



Hands-on Workshop on Network Technologies



Hands-on Session 2: MPLS Layer 3 VPN using MP-BGP Lab 7 - MPLS and Advanced BGP Topics Series



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Online

Lab Series: MPLS and Advanced BGP Topics

- Lab experiments
 - Lab 1 Configuring Multiprotocol BGP
 - Lab 2 IP Spoofing and Mitigation Techniques
 - Lab 3 BGP Hijacking
 - Lab 4 Introduction to MPLS
 - Lab 5 Label Distribution Protocol (LDP)
 - Lab 6 Virtual Routing and Forwarding (VRF)
 - Lab 7 MPLS Layer 3 VPN using MP-BGP
 - Lab 8 Ethernet VPN (EVPN) using MP-BGP
 - Lab 9 Introduction to Segment Routing over IPv6 (SRv6)

Organization of the labs

Each lab starts with a section *Overview*

- Objectives
- Lab topology
- Lab settings: passwords, device names
- Roadmap: organization of the lab

Section 1

- Background information of the topic being covered (e.g., fundamentals of MPLS)
- Section 1 is optional (i.e., the reader can skip this section and move to lab directions)

Section 2... n

- Step-by-step directions

MPLS Layer 3 VPN using MP-BGP

Lab activities are described in Lab 7, MPLS and Advanced BGP Topics Lab Series

Hands-on Labs on MPLS and Advanced BGP Topics

- Webpage with PowerPoint presentations:

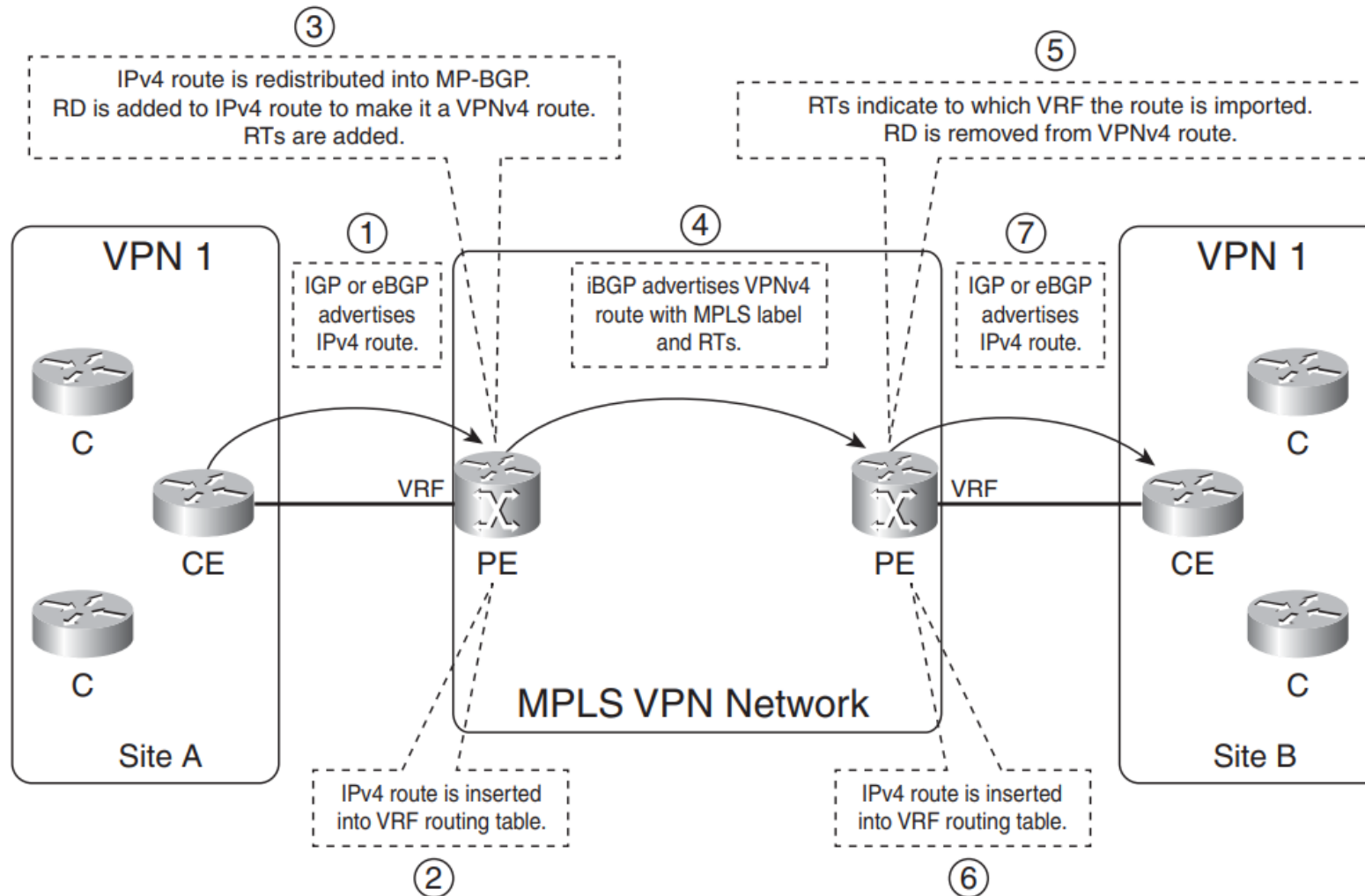
https://research.cec.sc.edu/cyberinfra/NT_2026

Hands-on session 3 (3:15PM-3:55PM): to access labs for Session 3 (MPLS Layer 3 VPN using MP-BGP).

The virtual platform (Netlab) is reachable through the following link:

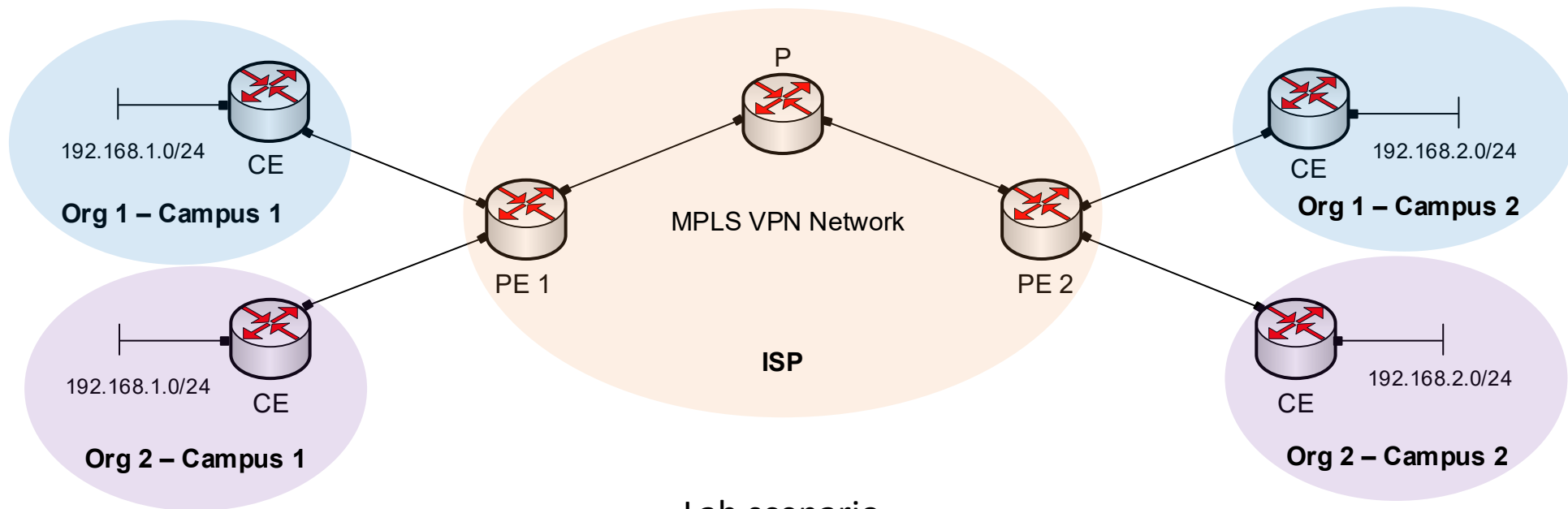
<https://netlab.cec.sc.edu>

MPLS Layer 3 VPN configuration



Lab Scenario

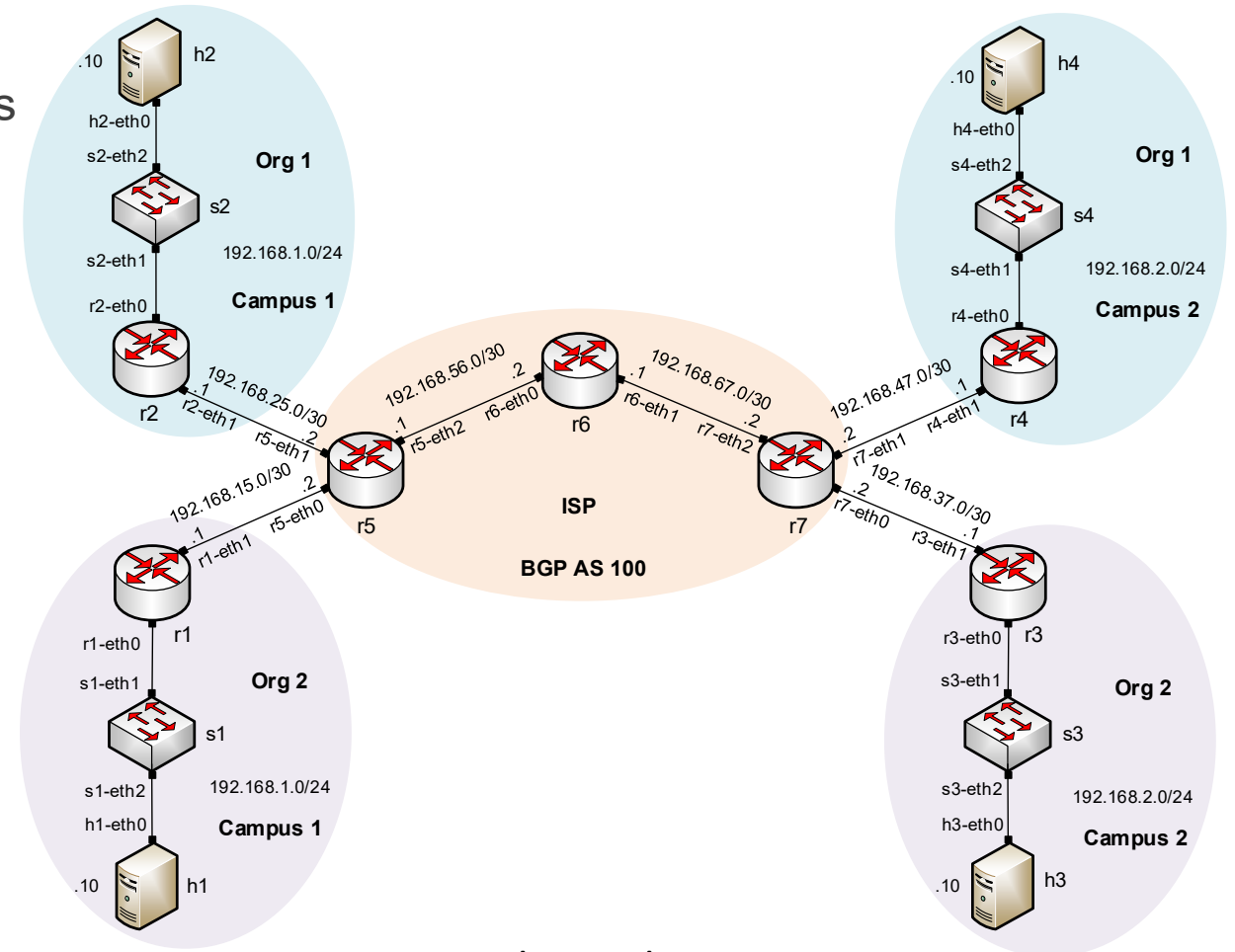
- The Organizations (org 1 and org 2) are connected to ISP, having overlapping IP addresses.
- Campus routers are connected to the ISP through static routes.



Lab scenario

Configuration Steps

- Step 1
 - Run LDP within ISP routers
- Step 2
 - Create VRF for each organization in routers r5 and r7
- Step 3
 - Create BGP peers between routers r5 and r7
- Step 4
 - Advertise VPNv4 routes to the BGP peer



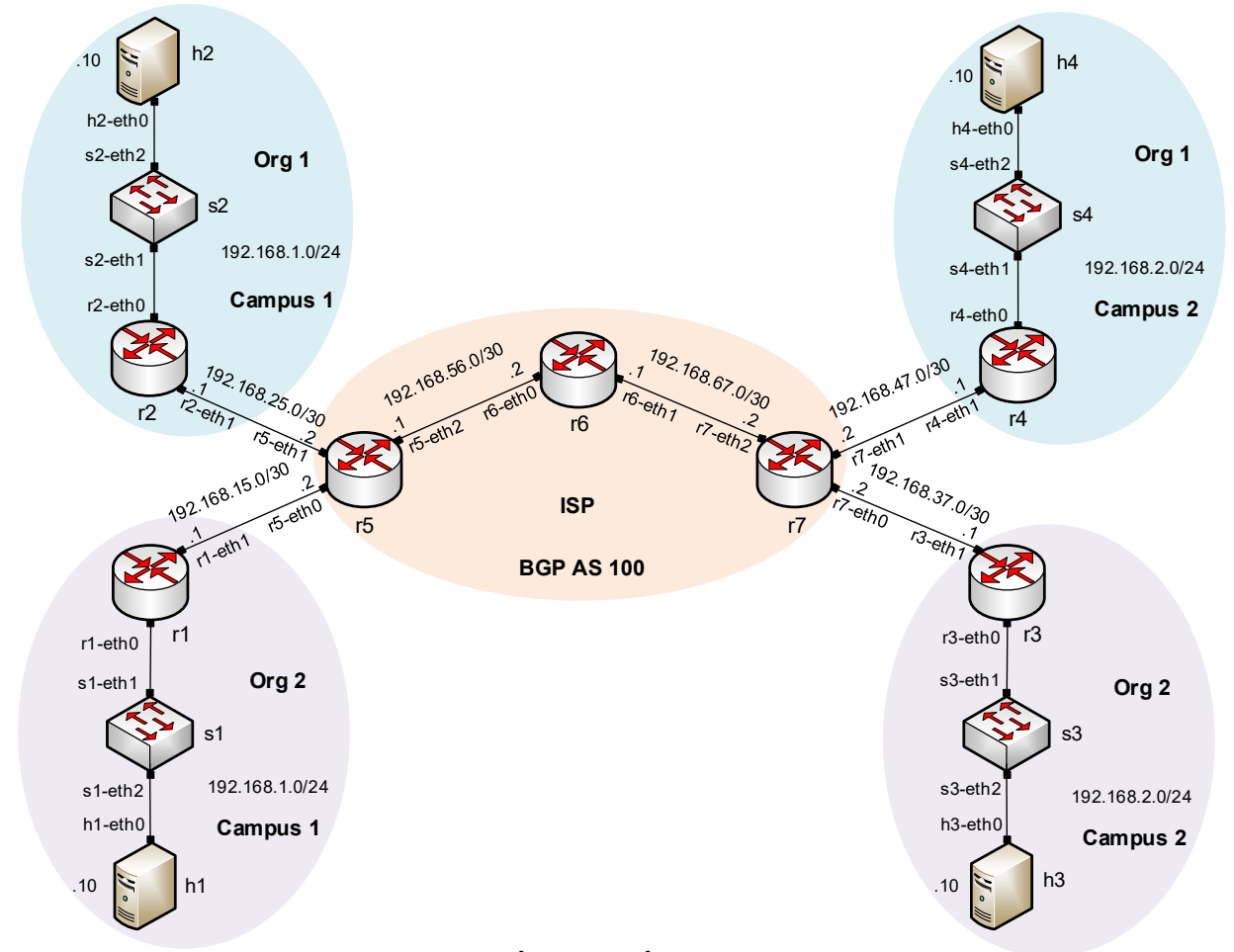
Lab topology

Lab Configuration

- Enable MPLS forwarding in routers r5, r6 and r7

```
frr@frr-pc: ~/MPLS_advanced_BGP/lab7
File Actions Edit View Help
frr@frr-pc: ~/MPLS_advanced_BGP/lab7
frr@frr-pc:~/MPLS_advanced_BGP/lab7$ ./config_routers.sh
[sudo] password for frr:
net.mpls.conf.lo.input = 1
net.mpls.conf.r5-eth2.input = 1
net.mpls.platform_labels = 100000
net.mpls.conf.lo.input = 1
net.mpls.conf.r6-eth0.input = 1
net.mpls.conf.r6-eth1.input = 1
net.mpls.platform_labels = 100000
net.mpls.conf.lo.input = 1
net.mpls.conf.r7-eth2.input = 1
net.mpls.platform_labels = 100000
frr@frr-pc:~/MPLS_advanced_BGP/lab7$
```

Enabling MPLS in the ISP routers



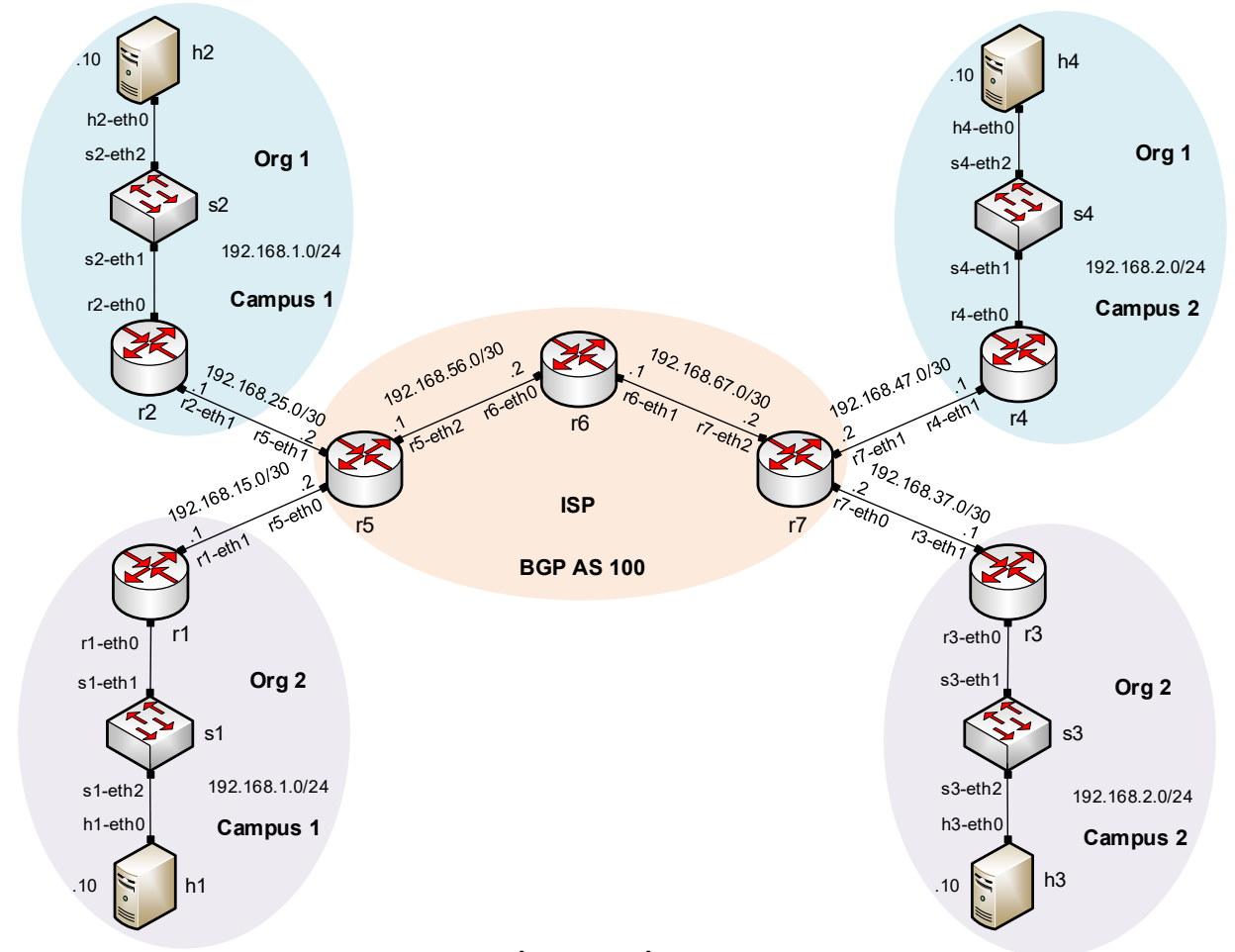
Lab topology

Lab Configuration

- Enable VRF operation in ISP routers

```
frr-pc# show vrf
vrf org1 id 5 table 1
vrf org2 id 6 table 2
frr-pc#
```

Configuring a VRF tunnel between r5 and r7



Lab topology

Lab Configuration

- Configure BGP on PE routers

```
Host: r5
root@frr-pc:/etc/routers/r5# bgpd
root@frr-pc:/etc/routers/r5# vtysh

Hello, this is FRRouting (version 7.2-dev).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

frr-pc# configure terminal
frr-pc(config)# router bgp 100
frr-pc(config-router)# bgp router-id 5.5.5.5
frr-pc(config-router)# neighbor 7.7.7.7 remote-as 100
frr-pc(config-router)# neighbor 7.7.7.7 update-source lo
frr-pc(config-router)# address-family ipv4 vpn
frr-pc(config-router-af)# neighbor 7.7.7.7 activate
frr-pc(config-router-af)# exit-address-family
frr-pc(config-router)#
```

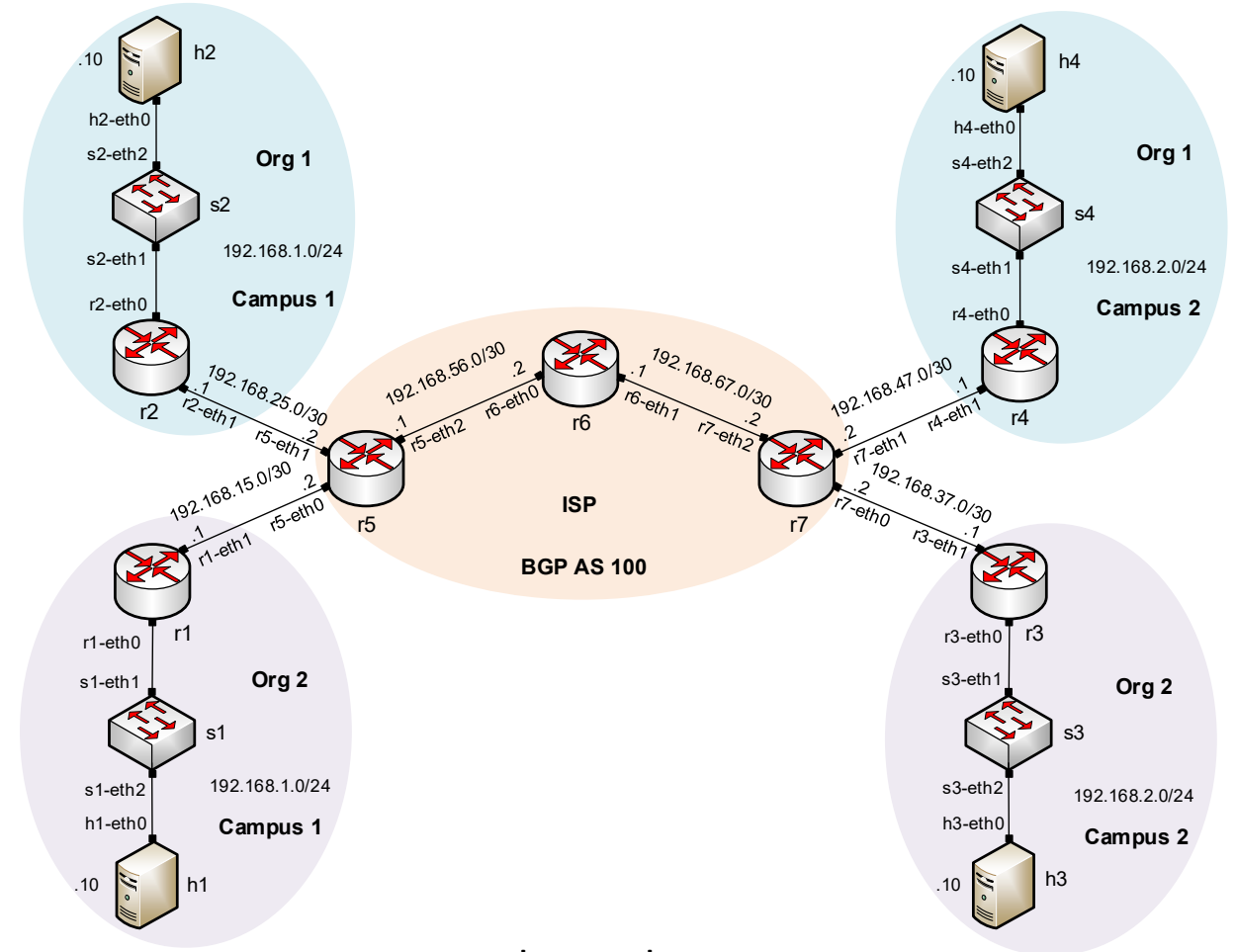
Configuring a BGP in router r5

```
Host: r7
root@frr-pc:/etc/routers/r7# bgpd
root@frr-pc:/etc/routers/r7# vtysh

Hello, this is FRRouting (version 7.2-dev).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

frr-pc# configure terminal
frr-pc(config)# router bgp 100
frr-pc(config-router)# bgp router-id 7.7.7.7
frr-pc(config-router)# neighbor 5.5.5.5 remote-as 100
frr-pc(config-router)# neighbor 5.5.5.5 update-source lo
frr-pc(config-router)# address-family ipv4 vpn
frr-pc(config-router-af)# neighbor 5.5.5.5 activate
frr-pc(config-router-af)# exit-address-family
frr-pc(config-router)#
```

Configuring a BGP in router r7



Lab topology

Lab Configuration

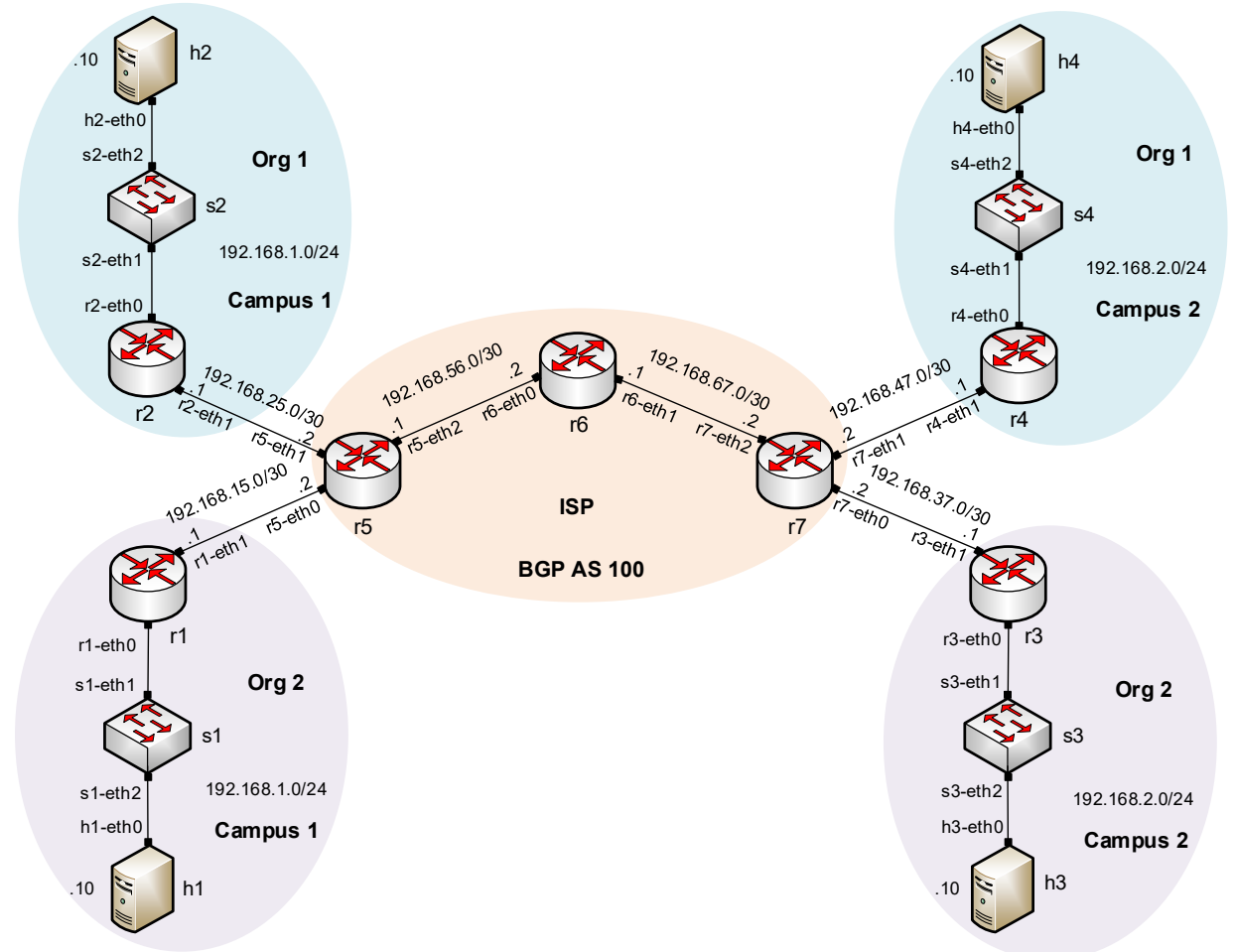
- Advertising VPN routes

```
"Host: r5"
frr-pc(config-router)# router bgp 100 vrf org1
frr-pc(config-router)# address-family ipv4 unicast
frr-pc(config-router-af)# redistribute static metric 12
frr-pc(config-router-af)# redistribute connected
frr-pc(config-router-af)# rd vpn export 1:1
frr-pc(config-router-af)# rt vpn both 1:1
frr-pc(config-router-af)# label vpn export auto
frr-pc(config-router-af)# export vpn
frr-pc(config-router-af)# import vpn
frr-pc(config-router-af)# exit
frr-pc(config-router)#
```

Advertising *org1* VPN information through BGP

```
"Host: r5"
frr-pc(config-router)# router bgp 100 vrf org2
frr-pc(config-router)# address-family ipv4 unicast
frr-pc(config-router-af)# redistribute static metric 12
frr-pc(config-router-af)# redistribute connected
frr-pc(config-router-af)# rd vpn export 2:2
frr-pc(config-router-af)# rt vpn both 2:2
frr-pc(config-router-af)# label vpn export auto
frr-pc(config-router-af)# export vpn
frr-pc(config-router-af)# import vpn
frr-pc(config-router-af)# end
frr-pc#
```

Advertising *org2* VPN information through BGP



Lab topology

Lab Configuration

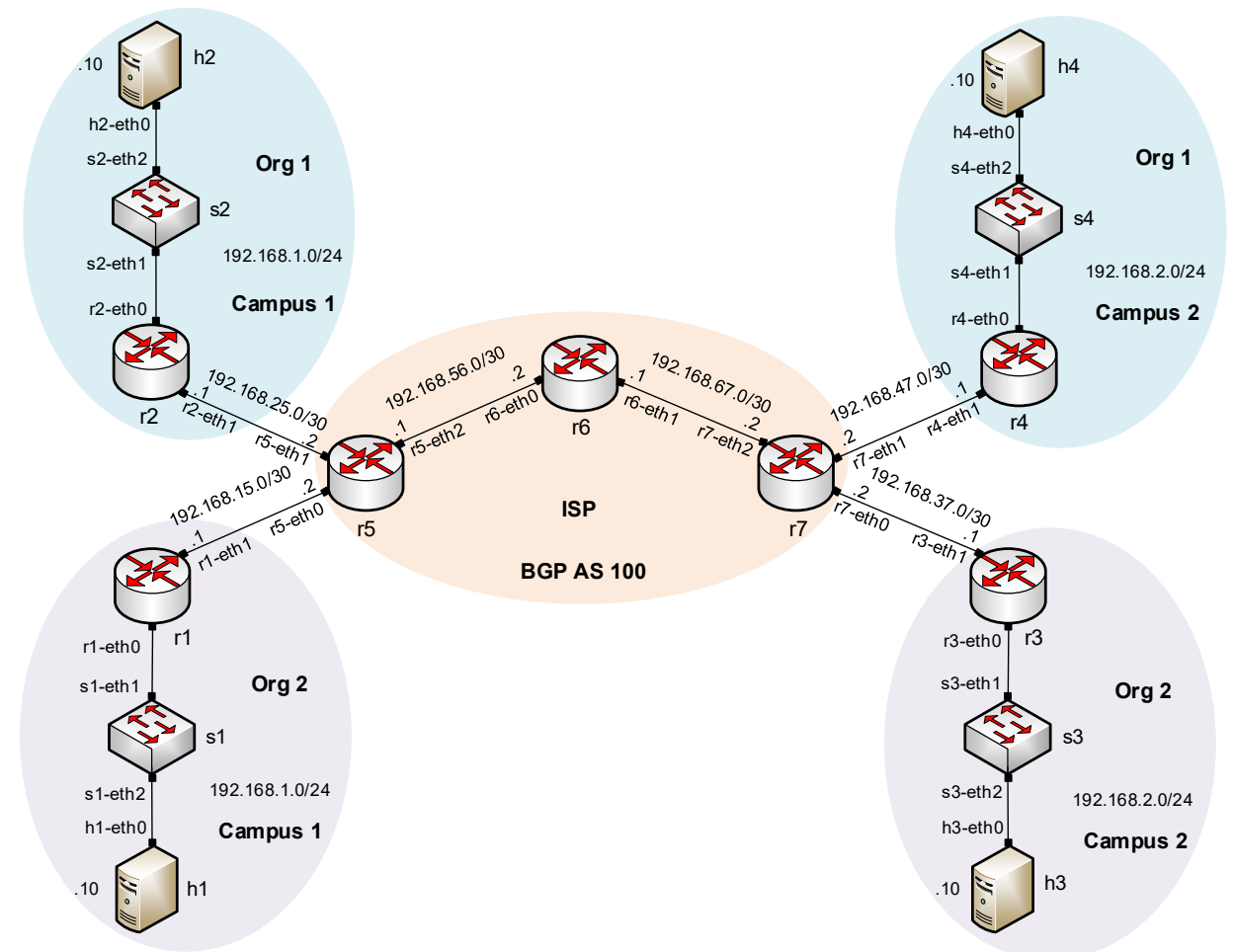
- Verifying configuration

```
"Host: r5"
frr-pc# show bgp ipv4 vpn
BGP table version is 4, local router ID is 5.5.5.5, vrf id 0
Default local pref 100, local AS 100
Status codes: s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Next hop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network        Next Hop        Metric LocPrf Weight Path
Route Distinguisher: 1:1
*> 192.168.1.0/24  192.168.25.1@5<      12         32768 ?
    UN=192.168.25.1 EC{1:1} label=144 type=bgp, subtype=5
*>i192.168.2.0/24  7.7.7.7             12         100    0 ?
    UN=7.7.7.7 EC{1:1} label=144 type=bgp, subtype=0
*> 192.168.25.0/30 0.0.0.0@5<          0         32768 ?
    UN=0.0.0.0 EC{1:1} label=144 type=bgp, subtype=5
*>i192.168.47.0/30 7.7.7.7             0         100    0 ?
    UN=7.7.7.7 EC{1:1} label=144 type=bgp, subtype=0
Route Distinguisher: 2:2
*> 192.168.1.0/24  192.168.15.1@6<      12         32768 ?
    UN=192.168.15.1 EC{2:2} label=145 type=bgp, subtype=5
*>i192.168.2.0/24  7.7.7.7             12         100    0 ?
    UN=7.7.7.7 EC{2:2} label=145 type=bgp, subtype=0
*> 192.168.15.0/30 0.0.0.0@6<          0         32768 ?
    UN=0.0.0.0 EC{2:2} label=145 type=bgp, subtype=5
*>i192.168.37.0/30 7.7.7.7             0         100    0 ?
    UN=7.7.7.7 EC{2:2} label=145 type=bgp, subtype=0

Displayed 8 routes and 8 total paths
frr-pc#
```

Verifying VPN information in router r5



Lab topology

Lab Configuration

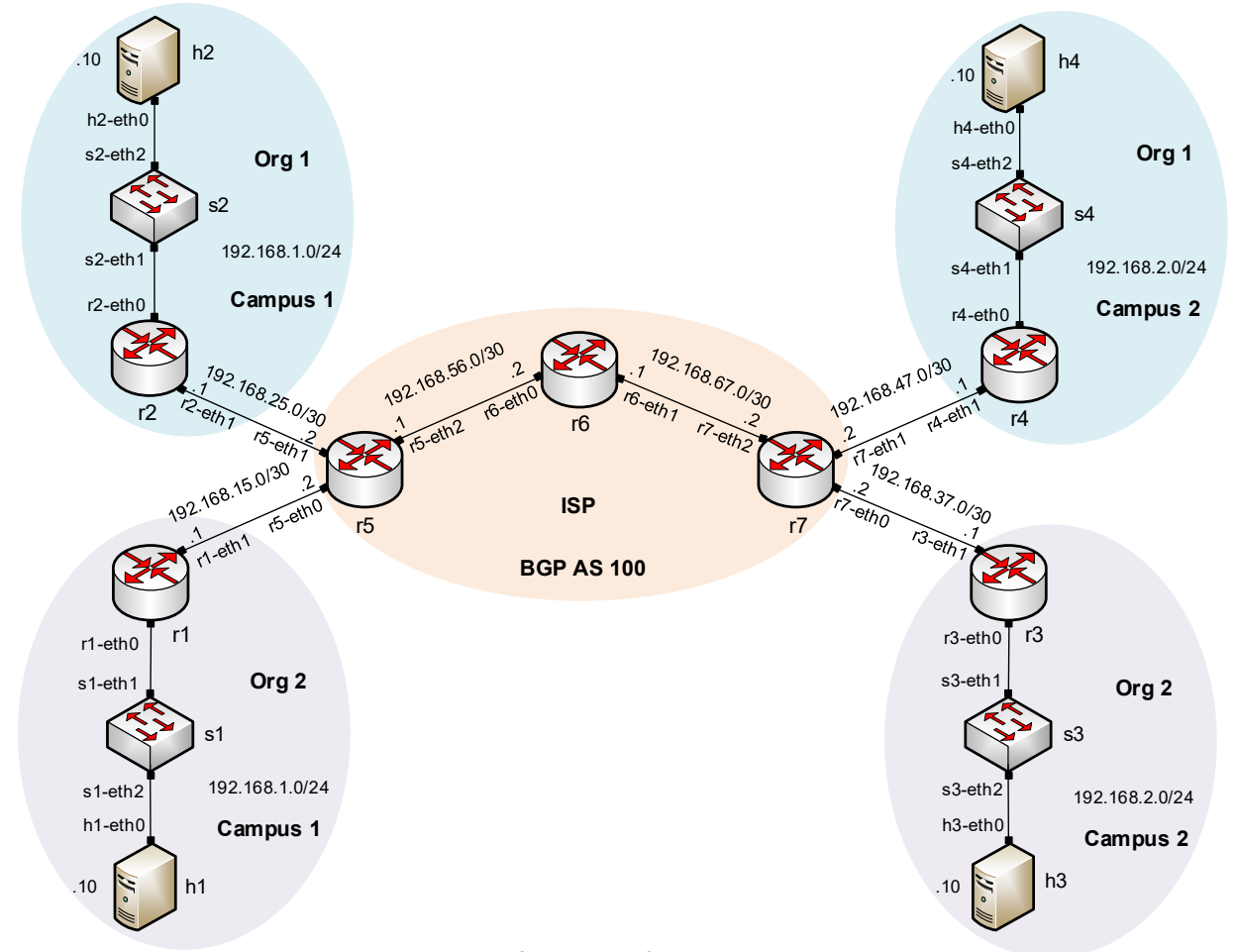
- Verifying connectivity

```
Host: h2
root@frr-pc:~# traceroute 192.168.2.10
traceroute to 192.168.2.10 (192.168.2.10), 30 hops max, 60 byte packets
 1 192.168.1.1 (192.168.1.1) 1.919 ms 1.895 ms 1.882 ms
 2 * * *
 3 * * *
 4 192.168.47.1 (192.168.47.1) 1.759 ms 1.748 ms 1.735 ms
 5 192.168.2.10 (192.168.2.10) 2.097 ms 2.099 ms 2.096 ms
root@frr-pc:~#
```

Testing connectivity within *org1*

```
Host: h3
root@frr-pc:~# traceroute 192.168.1.10
traceroute to 192.168.1.10 (192.168.1.10), 30 hops max, 60 byte packets
 1 192.168.2.1 (192.168.2.1) 2.223 ms 2.195 ms 2.173 ms
 2 * * *
 3 * * *
 4 192.168.15.1 (192.168.15.1) 2.050 ms 2.039 ms 2.025 ms
 5 192.168.1.10 (192.168.1.10) 2.422 ms 2.369 ms 2.370 ms
root@frr-pc:~#
```

Testing connectivity within *org2*



Lab topology

Accessing the Platform

We will use the NETLAB virtual platform:

- **URL:** <https://netlab.cec.sc.edu/>
- **Username:** <email address used for the registration>
- **Temporary Password:** nsf-2026