OSPF & DHCP

Jirasak Sittigorn
Internetworking Standards & Technologies
Department of Computer Engineering, Faculty of Engineering
King Mongkut's Institute of Technology Ladkrabang

Cisco Networking Academy®
Mind Wide Open™

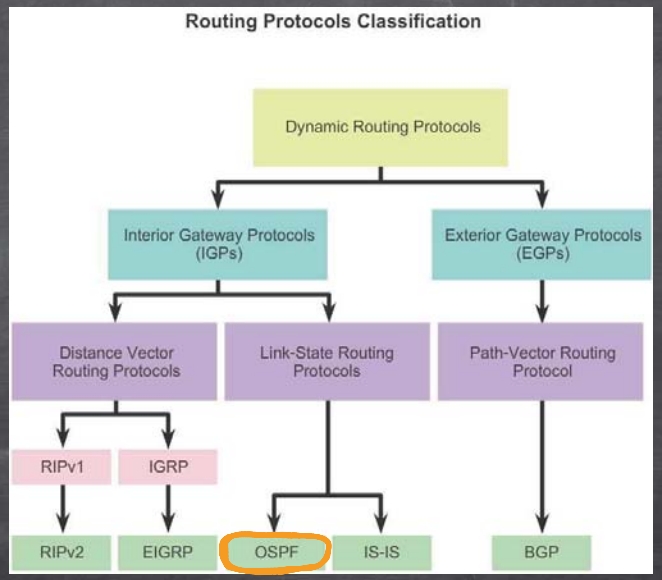
OSPF

- Link-State Routing Protocol & OSPF
- OSPF Messages
- OSPF Operation
- Configuring Single-Area OSPFv2
- Verify OSPF

DHCP

- DHCPv4 Operation
- Configuring a DHCPv4 Server
- DHCPv4 Relay
- Configuring a DHCPv4 client
- Troubleshoot DHCPv4

Link-State Routing Protocol



Link-State Routing Protocol

- A link-state routing protocol is like having a complete map of the network topology.
- The sign posts along the way from source to destination are not necessary, because all link-state routers are using an identical map of the network.
- A link-state router uses the link-state information to create a topology map and to select the best path to all destination networks in the topology.

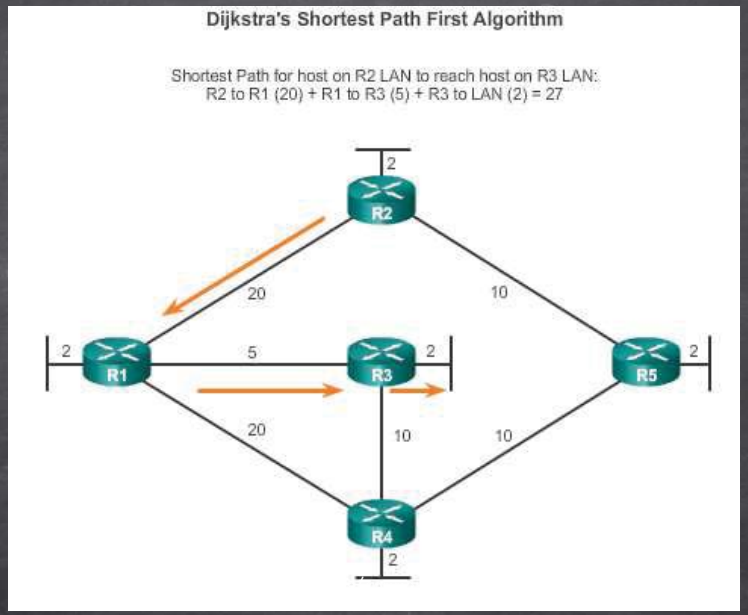
Link-State Routing Protocol

- Link-state protocols work best in situations where:
  - The network design is hierarchical, usually occurring in large networks
  - Fast convergence of the network is crucial
  - The administrators have good knowledge of the implemented link-state routing protocol
- There are two link-state IPv4 IGPs:
  - OSPF - Popular standards based routing protocol
  - IS-IS - Popular in provider networks

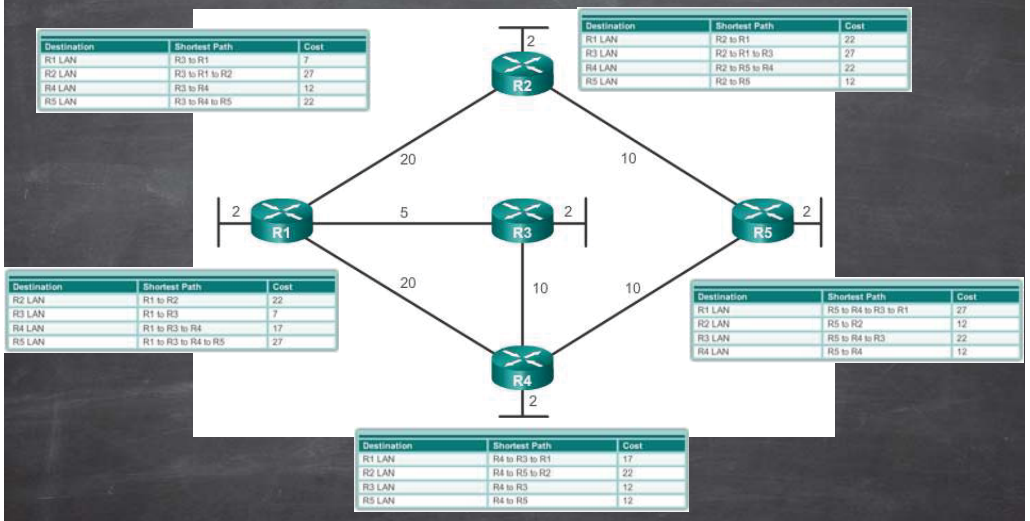
Link-State Routing Protocol

- All link-state routing protocols apply Dijkstra's algorithm to calculate the best path route.
- The algorithm is commonly referred to as the shortest path first (SPF) algorithm.
- This algorithm uses accumulated costs along each path, from source to destination, to determine the total cost of a route.

Link-State Routing Protocol



Link-State Routing Protocol



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Link-State Routing Protocol

- Link-State Updates

Link-State Routing Process

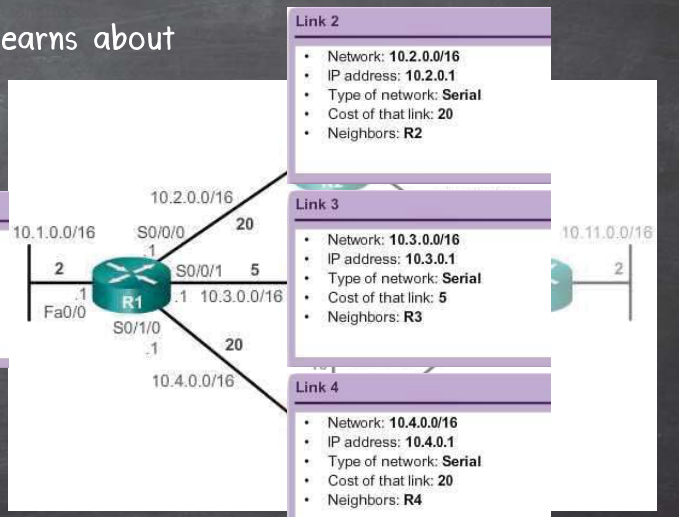
- Each router learns about each of its own directly connected networks.
- Each router is responsible for "saying hello" to its neighbors on directly connected networks.
- Each router builds a Link-State Packet (LSP) containing the state of each directly connected link.
- Each router floods the LSP to all neighbors who then store all LSP's received in a database.
- Each router uses the database to construct a complete map of the topology and computes the best path to each destination network.

Link & Link-State
Say Hello
Building the Link-State Packet
Flooding LSP & Building Database
Building the SPF Tree & Routing Table

4.1

Link-State Routing Protocol

- Link & Link-State
  - Each router learns about its own links



Link & Link-State
Say Hello
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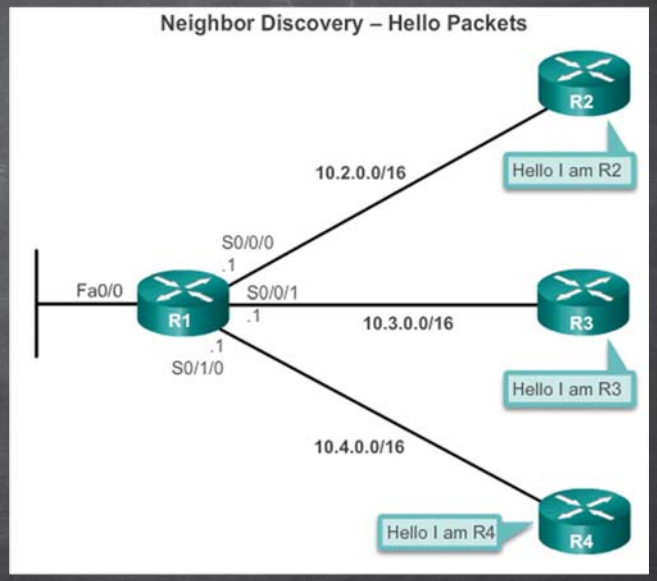
4.2

Link-State Routing Protocol

- Say Hello
  - Exchanging Hello packets with other link-state routers



Link & Link-State
Say Hello
Building the Link-State Packet
Flooding LSP & Building Database
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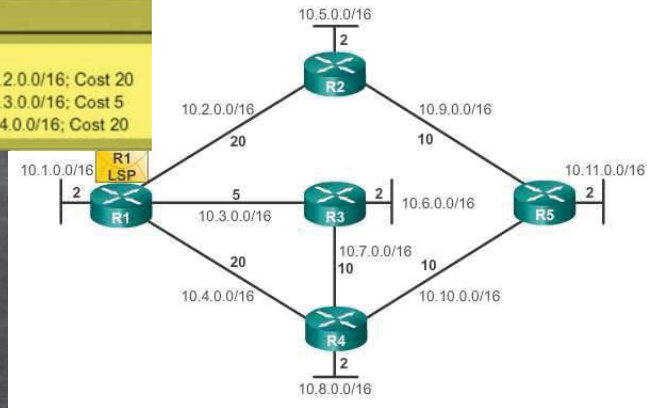
4.3

Link-State Routing Protocol

- Building the Link-State Packet (LSP)

R1 Link State Contents

- R1; Ethernet network; 10.1.0.0/16; Cost 2
- R1 -> R2; Serial point-to-point network; 10.2.0.0/16; Cost 20
- R1 -> R3; Serial point-to-point network; 10.3.0.0/16; Cost 5
- R1 -> R4; Serial point-to-point network; 10.4.0.0/16; Cost 20



Link & Link-State
Say Hello
Building the Link-State Packet
Flooding LSP & Building Database
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4.4

Link-State Routing Protocol

- Flooding the LSP
- Building the Link-State Database ทาม link st pk กาน ก็จะสร้าง DB

R1 Link-State Database

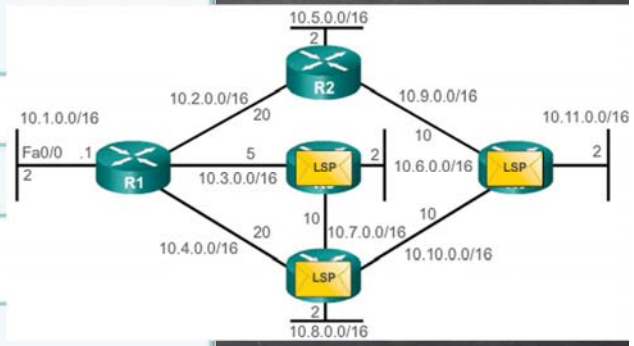
R1 Link-states:
- Connected to network 10.1.0.0/16, cost = 2
- Connected to R2 on network 10.2.0.0/16, cost = 20
- Connected to R3 on network 10.3.0.0/16, cost = 5
- Connected to R4 on network 10.4.0.0/16, cost = 20

R2 Link-states:
- Connected to network 10.5.0.0/16, cost = 2
- Connected to R1 on network 10.2.0.0/16, cost = 20
- Connected to R5 on network 10.9.0.0/16, cost = 10

R3 Link-states:
- Connected to network 10.6.0.0/16, cost = 2
- Connected to R1 on network 10.3.0.0/16, cost = 5
- Connected to R4 on network 10.7.0.0/16, cost = 10

R4 Link-states:
- Connected to network 10.8.0.0/16, cost = 2
- Connected to R1 on network 10.4.0.0/16, cost = 20
- Connected to R3 on network 10.7.0.0/16, cost = 10
- Connected to R5 on network 10.10.0.0/16, cost = 10

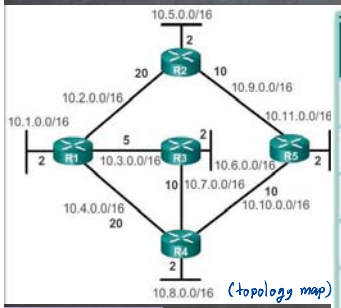
R5 Link-states:
- Connected to network 10.11.0.0/16, cost = 2
- Connected to R2 on network 10.9.0.0/16, cost = 10
- Connected to R4 on network 10.10.0.0/16, cost = 10



4.5

Link-State Routing Protocol

- Building the SPF Tree
- Adding OSPF Routes to the Routing Table



(topology map)

Destination	Shortest Path	Cost
10.5.0.0/16	R1 → R2	22
10.6.0.0/16	R1 → R3	7
10.7.0.0/16	R1 → R3	15
10.8.0.0/16	R1 → R3 → R4	17
10.9.0.0/16	R1 → R2	30
10.10.0.0/16	R1 → R3 → R4	25
10.11.0.0/16	R1 → R3 → R4 → R5	27

R1 Routing Table

Directly Connected Networks
- 10.1.0.0/16 Directly Connected Network
- 10.2.0.0/16 Directly Connected Network
- 10.3.0.0/16 Directly Connected Network
- 10.4.0.0/16 Directly Connected Network

Remote Networks
- 10.5.0.0/16 via R2 serial 0/0/0, cost = 22
- 10.6.0.0/16 via R3 serial 0/0/1, cost = 7
- 10.7.0.0/16 via R3 serial 0/0/1, cost = 15
- 10.8.0.0/16 via R3 serial 0/0/1, cost = 17
- 10.9.0.0/16 via R2 serial 0/0/0, cost = 30
- 10.10.0.0/16 via R3 serial 0/0/1, cost = 25
- 10.11.0.0/16 via R3 serial 0/0/1, cost = 27

Link & Link-State
Say Hello
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5 ดีแลัย

Link-State Routing Protocol

Advantages of Link-State Routing Protocols

- Each router builds its own topological map of the network to determine the shortest path. (มี complete)
- Immediate flooding of LSPs achieves faster convergence.
- LSPs are sent only when there is a change in the topology and contain only the information regarding that change.
- Hierarchical design used when implementing multiple areas. (ถ้ามาก เป็น area ๆ)

Disadvantages of Link-State Routing Protocols

- Maintaining a link-state database and SPF tree requires additional memory. (mem ที่เก็บ link st)
- Calculating the SPF algorithm also requires additional CPU processing. (ใช้ cpu เยอะในการคำนวณ shortest path)
- Bandwidth can be adversely affected by link-state packet flooding.

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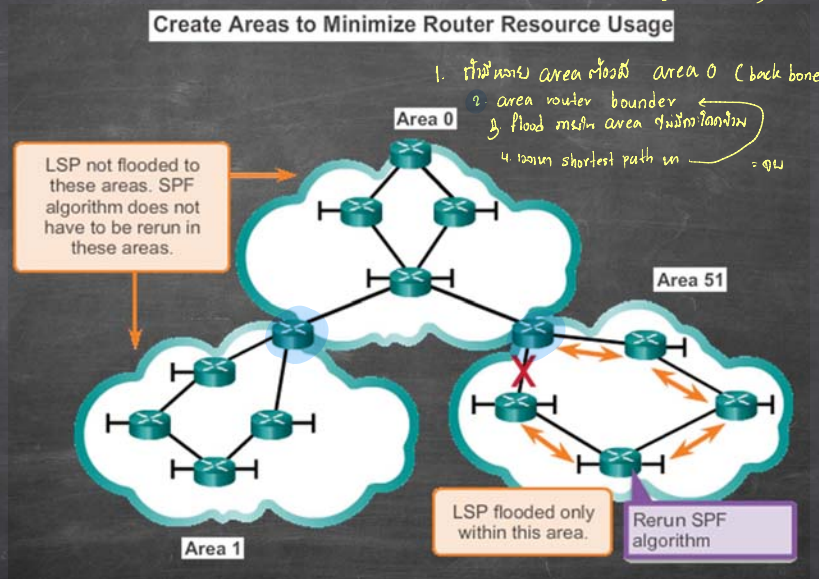
Link-State Routing Protocol

OSPF ถ้ามาก แบ่งเป็น area ๆได้ (config บอกว่าarea)

Create Areas to Minimize Router Resource Usage

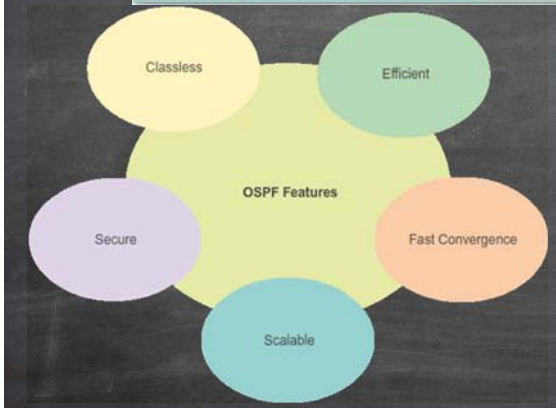
1. ที่มีหลาย area ต้องมี area 0 (back bone)
2. area router bounder
3. flood กรณี area ตัวมีการเปลี่ยนแปลง
4. คำนวน shortest path ใน = ตน



OSPF

IP กับ Protocol ที่ใช้

	Interior Gateway Protocols				Exterior Gateway Protocols
	Distance Vector		Link-State		Path Vector
IPv4	RIPv2	EIGRP	OSPFv2	IS-IS	BGP-4
IPv6	RIPng	EIGRP for IPv6	OSPFv3	IS-IS for IPv6	BGP-MP



OSPF Administrative Distance

Route Source	Administrative Distance
Connected	0
Static	1
EIGRP summary route	5
External BGP	20
Internal EIGRP	90
IGRP	100
OSPF	110
IS-IS	115
RIP	120
External EIGRP	170
Internal BGP	200

กล. show ข้อมูล OSPF

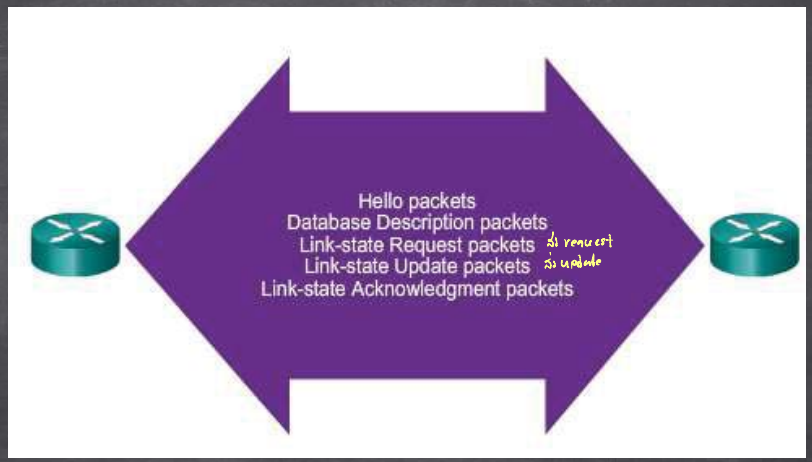
OSPF คล. 1

OSPF Data Structures

ไม่มีผล routing table

Database	Table	Description
Adjacency Database	Neighbor Table	• List of all neighbor routers to which a router has established bidirectional communication. • This table is unique for each router. • Can be viewed using the **`show ip ospf neighbor`** command.
Link-state Database (LSDB)	Topology Table	• Lists information about all other routers in the network. • The database shows the network topology. • All routers within an area have identical LSDB. • Can be viewed using the **`show ip ospf database`** command.
Forwarding Database	Routing Table	• List of routes generated when an algorithm is run on the link-state database. • Each router's routing table is unique and contains information on how and where to send packets to other routers. • Can be viewed using the **`show ip route`** command.

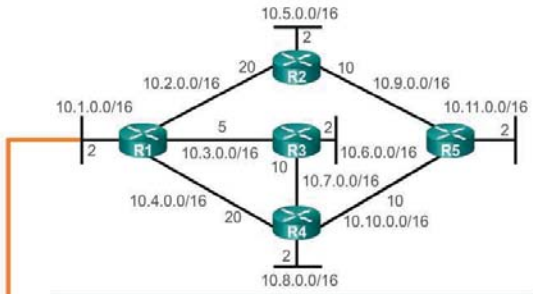
OSPF



ขอ request
ขอ update

OSPF

Content of the R1 SPF Tree



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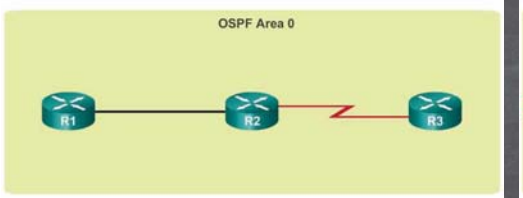
CCNA ระดับ

OSPF

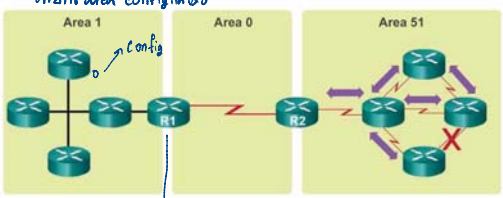
- Single-area and Multiarea OSPF

Single-Area OSPF



- Area 0 is also called the backbone area.
- Single-Area OSPF is useful in smaller networks with few routers.

Link Change Impacts Local Area Only



- Link failure affects the local area only (area 51).
- The ABR (R2) isolates the fault to area 51 only.
- Routers in areas 0 and 1 do not need to run the SPF algorithm.

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OSPF Messages

- Encapsulating OSPF Messages

OSPF IPv4 Header Fields

Data Link Frame Header	IP Packet Header	OSPF Packet Header	OSPF Packet Type-Specific Database

Data Link Frame (Ethernet Fields shown here)
MAC Destination Address = Multicast: 01-00-5E-00-00-05 or 01-00-5E-00-00-06
MAC Source Address = Address of sending interface

IP Packet
IP Source Address = Address of sending interface
IP Destination Address = Multicast: 224.0.0.5 or 224.0.0.6
Protocol Field = 89 for OSPF

OSPF Packet Header
Type code for OSPF Packet type
Router ID and Area ID

OSPF Packet Types
0x01 Hello
0x02 Database Description (DD)
0X03 Link State Request
0X04 Link State Update
0X05 Link State Acknowledgment

4.5

OSPF Messages

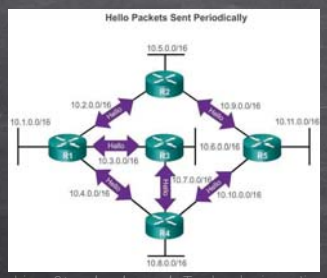
- Types of OSPF Packets

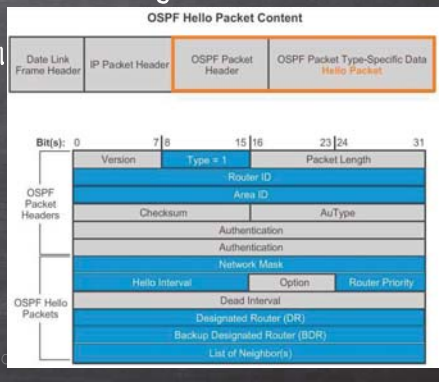
OSPF Packet Descriptions

Type	Packet Name	Description
1	Hello	Discovers neighbors and builds adjacencies between them
2	Database Description (DBD)	Checks for database synchronization between routers
3	Link-State Request (LSR)	Requests specific link-state records from router to router
4	Link-State Update (LSU)	Sends specifically requested link-state records
5	Link-State Acknowledgment (LSAck)	Acknowledges the other packet types

OSPF Messages

- OSPF Hello packets are transmitted
  - To 224.0.0.5 in IPv4 and FF02::5 in IPv6 (all OSPF routers)
  - Every 10 seconds (default on multiaccess and point-to-point networks)
  - Every 30 seconds (default on non-broadcast multiaccess [NBMA] networks)
  - Dead interval is the period that the router waits to receive a Hello packet before declaring the neighbor down
  - Router floods the LSDB with information about down neighbors out all OSPF enabled interfaces
  - Cisco's default is 4 times the Hello interval





OSPF Messages

- Link-State Updates

LSUs Contain LSAs

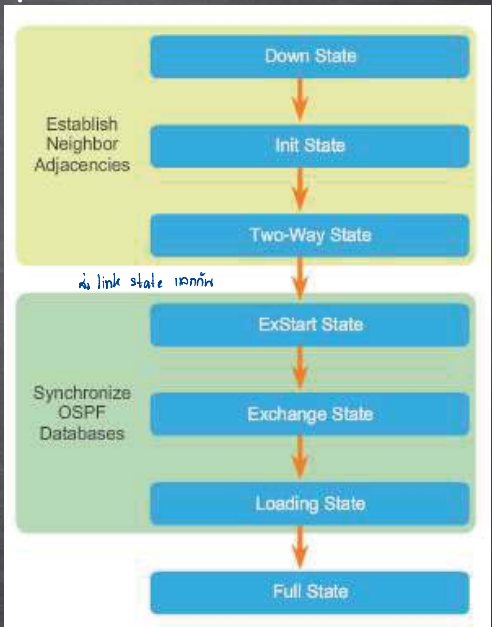
Type	Packet Name	Description
1	Hello	Discovers neighbors and builds adjacencies between them
2	DBD	Checks for database synchronization between router
3	LSR	Requests specific link-state records from router to router
4	LSU	Sends specifically requested link-state records
5	LSAck	Acknowledges the other packet types

- An LSU contains one or more LSAs.
- LSAs contain route information for destination networks.

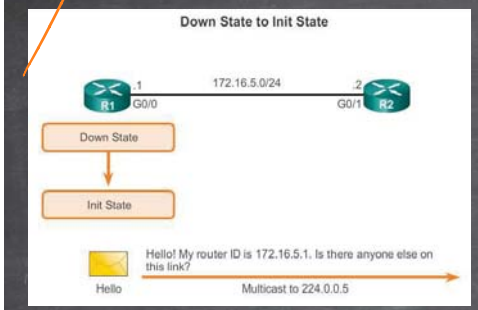
LSA Type	Description
1	Router LSAs
2	Network LSAs
3 or 4	Summary LSAs
5	Autonomous System External LSAs
6	Multicast OSPF LSAs
7	Defined for Not-So-Stubby Areas
8	External Attributes LSA for Border Gateway Protocol (BGP)
9,10,11	Opaque LSAs

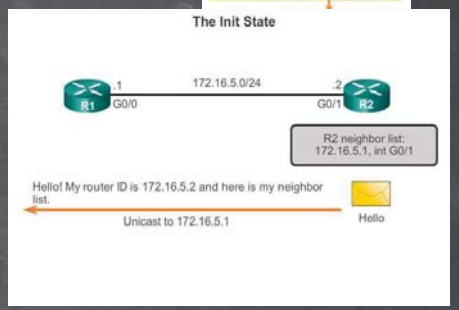
OSPF Operation

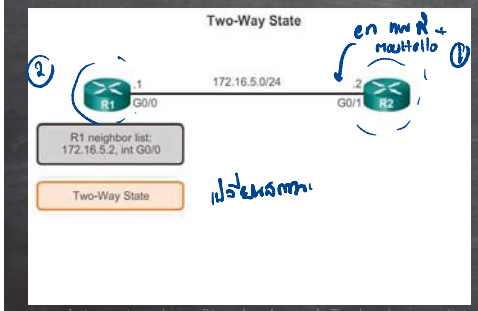
- When an OSPF router is initially connected to a network, it attempts to:
  - Create adjacencies with neighbors
  - Exchange routing information
  - Calculate the best routes
  - Reach convergence
  - OSPF progresses through several states while attempting to reach convergence.

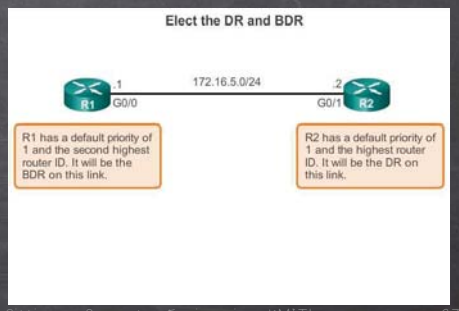


OSPF Operation



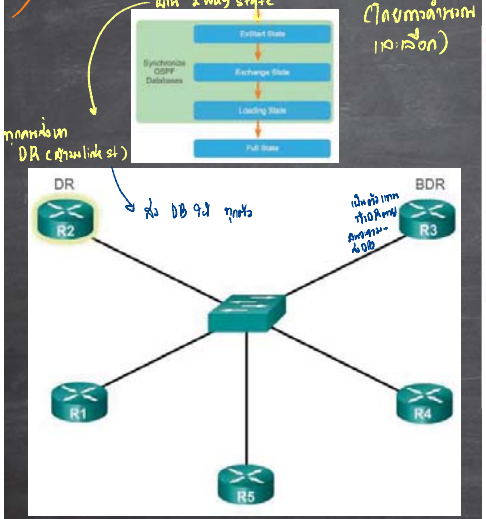


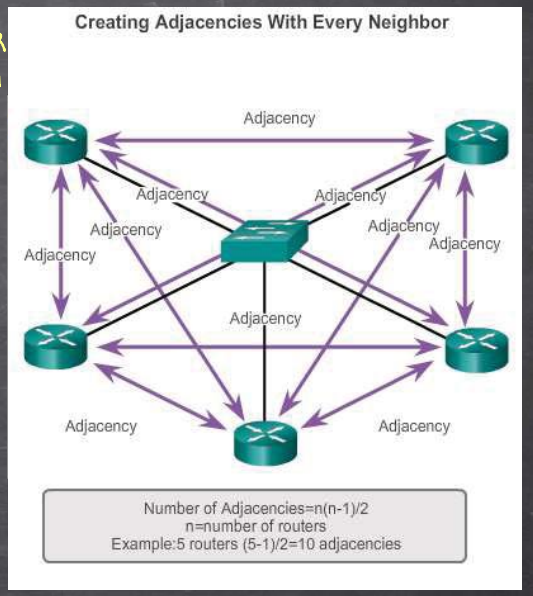


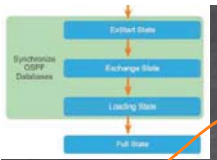


OSPF Operation

- DR and BDR







OSPF Operation

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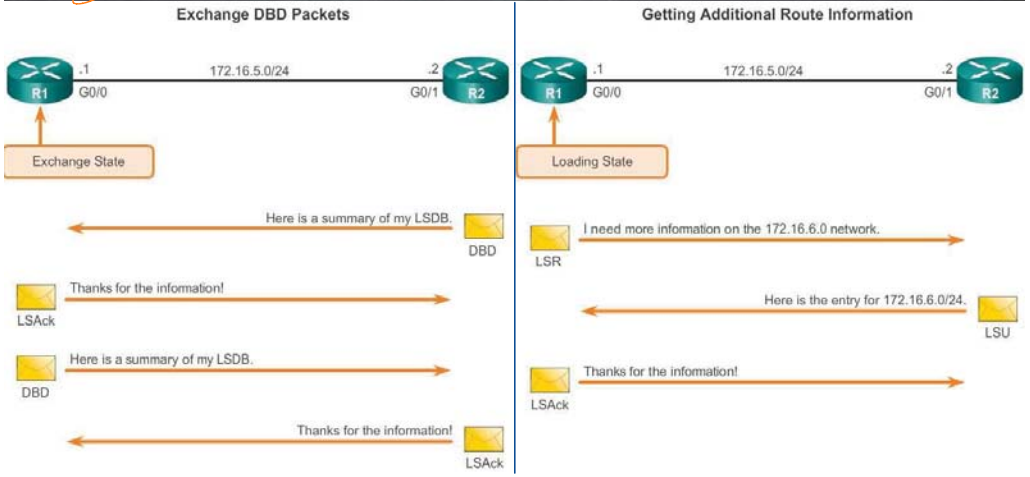


ครั้ง 2 Configuring Single-Area OSPFv2

เป็น local significant

router ospf *process-id* process ที่สั่งรัน process อยู่ใน OSPF

ใช่ ค่าไม่เหมือนกันเครื่องอื่น

- process-id value
  - a number between 1 and 65,535
  - locally significant

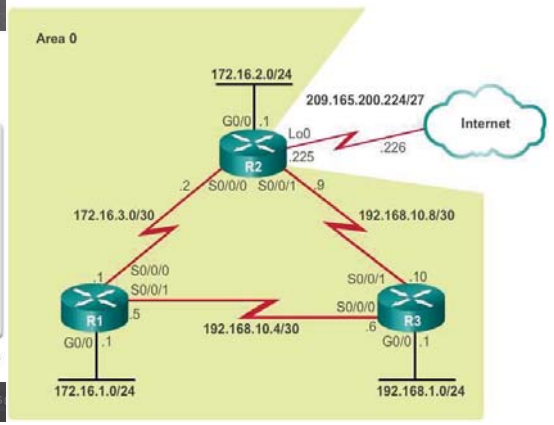
แก้ไขอย่างไร? ต้องconfig ลบ process เดิม

Entering Router OSPF Configuration Mode on R1

```
R1(config)# router ospf 10
R1(config-router)# ?
Router configuration commands:
  auto-cost             Calculate OSPF interface cost
                        according to bandwidth
  network               Enable routing on an IP network
  no                    Negate a command or set its defaults
  passive-interface     Suppress routing updates on an
                        interface
  priority              OSPF topology priority
  router-id             router-id for this OSPF process
```

Note: Output has been altered to display only the commands that will be used in this chapter.

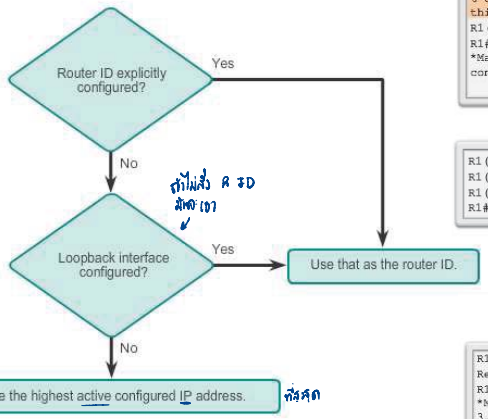
OSPF Reference Topology



Configuring Single-Area OSPFv2

- OSPF Router IDs

Router ID Order of Precedence




```
R1(config)# router ospf 10
R1(config-router)# router-id 1.1.1.1
% OSPF: Reload or use "clear ip ospf process" command, for
this to take effect
R1(config-router)# end
R1#
*Mar 25 19:46:09.711: %SYS-5-CONFIG_I: Configured from
console by console
```

```
R1(config)# interface loopback 0
R1(config-if)# ip address 1.1.1.1 255.255.255.255
R1(config-if)# end
R1#
```

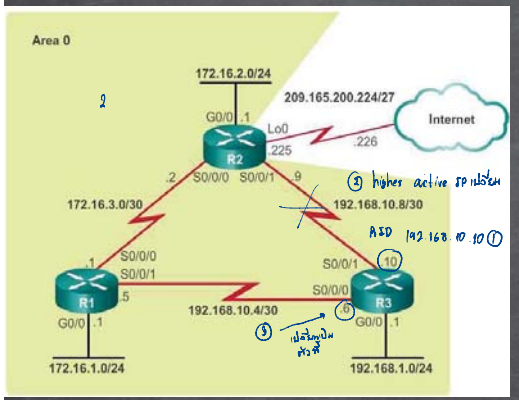
Clearing the OSPF Process

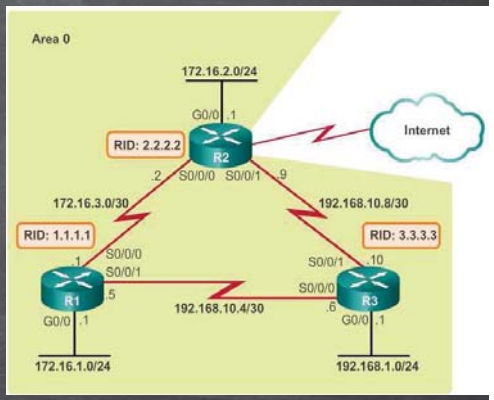
เวลาสั่ง ip interface ที่หลัง ต้อง

```
R1# clear ip ospf process
Reset ALL OSPF processes? [no]: y
R1#
*Mar 25 19:46:22.423: %OSPF-5-ADJCHG: Process 10, Nbr
3.3.3.3 on Serial0/0/1 from FULL to DOWN, Neighbor Down:
Interface down or detached
*Mar 25 19:46:22.423: %OSPF-5-ADJCHG: Process 10, Nbr
2.2.2.2 on Serial0/0/0 from FULL to DOWN, Neighbor Down:
Interface down or detached
```


Configuring Single-Area OSPFv2

- OSPF Router IDs

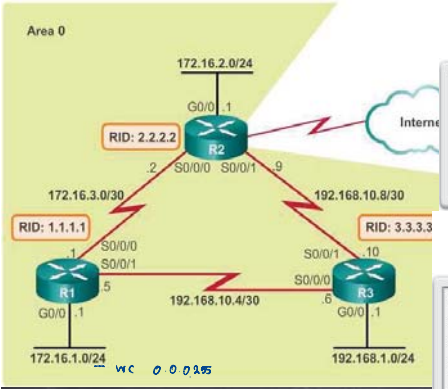




1. ลบ R ID
2. หรือ ip int

Configuring Single-Area OSPFv2

```
router ospf process-id
network network-address wildcard-mask area area-id
```



Assigning Interfaces to an OSPF Area

```
R1(config)# router ospf 10
R1(config-router)# network 172.16.1.0 0.0.0.255 area 0
R1(config-router)# network 172.16.3.0 0.0.0.3 area 0
R1(config-router)# network 192.168.10.4 0.0.0.3 area 0
R1(config-router)#
R1#
```

Assigning Interfaces to an OSPF Area with a Quad Zero

```
R1(config)# router ospf 10
R1(config-router)# network 172.16.1.1 0.0.0.0 area 0
R1(config-router)# network 172.16.3.1 0.0.0.0 area 0
R1(config-router)# network 192.168.10.5 0.0.0.0 area 0
R1(config-router)#
R1#
```


Configuring Single-Area OSPFv2

Configuring a Passive Interface on R1

```
R1(config)# router ospf 10
R1(config-router)# passive-interface GigabitEthernet 0/0
R1(config-router)# end
R1#
```

Verifying a Default Route on R1

```
R1# show ip protocols
*** IP Routing is NSF aware ***

Routing Protocol is "ospf 10"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 1.1.1.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    172.16.1.1 0.0.0.0 area 0
    172.16.3.1 0.0.0.0 area 0
    192.168.10.5 0.0.0.0 area 0
  Passive Interface(s):
    GigabitEthernet0/0
  Routing Information Sources:
    Gateway         Distance      Last Update
    3.3.3.3              110      00:08:35
    2.2.2.2              110      00:08:35
  Distance: (default is 110)

R1#
```


14 OSPF Cost

- The formula used to calculate the OSPF cost is:

Cost = reference bandwidth/interface bandwidth

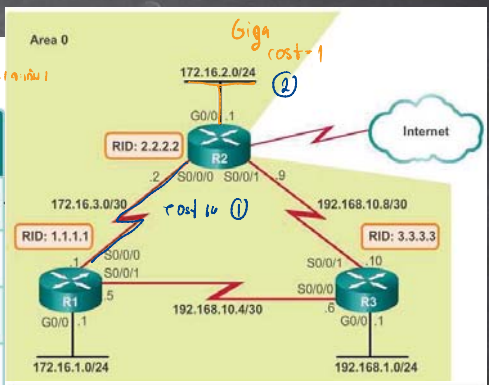
- The default reference bandwidth is 10^8 (100,000,000); therefore, the formula is:

Cost = 100,000,000 bps/interface bandwidth in bps

OSPF Cost

Default Cisco OSPF Cost Values

Interface Type	Reference Bandwidth in bps		Default Bandwidth in bps	Cost
10 Gigabit Ethernet 10 Gbps	100,000,000	÷	10,000,000,000	1
Gigabit Ethernet 1 Gbps	100,000,000	÷	1,000,000,000	1
Fast Ethernet 100 Mbps	100,000,000	÷	100,000,000	1
Ethernet 10 Mbps	100,000,000	÷	10,000,000	10
Serial 1.544 Mbps	100,000,000	÷	1,544,000	64
Serial 128 kbps	100,000,000	÷	128,000	781
Serial 64 kbps	100,000,000	÷	64,000	1562




```
R1# show ip route | include 172.16.2.0
O        172.16.2.0/24 [110/65] via 172.16.3.2, 03:39:07,
         Serial0/0/0
R1#
R1# show ip route 172.16.2.0
Routing entry for 172.16.2.0/24
  Known via "ospf 10", distance 110, metric 65, type intra
  area
  Last update from 172.16.3.2 on Serial0/0/0, 03:39:15 ago
  Routing Descriptor Blocks:
  * 172.16.3.2, from 2.2.2.2, 03:39:15 ago, via Serial0/0/0
      Route metric is 65, traffic share count is 1
R1#
```

OSPF Cost

เปลี่ยน ref bw

เปลี่ยน Auto cost

เปลี่ยนที่ OSPF

ต้องเปลี่ยน Routerทุกตัว

```
auto-cost reference-bandwidth bandwidth_mbps
```

① ถ้าเป็น

— Fast Ethernet

เปลี่ยนเป็น

```
auto-cost reference-bandwidth 100
```

100mb หน่วย

— Gigabit Ethernet

```
auto-cost reference-bandwidth 1000
```

— 10 Gigabit Ethernet

```
auto-cost reference-bandwidth 10000
```

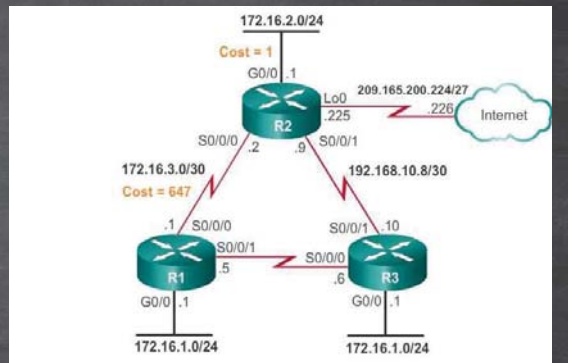

OSPF Cost

```
auto-cost reference-bandwidth 1000
```

Interface Type	Reference Bandwidth in bps		Default Bandwidth in bps	Cost
10 Gigabit Ethernet 10 Gbps	1,000,000,000	+	10,000,000,000	1
Gigabit Ethernet 1 Gbps	1,000,000,000	+	1,000,000,000	1
Fast Ethernet 100 Mbps	1,000,000,000	+	100,000,000	10
Ethernet 10 Mbps	1,000,000,000	+	10,000,000	100
Serial 1.544 Mbps	1,000,000,000	+	1,544,000	647

```
auto-cost reference-bandwidth 10000
```

Interface Type	Reference Bandwidth in bps		Default Bandwidth in bps	Cost
10 Gigabit Ethernet 10 Gbps	10,000,000,000	+	10,000,000,000	1
Gigabit Ethernet 1 Gbps	10,000,000,000	+	1,000,000,000	10
Fast Ethernet 100 Mbps	10,000,000,000	+	100,000,000	100
Ethernet 10 Mbps	10,000,000,000	+	10,000,000	1000
Serial 1.544 Mbps	10,000,000,000	+	1,544,000	6477




```
R1# show ip ospf interface serial 0/0/0
Serial0/0/0 is up, line protocol is up
  Internet Address 172.16.3.1/30,Area 0,Attached via Network Statement
  Process ID 10,Router ID 1.1.1.1,Network Type POINT_TO_POINT,Cost:647
```

```
R1# show ip route | include 172.16.2.0
O       172.16.2.0/24 [110/648] via 172.16.3.2, 00:06:03, Serial0/0/0
R1#
R1# show ip route 172.16.2.0
Routing entry for 172.16.2.0/24
  Known via "ospf 10", distance 110, metric 648, type intra area
  Last update from 172.16.3.2 on Serial0/0/0, 00:06:17 ago
  Routing Descriptor Blocks:
  * 172.16.3.2, from 2.2.2.2, 00:06:17 ago, via Serial0/0/0
      Route metric is 648, traffic share count is 1
```


OSPF Cost

- Default Interface Bandwidths
  - On Cisco routers, the default bandwidth on most serial interfaces is set to 1.544 Mb/s

```
R1# show interfaces serial 0/0/0
Serial0/0/0 is up, line protocol is up
  Hardware is WIC MBRD Serial
  Description: Link to R2
  Internet address is 172.16.3.1/30
  MTU 1500 bytes, BW 1544 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:05, output 00:00:03, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total
```

int ที่ check

OSPF Cost

เปลี่ยน bw ที่ int

* คำนวณ cost ใหม่

ถ้าเปลี่ยน bw ต้องเปลี่ยนคู่สัน

Auto เปลี่ยนทุก ✕

เปลี่ยนเพื่อการคำนวณ

- bw ที่ show เปลี่ยน → cost เปลี่ยน

- Adjusting the Interface Bandwidths
  - The command only modifies the bandwidth metric used by EIGRP and OSPF. The command does not modify the actual bandwidth on the link.

```
R1(config)# int s0/0/1
R1(config-if)# bandwidth 64
R1(config-if)# end
R1#
*Mar 27 10:10:07.735: %SYS-5-CONFIG_I: Configured from console by c
R1#
R1# show interfaces serial 0/0/1 | include BW
  MTU 1500 bytes, BW 64 Kbit/sec, DLY 20000 usec,
R1#
R1# show ip ospf interface serial 0/0/1 | include Cost:
  Process ID 10, Router ID 1.1.1.1, Network Type
  POINT_TO_POINT, Cost: 15625
R1#
```

OSPF Cost

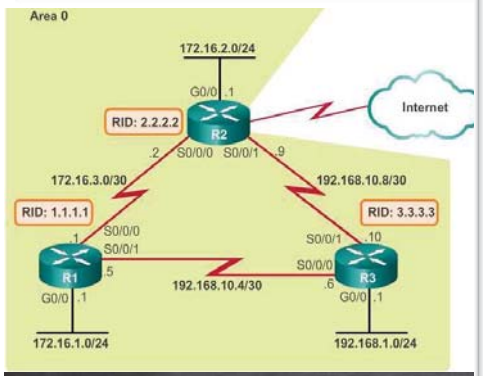
- Manually Setting the OSPF Cost
  - Both the bandwidth interface command and the ip ospf cost interface command achieve the same result, which is to provide an accurate value for use by OSPF in determining the best route.

```
R1(config)# int s0/0/1
R1(config-if)# no bandwidth 64
R1(config-if)# ip ospf cost 15625
R1(config-if)# end
R1#
R1# show interface serial 0/0/1 | include BW
    MTU 1500 bytes, BW 1544 Kbit/sec, DLY 20000 usec,
R1#
R1# show ip ospf interface serial 0/0/1 | include Cost:
    Process ID 10, Router ID 1.1.1.1, Network Type POINT_TO_POINT,
    Cost: 15625
R1#
```


Verify OSPF

```
R1# show ip ospf neighbor

Neighbor ID  Pri  State     Dead Time  Address        Interface
3.3.3.3        0  FULL/-    00:00:37   192.168.10.6   Serial0/0/1
2.2.2.2        0  FULL/-    00:00:30   172.16.3.2     Serial0/0/0
R1#
```




```
R1# show ip protocols
*** IP Routing is NSF aware ***

Routing Protocol is "ospf 10"
  Outgoing update filter list for all interfaces is not
  set
  Incoming update filter list for all interfaces is not
  set
  Router ID 1.1.1.1
  Number of areas in this router is 1. 1 normal 0 stub 0
  nssa
  Maximum path: 4
  Routing for Networks:
    172.16.1.0 0.0.0.255 area 0
    172.16.3.0 0.0.0.3 area 0
    192.168.10.4 0.0.0.3 area 0
  Routing Information Sources:
    Gateway         Distance      Last Update
    2.2.2.2              110      00:17:18
    3.3.3.3              110      00:14:49
  Distance: (default is 110)

R1#
```


Verify OSPF

```
R1# show ip ospf interface brief
Interface  PID   Area  IP Address/Mask    Cost  State  Nbrs F/C
Se0/0/1    10    0     192.168.10.5/30    15625 P2P    1/1
Se0/0/0    10    0     172.16.3.1/30      647   P2P    1/1
Gi0/0      10    0     172.16.1.1/24      1     DR     0/0
R1#
```

```
R1# show ip ospf
Routing Process "ospf 10" with ID 1.1.1.1
Start time: 01:37:15.156, Time elapsed: 01:32:57.776
Supports only single TOS(TOS0) routes
Supports opaque LSA
Supports Link-local Signaling (LLS)
Supports area transit capability
Supports NSSA (compatible with RFC 3101)
Event-log enabled, Maximum number of events: 1000, Mode:
cyclic
```


More OSPF Configuration

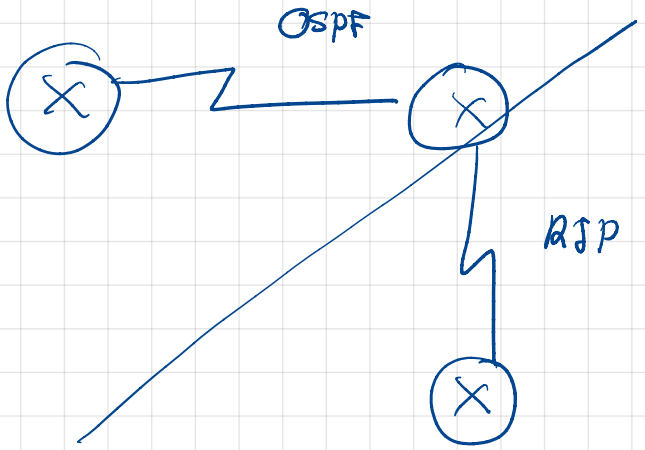
- Redistributing an OSPF Default Route

```
R(config)# ip route 0.0.0.0 0.0.0.0 loopback N

R(config)# router ospf process-id
R(config-router)# default-information originate
```

- Redistributing an OSPF other

```
R(config-router)#redistribute ?
  bgp          Border Gateway Protocol (BGP)
  connected    Connected
  eigrp        Enhanced Interior Gateway Routing Protocol (EIGRP)
  metric       Metric for redistributed routes
  ospf         Open Shortest Path First (OSPF)
  rip          Routing Information Protocol (RIP)
  static       Static routes
```



router rip
network
redistribute ospf (option nilai)

---

router ospf 10
network (ip) (wc) (area)
redistribute RIP
(protocol)

DHCP

1

- Introduction
- Dynamic Host Configuration Protocol (DHCP) is a network protocol that provides automatic IP addressing and other information to clients:IP address
  - Subnet mask (IPv4) or prefix length (IPv6)
  - Default gateway address
  - DNS server address
- Available for both IPv4 and IPv6
- This chapter explores the functionality, configuration, and troubleshooting of DHCPv4

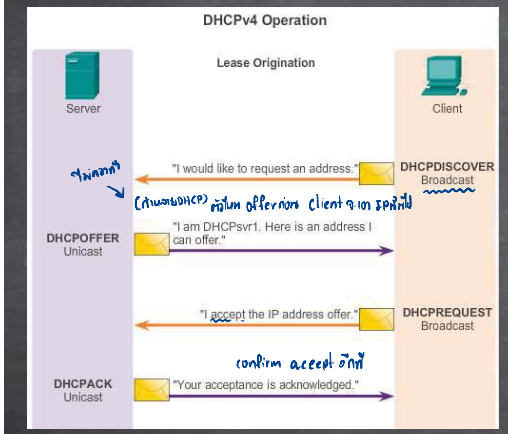
DHCP

2

- DHCPv4 uses three different address allocation methods
  - **Manual Allocation** - The administrator assigns a pre-allocated IPv4 address to the client, and DHCPv4 communicates only the IPv4 address to the device.
  - **Automatic Allocation** - DHCPv4 automatically assigns a static IPv4 address permanently to a device, selecting it from a pool of available addresses. No lease.
  - **Dynamic Allocation** - DHCPv4 dynamically assigns, or leases, an IPv4 address from a pool of addresses for a limited period of time chosen by the server, or until the client no longer needs the address. Most commonly used.

DHCPv4 Operation

3



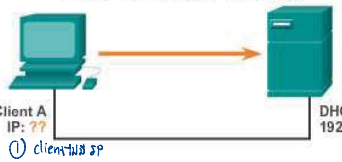
DHCPv4 Message Format

8	16	24	32
OP Code (1)	Hardware type (1)	Hardware address length (1)	Hops (1)
Transaction Identifier			
Seconds - 2 bytes		Flags - 2 bytes	
Client IP Address (CIADDR) - 4 bytes			
Your IP Address (YIADDR) - 4 bytes			
Server IP Address (SIADDR) - 4 bytes			
Gateway IP Address (GIADDR) - 4 bytes			
Client Hardware Address (CHADDR) - 16 bytes			
Server name (SNAME) - 64 bytes			
Boot Filename - 128 bytes			
DHCP Options - variable			

DHCPv4 Operation

4

DHCPv4 Discover Message



Ethernet Frame	IP	UDP	DHCPDISCOVER
SRC MAC: MAC A DST MAC:FF:FF:FF:FF:FF:FF	IP SRC: 0.0.0.0 IP DST:255.255.255.255	UDP 67	CIADDR: 0.0.0.0 GIADDR: 0.0.0.0 Mask: 0.0.0.0 CHADDR: MAC A

MAC: Media Access Control Address
CIADDR: Client IP Address
GIADDR: Gateway IP Address
CHADDR: Client Hardware Address

The DHCP client sends a directed IP broadcast with a DHCPDISCOVER packet. In this example, the DHCP server is on the same segment and will pick up this request. The server notes the GIADDR field is blank; therefore, the client is on the same segment. The server also notes the hardware address of the client in

config

Configuring a DHCPv4 Server

- A Cisco router running Cisco IOS software can be configured to act as a DHCPv4 server. To set up DHCP
  - Exclude addresses from the pool.
  - Set up DHCP pool name
  - Configuring Specific Tasks -define range of addresses and subnet mask. Use default-router command for default gateway. Optional items that can be included in pool - dns server, domain-name

```
R1(config)# ip dhcp excluded-address 192.168.10.1 192.168.10.9
R1(config)# ip dhcp excluded-address 192.168.10.254
R1(config)# ip dhcp pool LAN-POOL-1
R1(dhcp-config)# network 192.168.10.0 255.255.255.0
R1(dhcp-config)# default-router 192.168.10.1
R1(dhcp-config)# dns-server 192.168.11.5
R1(dhcp-config)# domain-name example.com
R1(dhcp-config)# end
R1#
```

- To disable dhcp - **no service dhcp**

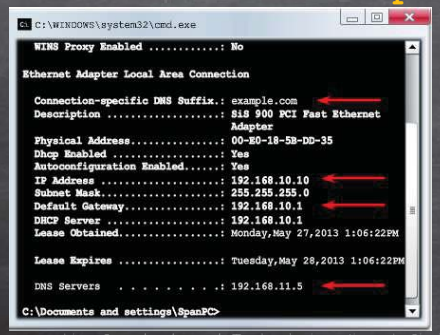
show DHCP

Verifying a DHCPv4 Server

- Commands to verify DHCP

```
show running-config | section dhcp
show ip dhcp binding
show ip dhcp server statistics
```

- On the PC -issue the **ipconfig /all** command



/ ?

/ release คืน IP

/ renew ขอ IP ใหม่

ถ้าใช้ DHCP window จะมีโดเมน เช่น 169.....

5

DHCPv4 Relay

ปกติ broadcast มันจะส่งทั้งหมด แต่มันจะไม่ส่ง broad cast ข้าม

- Using an IP helper address enables a router to forward DHCPv4 broadcasts to the DHCPv4 server. Acting as a relay.

```
R1(config)# interface g0/0
R1(config-if)# ip helper-address 192.168.11.6
R1(config-if)# end
R1# show ip interface g0/0
GigabitEthernet0/0 is up, line protocol is up
  Internet address is 192.168.10.1/24
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is 192.168.11.6
<Output omitted>
```

By default, the **ip helper-address** command forwards the following eight UDP services:
Port 37: Time
Port 49: TACACS
Port 53: DNS
Port 67: DHCP/BOOTP client
Port 68: DHCP/BOOTP server
Port 69: TFTP
Port 137: NetBIOS name service
Port 138: NetBIOS datagram service

request IP

Configuring a DHCPv4 client


```
SOHO(config)# interface g0/1
SOHO(config-if)# ip address dhcp
SOHO(config-if)# no shutdown
SOHO(config-if)#
*Jan 31 17:31:11.507: %DHCP-6-ADDRESS_ASSIGN: Interface
GigabitEthernet0/1 assigned DHCP address 209.165.201.12, mask
255.255.255.224, hostname SOHO
SOHO(config-if)# end
SOHO# show ip interface g0/1
GigabitEthernet0/1 is up, line protocol is up
  Internet address is 209.165.201.12/27
  Broadcast address is 255.255.255.255
  Address determined by DHCP
  <Output omitted>
```

Troubleshoot DHCPv4

- Troubleshooting Tasks

วิธีแก้เมื่อมีปัญหา

Troubleshooting Task 1:	Resolve conflicts.
Troubleshooting Task 2:	Verify physical connectivity.
Troubleshooting Task 3:	Test with a static IPv4 address.
Troubleshooting Task 4:	Verify switch port configuration.
Troubleshooting Task 5:	Test from the same subnet or VLAN.

Troubleshoot DHCPv4

- Verify Router DHCPv4 Configuration

Verifying DHCPv4 Relay and DHCPv4 Services

```
R1# show running-config | section interface GigabitEthernet0/0
interface GigabitEthernet0/0
 ip address 192.168.10.1 255.255.255.0
 ip helper-address 192.168.11.6
 duplex auto
 speed auto
R1#

R1# show running-config | include no service dhcp
R1#
```


Troubleshoot DHCPv4

- Debugging DHCPv4

Verifying DHCPv4 Using Router debug Commands

```
R1(config)# access-list 100 permit udp any any eq 67
R1(config)# access-list 100 permit udp any any eq 68
R1(config)# end
R1# debug ip packet 100
IP packet debugging is on for access list 100
*IP: s=0.0.0.0 (GigabitEthernet0/1), d=255.255.255.255, len 333,
rcvd 2
*IP: s=0.0.0.0 (GigabitEthernet0/1), d=255.255.255.255, len 333,
stop process pak for forus packet
*IP: s=192.168.11.1 (local), d=255.255.255.255
(GigabitEthernet0/1), len 328, sending broad/multicast

<Output omitted>

Router1# debug ip dhcp server events
DHCPD: returned 192.168.10.11 to address pool LAN-POOL-1
DHCPD: assigned IP address 192.168.10.12 to client
0100.0103.85e9.87.
DHCPD: checking for expired leases.
DHCPD: the lease for address 192.168.10.10 has expired.
DHCPD: returned 192.168.10.10 to address pool LAN-POOL-1
```


Questions and Answers

Command

1 Routing Table Terms

- A dynamically built routing table provides a great deal of information, as shown in the figure. Therefore, it is crucial to understand the output generated by the routing table. Special terms are applied when discussing the contents of a routing table.
- The Cisco IP routing table is not a flat database. The routing table is actually a hierarchical structure that is used to speed up the lookup process when locating routes and forwarding packets. Within this structure, the hierarchy includes several levels.
- Routes are discussed in terms of:
  - Ultimate route
  - Level 1 route
  - Level 1 parent route
  - Level 2 child routes

2 Routing Table Terms

- Ultimate Route
  - An ultimate route is a routing table entry that contains either a next-hop IPv4 address or an exit interface. Directly connected, dynamically learned, and local routes are ultimate routes.
  - In the figure, the highlighted areas are examples of ultimate routes. Notice that all of these routes specify either a next-hop IPv4 address or an exit interface.

Routing Table Terms

- Ultimate Route

```
R1# show ip route | begin Gateway
Gateway of last resort is 209.165.200.234 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 209.165.200.234, Serial0/0/1
                is directly connected, Serial0/0/1
      172.16.0.0/16 is variably subnetted, 5 subnets, 3 masks
C     172.16.1.0/24 is directly connected, GigabitEthernet0/0
L     172.16.1.1/32 is directly connected, GigabitEthernet0/0
R     172.16.2.0/24 [120/1] via 209.165.200.226, 00:00:12, Serial0/0/0
R     172.16.3.0/24 [120/2] via 209.165.200.226, 00:00:12, Serial0/0/0
R     172.16.4.0/28 [120/2] via 209.165.200.226, 00:00:12, Serial0/0/0
R     192.168.0.0/16 [120/2] via 209.165.200.226, 00:00:03,Serial0/0/0
      209.165.200.0/24 is variably subnetted, 5 subnets, 2 masks
C     209.165.200.224/30 is directly connected, Serial0/0/0
L     209.165.200.225/32 is directly connected, Serial0/0/0
R     209.165.200.228/30 [120/1] via 209.165.200.226, 00:00:12, Serial0/0/0
C     209.165.200.232/30 is directly connected, Serial0/0/1
L     209.165.200.233/32 is directly connected, Serial0/0/1
R1#
```

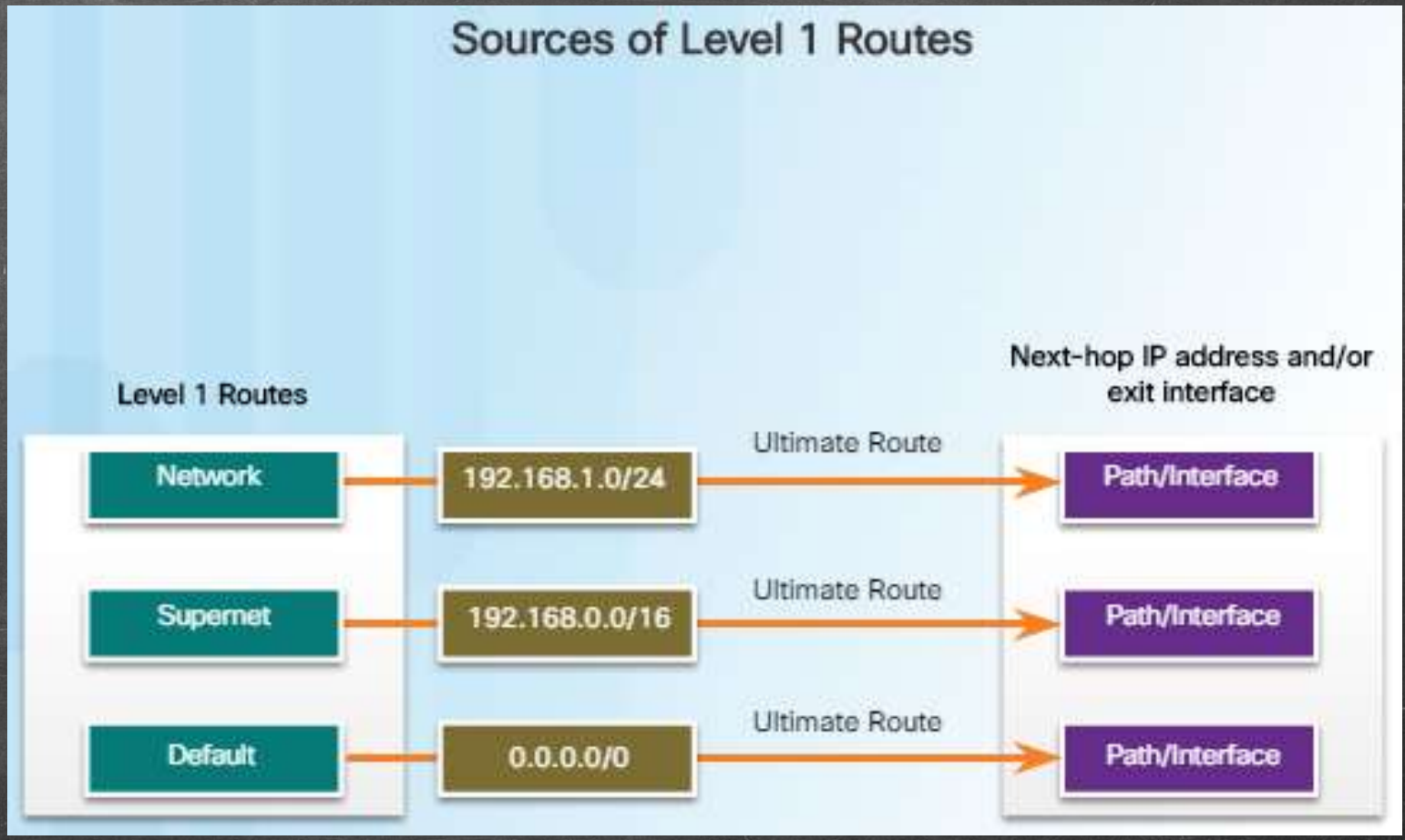
Routing Table Terms

- Level 1 Route
  - A level 1 route is a route with a subnet mask equal to or less than the classful mask of the network address. Therefore, a level 1 route can be a:
    - Network route - A network route that has a subnet mask equal to that of the classful mask.
    - Supernet route - A supernet route is a network address with a mask less than the classful mask, for example, a summary address.
    - Default route - A default route is a static route with the address 0.0.0.0/0.
    - The source of the level 1 route can be a directly connected network, static route, or a dynamic routing protocol.

เป็น Ultimate route สมบูรณ์

Routing Table Terms

- Level 1 Route
  - Figure 1 highlights how level 1 routes are also ultimate routes.



Routing Table Terms

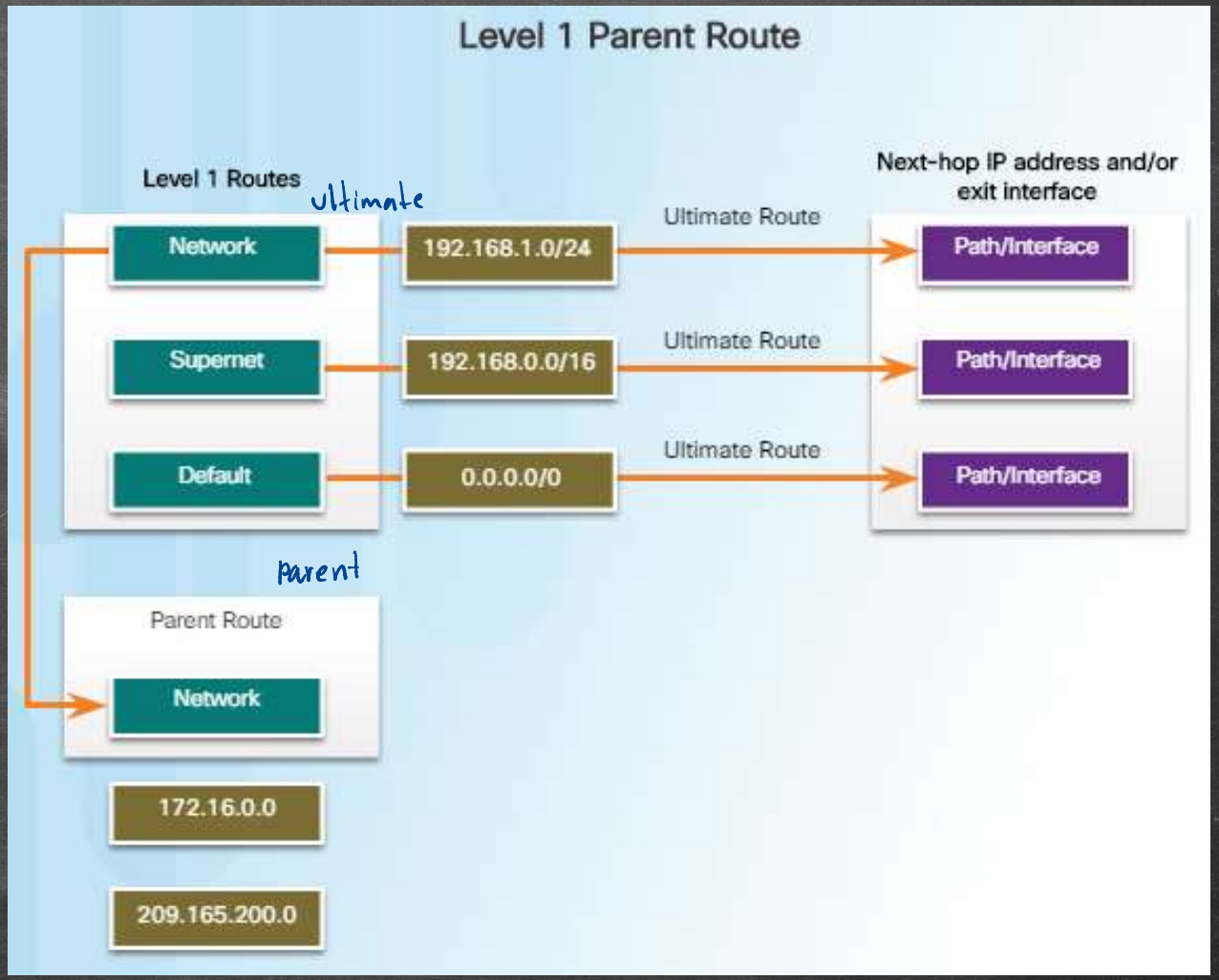
- Level 1 Route
  - Figure 2 highlights level 1 routes.

```
R1# show ip route | begin Gateway
Gateway of last resort is 209.165.200.234 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 209.165.200.234
      172.16.0.0/16 is variably subnetted, 5 subnets, 2 masks
C        172.16.1.0/24 is directly connected, GigabitEthernet0/0
L        172.16.1.1/32 is directly connected, GigabitEthernet0/0
R        172.16.2.0/24 [120/1] via 209.165.200.226, 00:00:21, Serial0/0/0
R        172.16.3.0/24 [120/2] via 209.165.200.226, 00:00:21, Serial0/0/0
R        172.16.4.0/28 [120/2] via 209.165.200.226, 00:00:21, Serial0/0/0
R     192.168.0.0/16 [120/2] via 209.165.200.226, 00:00:16, Serial0/0/0
      209.165.200.0/24 is variably subnetted, 5 subnets, 2 masks
C        209.165.200.224/30 is directly connected, Serial0/0/0
L        209.165.200.225/32 is directly connected, Serial0/0/0
R        209.165.200.228/30 [120/1] via 209.165.200.226, 00:00:21, Serial0/0/0
C        209.165.200.232/30 is directly connected, Serial0/0/1
L        209.165.200.233/32 is directly connected, Serial0/0/1
R1#
```

Routing Table Terms

- Level 1 Parent Route
  - As illustrated in Figure 1, the 172.16.0.0 and 209.165.200.0 routes are level 1 parent routes. A parent route is a level 1 network route that is subnetted. A parent route can never be an ultimate route.



9 Routing Table Terms

- Level 1 Parent Route
  - Figure 2 highlights the level 1 parent routes in the routing table of R1. In the routing table, it basically provides a heading for the specific subnets it contains. Each entry displays the classful network address, the number of subnets and the number of different subnet masks into which the classful address has been subdivided.

ถ้าไม่มี Level route มักจะต้องทำ match ทุกเมื่อทุกที

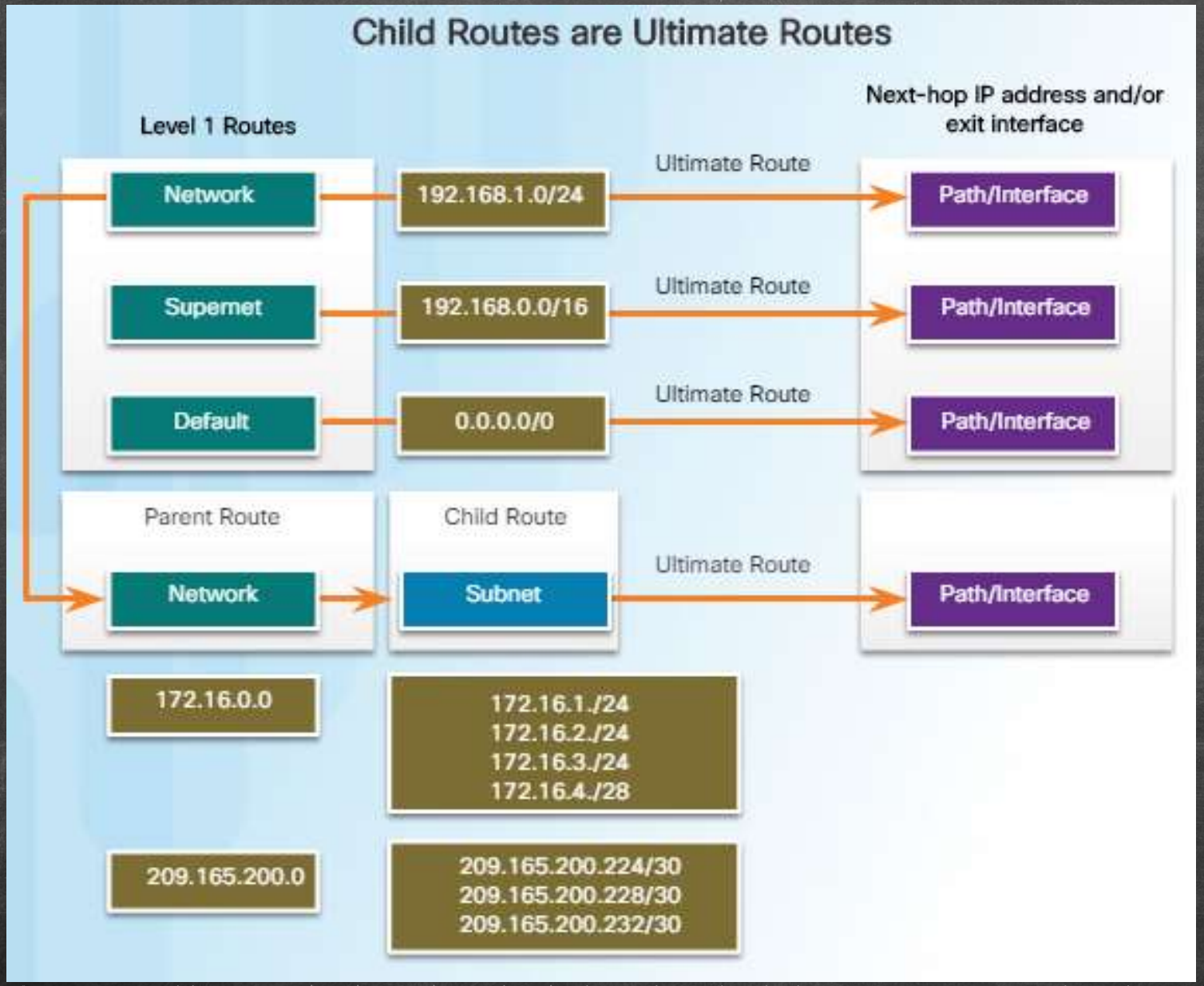
```
R1# show ip route | begin Gateway
Gateway of last resort is 209.165.200.234 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 209.165.200.234
      172.16.0.0/16 is variably subnetted, 5 subnets, 2 masks
C        172.16.1.0/24 is directly connected, GigabitEthernet0/0
L        172.16.1.1/32 is directly connected, GigabitEthernet0/0
R        172.16.2.0/24 [120/1] via 209.165.200.226, 00:00:21, Serial0/0/0
R        172.16.3.0/24 [120/2] via 209.165.200.226, 00:00:21, Serial0/0/0
R        172.16.4.0/28 [120/2] via 209.165.200.226, 00:00:21, Serial0/0/0
R     192.168.0.0/16 [120/2] via 209.165.200.226, 00:00:16, Serial0/0/0
      209.165.200.0/24 is variably subnetted, 5 subnets, 2 masks
C        209.165.200.224/30 is directly connected, Serial0/0/0
L        209.165.200.225/32 is directly connected, Serial0/0/0
R        209.165.200.228/30 [120/1] via 209.165.200.226, 00:00:21, Serial0/0/0
C        209.165.200.232/30 is directly connected, Serial0/0/1
L        209.165.200.233/32 is directly connected, Serial0/0/1
R1#
```

9 Routing Table Terms

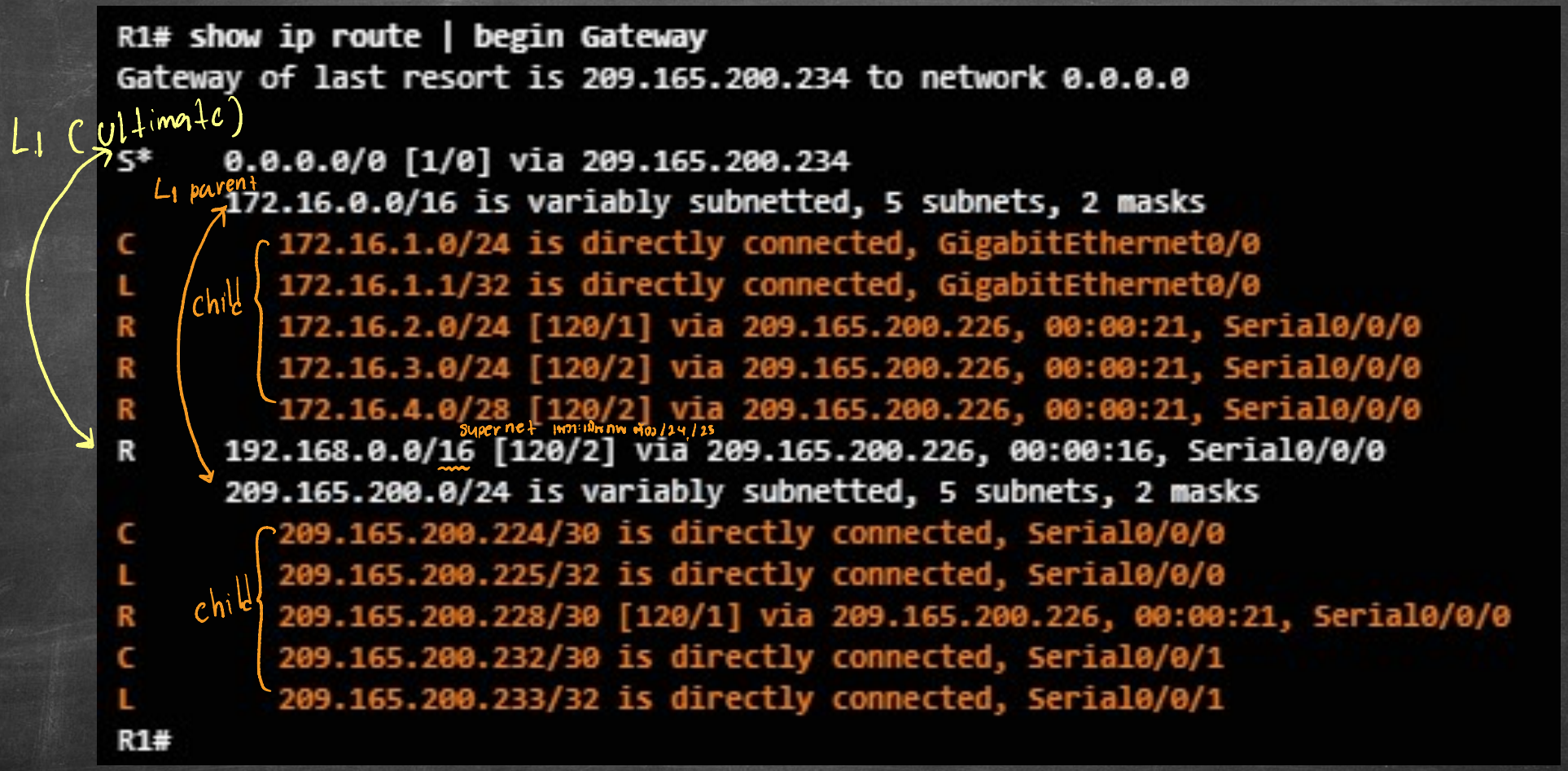
- Level 2 Child Route
  - A level 2 child route is a route that is a subnet of a classful network address. As illustrated in Figure 1, a level 1 parent route is a level 1 network route that is subnetted. Level 1 parent routes contain level 2 child routes, as shown in Figure 2.
  - Like a level 1 route, the source of a level 2 route can be a directly connected network, a static route, or a dynamically learned route. Level 2 child routes are also ultimate routes.
  - Note: The routing table hierarchy in Cisco IOS has a classful routing scheme. A level 1 parent route is the classful network address of the subnet route. This is the case even if a classless routing protocol is the source of the subnet route.
  - Figure 3 highlights the child routes in the routing table of R1.

10 Routing Table Terms



Routing Table Terms

- Level 2 Child Route

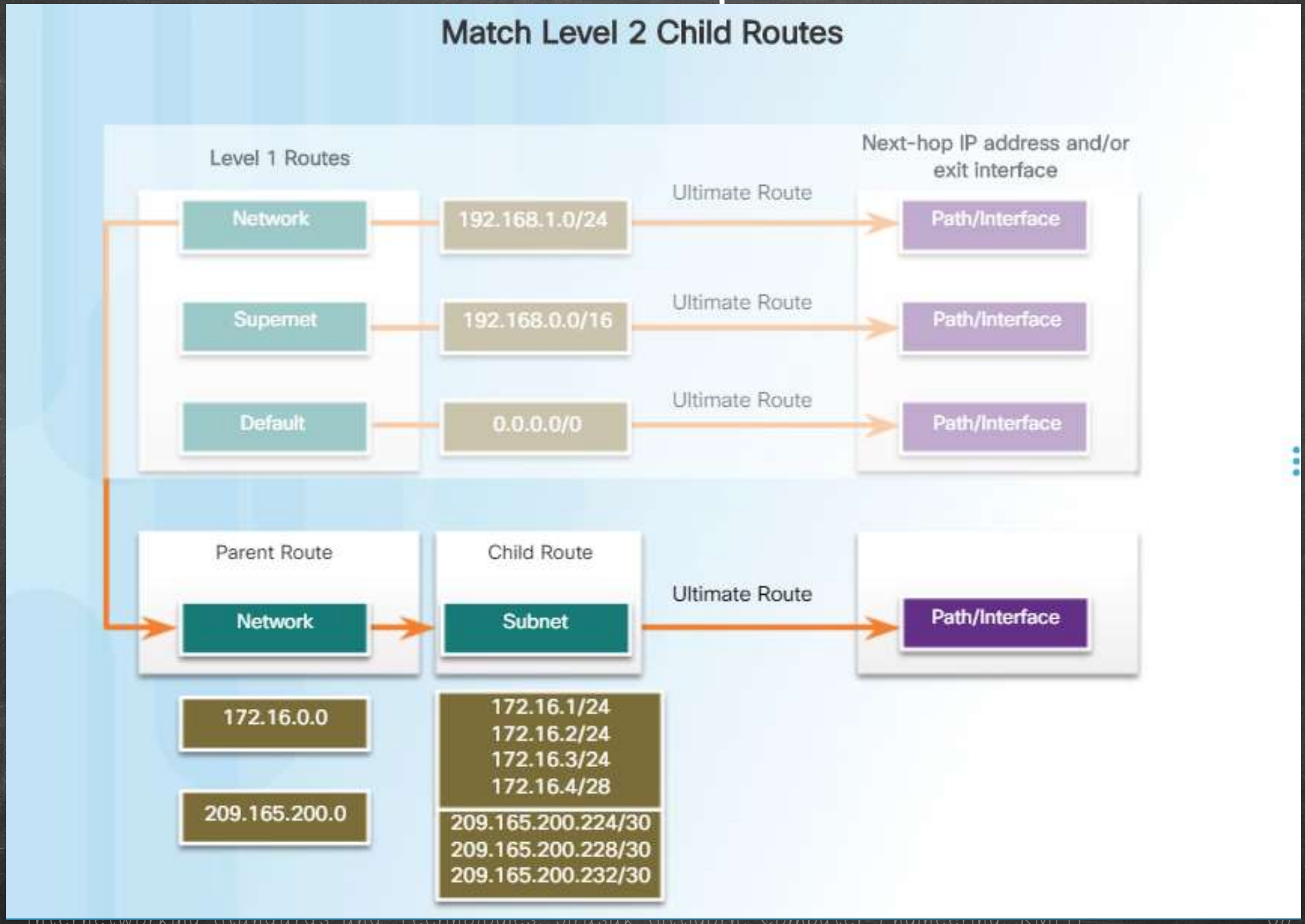


Route Lookup Process

match กับ L. 1 (Ultimate NW)
= ส่งออกไปเลย

ถ้าไม่ match L1 network → L1 parent → match ↘
ส่ง command ← child

Route Lookup Process



Route Lookup Process