TP2 – SETUP
Using EVE-NG Community Edition

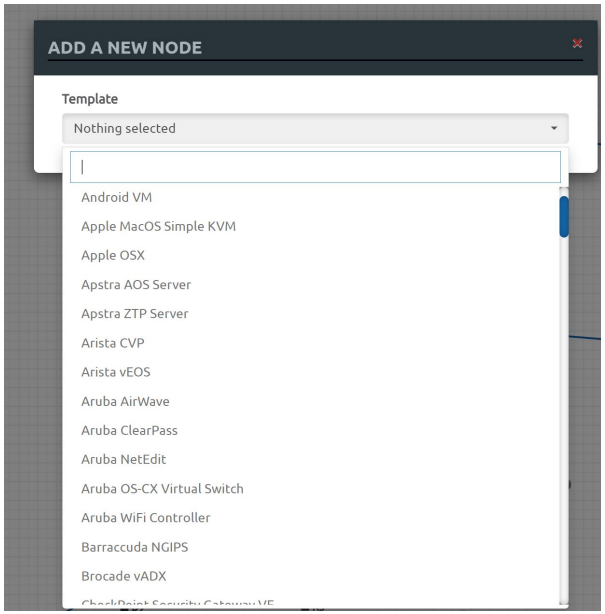
- Using EVE-NG
  - https://www.eve-ng.net/
- Documentation
  - https://www.eve-ng.net/index.php/documentation/
- Download
  - Free EVE Community Edition Version 5.0.1-22
    - https://www.eve-ng.net/index.php/download/#DL-COMM
  - VMWare Workstation
    - https://www.vmware.com/products/workstation-player
  - Windows Client Side Pack
    - https://www.eve-ng.net/index.php/download/#DL-WIN
    - Available also for Apple and Linux
  - ENE-NG Cookbook
    - Community Cookbook
      - https://www.eve-ng.net/index.php/documentation/community-cookbook/
  - Follow installation instructions in the cookbook
  - For further information: EVE-NG Installation (David Bombal)
    - https://www.youtube.com/watch?v=FDbgTlr-tnw&t=1177s

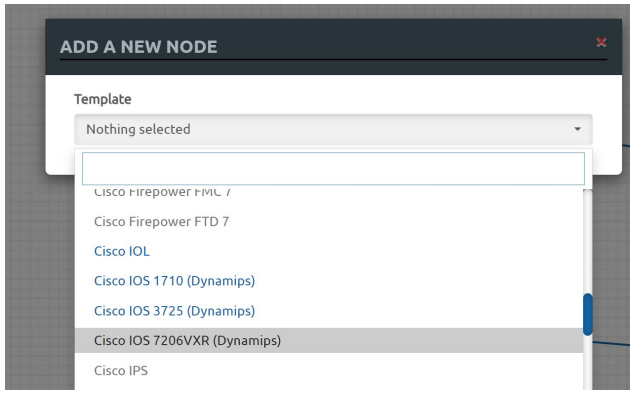
TP2 – SETUP – EVE-NG Intel VT-x/EPT Problem

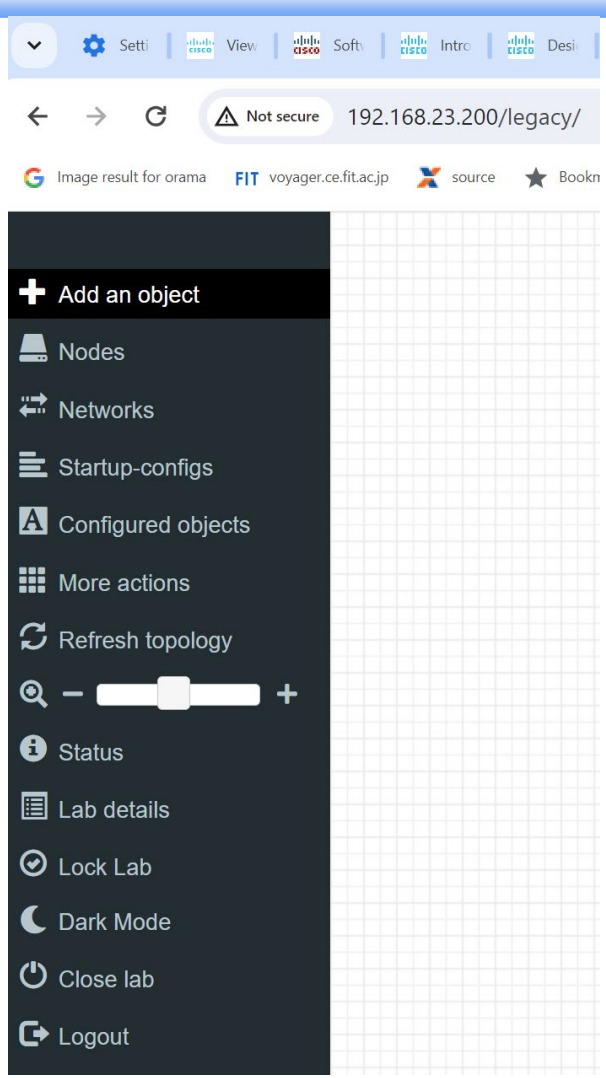
- Hardware requirements
  - Necessary to have Intel VT-x/EPT virtualization engine enabled
- How to solve this
  - Solved : Virtualized Intel VT-X/EPT is not supported on this platform
    - https://www.youtube.com/watch?v=6f1Qckg2Zx0
  - Virtualized Intel VT-x/EPT is not supported on this platform
    - https://communities.vmware.com/t5/VMware-Workstation-Player/Virtualized-Intel-VT-x-EPT-is-not-supported-on-this-platform/td-p/2924968
  - Memory Integrity greyed out or won't Turn On/Off
    - https://www.thewindowsclub.com/memory-integrity-greyed-out-or-wont-turn-on-off
  - Configure Credential Guard
    - https://learn.microsoft.com/en-us/windows/security/identity-protection/credential-guard/configure?tabs=intune
- Side Effect On Windows
  - VMware Workstation and Device/Credential Guard are not compatible
    - https://kb.vmware.com/s/article/2146361

TP2 – SETUP – EVE-NG

- After a successful install
  - Start EVE-NG VM on VMWare Player
  - Access the EVE GUI
    - http://192.168.23.200/
    - User: admin PW: eve
- Create the network topology adding node
  - Initially almost all option are not available (grayed)
- Necessary to add nodes images
  - Available ones are in blue







TP2 – SETUP – EVE-NG Image Installations

- Image Installations How-tos
  - https://www.eve-ng.net/index.php/documentation/howtos/
  - Router, Switches, Linux and Windows PCs, Firewall, Android; Other appliances.
  - CISCO, JUNIPER, FORTINET, MIKROTIK, among others
- Cisco Images for GNS3 and EVE-NG
  - https://github.com/hegdepavankumar/Cisco-Images-for-GNS3-and-EVE-NG
  - Download images and unpack them in a specific folder
- Specific How-tos
  - Linux Images (/opt/unetlab/addons/qemu/)
    - https://www.eve-ng.net/index.php/documentation/howtos/howto-create-own-linux-host-image/
  - Cisco Dynamips (/opt/unetlab/addons/dynamips/)
    - https://www.eve-ng.net/index.php/documentation/howtos/howto-add-cisco-dynamips-images-cisco-ios/
  - Cisco IOL images (/opt/unetlab/addons/iol/bin/)
    - https://www.eve-ng.net/index.php/documentation/howtos/howto-add-cisco-iol-ios-on-linux/
- Necessary to have WINSCP (or similar) to copy images between your PC and EVE-NG VM
- Follow the specific how-tos for each type of node you want to add to EVE-NG

TP2 – SETUP – EVE-NG

Image Installations – LINUX

- Linux images (Computing Nodes)
  - How-to
    - https://www.eve-ng.net/index.php/documentation/howtos/howto-create-own-linux-host-image/
  - Download Linux Images
    - https://mega.nz/folder/30p3TKob#42_S__9wwPVO0zHIfC4xow
      - `linux-alpine-3.18.4.tar.gz`
      - `linux-tinycore-6.4.tar.gz`
    - Other possible images: Android VM; Other Linux flavors VMs
  - Folder at the EVE-NG VM to upload the images
    - /opt/unetlab/addons/qemu/
    - Necessary to create a folder to each Image
      - mkdir /opt/unetlab/addons/qemu/ linux-alpine-3.18.4
      - mkdir /opt/unetlab/addons/qemu/ linux-tinycore-6.4
    - It is necessary to use the QUEMU folder naming conventions used by EVE-NG
      - https://www.eve-ng.net/index.php/documentation/qemu-image-namings/
      - In this case the folders must start with the prefix "linux-"
      - The names above start with the correct prefix
  - Upload and rename the images. It necessary to use the QUEMU image naming conventions used by EVE-NG
    - https://www.eve-ng.net/index.php/documentation/qemu-image-namings/
    - In this case each linux VM image must have the name: virtioa.qcow2
  - Clean and fix permissions in the ENE-NG VM
    - Run the command
      - /opt/unetlab/wrappers/unl_wrapper -a fixpermissions
  - Users Credentials
    - root/root; root/eve; user/Test123; root/Test123

TP2 – SETUP – EVE-NG
Image Installations – CISCO IOS

- Cisco Dynamips images (Cisco IOS)
  - How-to
    - https://www.eve-ng.net/index.php/documentation/howtos/howto-add-cisco-dynamips-images-cisco-ios/
  - Cisco IOS Routers Images For EVE-NG
    - https://github.com/hegdepavankumar/Cisco-Images-for-GNS3-and-EVE-NG
      - c7200-adventerprisek9-mz.152-4.S6.image
      - c3725-adventerprisek9-mz.124-15.T14.image
      - c1710-bk9no3r2sy-mz.124-23.image
  - Folder at the EVE-NG VM to upload the images
    - /opt/unetlab/addons/dynamips/
  - Clean and fix permissions in the ENE-NG VM
    - Run the command
      - /opt/unetlab/wrappers/unl_wrapper -a fixpermissions

TP2 – SETUP – EVE-NG
Image Installations – CISCO IOL

- Cisco IOL (IOS on Linux) – Cisco L2 and L3 devices
  - How-to
    - https://www.eve-ng.net/index.php/documentation/howtos/howto-add-cisco-iol-ios-on-linux/
  - Cisco Images For EVE-NG
    - https://drive.google.com/drive/folders/1UseAP6sX2c_15K-Zujw5P0vCiTdxyPj0
      - Download and unpack the file "**CISCO IOS L2 & L3 Image**" and use the following files:
        - i86bi-linux-l2-ipbasek9-15.1g.bin
        - i86bi-linux-l3-adventerprisek9-15.4.2T.bin
        - lourc
        - L2-ADVENTERPRISE-M-15.1-20140814.bin
        - L3-adventerprisek9-15.5.2T.bin
        - sw_firmware_current.bin
  - Folder at the EVE-NG VM to upload the images
    - /opt/unetlab/addons/iol/bin
  - Clean and fix permissions in the ENE-NG VM
    - Run the command
      - /opt/unetlab/wrappers/unl_wrapper -a fixpermissions
  - For further information
    - Add CISCO L2 and L3 images in EVE-NG
      - https://www.youtube.com/watch?v=uy-lXKVD1yY

TP2 – SETUP – EVE-NG

Image Installations – CISCO vIOS

- Cisco vIOS from CML
  - How-to
    - https://www.eve-ng.net/index.php/documentation/howtos/howto-add-cisco-vios-from-virl/
  - Cisco Images For EVE-NG
    - Router (vios-adventerprisek9-m.SPA.156-1.T.tar.gz)
    - Switch (viosl2-adventerprisek9-m-15.2.4055.tar.gz
  - Folder at the EVE-NG VM to upload the images
    - /opt/unetlab/addons/qemu/
    - Necessary to create a folder to each Image
      - **Router:** mkdir /opt/unetlab/addons/qemu/vios-adventerprisek9-m.SPA.159-3.M6
      - **Switch**: mkdir /opt/unetlab/addons/qemu/viosl2-adventerprisek9-m.SSA.high_iron_20200929
    - It is necessary to use the QUEMU folder naming conventions used by EVE-NG
      - https://www.eve-ng.net/index.php/documentation/qemu-image-namings/
      - In this case the folders must start with the following names:
        - » **L3 vIOS Cisco Router**: vios-
        - » **L2 vIOS Cisco Switch:** viosl2-
      - The names above start with the correct prefix
  - Upload and rename the images
    - It necessary to use the QUEMU image naming conventions used by EVE-NG
      - https://www.eve-ng.net/index.php/documentation/qemu-image-namings/
      - In this case the folders must start with the following names:
        - » **L3 vIOS Cisco Router and** L2 vIOS Cisco SW: virtioa.qcow2
    - **Router:** mv vios-adventerprisek9-m.spa.159-3.m6.qcow2 virtioa.qcow2
    - **Switch:** mv vios_l2-adventerprisek9-m.ssa.high_iron_20200929.qcow2 virtioa.qcow2
  - Clean and fix permissions in the ENE-NG VM
    - Run the command
      - /opt/unetlab/wrappers/unl_wrapper -a fixpermissions
  - For further information
    - Cisco VIRL images in Eve ng
      - https://www.youtube.com/watch?v=B5ALrcZZJAw

TP2 – SETUP – EVE-NG
Image Installations – CISCO CSRV

- Cisco Cloud Services Router (CSR 1000v)
  - How-to
    - https://www.eve-ng.net/index.php/documentation/howtos/howto-add-cisco-csrv1000-16-x-denali-everest-fuji/
  - Cisco Images For EVE-NG
    - CSR1000vng-universalk9.16.04.01.Everest:
      - https://drive.usercontent.google.com/download?id=1fgDqUq6XjY4c_Kx24ie-zXDR8iDcDpE-&export=download&authuser=0
  - Folder at the EVE-NG VM to upload the images
    - /opt/unetlab/addons/qemu/
    - Necessary to create a folder to each Image
      - mkdir /opt/unetlab/addons/qemu/csr1000vng-universalk9.16.04.01.Everest
    - It is necessary to use the QUEMU folder naming conventions used by EVE-NG
      - https://www.eve-ng.net/index.php/documentation/qemu-image-namings/
      - In this case the folder must start with the following names:
        - » csr1000vng-
      - The folder name above start with the correct prefix
  - Upload and rename the images
    - It necessary to user the QUEMU image naming conventions used by EVE-NG
      - https://www.eve-ng.net/index.php/documentation/qemu-image-namings/
        - » virtioa.qcow2
  - Clean and fix permissions in the ENE-NG VM
    - Run the command
      - /opt/unetlab/wrappers/unl_wrapper -a fixpermissions
  - For further information
    - Emulando Cisco CSR1000V no EVE-NG
      - https://www.youtube.com/watch?v=8m4w6HOZ2_o

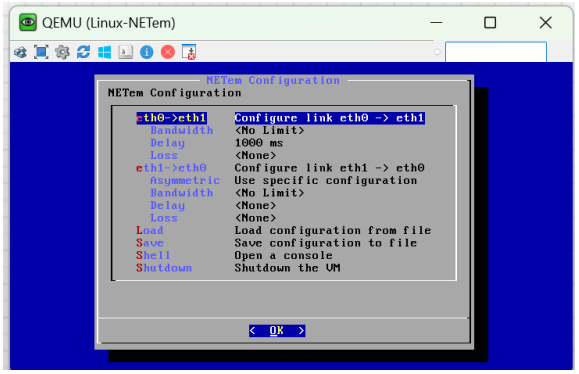
TP2 – SETUP – EVE-NG
Image Installations – CISCO Nexus 9000V

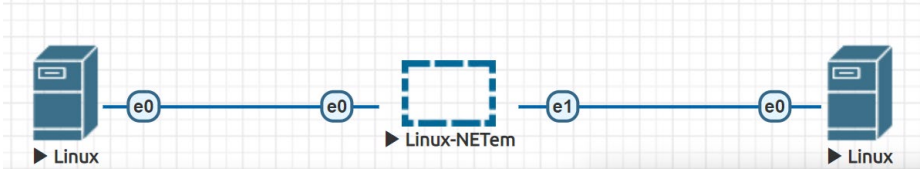
- Cisco Nexus 9000v Switch
  - How-to
    - https://www.eve-ng.net/index.php/documentation/howtos/howto-add-cisco-nexus-9000v-switch/
  - Cisco Images For EVE-NG
    - nxosv9k-9300-9.3.9.tgz
      - https://labhub.eu.org/UNETLAB%20II/addons/qemu/Cisco%20Nexus%209000v%20switch/
  - Folder at the EVE-NG VM to upload the images
    - /opt/unetlab/addons/qemu/
    - Necessary to create a folder to each Image
      - mkdir /opt/unetlab/addons/qemu/nxosv9k-9300v-9.3.9
    - It is necessary to use the QUEMU folder naming conventions used by EVE-NG
      - In this case the folder must start with the following names:
        - » nxosv9k-
      - The folder name above start with the correct prefix
  - Upload and rename the images
    - It necessary to user the QUEMU image naming conventions used by EVE-NG
      - https://www.eve-ng.net/index.php/documentation/qemu-image-namings/
        - » sataa.qcow2
  - Clean and fix permissions in the ENE-NG VM
    - Run the command
      - /opt/unetlab/wrappers/unl_wrapper -a fixpermissions
  - Add a Switch in an EVE-NG topology
  - Perform NX9K first boot setup steps according to the how-to
    - https://www.eve-ng.net/index.php/documentation/howtos/howto-add-cisco-nexus-9000v-switch/
  - For further information
    - Cisco Data Center Nexus 9000v VXLAN 000 - Deploying Nexus 9000v in EVE-NG
      - https://www.youtube.com/watch?v=bSiriF8kM7E

EVE-NG Community

Modeling Link Parameters

- EVE-NG supports modeling link
  - This Feature allows apply link quality functions: packet loss, delay and rate
  - It is only available in the EVE-NG Pro Edition
- To model this in EVE-NG Community there is an addon called NETem
  - https://www.networkacademy.io/ccie-enterprise/sdwan/packet-loss-latency-and-jitter-on-eve-ng
- Necessary steps to install NETem
  - Download the addon from EVE-NG Repo
    - https://www.eve-ng.net/repo/pool/main/e/eve-ng-addons-netem/
  - Using WinSCP Copy the add to the QEMU path on EVE-NG
    - /opt/unetlab/addons/qemu/
  - In the EVE-NG VM install the addon
    - cd /opt/unetlab/addons/qemu/
    - sudo dpkg --install eve-ng-addons-netem_2.0.3-61_amd64.deb
  - In the EVE-NG UI under the Linux template **linux-netem** will appear
    - For example, to test use two other Linux templates and NETem between them
      - Linux Alpine
        - » root / eve
        - » ifconfig eth0 192.168.1.1 netmask 255.255.255.0
        - » ifconfig eth0 192.168.1.2 netmask 255.255.255.0
      - Start and login no NETem (user: eve / pw: eve)
        - » Change Link parameters and verify

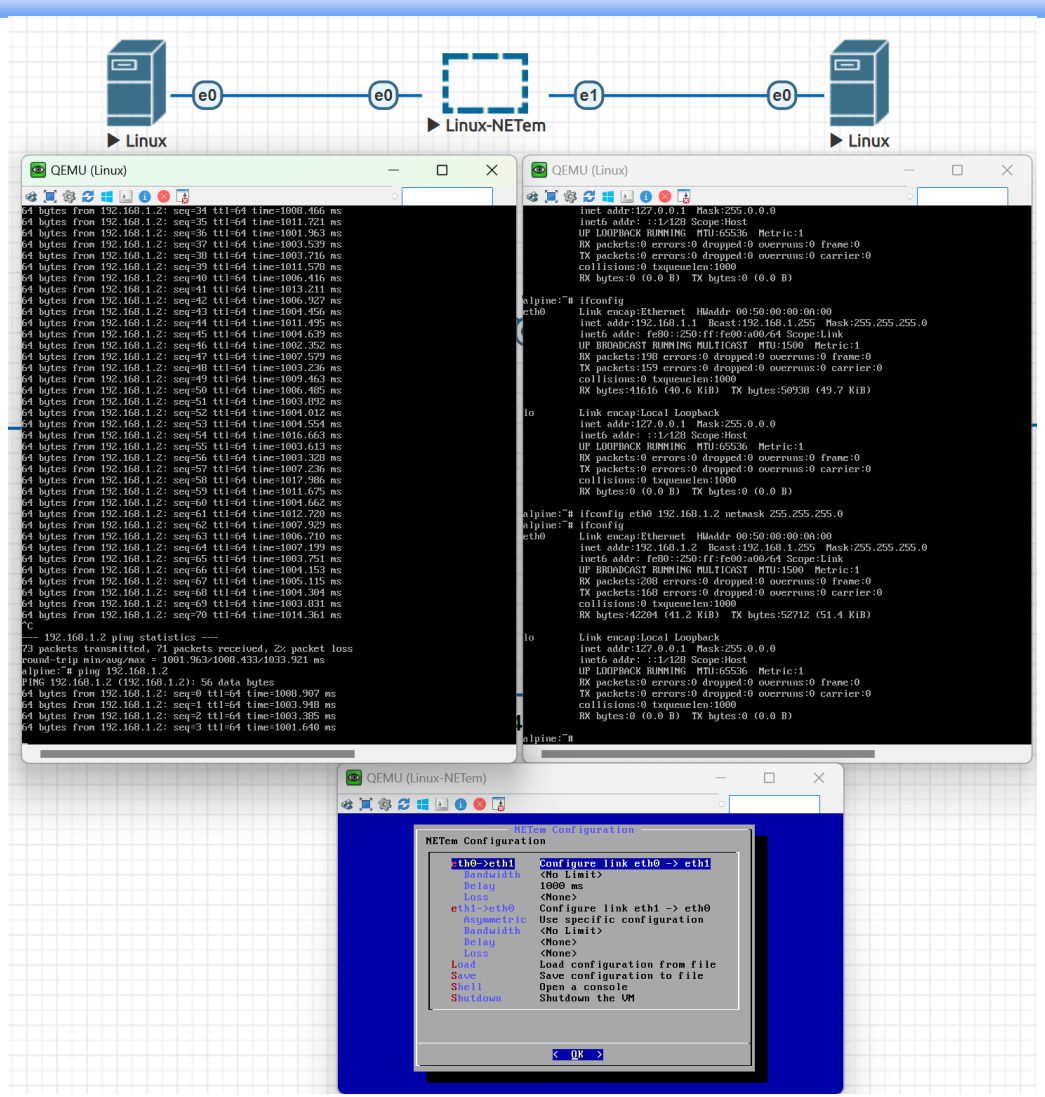




- For further information
  - EVE-NG: How To Install NETem on EVE-NG (Make Loss, Delay, Jilter On EVE-NG)
    - https://www.youtube.com/watch?v=uA9edSwJsS4

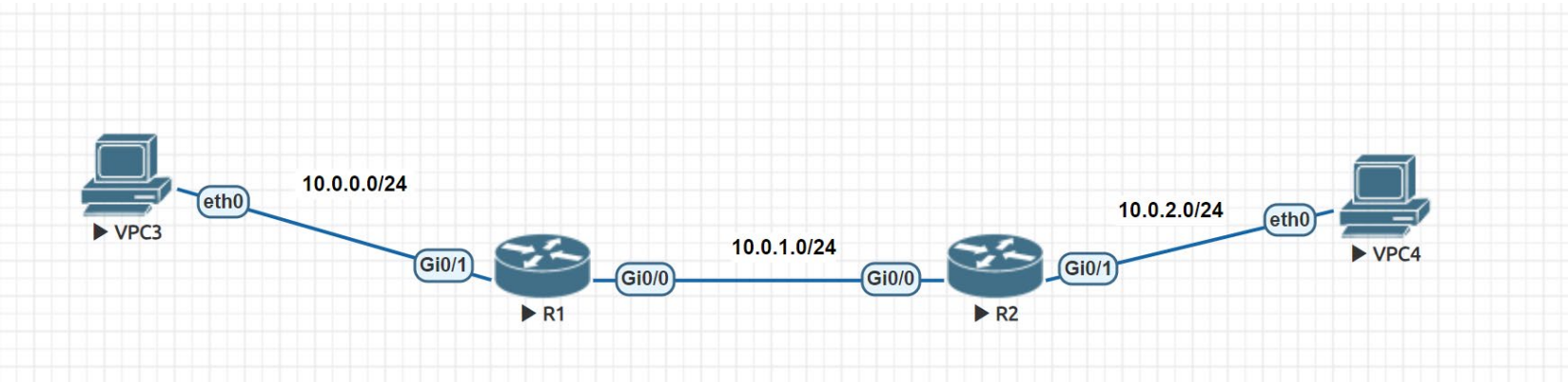
EVE-NG Community
Modeling Link Parameters

- Overall Scenario using NETem



EVE-NG Sample Configuration

- Configure Static Routes on Your network



  - Using CISCO vIOS Router
  - Steps
    - Create the Topology
    - Configure R1 and R2 (see below)
    - Configure EVE-NG VPC
      - VPC3> ip 10.0.0.5/24 10.0.0.1
      - VPC4> ip 10.0.2.5/24 10.0.0.2
    - VPC3 and VPC4 can ping each other

CISCO Configuration 101

- en
  - go to privilige mode
    - sh run
      - show running configuration
    - sh startup-config
      - show startup configuration
    - sh ver
      - show software version
    - sh in int br
      - show ip interface brief
- config
  - enter configuration mode
    - Int
      - enter interface configuration mode
    - interface e0/0 | interface gi0/0
      - select interface for configuration
    - ip add 192.168.1.1 255.255.255.0
      - add manually ip and mask to interface
    - no sh
      - No shutdown the interface

- Cisco's Modes
  - User execution mode
    - R>
  - Privileged mode (en)
    - Can view or change configuration
    - Troubleshooting purposes
    - R#
  - Global Configuration (configure terminal)
    - Global commands that affect the running configuration.
    - Hostname,username and password
    - R(config)#
  - Interface configuration mode
    - Assign IP; Put interface up
    - R(config-if)#

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- en
  - go to privilige mode
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      - show startup configuration
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      - show software version
    - sh ip int br
      - show ip interface brief
    - wr
      - Write the configuration
- config
  - enter configuration mode
    - Int
      - enter interface configuration mode
    - interface e0/0 | interface gi0/0
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  - Interface configuration mode
    - Assign IP; Put interface up
    - R(config-if)#

Cisco Basic Routing Config

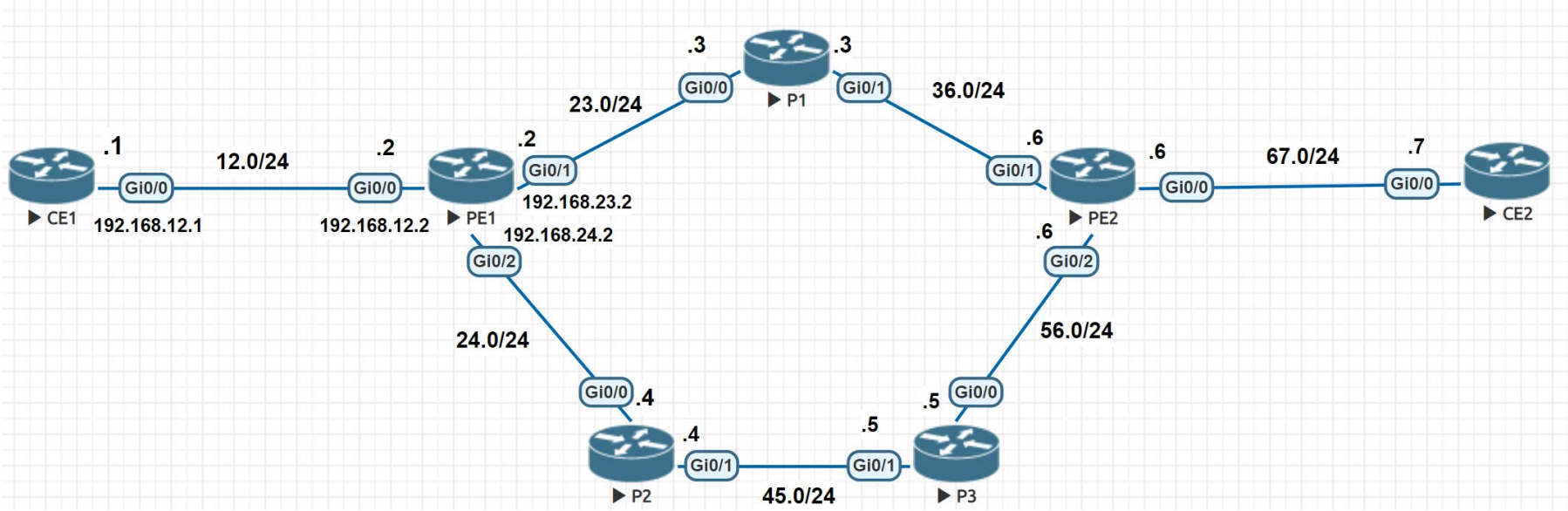
- R1
  - `Router>en`
  - `Router#conf t`
  - `Enter configuration commands, one per line.  End with CNTL/Z.`
  - `Router(config)hostname R1`
  - `R1(config)#int gi0/0`
  - `R1(config-if)#ip address 10.0.1.1 255.255.255.0`
  - `R1(config-if)#no shut`
  - `R1(config-if)#int gi0/1`
  - `R1(config-if)#ip address 10.0.0.1 255.255.255.0`
  - `R1(config-if)#no shut`
  - `R1(config-if)#exit`
  - `R1(config)# ip route 10.0.2.0 255.255.255.0 gigabitEthernet 0/0`
  - `R1#wr`
- R2
  - `Router>en`
  - `Router#conf t`
  - `Enter configuration commands, one per line.  End with CNTL/Z.`
  - `Router(config)hostname R2`
  - `R2(config)#int gi0/1`
  - `R2(config-if)#ip address 10.0.2.1 255.255.255.0`
  - `R2(config-if)#no shut`
  - `R2(config-if)#int gi 0/0`
  - `R2(config-if)#ip address 10.0.1.2 255.255.255.0`
  - `R2(config-if)#no shut`
  - `R2(config)#ip route 10.0.0.0 255.255.255.0 gigabitEthernet 0/0`
  - `R2#wr`

EVE-NG VPCS

- VPCS> ?
  - arp Shortcut for: show arp. Show arp table
  - clear ARG Clear IPv4/IPv6, arp/neighbor cache, command history
  - dhcp [OPTION] Shortcut for: ip dhcp. Get IPv4 address via DHCP
  - disconnect Exit the telnet session (daemon mode)
  - echo TEXT Display TEXT in output. See also set echo ?
  - help Print help
  - history Shortcut for: show history. List the command history
  - ip ARG ... [OPTION] Configure the current VPC's IP settings. See ip ?
  - load [FILENAME] Load the configuration/script from the file FILENAME
  - ping HOST [OPTION ...] Ping HOST with ICMP (default) or TCP/UDP. See ping ?
  - quit Quit program
  - relay ARG ... Configure packet relay between UDP ports. See relay ?
  - rlogin [ip] port Telnet to port on host at ip (relative to host PC)
  - save [FILENAME] Save the configuration to the file FILENAME
  - set ARG ... Set VPC name and other options. Try set ?
  - show [ARG ...] Print the information of VPCs (default). See show ?
  - sleep [seconds] [TEXT] Print TEXT and pause running script for seconds
  - trace HOST [OPTION ...] Print the path packets take to network HOST
  - version Shortcut for: show version
- show ip
- In Example above
  - VPC3
    - VPC3> ip 10.0.0.5/24 10.0.0.1
  - VPC4
    - VPC4> ip 10.0.2.5/24 10.0.2.1

MPLS TE - Sample

- Topology



- In this sample we will use MPLS TE with OSPF configuration

MPLS TE - Sample

- Initial Configuration
  - Create the topology on EVE-NG
  - Using CISCO vIOS Router (such as VIOS-ADVENTERPRISEK9-M, Version 15.9(3)M6
  - Configure each Router in the topology: CE1, PE1, P1, P2, P3, PE2, CE2
- Final Steps – Tunnel Creation
  - Global
  - Interfaces
  - OSPF
  - RSVP
  - Tunnel Interface
- Verification
  - OSPF
  - MPLS TE
  - RSVP
  - Tunnel
  - Routing

MPLS TE – Initial Configuration

- CE1
  - `Router>en`
  - `Router#configure terminal`
  - `Enter configuration commands, one per line.  End with CNTL/Z.`
  - `Router(config)hostname CE1`
  - `CE1(config)#int gi0/0`
  - `CE1(config-if)#ip address 192.168.12.1 255.255.255.0`
  - `CE1(config-if)#no shut`
  - `CE1(config-if)#exit`
  - `CE1(config)#interface loopback 0`
  - `CE1(config-if)#ip address 1.1.1.1 255.255.255.255`
  - `CE1(config-if)#no shut`
  - `CE1(config-if)#exit`
  - `CE1(config)#router ospf 1`
  - `CE1(config-router)#network 1.1.1.1 0.0.0.0 area 0`
  - `CE1(config-router)#network 192.168.12.0 0.0.0.255 area 0`
  - `CE1(config-router)#exit`
  - `CE1(config)#`

MPLS TE – Initial Configuration

- P1

```
Router>en
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)hostname P1
P1(config)#int gi0/0
P1(config-if)#ip address 192.168.23.3 255.255.255.0
P1(config-if)#mpls ip
P1(config-if)#no shut
P1(config-if)#exit
P1(config)#int gi0/1
P1(config-if)#ip address 192.168.36.3 255.255.255.0
P1(config-if)#mpls ip
P1(config-if)#no shut
P1(config-if)#exit
P1(config)#interface loopback 0
P1(config-if)#ip address 3.3.3.3 255.255.255.255
P1(config-if)#no shut
P1(config-if)#exit
P1(config)#router ospf 1
P1(config-router)#network 3.3.3.3 0.0.0.0 area 0
P1(config-router)#network 192.168.23.0 0.0.0.255 area 0
P1(config-router)#network 192.168.36.0 0.0.0.255 area 0
P1(config-router)#exit
P1(config)#mpls ldp router-id loopback 0 force
P1#sh run
P1#sh ip int br
P1#sh mpls ldp disco
```

MPLS TE – Initial Configuration

- P2

```
Router>en
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)hostname P2
P2(config)#int gi0/0
P2(config-if)#ip address 192.168.24.4 255.255.255.0
P2(config-if)#mpls ip
P2(config-if)#no shut
P2(config-if)#exit
P2(config)#int gi0/1
P2(config-if)#ip address 192.168.45.4 255.255.255.0
P2(config-if)#mpls ip
P2(config-if)#no shut
P2(config-if)#exit
P2(config)#interface loopback 0
P2(config-if)#ip address 4.4.4.4 255.255.255.255
P2(config-if)#no shut
P2(config-if)#exit
P2(config)#router ospf 1
P2(config-router)#network 4.4.4.4 0.0.0.0 area 0
P2(config-router)#network 192.168.24.0 0.0.0.255 area 0
P2(config-router)#network 192.168.45.0 0.0.0.255 area 0
P2(config-router)#exit
P2(config)#mpls ldp router-id loopback 0 force
P2#sh run
P2#sh ip int br
P2#sh mpls ldp disco
```

MPLS TE – Initial Configuration

- P3
  - `Router>en`
  - `Router#configure terminal`
  - `Enter configuration commands, one per line.  End with CNTL/Z.`
  - `Router(config)hostname P3`
  - `P3(config)#int gi0/0`
  - `P3(config-if)#ip address 192.168.56.5 255.255.255.0`
  - `P3(config-if)#mpls ip`
  - `P3(config-if)#no shut`
  - `P3(config-if)#exit`
  - `P3(config)#int gi0/1`
  - `P3(config-if)#ip address 192.168.45.5 255.255.255.0`
  - `P3(config-if)#mpls ip`
  - `P3(config-if)#no shut`
  - `P3(config-if)#exit`
  - `P3(config)#interface loopback 0`
  - `P3(config-if)#ip address 5.5.5.5 255.255.255.255`
  - `P3(config-if)#no shut`
  - `P3(config-if)#exit`
  - `P3(config)#router ospf 1`
  - `P3(config-router)#network 5.5.5.5 0.0.0.0 area 0`
  - `P3(config-router)#network 192.168.45.0 0.0.0.255 area 0`
  - `P3(config-router)#network 192.168.56.0 0.0.0.255 area 0`
  - `P3(config-router)#exit`
  - `P3(config)#mpls ldp router-id loopback 0 force`
  - `P3#sh run`
  - `P3#sh ip int br`
  - `P3#sh mpls ldp disco`

MPLS TE – Initial Configuration

- PE1

```
Router>en
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)hostname PE1
PE1(config)#int gi0/0
PE1(config-if)#ip address 192.168.12.2 255.255.255.0
PE1(config-if)#no shut
PE1(config-if)#exit
PE1(config)#int gi0/1
PE1(config-if)#ip address 192.168.23.2 255.255.255.0
PE1(config-if)#mpls ip
PE1(config-if)#no shut
PE1(config-if)#exit
PE1(config)#int gi0/2
PE1(config-if)#ip address 192.168.24.2 255.255.255.0
PE1(config-if)#mpls ip
PE1(config-if)#no shut
PE1(config-if)#exit
PE1(config)#interface loopback 0
PE1(config-if)#ip address 2.2.2.2 255.255.255.255
PE1(config-if)#no shut
PE1(config-if)#exit
PE1(config)#router ospf 1
PE1(config-router)#network 2.2.2.2 0.0.0.0 area 0
PE1(config-router)#network 192.168.12.0 0.0.0.255 area 0
PE1(config-router)#network 192.168.23.0 0.0.0.255 area 0
PE1(config-router)#network 192.168.24.0 0.0.0.255 area 0
PE1(config-router)#exit
PE1(config)#mpls ldp router-id loopback 0 force
PE1#sh run
PE1#sh ip int br
PE1#sh mpls ldp disco
```

MPLS TE – Initial Configuration

- PE2

```
Router>en
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)hostname PE2
PE2(config)#int gi0/0
PE2(config-if)#ip address 192.168.67.6 255.255.255.0
PE2(config-if)#no shut
PE2(config-if)#exit
PE2(config)#int gi0/1
PE2(config-if)#ip address 192.168.36.6 255.255.255.0
PE2(config-if)#mpls ip
PE1(config-if)#no shut
PE2(config-if)#exit
PE2(config)#int gi0/2
PE2(config-if)#ip address 192.168.56.6 255.255.255.0
PE2(config-if)#mpls ip
PE2(config-if)#no shut
PE2(config-if)#exit
PE2(config)#interface loopback 0
PE2(config-if)#ip address 6.6.6.6 255.255.255.255
PE2(config-if)#no shut
PE2(config-if)#exit
PE2(config)#router ospf 1
PE2(config-router)#network 6.6.6.6 0.0.0.0 area 0
PE2(config-router)#network 192.168.36.0 0.0.0.255 area 0
PE2(config-router)#network 192.168.56.0 0.0.0.255 area 0
PE2(config-router)#network 192.168.67.0 0.0.0.255 area 0
PE2(config-router)#exit
PE2(config)#mpls ldp router-id loopback 0 force
PE2#sh run
PE2#sh ip int br
PE2#sh mpls ldp disco
```

MPLS TE – Initial Configuration

- CE2
  - `Router>en`
  - `Router#configure terminal`
  - `Enter configuration commands, one per line.  End with CNTL/Z.`
  - `Router(config)hostname CE2`
  - `CE2(config)#int gi0/0`
  - `CE2(config-if)#ip address 192.168.67.7 255.255.255.0`
  - `CE2(config-if)#no shut`
  - `CE2(config-if)#exit`
  - `CE2(config)#interface loopback 0`
  - `CE2(config-if)#ip address 7.7.7.7 255.255.255.255`
  - `CE2(config-if)#no shut`
  - `CE2(config-if)#exit`
  - `CE2(config)#router ospf 1`
  - `CE2(config-router)#network 7.7.7.7 0.0.0.0 area 0`
  - `CE2(config-router)#network 192.168.67.0 0.0.0.255 area 0`
  - `CE2(config-router)#exit`
  - `CE2(config)#exit`
  - `CE2#sh run`
  - `CE2#sh ip int br`

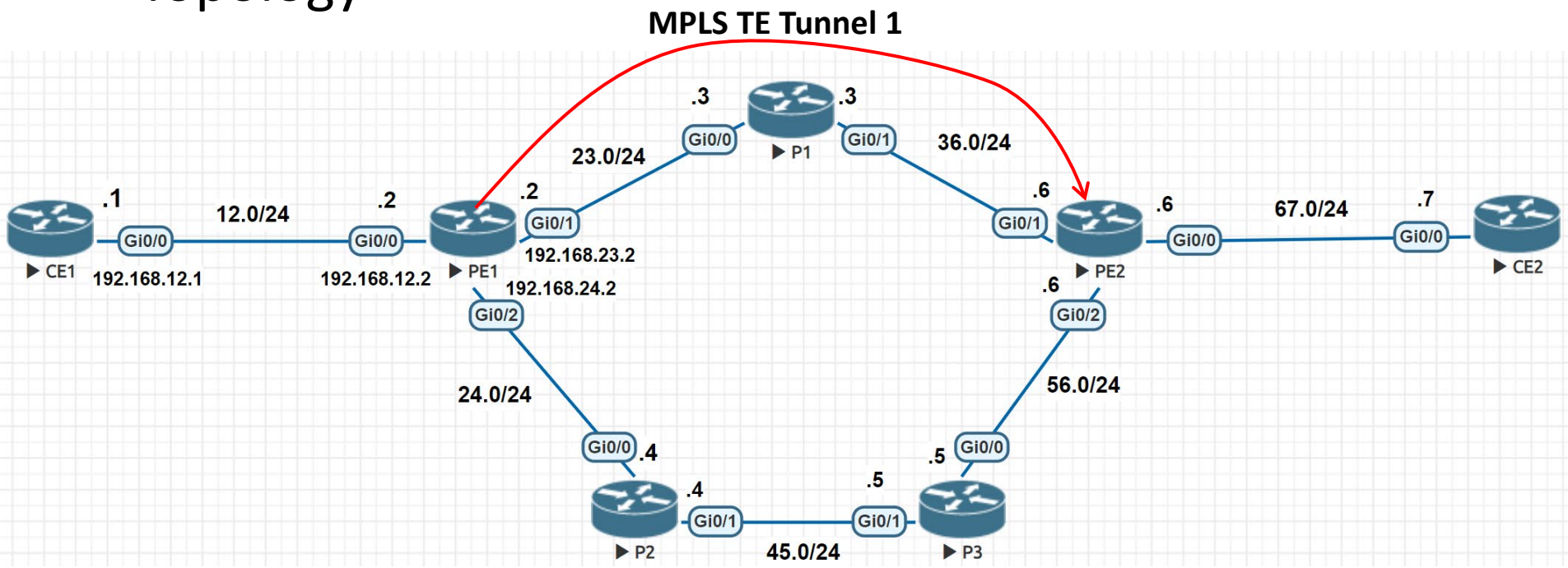
MPLS TE – Initial Configuration

- Test Configuration to verify the existence of a label-switched path (LSP) by sending traffic from CE1 to CE2

```
CE1>en
CE1#traceroute 7.7.7.7 source 1.1.1.1 probe 1
Type escape sequence to abort.
Tracing the route to 7.7.7.7
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.12.2 11 msec
  2 192.168.23.3 [MPLS: Label 26 Exp 0] 18 msec
  3 192.168.36.6 [MPLS: Label 24 Exp 0] 11 msec
  4 192.168.67.7 17 msec
CE1#
```

MPLS TE – Sample
Final Steps – Tunnel Creation

- Topology



- After configuring MPLS it necessary some final steps to enable MPLS TE and then create a Tunnel

MPLS TE – Final Steps

- To support MPLS TE it is necessary to following steps:
  - Enable MPLS TE support
  - Configure OSPF to support MPLS TE
  - Configure RSVP.
  - Configure a TE tunnel interface
- Enable MPLS TE support:
  - Enable on all interfaces that connect PE e P routers
  - Globally
    - On each router (PE1, P1, P2, P3, and PE2)
    - `(config)#mpls traffic-eng tunnels`
  - Interfaces
    - Enable MPLS TE support on all interfaces that connect the PE and P routers:
    - PE1 and PE2
      - `(config)#interface range GigabitEthernet 0/1 - 2`
      - `(config-if-range)#mpls traffic-eng tunnels`
    - P1, P2, and P3
      - `(config)#interface range GigabitEthernet 0/0 - 1`
      - `(config-if-range)#mpls traffic-eng tunnels`

MPLS TE – Final Steps

- Configure OSPF to support MPLS TE
  - Enable MPLS TE for the area
  - Configure the router ID
  - On each router (PE1, PE2, P1, P2 & P3)
    - `(config)#router ospf 1`
    - `(config-router)#mpls traffic-eng area 0`
    - `(config-router)#mpls traffic-eng router-id loopback 0`
- Configure RSVP to define the superior limit of the interface bandwidth (kps)
  - PE1 and PE2
    - `(config)#interface range GigabitEthernet 0/1 - 2`
    - `(config-if-range)#ip rsvp bandwidth 1000000`
  - P1, P2, and P3
    - `(config)#interface range GigabitEthernet 0/0 - 1`
    - `(config-if-range)#ip rsvp bandwidth 1000000`
  - For further information:
    - Cisco IOS Quality of Service Solutions Command Reference

MPLS TE – Final Steps

- Configure a TE tunnel interface
  - Tunnel interface between PE1 and PE2
    - `PE1(config)#interface Tunnel 1`
    - `PE1(config-if)#ip unnumbered Loopback 0`
    - `PE1(config-if)#tunnel mode mpls traffic-eng`
    - `PE1(config-if)#tunnel destination 6.6.6.6`
    - `PE1(config-if)#tunnel mpls traffic-eng bandwidth 750`
    - `PE1(config-if)#tunnel mpls traffic-eng path-option 1 dynamic`
- Everything configured and the network is ready for MPLS TE

MPLS TE – Verification

- Let's verify the configurations
- Verify OSPF
  - `PE1#show ip ospf mpls traffic-eng link`
  - `PE1#show ip ospf database opaque-area`
- Verify the MPLS TE Topology
  - `PE1#show mpls traffic-eng topology 2.2.2.2`
  - `PE1#show mpls traffic-eng topology | include MPLS TE Id`
  - `PE1#show mpls traffic-eng topology | include Intf`
- Verify RSVP
  - `PE1#show ip rsvp interface`
    - `interface  rsvp  allocated  i/f max  flow max sub max  VRF`
    - `Gi0/1  ena  0  1G  1G  0`
    - `Gi0/2  ena  0  1G  1G  0`
  - `PE1#show mpls traffic-eng tunnels summary`
- Verify Tunnel
  - `PE1#show ip interface brief | include Tunnel`
    - `Tunnel1  2.2.2.2  YES TFTP  up  up`
  - `PE1#show mpls traffic-eng tunnels`
- Verify Routing
  - `PE1#show ip route`

MPLS TE – Verification
Verify OSPF

- **PE1#show ip ospf mpls traffic-eng link**
- PE1>
- PE1>en

```
PE1#show ip ospf mpls traffic-eng link
            OSPF Router with ID (2.2.2.2) (Process ID 1)
  Area 0 has 2 MPLS TE links. Area instance is 4.
  Links in hash bucket 16.
    Link is associated with fragment 2. Link instance is 4
      Link connected to Broadcast network
      Link ID : 192.168.23.3
      Interface Address : 192.168.23.2
      Admin Metric te: 1 igp: 1
      Maximum bandwidth : 125000000
      Maximum reservable bandwidth : 125000000
      Number of Priority : 8
      Priority 0 : 125000000    Priority 1 : 125000000
      Priority 2 : 125000000    Priority 3 : 125000000
      Priority 4 : 125000000    Priority 5 : 125000000
      Priority 6 : 125000000    Priority 7 : 125000000
      Affinity Bit : 0x0
  Links in hash bucket 17.
    Link is associated with fragment 3. Link instance is 4
      Link connected to Broadcast network
      Link ID : 192.168.24.4
      Interface Address : 192.168.24.2
      Admin Metric te: 1 igp: 1
      Maximum bandwidth : 125000000
      Maximum reservable bandwidth : 125000000
      Number of Priority : 8
      Priority 0 : 125000000    Priority 1 : 125000000
      Priority 2 : 125000000    Priority 3 : 125000000
      Priority 4 : 125000000    Priority 5 : 125000000
      Priority 6 : 125000000    Priority 7 : 125000000
      Affinity Bit : 0x0
```

MPLS TE – Verification
Verify OSPF

- **PE1#show ip ospf database opaque-area**
- PE1>
- PE1>en
- PE1#show ip ospf database opaque-area

```
            OSPF Router with ID (2.2.2.2) (Process ID 1)
                Type-10 Opaque Link Area Link States (Area 0)
  LS age: 243
  Options: (No TOS-capability, DC)
  LS Type: Opaque Area Link
  Link State ID: 1.0.0.0
  Opaque Type: 1
  Opaque ID: 0
  Advertising Router: 2.2.2.2
  LS Seq Number: 80000003
  Checksum: 0x58C7
  Length: 28
  Fragment number : 0

    MPLS TE router ID : 2.2.2.2

    Number of Links : 0
...
```

MPLS TE – Verification
Verify the MPLS TE Topology

- **PE1#show mpls traffic-eng topology 2.2.2.2**

```
IGP Id: 2.2.2.2, MPLS TE Id:2.2.2.2 Router Node  (ospf 1  area 0) id 7
      link[0]: Broadcast, DR: 192.168.24.4, nbr_node_id:3, gen:15
          frag_id 3, Intf Address:192.168.24.2
          TE metric:1, IGP metric:1, attribute flags:0x0
          SRLGs: None
          physical_bw: 1000000 (kbps), max_reservable_bw_global: 1000000 (kbps)
          max_reservable_bw_sub: 0 (kbps)
                                 Global Pool       Sub Pool
               Total Allocated   Reservable        Reservable
               BW (kbps)         BW (kbps)         BW (kbps)
               ---------------   -----------       ----------
        bw[0]:            0          1000000                0
        bw[1]:            0          1000000                0
        bw[2]:            0          1000000                0
        bw[3]:            0          1000000                0
        bw[4]:            0          1000000                0
        bw[5]:            0          1000000                0
        bw[6]:            0          1000000                0
        bw[7]:            0          1000000                0
      link[1]: Broadcast, DR: 192.168.23.3, nbr_node_id:2, gen:15
          frag_id 2, Intf Address:192.168.23.2
          TE metric:1, IGP metric:1, attribute flags:0x0
          SRLGs: None
          physical_bw: 1000000 (kbps), max_reservable_bw_global: 1000000 (kbps)
          max_reservable_bw_sub: 0 (kbps)
                                 Global Pool       Sub Pool
               Total Allocated   Reservable        Reservable
               BW (kbps)         BW (kbps)         BW (kbps)
               ---------------   -----------       ----------
        bw[0]:            0          1000000                0
        bw[1]:            0          1000000                0
        bw[2]:            0          1000000                0
        bw[3]:            0          1000000                0
        bw[4]:            0          1000000                0
        bw[5]:            0          1000000                0
        bw[6]:            0          1000000                0
        bw[7]:            0          1000000                0
PE1#
```

MPLS TE – Verification
Verify the MPLS TE Topology

- **PE1#show mpls traffic-eng topology | include MPLS TE Id**

```
PE1>en
PE1#show mpls traffic-eng topology | include MPLS TE Id
PE1#show mpls traffic-eng topology | include MPLS TE Id
IGP Id: 2.2.2.2, MPLS TE Id:2.2.2.2 Router Node  (ospf 1  area 0)
IGP Id: 4.4.4.4, MPLS TE Id:4.4.4.4 Router Node  (ospf 1  area 0)
IGP Id: 5.5.5.5, MPLS TE Id:5.5.5.5 Router Node  (ospf 1  area 0)
IGP Id: 6.6.6.6, MPLS TE Id:6.6.6.6 Router Node  (ospf 1  area 0)
```

- **PE1#show mpls traffic-eng topology | include Intf**

```
PE1>en
PE1#show mpls traffic-eng topology | include Intf
          frag_id 3, Intf Address:192.168.24.2
          frag_id 2, Intf Address:192.168.23.2
          frag_id 2, Intf Address:192.168.45.4
          frag_id 1, Intf Address:192.168.24.4
          frag_id 1, Intf Address:192.168.56.5
          frag_id 3, Intf Address:192.168.56.6
          frag_id 2, Intf Address:192.168.36.6
```

MPLS TE – Verification
Verify RSVP

- **PE1#show ip rsvp interface**

```
PE1>en
PE1#
PE1#show ip rsvp interface
interface     rsvp  allocated  i/f max   flow max sub max   VRF
Gi0/1         ena   0          1G        1G        0
Gi0/2         ena   0          1G        1G        0
```

- **PE1#show mpls traffic-eng tunnels summary**

```
PE1>en
PE1#show mpls traffic-eng tunnels summary
Signalling Summary:
    LSP Tunnels Process:            running
    Passive LSP Listener:           running
    RSVP Process:                   running
    Forwarding:                     enabled
    Head: 1 interfaces, 0 active signalling attempts, 0 established
          0 activations, 0 deactivations
          0 SSO recovery attempts, 0 SSO recovered
    Midpoints: 0, Tails: 0
    Periodic reoptimization:        every 3600 seconds, next in 1947 seconds
    Periodic FRR Promotion:         Not Running
    Periodic auto-bw collection:    every 300 seconds, next in 147 seconds
```

MPLS TE – Verification
Verify Tunnel

- **PE1#show ip interface brief | include Tunnel**

```
PE1>en
PE1#show ip interface brief | include Tunnel
Tunnel1                2.2.2.2         YES TFTP    up       up
```

- **PE1#show mpls traffic-eng tunnels**

```
PE1>en
PE1#show mpls traffic-eng tunnels
Name: PE1_t1                              (Tunnel1) Destination: 6.6.6.6
  Status:
    Admin: up         Oper: up     Path: valid       Signalling: connected
    path option 1, type dynamic (Basis for Setup, path weight 2)
  Config Parameters:
    Bandwidth: 750      kbps (Global)  Priority: 7  7   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute:  disabled  LockDown: disabled  Loadshare: 750      bw-based
    auto-bw: disabled
  Active Path Option Parameters:
    State: dynamic path option 1 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: disabled
  InLabel  :  -
  OutLabel : GigabitEthernet0/1, 27
  RSVP Signalling Info:
       Src 2.2.2.2, Dst 6.6.6.6, Tun_Id 1, Tun_Instance 173
    RSVP Path Info:
      My Address: 192.168.23.2
      Explicit Route: 192.168.23.3 192.168.36.3 192.168.36.6 6.6.6.6
      Record   Route:   NONE
      Tspec: ave rate=750 kbits, burst=1000 bytes, peak rate=750 kbits
    RSVP Resv Info:
      Record   Route:   NONE
      Fspec: ave rate=750 kbits, burst=1000 bytes, peak rate=750 kbits
  History:
    Tunnel:
      Time since created: 1 hours, 25 minutes
      Time since path change: 1 minutes, 9 seconds
      Number of LSP IDs (Tun_Instances) used: 173
    Current LSP:
      Uptime: 1 minutes, 9 seconds
```

MPLS TE – Verification
Verify Route

- **PE1#show ip route**

```
PE1#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR
Gateway of last resort is not set
      1.0.0.0/32 is subnetted, 1 subnets
O        1.1.1.1 [110/2] via 192.168.12.1, 02:04:30, GigabitEthernet0/0
      2.0.0.0/32 is subnetted, 1 subnets
C        2.2.2.2 is directly connected, Loopback0
      3.0.0.0/32 is subnetted, 1 subnets
O        3.3.3.3 [110/2] via 192.168.23.3, 00:04:07, GigabitEthernet0/1
      4.0.0.0/32 is subnetted, 1 subnets
O        4.4.4.4 [110/2] via 192.168.24.4, 02:04:20, GigabitEthernet0/2
      5.0.0.0/32 is subnetted, 1 subnets
O        5.5.5.5 [110/4] via 192.168.23.3, 02:04:20, GigabitEthernet0/1
      6.0.0.0/32 is subnetted, 1 subnets
O        6.6.6.6 [110/3] via 192.168.23.3, 02:04:20, GigabitEthernet0/1
      7.0.0.0/32 is subnetted, 1 subnets
S        7.7.7.7 is directly connected, Tunnel1
      192.168.12.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.12.0/24 is directly connected, GigabitEthernet0/0
L        192.168.12.2/32 is directly connected, GigabitEthernet0/0
      192.168.23.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.23.0/24 is directly connected, GigabitEthernet0/1
L        192.168.23.2/32 is directly connected, GigabitEthernet0/1
      192.168.24.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.24.0/24 is directly connected, GigabitEthernet0/2
L        192.168.24.2/32 is directly connected, GigabitEthernet0/2
O     192.168.36.0/24 [110/2] via 192.168.23.3, 02:04:30, GigabitEthernet0/1
O     192.168.45.0/24 [110/2] via 192.168.24.4, 02:04:20, GigabitEthernet0/2
O     192.168.56.0/24 [110/3] via 192.168.23.3, 02:04:20, GigabitEthernet0/1
O     192.168.67.0/24 [110/3] via 192.168.23.3, 02:04:20, GigabitEthernet0/1
```

MPLS TE – Route Traffic

- Once your MPLS Traffic Engineering (TE) tunnel is up and running
- To use it is necessary to route traffic down your tunnel
  - One option is to use MPLS TE Static Routes
- For example, to reach the loopback interface of CE2. We can use the following static route:
  - **`PE1(config)#ip route 7.7.7.7 255.255.255.255 Tunnel 1`**
- After that use can do some Verification steps
  - **`PE1#show ip route 7.7.7.7`**
  - **`PE1#show mpls forwarding-table`**
  - **`PE1#show mpls forwarding-table 7.7.7.7 detail`**
  - **`PE1#show ip cef 7.7.7.7 detail`**
- Send packets using tunnel
  - **`PE1#traceroute 7.7.7.7 source Loopback 0 numeric probe 1`**
  - **`ping 7.7.7.7 repeat 100`**
  - **`show interfaces Tunnel 1 | include output`**

MPLS TE – Route Traffic Verification

- Verification
  - **PE1#show ip route 7.7.7.7**

```
Routing entry for 7.7.7.7/32
  Known via "static", distance 1, metric 0 (connected)
  Routing Descriptor Blocks:
  * directly connected, via Tunnel1
      Route metric is 0, traffic share count is 1
```

  - **PE1#show mpls forwarding-table**

```
PE1#show mpls forwarding-table
Local      Outgoing   Prefix           Bytes Label   Outgoing    Next Hop
Label      Label      or Tunnel Id     Switched      interface
16         No Label   1.1.1.1/32       868           Gi0/0       192.168.12.1
17         Pop Label  192.168.36.0/24  0             Gi0/1       192.168.23.3
18    [T]  Pop Label  7.7.7.7/32       0             Tu1         point2point
19         16         6.6.6.6/32       0             Gi0/1       192.168.23.3
20         24         5.5.5.5/32       1924          Gi0/1       192.168.23.3
21         No Label   4.4.4.4/32       19723         Gi0/2       192.168.24.4
22         Pop Label  192.168.45.0/24  0             Gi0/2       192.168.24.4
23         20         192.168.56.0/24  0             Gi0/1       192.168.23.3
24         19         192.168.67.0/24  0             Gi0/1       192.168.23.3
25         Pop Label  3.3.3.3/32       0             Gi0/1       192.168.23.3
[T]     Forwarding through a LSP tunnel.
        View additional labelling info with the 'detail' option
```

MPLS TE – Route Traffic Verification

- **PE1#show mpls forwarding-table 7.7.7.7 detail**

```
PE1#show mpls forwarding-table 7.7.7.7 detail
Local      Outgoing   Prefix           Bytes Label   Outgoing    Next Hop
Label      Label      or Tunnel Id     Switched      interface
18         Pop Label  7.7.7.7/32       0             Tu1         point2point
        MAC/Encaps=14/18, MRU=1500, Label Stack{27}, via Gi0/1
        500000070000500000020001884 7 0001B000
        No output feature configured
```

- **PE1#show ip cef 7.7.7.7 detail**

```
PE1#show ip cef 7.7.7.7 detail
7.7.7.7/32, epoch 0, flags [attached]
  local label info: global/18
  attached to Tunnel1
```

- **PE1#traceroute 7.7.7.7 source Loopback 0 numeric probe 1**

```
PE1#traceroute 7.7.7.7 source Loopback 0 numeric probe 1
Type escape sequence to abort.
Tracing the route to 7.7.7.7
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.23.3 [MPLS: Label 27 Exp 0] 7 msec
  2 192.168.36.6 20 msec
  3 192.168.67.7 10 msec
```

MPLS TE – Route Traffic Verification

- **PE1#ping 7.7.7.7 repeat 100**

```
PE1#ping 7.7.7.7 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 7.7.7.7, timeout is 2 seconds:
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Success rate is 100 percent (100/100), round-trip min/avg/max = 2/6/21 ms
```

- **PE1#show interfaces Tunnel 1 | include output**

```
PE1#show interfaces Tunnel 1 | include output
  Last input never, output 00:00:09, output hang never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  5 minute output rate 0 bits/sec, 0 packets/sec
     103 packets output, 10084 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 output buffer failures, 0 output buffers swapped out
```

EVE-NG Saving and Loading Configurations

- The device configuration are stored in its RAM
- To not loose the configuration is its necessary to write to a permanent storage (Flash or NVRAM (Non-Volatile RAM)

```
PE1>en
PE1#wr
Building configuration...
[OK]
```

- In real device It is possible to export the configuration NVRAM to an external file, EVE-NG also offers this feature to transfer NVRAM to startup-configs
  - **More Actions → Export All CFGs**
- To see Startup-configs
  - Select "Startup-configs" in the main menu and select the device to check its configurations
- To Use startup-configs files
  - **More Actions → Set nodes startup-cfg to exported**
- To Reload Configuration
  - Select all Nodes
  - Right Click → Wipe Selected (remove NVRAM from selected devices)
  - Right Click → Start Selected (restart all devices and load "startup-configs"
- For further information
  - EVE HowTo operate with initial configs
    - https://www.youtube.com/watch?v=uRmuLvbwAkk