Lecture 4 – Dynamic Routing Protocols (RIP &OSPF)

CPSC 456 Network Security Fundamentals

Routing Fundamentals:

- Forwards Traffic between subnets, between an internal and external network, or between two external networks.
- Each Subnet or external network is going to be its own broadcast domain.
- Multilayer switches also perform routing functions

Dynamic Routing Overview

What is Dynamic Routing?

- Adaptive in available routing changes; Network devices can be added, removed, and/or fail.

- Simplify network configurations;

- Scalable with much less overhead than static routing

What is Administrative Distance?

- The administrative distance (AD) is used by a router in its decision-making over how to route a specific traffic. AD simply means how believable such route can be. The lower the AD number, the better route it will be from the router's point of view.

Dynamic Routing Overview

Routing Source	Administrative Distance
Connected	0
Static	1 (by default)
EIGRP	90
OSPF	110
RIP	120

```
R1#
R1#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 10.1.1.2 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 10.1.1.2
      10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C        10.1.1.0/24 is directly connected, GigabitEthernet0/2
L        10.1.1.1/32 is directly connected, GigabitEthernet0/2
S        10.2.2.0/24 [1/0] via 10.1.1.2
      172.16.0.0/24 is subnetted, 1 subnets
D        172.16.1.0 [90/3072] via 10.1.1.2, 00:05:13, GigabitEthernet0/2
      192.168.1.0/32 is subnetted, 1 subnets
O        192.168.1.1 [110/2] via 10.1.1.2, 00:05:24, GigabitEthernet0/2
R1#
```

Dynamic Routing Overview

Types of Dynamic Routing

- Distance Vector Routing: Each router computes distance from itself to its next immediate neighbors. (RIP, EIGRP, & BGP)

  - Does not build a full map of the network
  - Focuses more on the next hop towards the destination

  «Vector» « Distance »
  Which way to the destination network

- Link State Routing: Each router shares knowledge of its neighbors with every other router in the network. (OSPF and IS-IS)

  - Builds a full map of the network
  - Each router shares information

Dynamic Routing: Routing Information Protocol

What is RIP?

- Shares routing information with neighboring routers
- An interior gateway protocol that operates *within* autonomous system (AS)
- Oldest of all dynamic routing protocols; RIPv1 (classful), RIPv2 (classless)
- Widely used open standard developed by IETF (RFCs 1058, 1388, 1723, 2453, and 4822)
- A distance vector routing protocol
- Limited to maximum 15 hops; The 16th hop advertisement

Dynamic Routing: RIP Implementation

How RIP works?

- Rip sends regular update message (advertisements) to neighboring routers)
  - Every 30 seconds that resets after each successful advertisement
  - A route becomes invalid if it has not received a message for 180 seconds. Flush timer is 240 Sec (4 min)
  - RIPv1 (obsolete) uses broadcast, while RIPv2 uses a multicast address (224.0.0.9)
  - Update message only travel to a single hop
  - NO support for VLSM(Variable Length Subnet Mask)

Dynamic Routing: RIP Implementation

RIP v2 :

- Uses Multicasting for advertisement
- Allows classless subnet masks
- Authentication Supported
- Does not support IPv6 Routing (Only IPv4) > RIPng(IPv6)
- Chooses the best route best on hop counts
- RIP is based on Hop Count Matrix (No intelligence to bandwidth)

Dynamic Routing: RIP Implementation

RIP v2 :

- Slow Convergence: If any of the link goes down it should quickly choose an alternate route but in RIP it takes long time.

- Less Administrative distance (AD) is 120. The less AD value is more reliable but the RIP has the highest AD Value and its not as reliable as other routing protocols.

Dynamic Routing: RIP Implementation

Advantages of RIP:

- Easy to configure
- No complexity
- Less CPU Utilization

Dynamic Routing: Open Shortest Path First

What is OSPF?

- An interior gateway protocol that operates *within* autonomous system (AS) to build a full map of the network

- Widely used open standard developed by IETF (RFCs 2328, 5709, 6549, 6845, 6860, 7474, and 8042)

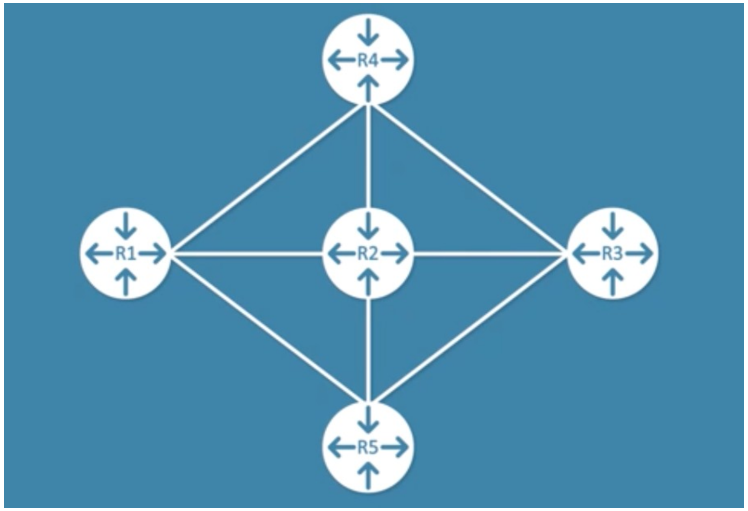
- A link state routing protocol

Dynamic Routing: Open Shortest Path First

What is a Link-State Advertisements (LSA)?

- LSA contains data about a router, its subnets and some other network information.
- OSPF puts all the LSAs from different routers into a Link-State Database (LSDB).

The goal of OSPF is to be able to determine a complete map of the interior routing path to be able to create the best route possible. The way this is done is that OSPF finds all the routers and subnets that that can be reached within the entire network. The result is that each router will have the same information (LSDB) about the network by sending out LSA.



Dynamic Routing: OSPF Implementation

How does OSPF create a map of the entire network?

Step 1: Acquire neighbor relationship to exchange network information

e.g., two routers running OSPF on the same link agree to form a neighboring relationship

Step 2: Exchange database information - *i.e.,* Neighboring routers swap LSDB information with each other

Step 3: Choosing the best routes – each router chooses the best routes to add to its routing table based on the learned LSDB information

Dynamic Routing: OSPF Implementation - Step 1

Step 1: Become neighbor routers - two routers running OSPF on the same link agree to form a neighbor relationship

i. Manually set router to higher priority (all routers have priority of 1 by default)

ii. Manually set the Router ID
Each router chooses a router ID (RID) to identify itself in OSFP. RID is in the format of IPv4. RID is determine in the following order:

e.g.
```
R1(config)#router ospf 1
R1(config-router)#router-id 1.1.1.1
```

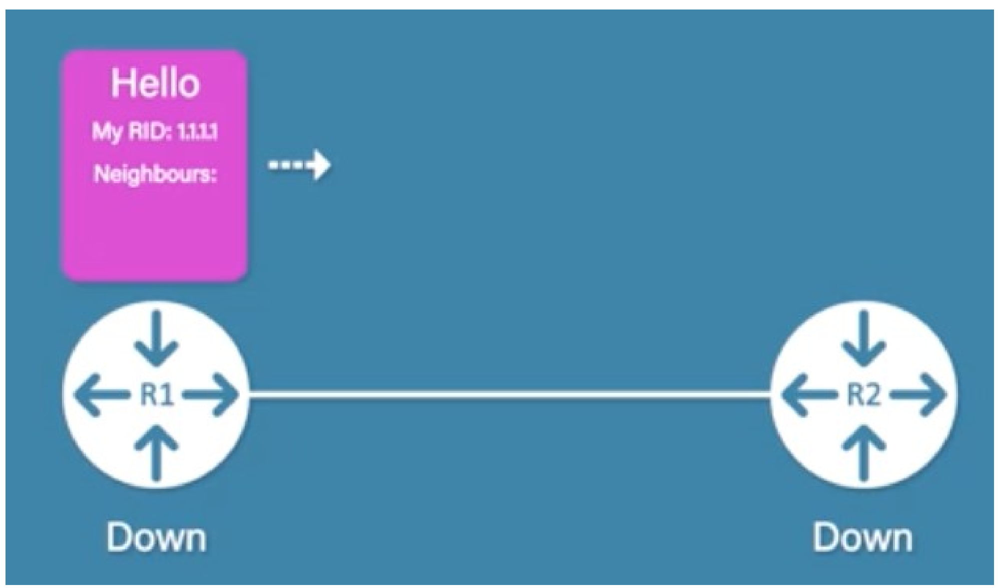
iii. Set by choosing "the highest 'up' status loopback interface IP address"

iv. Set by choosing "the highest 'up' status non-loopback interface IP address"

Dynamic Routing: OSPF Implementation – Step 1

Step 1: Become neighbor routers - two routers running OSPF on the same link agree to form a neighbor relationship

(a) A neighbor sends out a Hello packet including the router ID along with subnets that it routes to the given multicast address (224.0.0.x) to a given OSPF area ID (grouped neighboring routers). This is also a way for routers to tell their neighbors that they are still on and good to go.

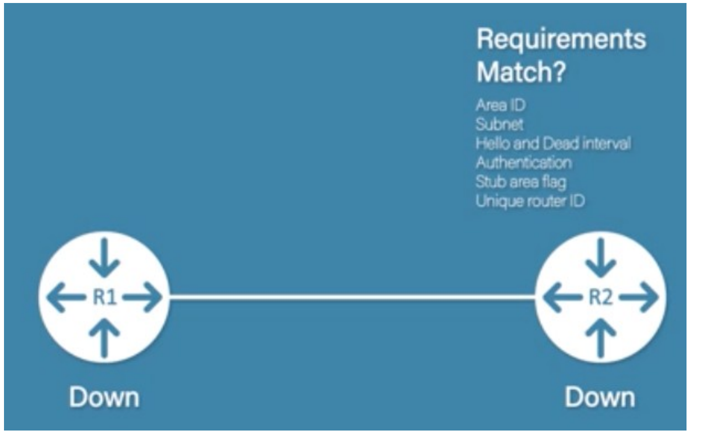


Dynamic Routing: OSPF Implementation - Step 1

Step 1: Become neighbor routers - two routers running OSPF on the same link agree to form a neighbor relationship

(b) Once other routers receives this packet, they run some checks. The neighboring routers must match the following requirements:

- **Area ID** needs to be the same (also used when scaling up OSPF)
- The shared or connecting link should be on the same subnet
- The Hello and Dead timer must be the same
  - the dead timer is having enough time before the sending router assumes that the neighbor is down
  - this timer is typically 10 secs for point-to-point and broadcast networks

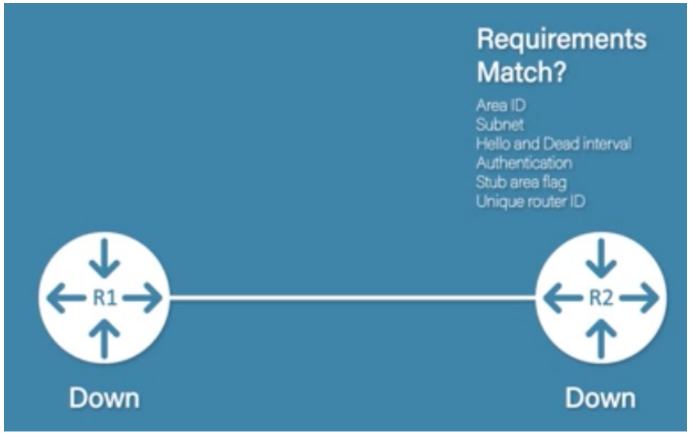


Dynamic Routing: OSPF Implementation – Step 1

Step 1: Become neighbor routers - two routers running OSPF on the same link agree to form a neighbor relationship

(b) Once other routers receives this packet, they run some checks. The neighboring routers must match the following requirements:

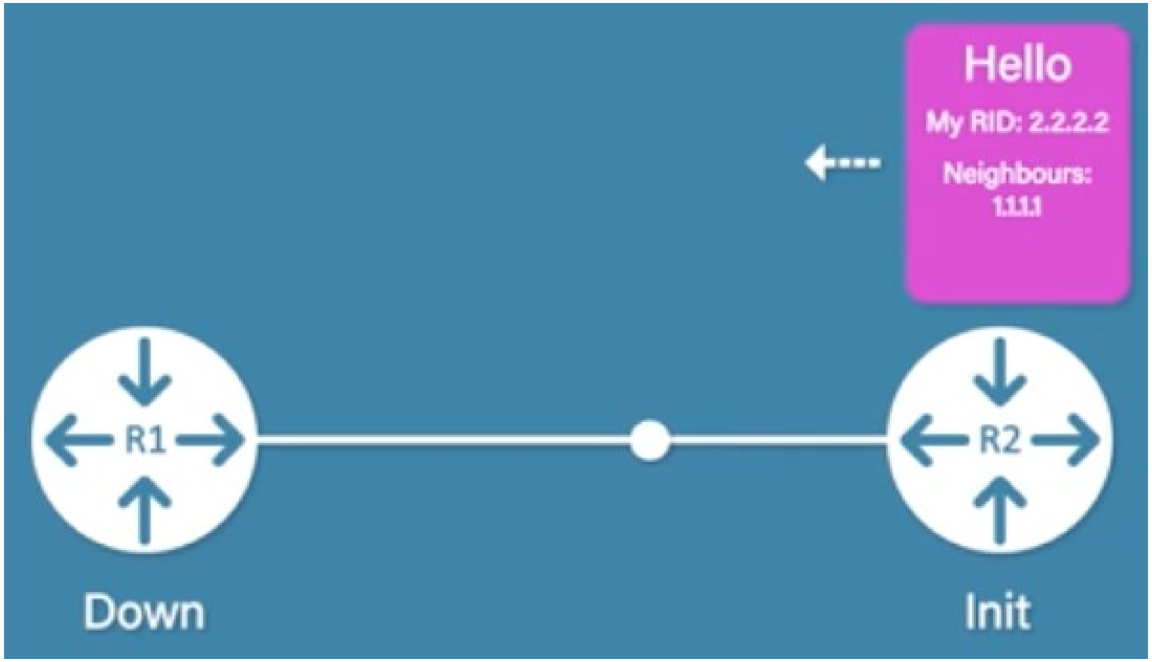
- If using authentication, must be consistently matched
- Stub area flag must be the same
  - A **stub area** is an **area** in which you do not allow advertisements of external routes, which thus reduces the size of the database even more.
- Each router must have unique RID



Dynamic Routing: OSPF Implementation - Step 1

Step 1: Become neighbor routers

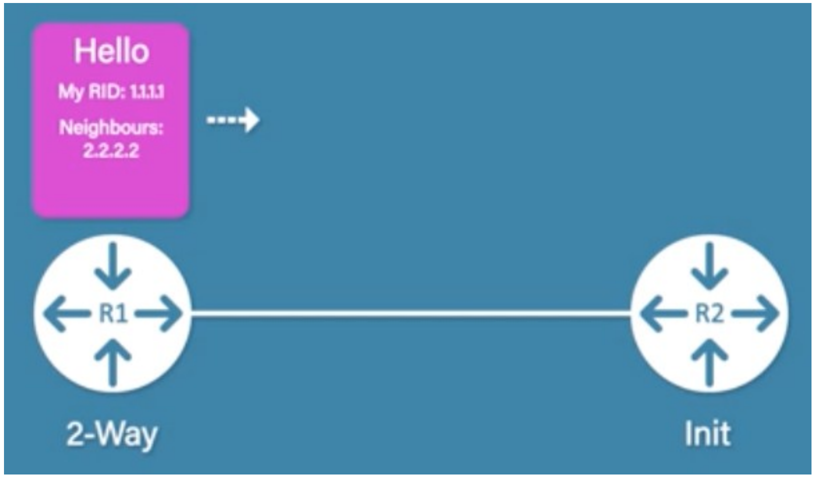
(c) If all is fine, the receiving router will go into Init stage and sends a Hello message of its own. This Hello packet list its own network info along with the known neighbor R1 (1.1.1.1). This puts R1 now into a 2-way communication status.



Dynamic Routing: OSPF Implementation – Step 1

Step 1: Become neighbor routers - two routers running OSPF on the same link agree to form a neighbor relationship

(d) R1 sends another Hello message to R2 with the information as a known neighbor. This allows the R2 now with a 2-way communication status as well.



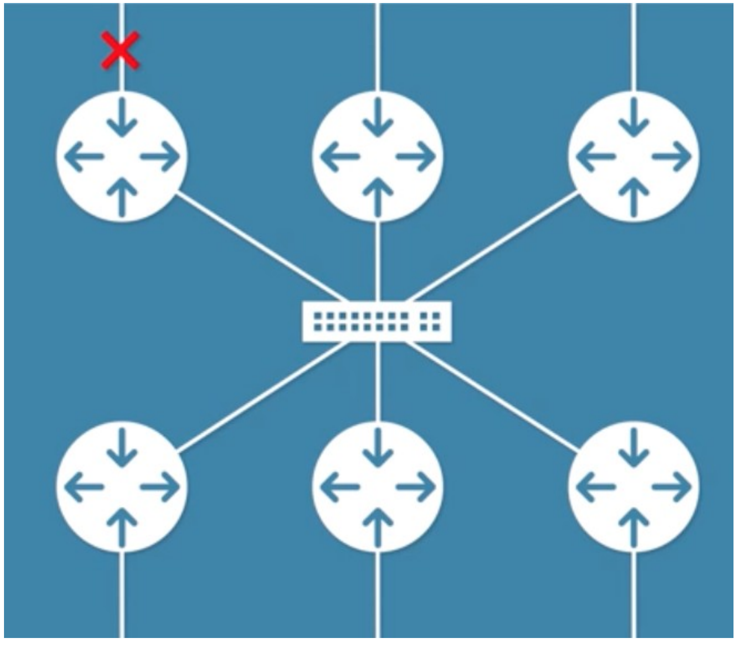
(e) We now have a 2-way neighboring routers

Dynamic Routing: OSPF Implementation – Step 2

Step 2: Exchange of database information as the neighbor routers swap their LSDB info with each other.

OSPF uses a **DR** (Designated Router) and **BDR** (Backup Designated Router) on each multi-access network.

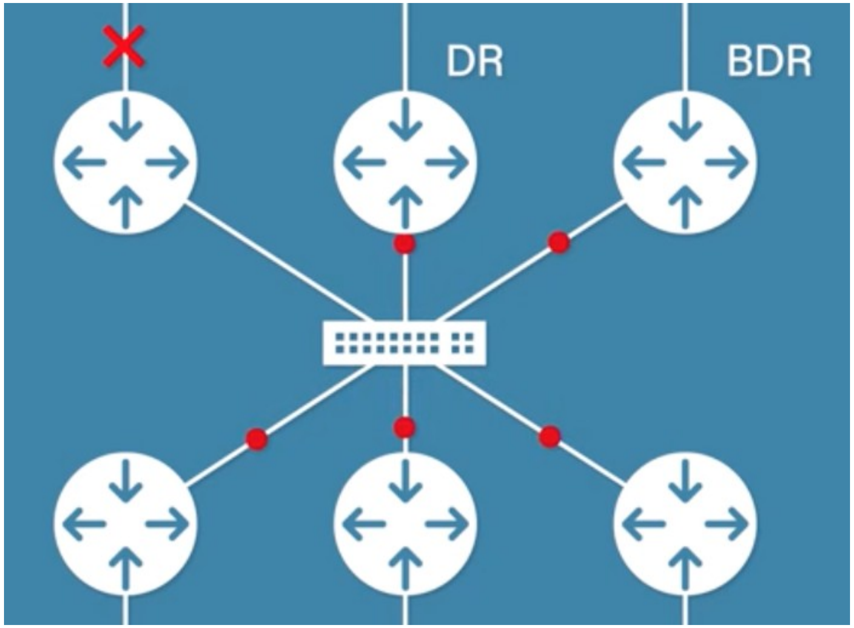
Without DR or BDR, all routers in the same broadcast domain will send LSA. If one link goes down, the affected router will send an update to all other routers about this. And each receiving router will then tell all the other neighbors which already received the same update. This can happen each time a change in the routing topology occurs.



Dynamic Routing: OSPF Implementation – Step 2

Step 2: Exchange of database information as the neighbor routers swap their LSDB info with each other.

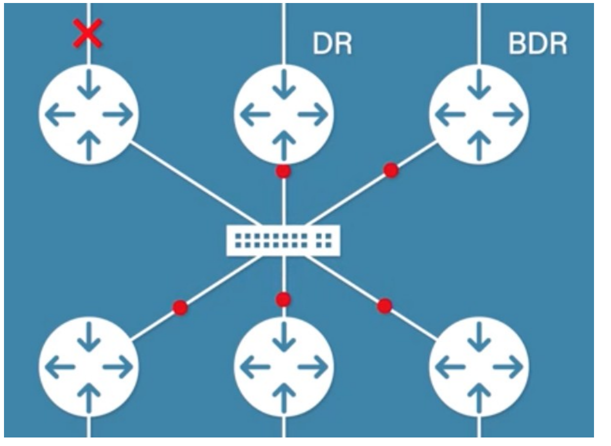
Instead, a DR and BDR are elected. The elected is done by picking the highest OSPF priority. The priority is to 1 by default. This can be changed to influence the election. If two routers are tied, then router with the higher RID is elected. When in the same segment, routers can only be full neighbors with DR and BDR. The other routers will only be in a 2-way neighbor relationship.



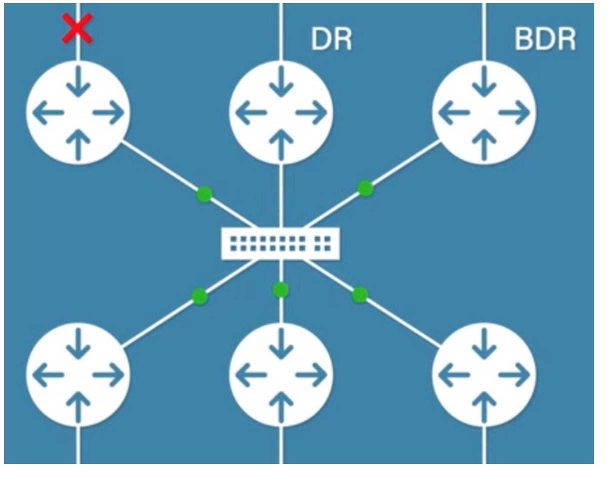
Dynamic Routing: OSPF Implementation – Step 2

Step 2: Exchange of database information as the neighbor routers swap their LSDB info with each other.

With DR/BDR, when a change occurs, all the other non- DR/BDR routers will ignore the update.



The DR resends the update from the affected router to all other routers



Dynamic Routing: OSPF Implementation – Step 2

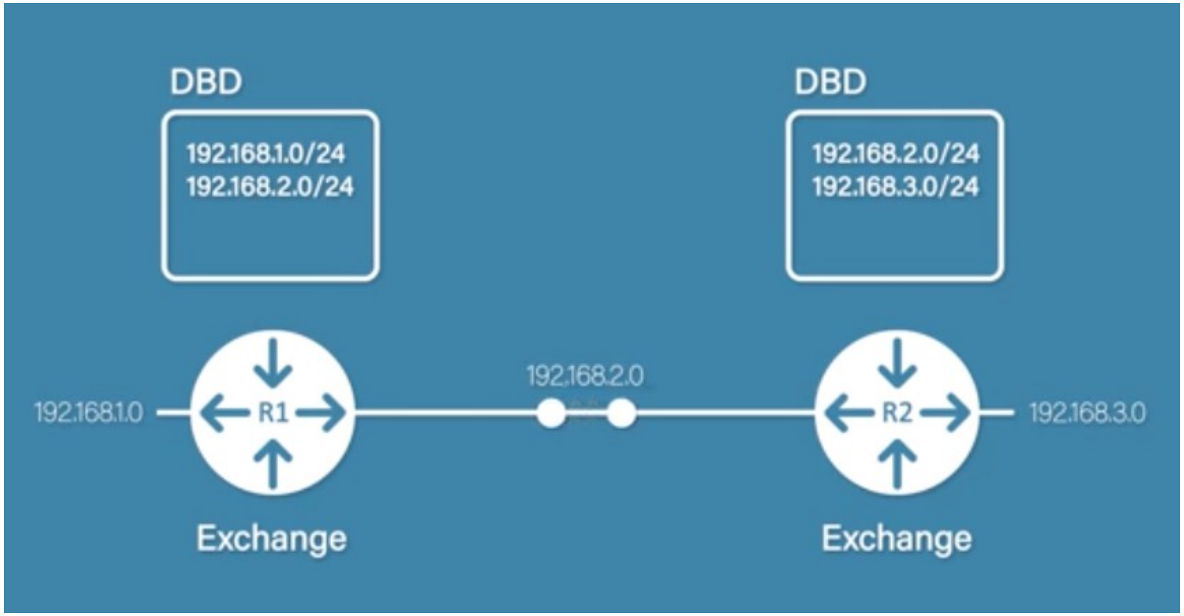
Step 2: Exchange of database information as the neighbor routers swap their LSDB info with each other.

(a) Once 2-way neighboring relationship is established, both routers will enter the Exstart state. At this point, the routers select a master and slave, this is based on the RID. The master will control the sequence numbers and start the exchange process.

Dynamic Routing: OSPF Implementation – Step 2

Step 2: Exchange of database information as the neighbor routers swap their LSDB info with each other.

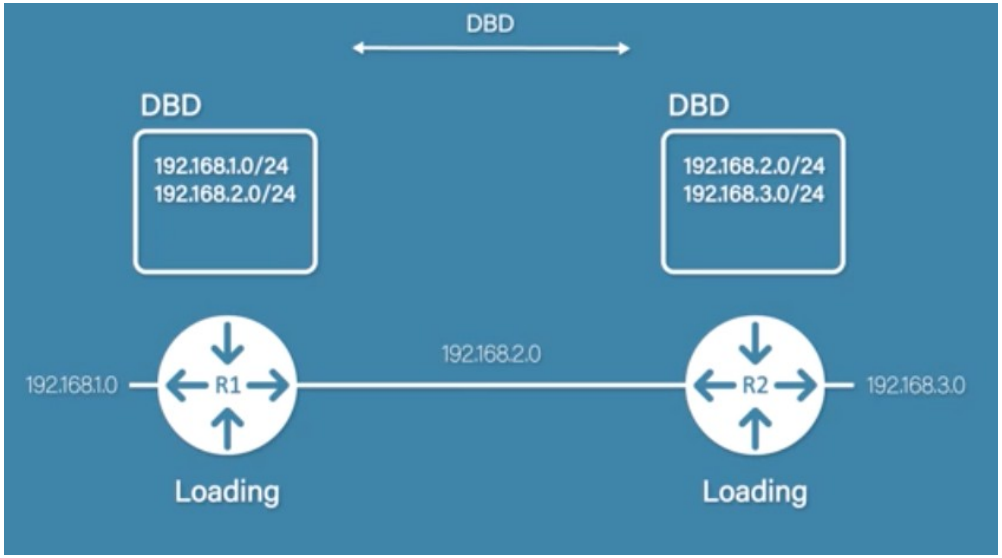
(b) The routers go into the exchange state to starting exchanging LSAs which is called a Database Description (DBD). Let's look at the following LSA Exchange



Dynamic Routing: OSPF Implementation – Step 2

Step 2: Exchange of database information as the neighbor routers swap their LSDB info with each other.

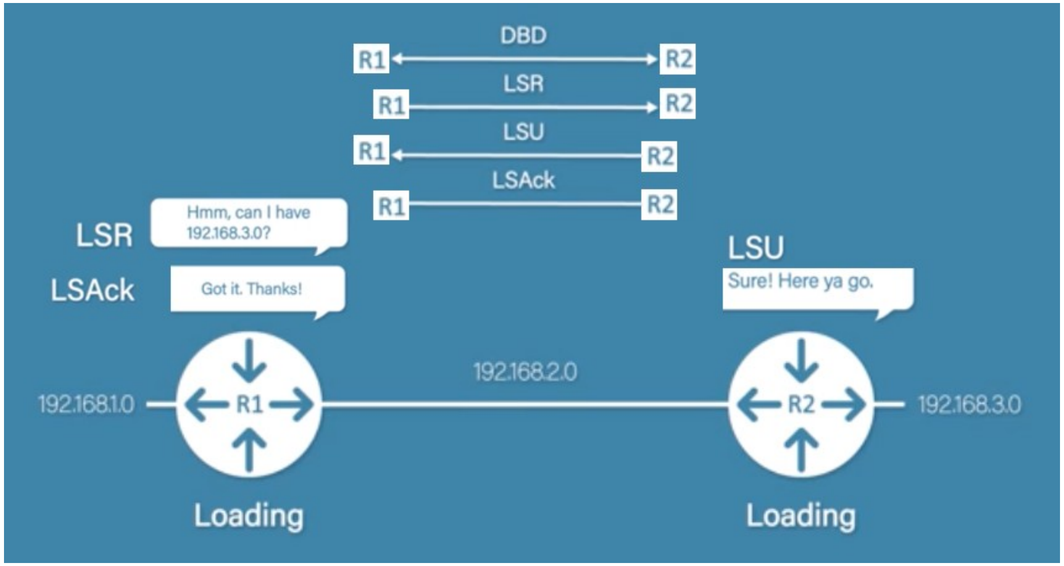
(c) Once over the Loading state, each router will look at the its DBD and request any information that does not already have. The reason for the pull (request) method, rather than push method, is to prevent routes by requiring routers to request info than sending out updates



Dynamic Routing: OSPF Implementation – Step 2

Step 2: Exchange of database information as the neighbor routers swap their LSDB info with each other.

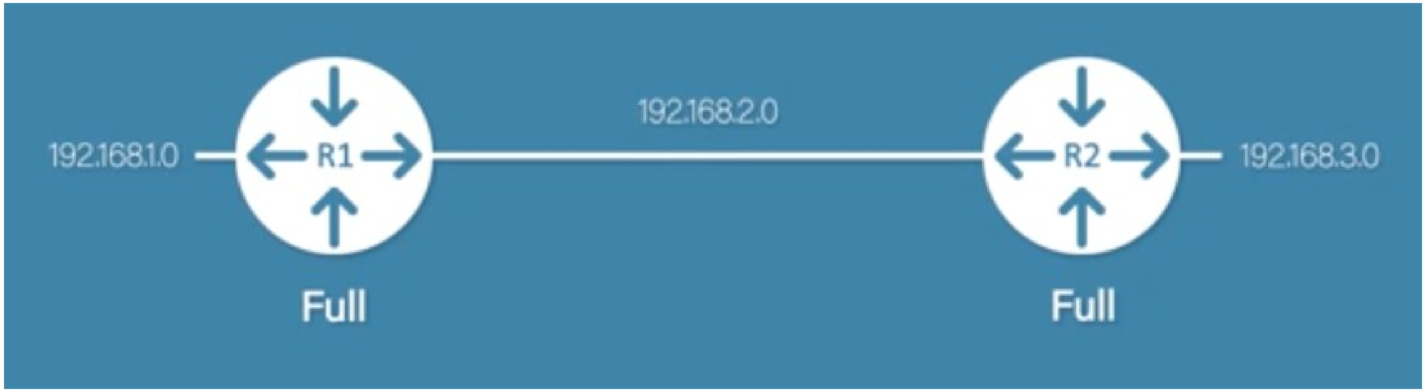
(d) For example, R1 sees that R2 has a route to reach the network 192.168.3.0/24. R1 asks this by sending a LSR (link-state request) packet to R2 for that information. R2 in turn sends an LSU (link-state update) packet to R1. Upon receiving an LSU, R1 confirms and sends back an LSAck packet to R2.



Dynamic Routing: OSPF Implementation – Step 2

Step 2: Exchange of database information as the neighbor routers swap their LSDB info with each other.

(e) Likewise, R2 sees that it does not have a routing to 192.168.1.0 on its DBD found in R1. R2 does what R1 did to request such update from R1. When that is done, both routers become full neighbor state. Now this is a point-to-point network. On a broadcast, full neighbor relationships are only formed using the DR and BDR.



Dynamic Routing: OSPF Implementation – Step 3

Step 3: Choosing the best routes – each router chooses the best routes to add to its routing table based on the learned LSDB information

(a) Adding the best route to the routing table based on the bandwidth of the specified link. The overall minimum cost would be added to the routing table as the best path to that network.

Cost Calculation

Reference bandwidth / Interface bandwidth
Default ref bandwidth 100,000 Kbps

Interface	Default Bandwidth	Cost
Serial	1,544 Kbps	64
Ethernet	10,000 Kbps	10
FastEthernet	100,000 Kbps	1

Dynamic Routing: OSPF Implementation – Step 3

Step 3: Choosing the best routes – each router chooses the best routes to add to its routing table based on the learned LSDB information

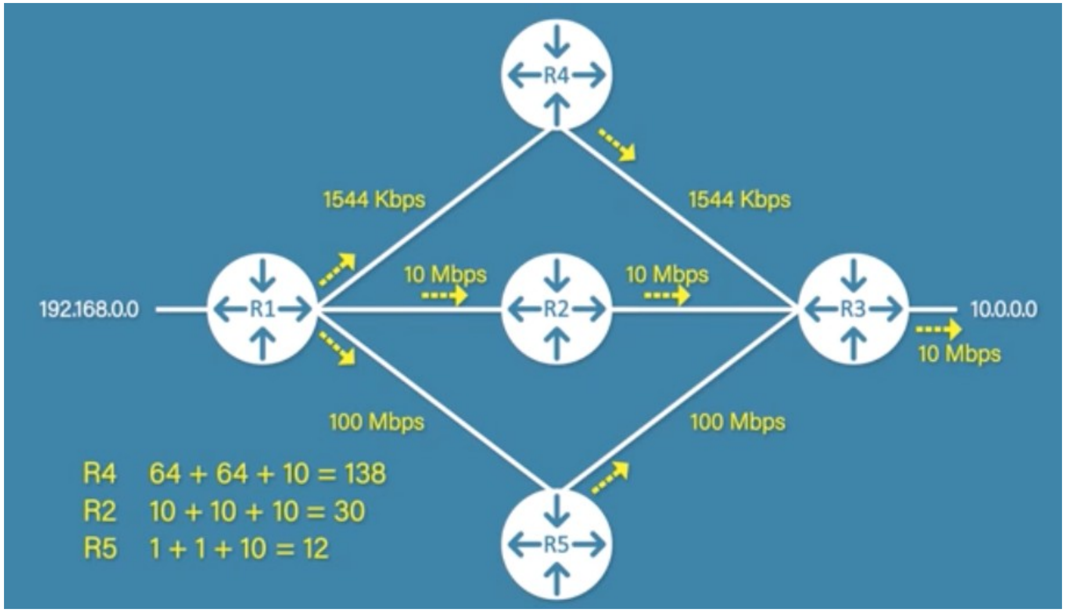
Example:

The 3 possible paths out of R1 to 10.0.0.0 network are through:

R4 => 138

R2 => 30

R5 => 12



As a result, R1's routing table would add R1->R5->R3-10.0.0.0 with a total cost of only 12

References

- CCNA 200-301 Official Cert Guide Library by Wendell Odom
- CCNA 200-301 by Kevin Wallace
- Some content based on the presentation by CertBros