CS5113: Network Engineering

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Tentative Course Schedule

Week 01: Orientation & VM related instructions

Week 02: Revisiting Basics through Linux Network Commands & Scripts

Week 03: Network Topology (IPv4/IPv6 addressing and VLAN)

Week 04: Configuring Open Software Router (VyOS)

Week 05: Interconnecting Routers using Static Routing

Week 06: Intra-AS Routing Protocols (OSPF)

Week 07: Inter-AS Routing Protocol (BGP)

Week 08: Introduction to Software Defined Networking

Week 09: Project Orientation

Week 10: Benchmarking, Monitoring and Trouble Shooting in Networks

Week 11: Managing Firewalls

Week 12: Designing Enterprise Networks and Summary

Week 13: Security (Managing Firewalls)

Week 14: Covering up left-over topics

Week 15: Project Evaluation

Outline of This Week

- What is routing protocol?
- What is OSPF?
- Let's touch OSPF, a dynamic routing protocol
  - Simplest configuration
  - Path control
  - Failure recovery

Brief Overview on Routing Protocol Open Shortest Path First (OSPF)

Routing Protocol

- Mechanism to exchange routing information among routers
  - Algorithms and Metric are different among protocols
  - Distance Vector / Hop Count / RIP
  - Link State / Link Cost / OSPF
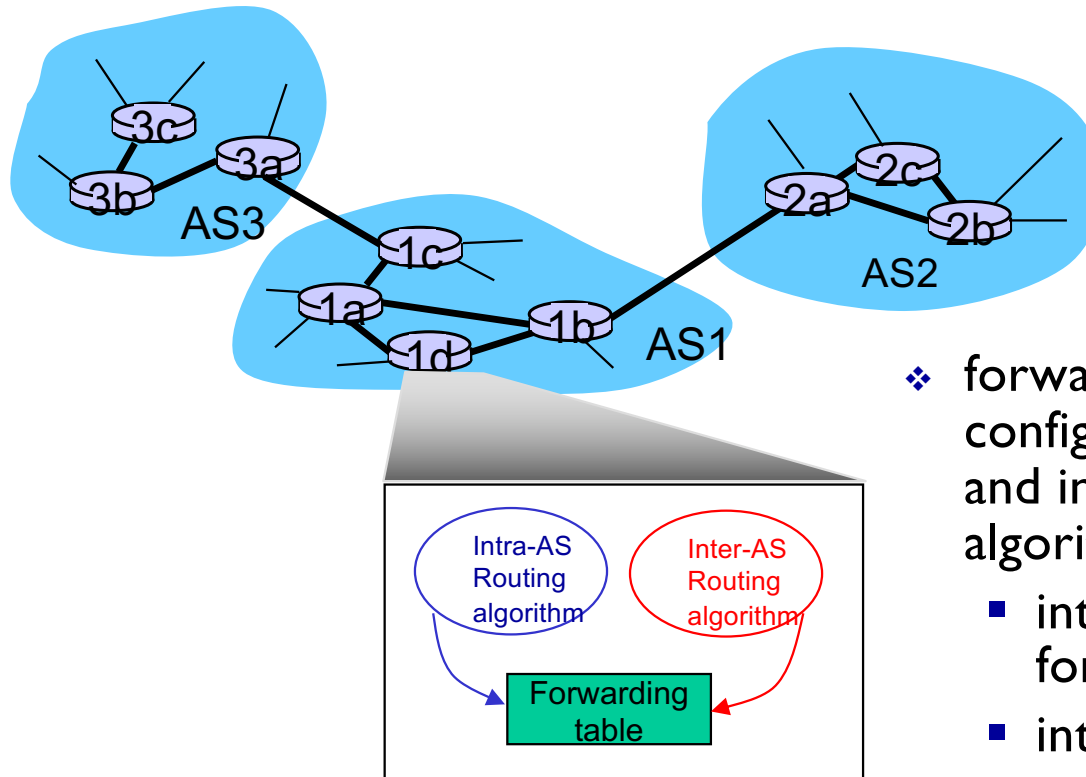 - Path Vector / Path Length / BGP

Hierarchical routing

❖ **aggregate routers into regions, "autonomous systems" (AS)**

❖ **routers in same AS run same routing protocol**

  ▪ **"intra-AS" routing protocol**

  ▪ **routers in different AS can run different intra-AS routing protocol**

gateway router:

❖ at "edge" of its own AS

❖ has link to router in another AS

Interconnected ASes

❖ **forwarding table configured by both intra- and inter-AS routing algorithm**
   - ▪ intra-AS sets entries for internal dests
   - ▪ inter-AS & intra-AS sets entries for external dests

OSPF (Open Shortest Path First)

❖ "open": publicly available

❖ uses link state algorithm
- LS packet dissemination
- topology map at each node
- route computation using Dijkstra's algorithm

❖ OSPF advertisement carries one entry per neighbor

❖ advertisements flooded to *entire* AS
- carried in OSPF messages directly over IP (rather than TCP or UDP

❖ *IS-IS routing* protocol: nearly identical to OSPF

OSPF "advanced" features (not in RIP)

- *security:* all OSPF messages authenticated (to prevent malicious intrusion)

- multiple same-cost paths allowed (only one path in RIP)

- for each link, multiple cost metrics for different TOS (e.g., satellite link cost set "low" for best effort ToS; high for real time ToS)

- integrated uni- and multicast support:
  - Multicast OSPF (MOSPF) uses same topology data base as OSPF
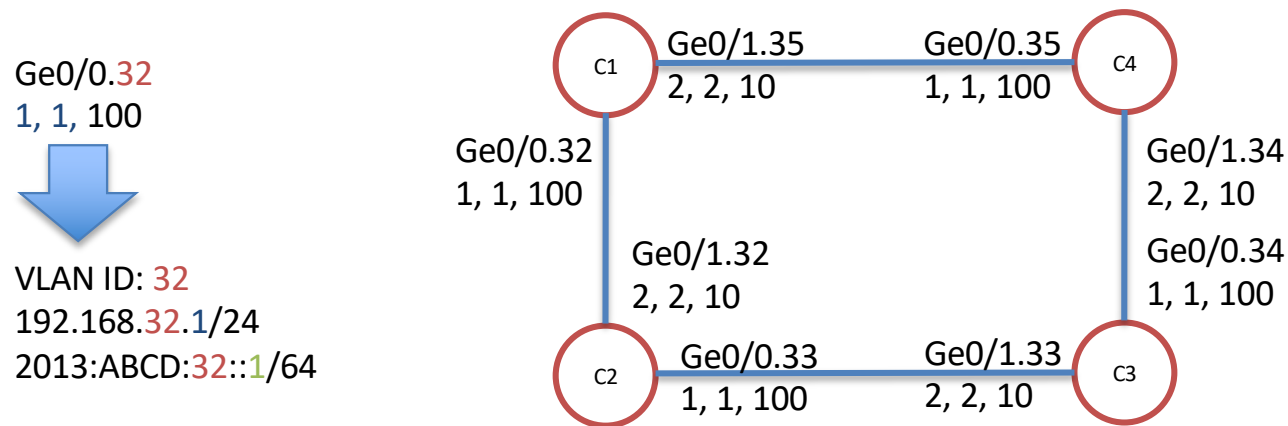
- hierarchical OSPF in large domains.

Hierarchical OSPF

boundary router

backbone router

backbone

area border routers

area 1

area 2

area 3

internal routers
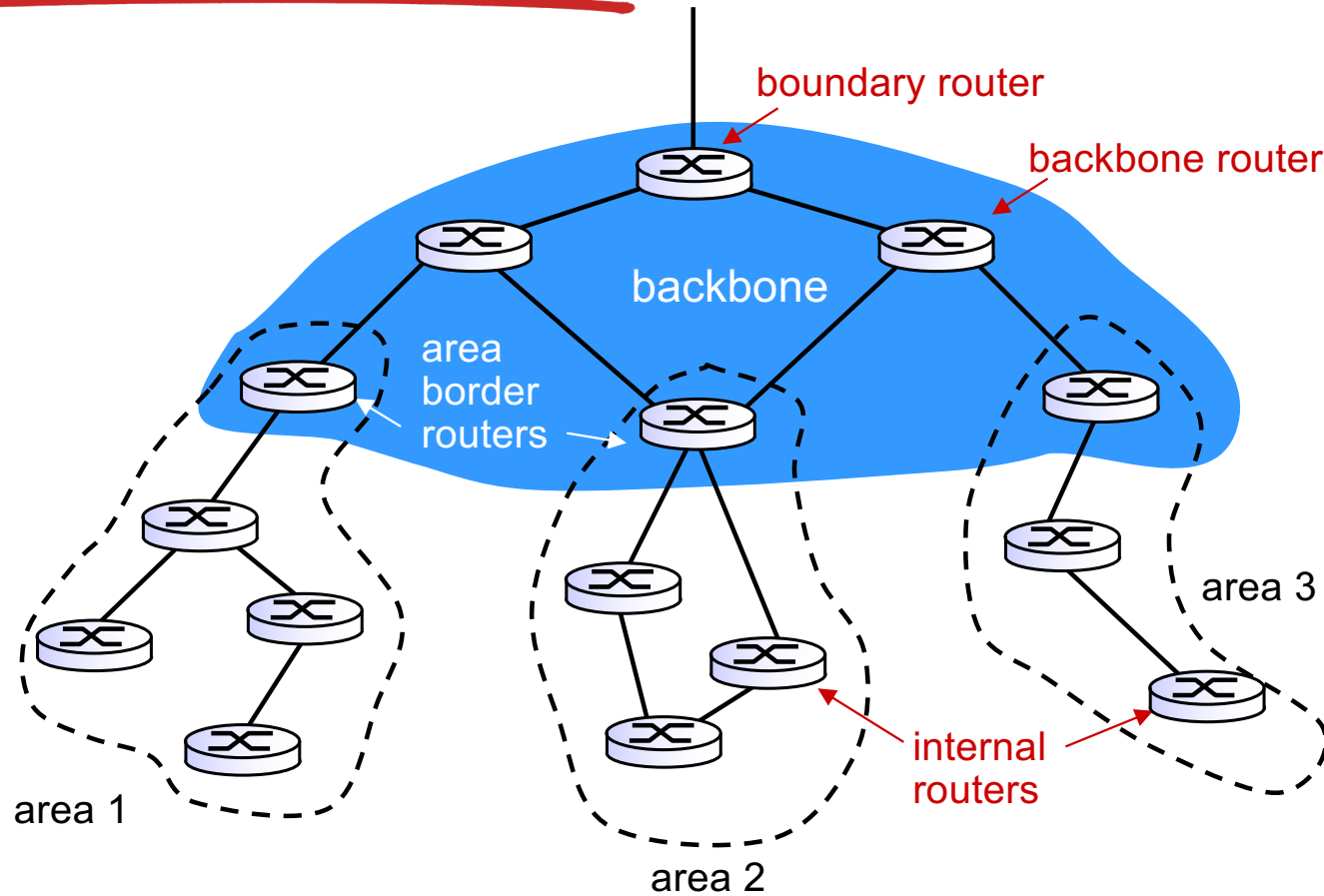
Hierarchical OSPF

- *two-level hierarchy:* local area, backbone.
  - link-state advertisements only in area
  - each nodes has detailed area topology; only know direction (shortest path) to nets in other areas.
- *area border routers:* "summarize" distances to nets in own area, advertise to other Area Border routers.
- *backbone routers:* run OSPF routing limited to backbone.
- *boundary routers:* connect to other AS's.

Configuring OSPF on Cisco Routers

Starting from a Small Network
with Cisco Routers

- Design
  - All networks will join a single area 0 (Backbone)
  - Packets will go clock-wise on the topology
  - In the case of link-down, path will switch to the alternative one

Ge0/0.32
1, 1, 100

↓

VLAN ID: 32
192.168.32.1/24
2013:ABCD:32::1/64

```
        Ge0/1.35        Ge0/0.35
 C1 ─────────────────────────────── C4
        2, 2, 10        1, 1, 100

Ge0/0.32                            Ge0/1.34
1, 1, 100                          2, 2, 10

        Ge0/1.32                    Ge0/0.34
        2, 2, 10                    1, 1, 100

        Ge0/0.33        Ge0/1.33
 C2 ─────────────────────────────── C3
        1, 1, 100       2, 2, 10
```

Basic Configuration

- Configure host name
- Configure NICs
  - Create Virtual I/F and specify VLAN ID
  - Configure IPv4/v6 address
  - No shutdown
- Check that your router can ping to the next routers

Configuring OSPFv2 for IPv4 (1/x)

- Enable OSPF and specifying the prefixes that join to the area 0 (backbone)

```
(config)# router ospf 5113
(config-router)# network 192.168.0.0 0.0.3.255 area 0
(config-router)# network 192.168.4.0 0.0.3.255 area 0
(config-router)# network 192.168.8.0 0.0.3.255 area 0
(config-router)# network 192.168.12.0 0.0.3.255 area 0
(config-router)# network 192.168.32.0 0.0.3.255 area 0
```

Configuring OSPFv2 for IPv4 (2/x)

- Set cost on each I/F
  (to make traffic go clock-wise)

```
(config)# interface GigabitEthernet0/0.32
(config-subif)# ip ospf cost 100
(config-subif)# exit
(config)# interface GigabitEthernet0/1.35
(config-subif)# ip ospf cost 10
(config-subif)# exit
```
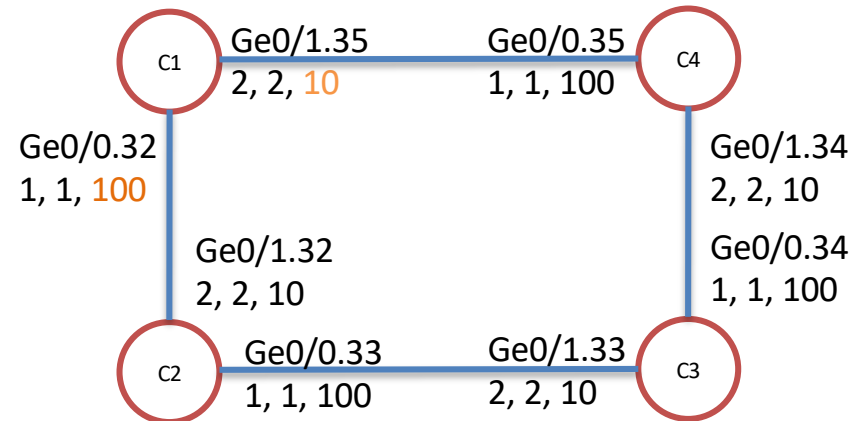
Configuring OSPFv2 for IPv4 (3/x)

- Check the neighbors, Designated Router (DR) and Backup DR

  ```
  # show ip ospf neighbor
  ```

- Check the routing table
  - Which route is learned from OSPF?
  - What are others?

  ```
  # show ip route
  ```

Configuring OSPFv3 for IPv6 (1/x)

- Enable OSPF

  ```
  (config)# ipv6 unicat routing
  ```


- No need to specify the prefixes that join to the specific an area

  ```
  (config)# ipv6 router ospf 5113
  (config-router)# exit
  ```

Configuring OSPFv3 for IPv6 (2/x)

- Set OSPF process, area and cost on each I/F (to make traffic go clock-wise)

```
(config)# interface GigabitEthernet0/0.32
(config-subif)# ipv6 ospf 5113 area 0
(config-subif)# ipv6 ospf cost 100
(config-subif)# exit
(config)# interface GigabitEthernet0/1.35
(config-subif)# ipv6 ospf 5113 area 0
(config-subif)# ipv6 ospf cost 10
(config-subif)# exit
```

C1 ──Ge0/1.35 2, 2, 10 ── Ge0/0.35 1, 1, 100── C4

C1 Ge0/0.32 1, 1, 100

C4 Ge0/1.34 2, 2, 10
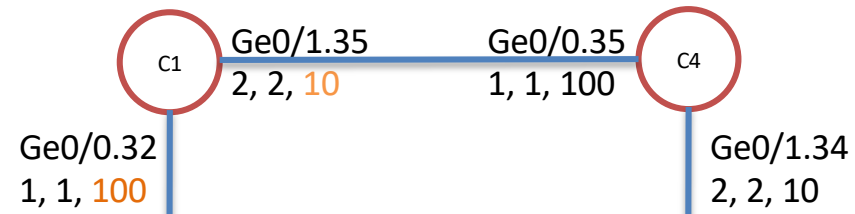
Configuring OSPFv3 for IPv6 (3/x)

- Check the neighbors, Designated Router (DR) and Backup DR

  ```
  # show ipv6 ospf neighbor
  ```

- Check the routing table
  - Which is learned from OSPF?
  - What are others?

  ```
  # show ipv6 route
  ```

Checking OSPF More on Cisco

- show ip protocols
- show ip ospf
- show ip ospf interface
- show ip ospf database self-originate
- show ip route ospf
- show ipv6 protocols
- show ipv6 ospf
- show ipv6 ospf interface
- show ipv6 ospf database self-originate
- and more…

IPv4 Routing Table on Cisco

IPv6 Routing Table on Cisco

Points to Check

- Use traceroute for checking normal path

- What happens if one router is disconnected? How long did it take to recover?

- What happens if you change "Hello Interval" to smaller number on the interface?

Configure OSPF on VyOS Routers

4 Cs + 11 Vs in Area 0

ethX.2
1, 1, 100

For VyOS

VLAN ID: 2
3rd Octet/Group = VLAN ID - 1
192.168.1.1/24
2013:ABCD:1::1/64
OSPF Cosc: 100
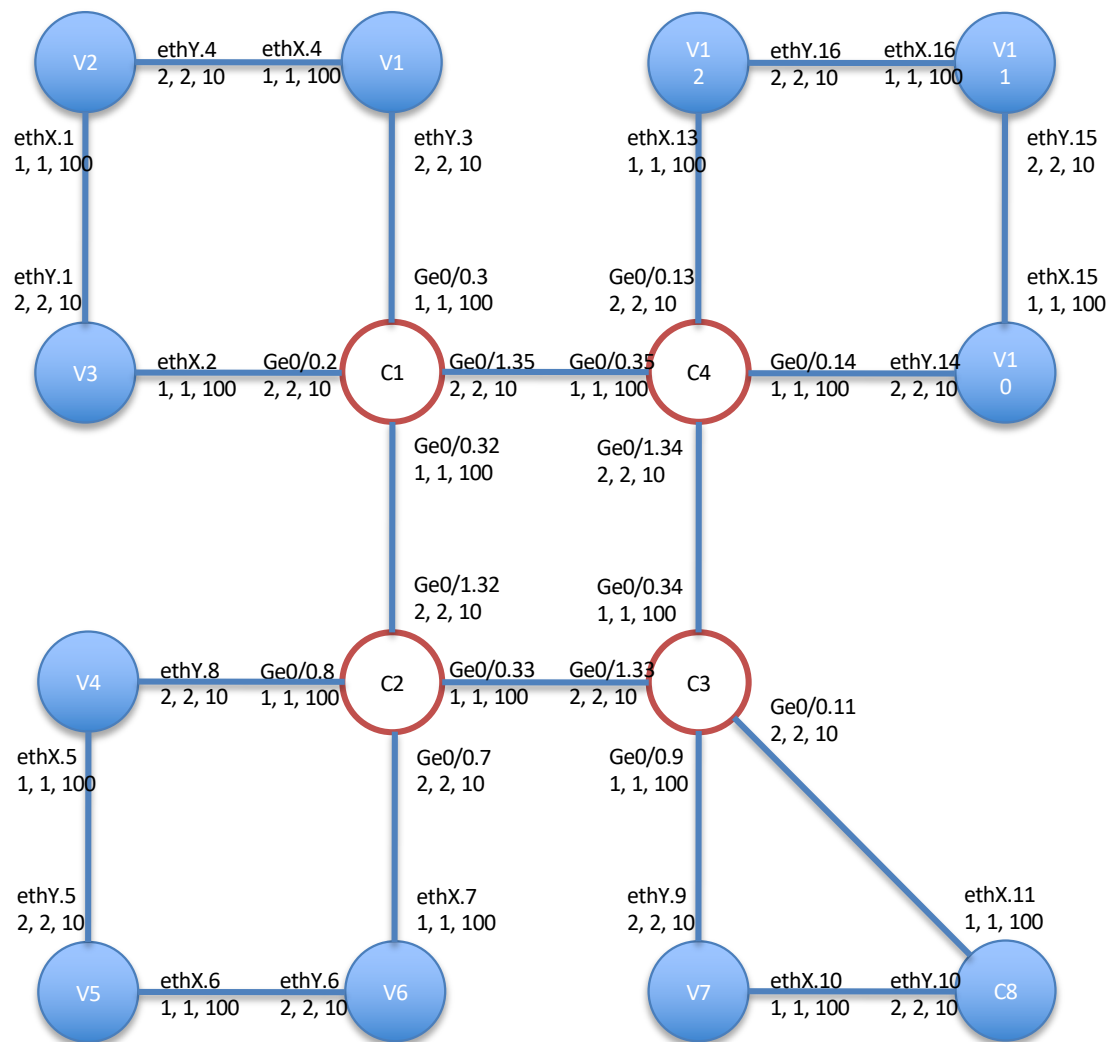
Configuring OSPF for IPv4 (1/x)

- Enable OSPF and specify the prefixes that join to the area 0 (backbone)

```
# set protocols ospf area 0 network 192.168.0.0/22
# set protocols ospf area 0 network 192.168.4.0/22
# set protocols ospf area 0 network 192.168.8.0/22
# set protocols ospf area 0 network 192.168.12.0/22
# set protocols ospf area 0 network 192.168.32.0/22
```

Configuring OSPF for IPv4 (2/x)

- Set cost on each I/F
  (to make traffic go clock-wise)

```
# set interfaces ethernet ethX ip ospf cost 100
# set interfaces ethernet ethY ip ospf cost 10
# commit
# save
```
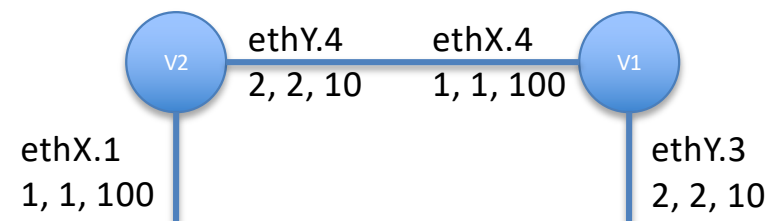
Configuring OSPF for IPv4 (3/x)

- Check the neighbors, Designated Router (DR) and Backup DR

  ```
  $ show ip ospf neighbor
  ```

- Check the routing table
  - Which route is learned from OSPF?
  - What are others?

  ```
  $ show ip route
  ```

- Check the connectivity using ping/traceroute

Configuring OSPF for IPv6 (1/x)

- No need to specify the prefixes that join to the specific an area

- Specify area and interface to speak OSPF

```
# set protocols ospfv3 area 0.0.0.0 interface ethX
# set protocols ospfv3 area 0.0.0.0 interface ethY
# commit
# save
```

Configuring OSPF for IPv6 (2/x)

- Set cost on each I/F (to make traffic go clock-wise)

```
# set interfaces ethernet ethX ipv6 ospfv3 cost 100
# set interfaces ethernet ethY ipv6 ospfv3 cost 10
# commit
# save
```
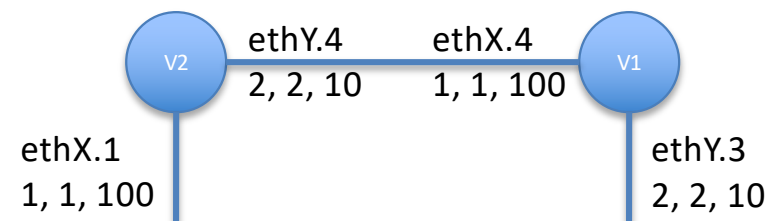
Configuring OSPF for IPv6 (3/x)

- Check the neighbors, Designated Router (DR) and Backup DR

  ```
  $ show ipv6 ospfv3 neighbor
  ```

- Check the routing table
  - Which is learned from OSPF?
  - What are others?

  ```
  $ show ipv6 route
  ```

- Check the connectivity using ping6/traceroute6

Checking OSPF More on VyOS

- show ip ospf interface
- show ip ospf database self-originated
- show ip ospf route
- show ipv6 ospfv3 interface
- show ipv6 ospfv3 linkstate
- show ipv6 ospfv3 database self-originated
- show ipv6 ospfv3 route
- and more…

IPv4 Routing Table on VyOS

IPv6 Routing Table on VyOS