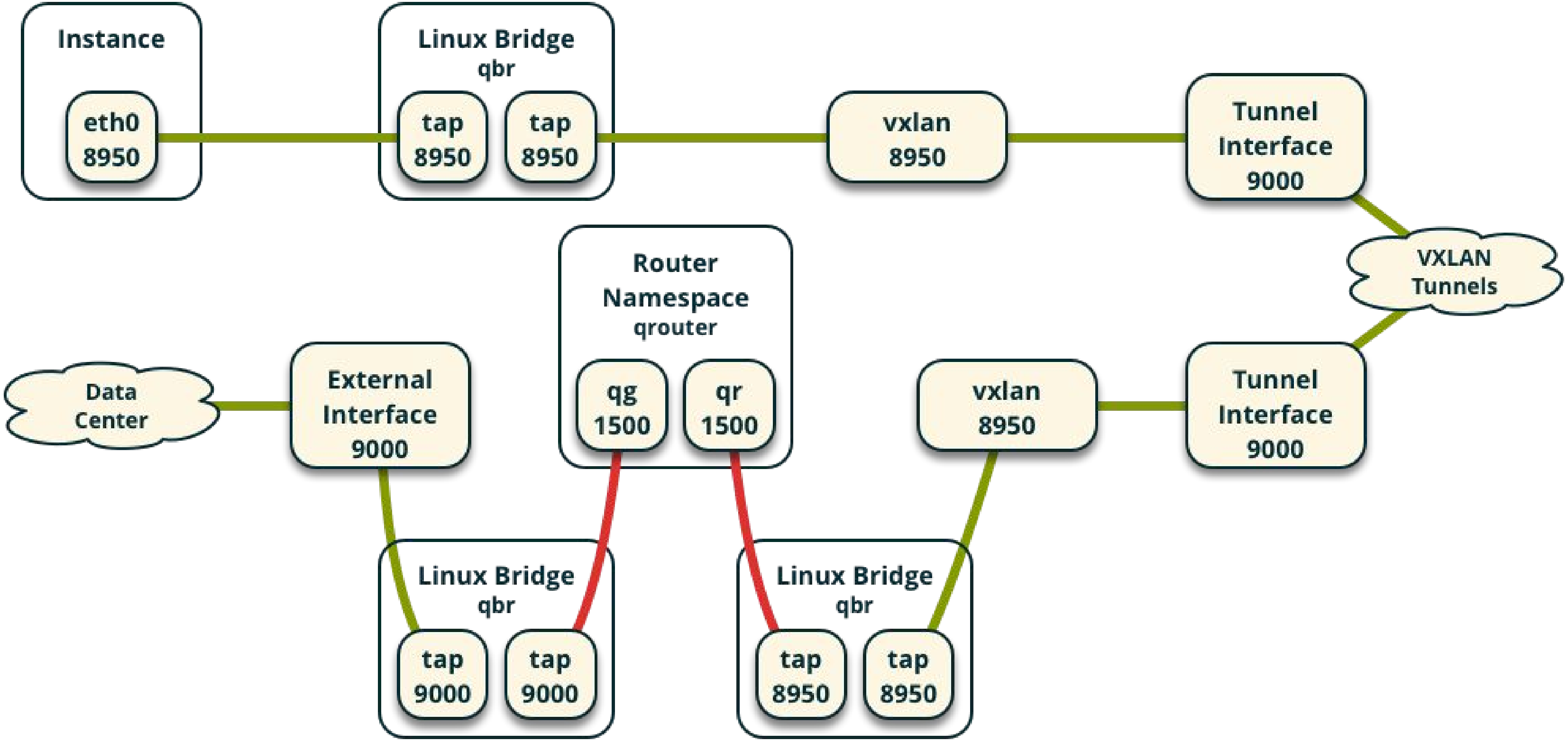
Case 3: Linux bridge agent with 1500-byte MTU

`advertise_mtu = true and path_mtu = 1500`



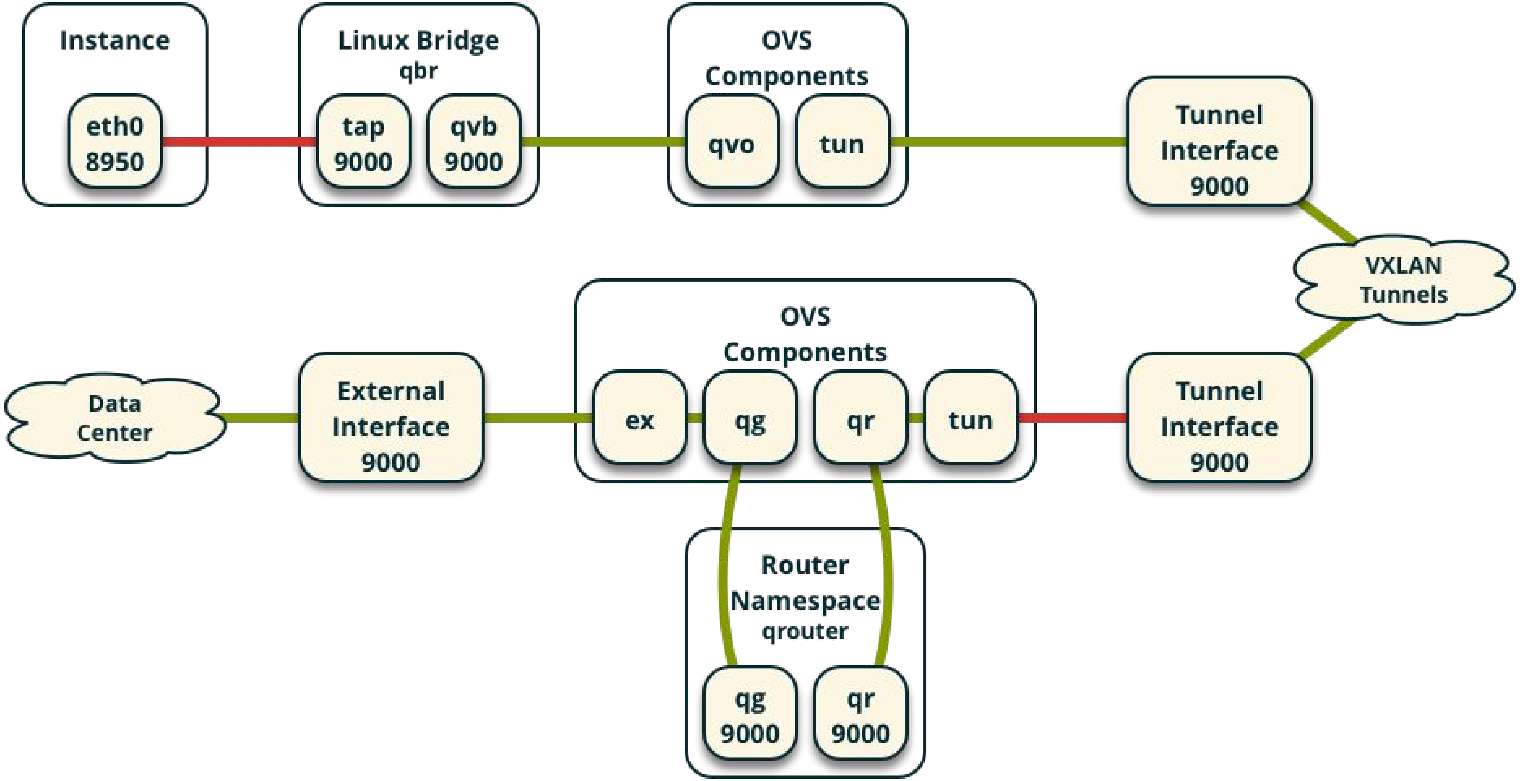
Case 4: Linux bridge agent with 9000-byte MTU

advertise_mtu = true and path_mtu = 9000



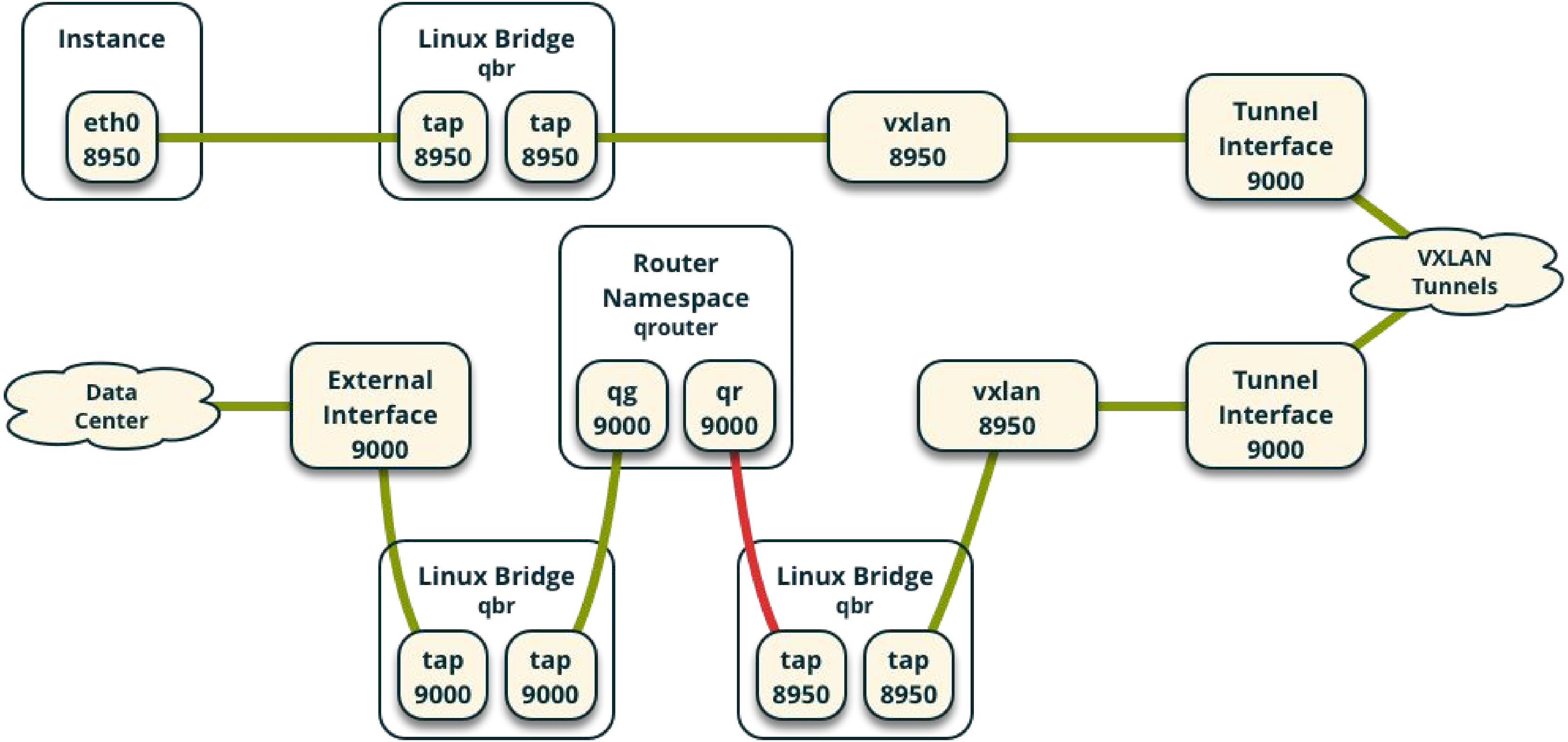
Case 5: Open vSwitch agent with 9000-byte MTU

```
network_device_mtu = 9000
```



Case 6: Linux bridge agent with 9000-byte MTU

```
network_device_mtu = 9000
```



OpenStack MTU solution (Mitaka+)

- Neutron
    - Replace variety of options with a single option suitable for most environments
    - Consistently calculate and set appropriate MTU for all virtual network components
    - By default, provide useful (non-zero) MTU value in API
- Nova
    - Use the MTU value that neutron provides via RPC for security group bridges and interfaces
- os-vif library
    - Replaces nova VIF code
    - Contains essentially the same MTU implementation that currently exists in nova

OpenStack MTU solution (Mitaka+)

- Implementation details
  - Move **`segment_mtu`** option from ML2 to neutron and rename to **`global_physnet_mtu`**
    - Resides in **`[DEFAULT]`** section
    - Visible to all plug-ins
    - Change default value from 0 to 1500
    - Yields calculation of correct MTU for virtual network components in nearly all environments
  - By default, enable **`advertise_mtu`** option in neutron
    - Provides correct MTU to instances via DHCP (IPv4) or RA (IPv6)
  - Deprecate **`path_mtu`** option in ML2
    - Neutron review #302089
  - Keep **`path_mtu`** and **`physical_network_mtus`** options in ML2
    - Supports rare environments that implement unique MTU value for each underlying physical or logical network

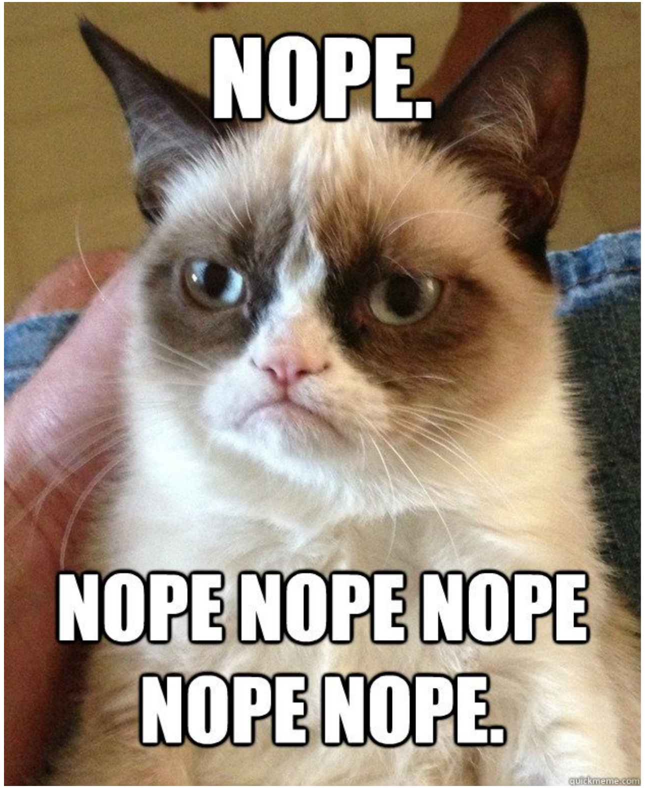
OpenStack MTU solution (Mitaka+)

- Not all rainbows and unicorns
  - The **`global_physnet_mtu`** option came after a separate effort to use “sane” values for other MTU options. As a result, the **`path_mtu`** value currently overrides the **`global_physnet_mtu`** value for overlay networks.
    - Use the same value for **`global_physnet_mtu`** and **`path_mtu`**
    - See neutron review #308989
  - Does not recalculate MTU for existing virtual networks
    - Manually update MTU values in the database
    - Only impacts new devices belonging to the same virtual network
    - Use with caution
- For your sanity, use single consistent MTU value for entire underlying physical network

But I can’t switch to Mitaka!

- Backporting primary resolution to Liberty
  - Nova review #285710
  - Neutron review #305782, review #308229
  - Requires using ML2 and the variety of additional options introduced in Kilo
- In addition to Liberty backports
  - [Neutron] Enable **`advertise_mtu`**
  - [ML2] set **`segment_mtu`** to reference underlying physical network MTU
    - Note location and name change for upgrade purposes
  - [Neutron/Nova] Unset **`network_device_mtu`**
  - [Neutron] Update ‘mtu’ column in ‘networks’ table and recreate networks

What about Kilo and earlier releases?



What about Kilo and earlier releases?

Seriously, plan an upgrade. OpenStack, especially Neutron, has come a long way in just a few releases.

Next steps

- Recalculate MTU for existing networks
  - Bug #1556182
- Remove `network_device_mtu` option from neutron and nova
  - Currently deprecated in nova
- Adopt os-vif to communicate MTU values between neutron and nova
- Deployment tools should remove MTU hacks

Questions?