Routing Dynamically

Routing & Switching

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Dynamic Routing Protocol Operation

Purpose of Dynamic Routing Protocols

Routing Protocols are used to facilitate the exchange of routing information between routers.

The purpose of dynamic routing protocols includes:

- Discovery of remote networks
- Maintaining up-to-date routing information
- Choosing the best path to destination networks
- Ability to find a new best path if the current path is no longer available

Dynamic Routing Protocol Operation

In general, the operations of a dynamic routing protocol can be described as follows:

1. The router sends and receives routing messages on its interfaces.
2. The router shares routing messages and routing information with other routers that are using the same routing protocol.
3. Routers exchange routing information to learn about remote networks.
4. When a router detects a topology change the routing protocol can advertise this change to other routers.

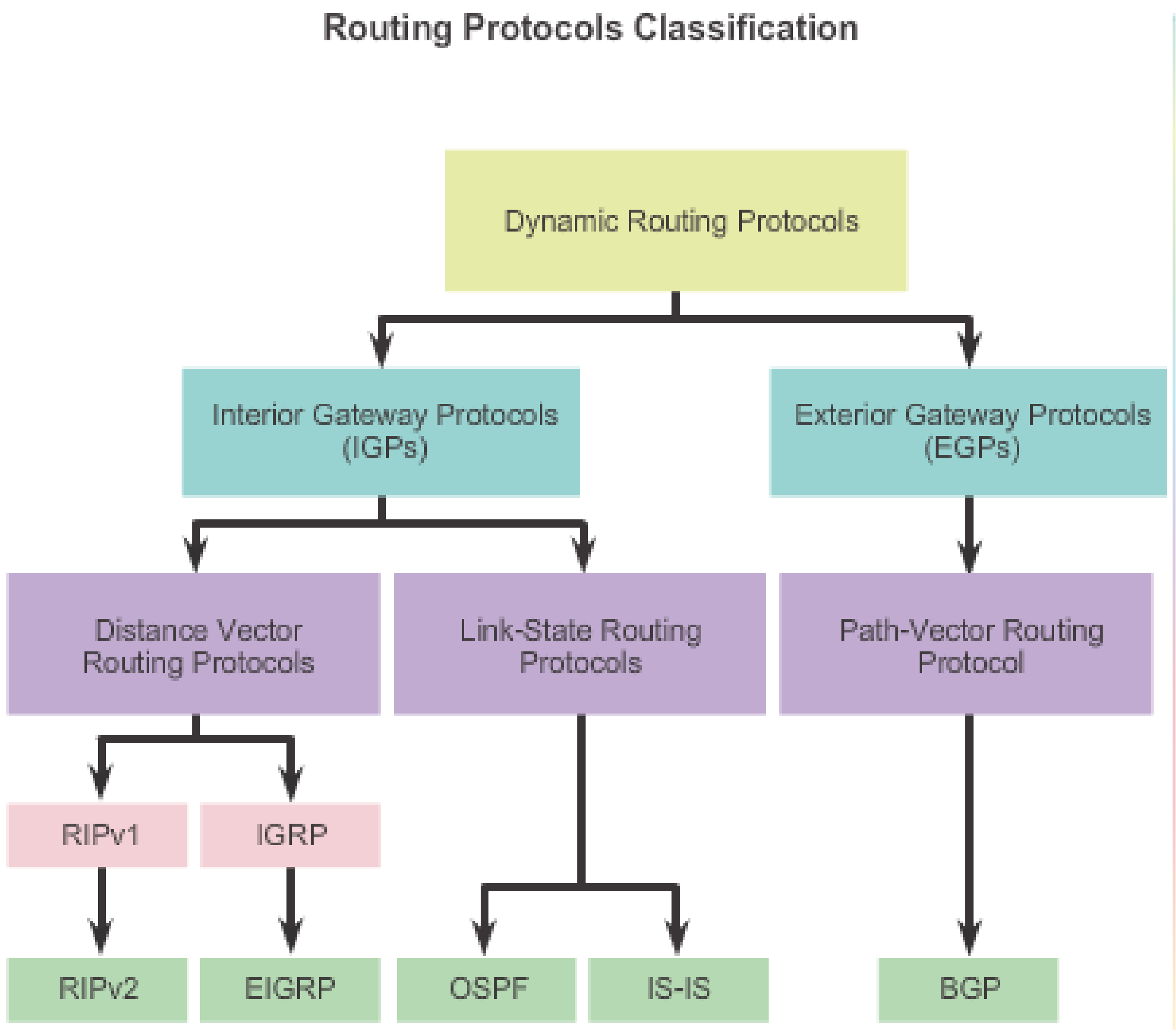
Routing Protocol Operating Fundamentals

Achieving Convergence

The network is converged when all routers have complete and accurate information about the entire network:

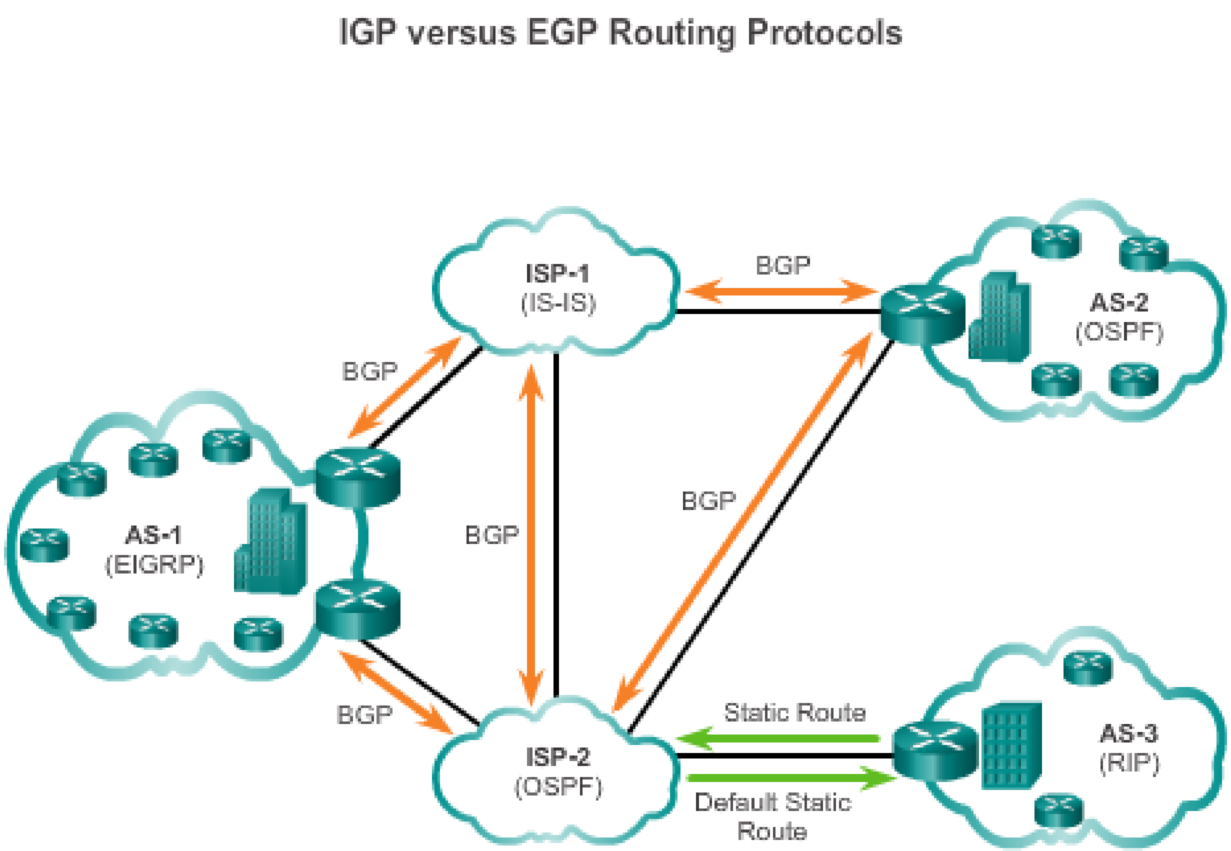
- Convergence time is the time it takes routers to share information, calculate best paths, and update their routing tables.
- A network is not completely operable until the network has converged.
- Convergence properties include the speed of propagation of routing information and the calculation of optimal paths. The speed of propagation refers to the amount of time it takes for routers within the network to forward routing information.
- Generally, older protocols, such as RIP, are slow to converge, whereas modern protocols, such as EIGRP and OSPF, converge more quickly.

Classifying Routing Protocols



Types of Routing Protocols

IGP and EGP Routing Protocols



Interior Gateway Protocols (IGP) -

- Used for routing within an AS
- Include RIP, EIGRP, OSPF, and IS-IS

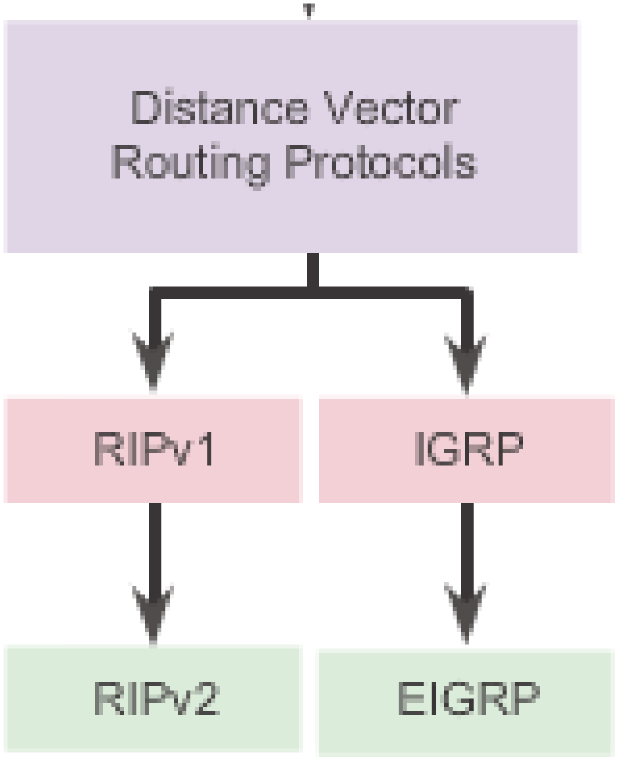
Exterior Gateway Protocols (EGP) -

- Used for routing between AS
- Official routing protocol used by the Internet

Distance Vector Technologies

Distance vector routing protocols:

- Share updates between neighbors
- Not aware of the network topology
- Some send periodic updates to broadcast IP 255.255.255.255 even if topology has not changed
- Updates consume bandwidth and network device CPU resources
- RIPv2 and EIGRP use multicast addresses
- EIGRP will only send an update when topology has changed

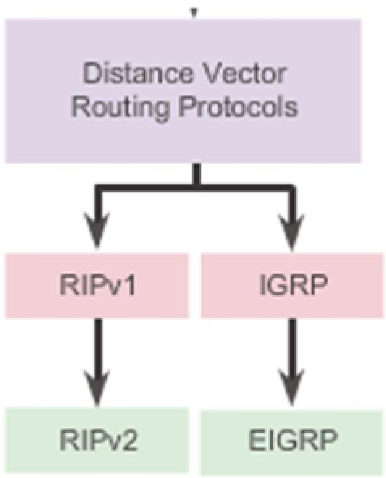


Distance Vector Routing Protocols

✓ ETÄISYYSVEKTORIPROTOKOLLIEN TOIMINTAPERIAATE

- Toiminta perustuu naapuriin luottamiseen ja omien verkkojen mainostukseen
- Mainostusta tehdään säännöllisin väliajoin (protokolla riippuvainen)
- Jos mainosta ei tiettyyn aikaan kuulu poistetaan ko. Reitti reititystaulusta

1) Reititin mainostaa tuntemiaan verkkoja lähettämällä etäisyysvektorin = etäisyys reitittimen tuntemiin verkkoihin
2) Vastaanottaja lisää jokaiseen etäisyysvektoriin mainostavan ja vastaanottajan välisen etäisyyden
3) Vastaanottaja tutkii onko saatu reititystieto entuudestaan tunnettu
   a) jos reititystieto on uusi lisätään se tauluun
   b) jos reititystieto tunnettu, mutta tullut alkuperäiseltä lähettäjältä päivitetään taulukko
   c) jos reititystieto tunnettu, ja tullut uudelta lähettäjältä päivitetään tieto vain, jos etäisyys on lyhentynyt

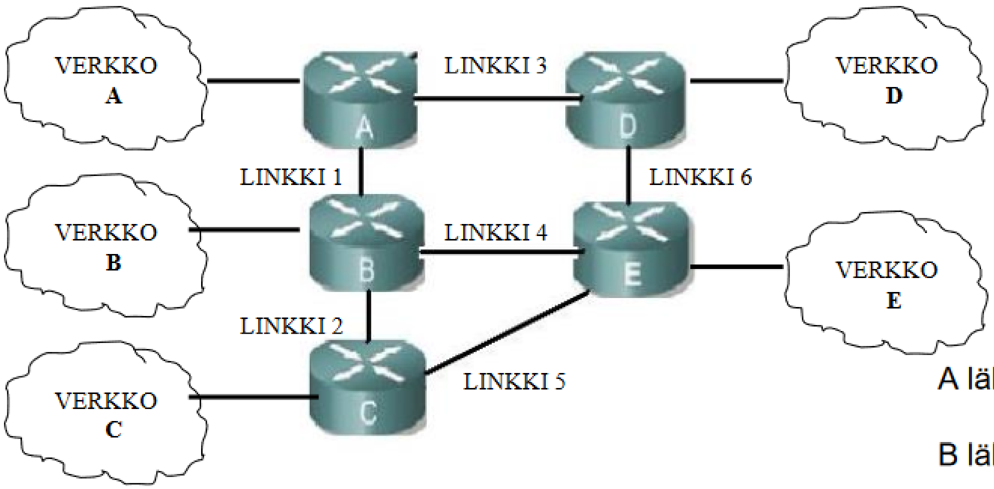


✓ ETÄISYYSVEKTORIPROTOKOLLIEN “ONGELMIA” (EI EIGRP)

- Helposti syntyvät reititys silmukat
- Ei sovellu suuriin verkkoihin, jossa linkkien kapasiteetti on pieni
- Reititystietojen päivitys kuormittaa verkkoa
- Maksimi hyppymäärä voi olla pieni (esim RIP 16)
- Edm. heikkouksien takia etäisyysvektoriprotokollia ei suositella käytettäväksi hiukkaakaan suurimmissa verkoissa

Distance Vector Routing Protocols

✓ ETÄISYYS VERKKOIHIN JA REITITYSTAULUN PÄIVITYS



A lähettää B:lle ja D:lle -> A=0

B lähettää A:lle, C:lle ja E:lle -> B=0 , A=1

C lähettää B:lle ja E:lle -> C=0 , B=1

D lähettää A:lle ja E:lle -> D=0 , A=1

E lähettää B:lle , D:lle ja C:lle -> E=0 , D=1 , C=1

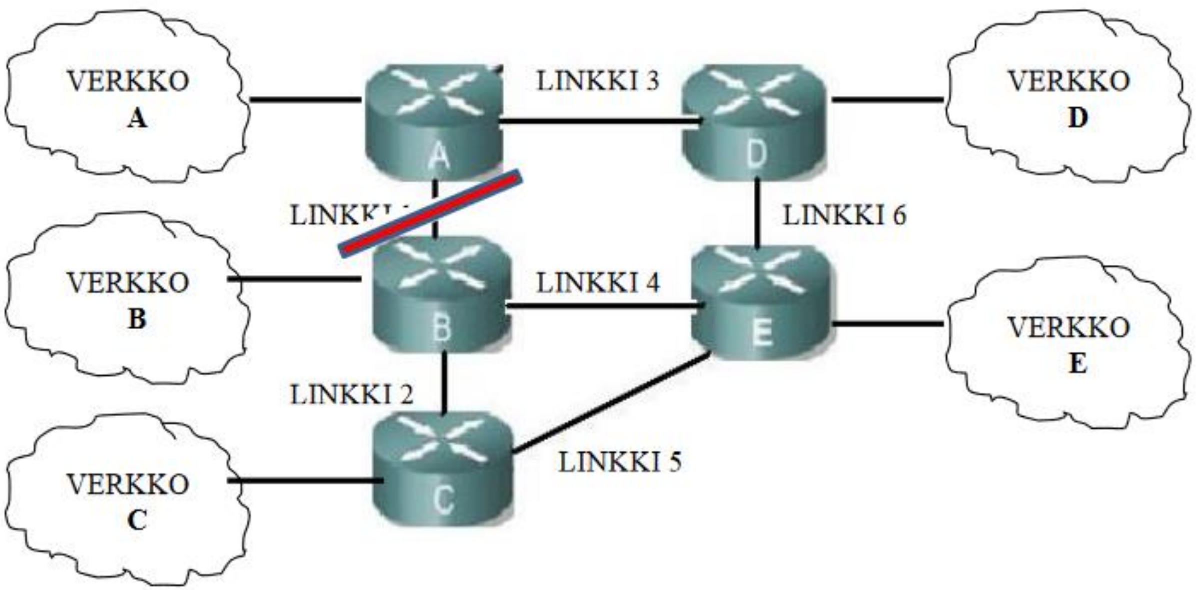
Reititin A	linkki	kustannus
A	paikal.	0
B	1	1
C	1	2
D	3	1
E	1	2

Reititin B	linkki	kustannus
A	1	1
B	paikal.	0
C	2	1
D	4	2
E	4	1

Reititin C	linkki	kustannus
A	2	2
B	2	1
C	paikal.	0
D	5	2
E	5	1

Distance Vector Routing Protocols

✓ LINKIN KATKEAMISEN VAIKUTUS REITITYSTAULUUN



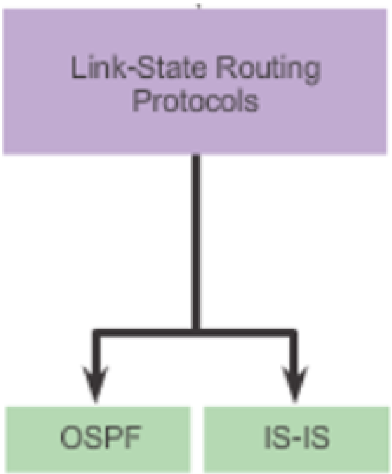
Reititin A	linkki	kustannus
A	paikal.	0
B	1	ääretön
C	1	ääretön
D	3	1
E	1	ääretön

Reititin A	linkki	kustannus
A	paikal.	0
B	3	3
C	3	3
D	3	1
E	3	2

Link-State Routing Protocols

✓ YHTEYDENTILAPROTOKOLLAT

- Toinen protokollaperhe etäisyysvektoriprotokollien ohella
- Yhteydentilapotokollia on IP-verkoissa vain kaksi erilaista
  - OSPF (Open Shortest Path First)
  - IS-IS (Intermediate System to Intermediate System)
- OSPF useimmiten ainoa vaihtoehto, isoissa ja useampia laitemerkkejä käyttävissä reititinverkoissa
- Cisco:n laitteilla vaihtoehtona myös EIGRP (ei ”puhdas” yhteydentilaprotokolla)
- Kaikilla verkon reitittimillä on SPC-algoritmillä laskettu tietokanta koko verkon topologiasta
- Reititystaulut muodostetaan topologiatietoon perustuen
- Reitittimet välittävät toisilleen yhteystila informaatiota (LSA=Link State Advertisement) ajoittain tai topologian muuttuessa
- Yhteydentila protokollat vaativat reitittimeltä etäisyysvektoriprotokollia enemmän muistia ja prosessori tehoa



Types of Routing Protocols
Classful Routing Protocols

Classful routing protocols do not send subnet mask information in their routing updates:

- Only RIPv1 and IGRP are classful.
- Created when network addresses were allocated based on classes (class A, B, or C).
- Cannot provide variable length subnet masks (VLSMs) and classless interdomain routing (CIDR).
- Create problems in discontiguous networks.

Types of Routing Protocols
Classless Routing Protocols

Classless routing protocols include subnet mask information in the routing updates:

- RIPv2, EIGRP, OSPF, and IS_IS
- Support VLSM and CIDR
- IPv6 routing protocols

Types of Routing Protocols

Routing Protocol Characteristics

	Distance Vector				Link State	
	RIPv1	RIPv2	IGRP	EIGRP	OSPF	IS-IS
Speed Convergence	Slow	Slow	Slow	Fast	Fast	Fast
Scalability - Size of Network	Small	Small	Small	Large	Large	Large
Use of VLSM	No	Yes	No	Yes	Yes	Yes
Resource Usage	Low	Low	Low	Medium	High	High
Implemenation and Maintenance	Simple	Simple	Simple	Complex	Complex	Complex

Routing Protocol Metrics

A metric is a measurable value that is assigned by the routing protocol to different routes based on the usefulness of that route:

- Used to determine the overall “cost” of a path from source to destination.
- Routing protocols determine the best path based on the route with the lowest cost.

Types of Distance Vector Routing Protocols
Routing Information Protocol

RIPv1 versus RIPv2

Routing updates broadcasted every 30 seconds

Characteristics and Features	RIPv1	RIPv2
Metric	Both use hop count as a simple metric. The maximum number of hops is 15.	
Updates Forwarded to Address	255.255.255.255	224.0.0.9
Supports VLSM	✗	✓
Supports CIDR	✗	✓
Supports Summarization	✗	✓
Supports Authentication	✗	✓

Updates use UDP port 520

RIPng is based on RIPv2 with a 15 hop limitation and the administrative distance of 120

Types of Distance Vector Routing Protocols
Enhanced Interior-Gateway Routing Protocol

IGRP versus EIGRP

Characteristics and Features	IGRP	EIGRP
Metric	Both use a composite metric consisting of bandwidth and delay. Reliability and load can also be included in the metric calculation.	
Updates Forwarded to Address	255.255.255.255	224.0.0.10
Supports VLSM	✗	✓
Supports CIDR	✗	✓
Supports Summarization	✗	✓
Supports Authentication	✗	✓

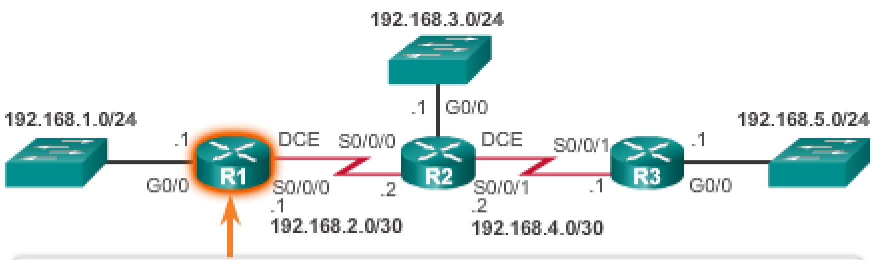
EIGRP:
- Is bounded triggered updates
- Uses a Hello keepalives mechanism
- Maintains a topology table
- Supports rapid convergence
- Is a multiple network layer protocol support

Configuring the RIP Protocol

Router RIP Configuration Mode
Advertising Networks

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# router rip
R1(config-router)#
```

Advertising the R1 Networks




```
R1(config)#router rip
R1(config-router)#network 192.168.1.0
R1(config-router)#network 192.168.2.0
R1(config-router)#
```

Configuring the RIP Protocol

Examining Default RIP Settings

Verifying RIP Settings on R1

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

Routing Protocol is "rip"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Sending updates every 30 seconds, next due in 16 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Redistributing: rip

  Default version control: send version 1, receive any version
    Interface             Send  Recv  Triggered RIP  Key-chain
    GigabitEthernet0/0    1     1 2
    Serial0/0/0           1     1 2

  Automatic network summarization is in effect
  Maximum path: 4
  Routing for Networks:
    192.168.1.0
    192.168.2.0

  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.2.2          120      00:00:15
  Distance: (default is 120)

R1#
```

Verifying RIP Routes on R1

```
R1# show ip route | begin Gateway
Gateway of last resort is not set

      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/0
L        192.168.1.1/32 is directly connected, GigabitEthernet0/0
      192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.2.0/24 is directly connected, Serial0/0/0
L        192.168.2.1/32 is directly connected, Serial0/0/0
R     192.168.3.0/24 [120/1] via 192.168.2.2, 00:00:24, Serial0/0/0
R     192.168.4.0/24 [120/1] via 192.168.2.2, 00:00:24, Serial0/0/0
R     192.168.5.0/24 [120/2] via 192.168.2.2, 00:00:24, Serial0/0/0
R1#
```

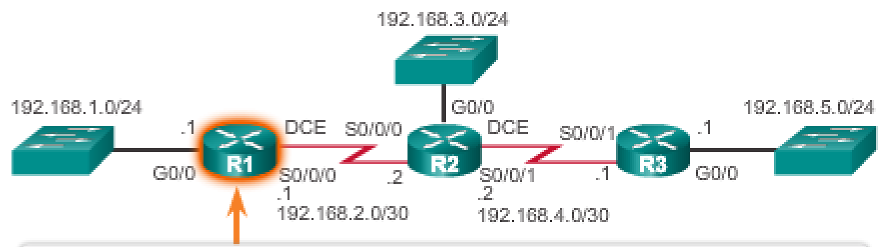
Configuring the RIP Protocol
Enabling RIPv2

Verifying RIP Settings on R1

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

Routing Protocol is "rip"
  Outgoing update filter list for all interfaces is not
set
  Incoming update filter list for all interfaces is not
set
  Sending updates every 30 seconds, next due in 16 seconds
  Invalid after 180 seconds, hold down 180, flushed after
240
  Redistributing: rip
  Default version control: send version 1, receive any
version
    Interface           Send  Recv  Triggered RIP  Key-chain
    GigabitEthernet0/0    1     1 2
    Serial0/0/0           1     1 2
  Automatic network summarization is in effect
  Maximum path: 4
  Routing for Networks:
    192.168.1.0
    192.168.2.0
  Routing Information Sources:
    Gateway         Distance      Last Update
```

Enable and Verify RIPv2 on R1

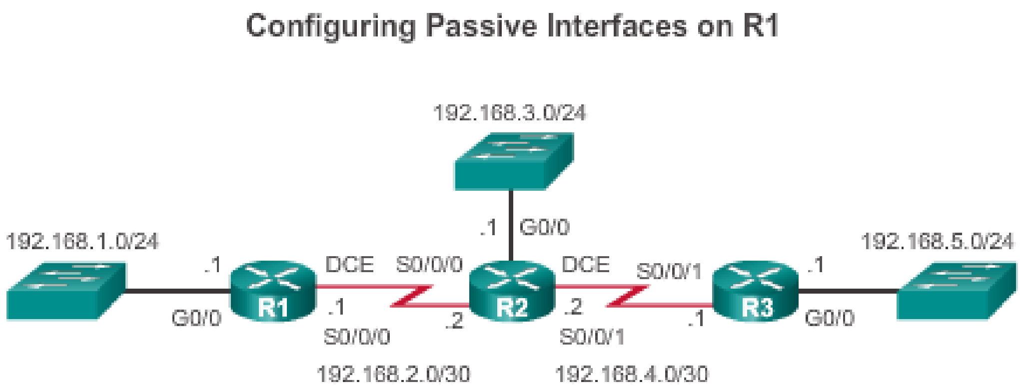



```
R1(config)# router rip
R1(config-router)# version 2
R1(config-router)# ^Z
R1#
R1# show ip protocols | section Default
  Default version control: send version 2, receive version 2
    Interface           Send  Recv  Triggered RIP  Key-chain
    GigabitEthernet0/0    2     2
    Serial0/0/0           2     2
R1#
```

Configuring the RIP Protocol
Disabling Auto Summarization

- Similarly to RIPv1, RIPv2 automatically summarizes networks at major network boundaries by default.
- To modify the default RIPv2 behavior of automatic summarization, use the **`no auto-summary`** router configuration mode command.
- This command has no effect when using RIPv1.
- When automatic summarization has been disabled, RIPv2 no longer summarizes networks to their classful address at boundary routers. RIPv2 now includes all subnets and their appropriate masks in its routing updates.
- The **`show ip protocols`** now states that automatic network summarization is not in effect.

Configuring Passive Interfaces



Sending out unneeded updates on a LAN impacts the network in three ways:

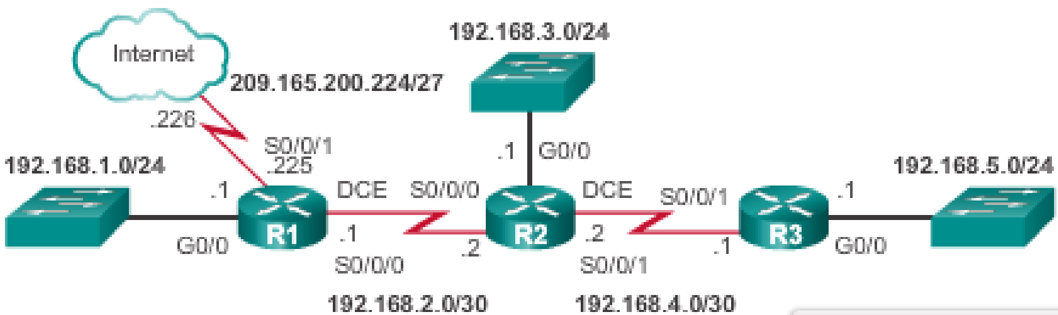
- Wasted Bandwidth
- Wasted Resources
- Security Risk

```
R1(config)# router rip
R1(config-router)# passive-interface g0/0
R1(config-router)# end
R1#
R1# show ip protocols | begin Default
  Default version control: send version 2, receive version 2
    Interface             Send  Recv  Triggered RIP  Key-chain
    Serial0/0/0           2     2
  Automatic network summarization is not in effect
  Maximum path: 4
  Routing for Networks:
    192.168.1.0
    192.168.2.0
  Passive Interface(s):
    GigabitEthernet0/0
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.2.2          120      00:00:06
  Distance: (default is 120)

R1#
```

Configuring the RIP Protocol
Propagating a Default Route

Propagating a Default Route on R1

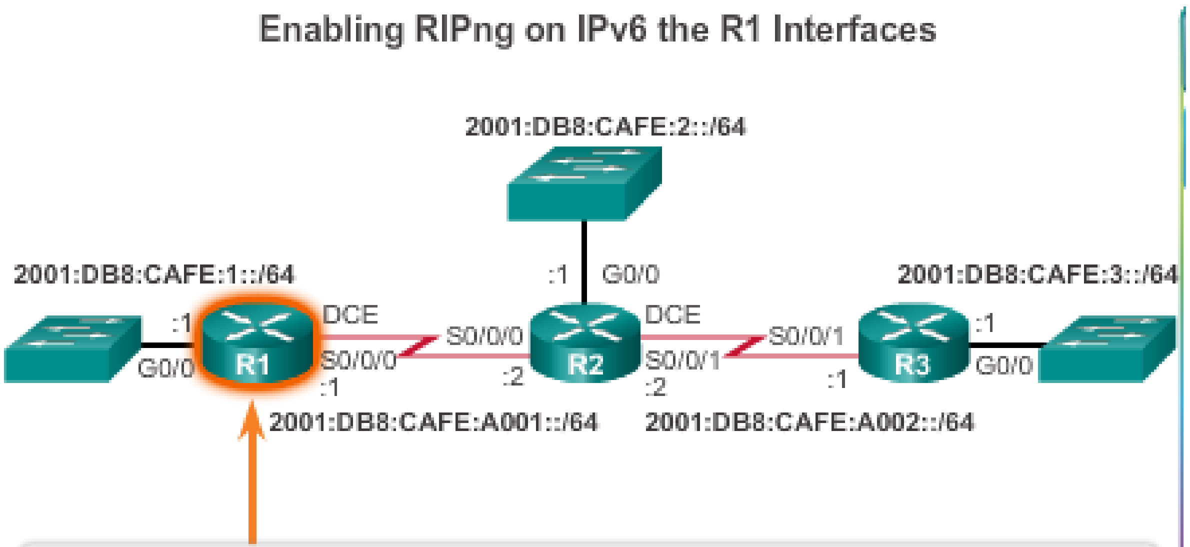



```
R1(config)# ip route 0.0.0.0 0.0.0.0 S0/0/1 209.165.200.226
R1(config)# router rip
R1(config-router)# default-information originate
R1(config-router)# ^Z
R1#
*Mar 10 23:33:51.801: %SYS-5-CONFIG_I: Configured from
console by console
R1# show ip route | begin Gateway
Gateway of last resort is 209.165.200.226 to network
0.0.0.0

S*    0.0.0.0/0 [1/0] via 209.165.200.226, Serial0/0/1
      192.168.1.0/24 is variably subnetted, 2 subnets, 2
masks
C        192.168.1.0/24 is directly connected,
GigabitEthernet0/0
L        192.168.1.1/32 is directly connected,
GigabitEthernet0/0
      192.168.2.0/24 is variably subnetted, 2 subnets, 2
masks
C        192.168.2.0/24 is directly connected, Serial0/0/0
L        192.168.2.1/32 is directly connected, Serial0/0/0
R     192.168.3.0/24 [120/1] via 192.168.2.2, 00:00:08,
```

Configuring the RIPng Protocol

Advertising IPv6 Networks




```
R1(config)# ipv6 unicast-routing
R1(config)#
R1(config)# interface gigabitethernet 0/0
R1(config-if)# ipv6 rip RIP-AS enable
R1(config-if)# exit
R1(config)#
R1(config)# interface serial 0/0/0
R1(config-if)# ipv6 rip RIP-AS enable
R1(config-if)# no shutdown
R1(config-if)#
```

Configuring the RIPng Protocol

Examining the RIPng Configuration

Verifying RIP Settings on R1

```
R1# show ipv6 protocols
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "ND"
IPv6 Routing Protocol is "rip RIP-AS"
  Interfaces:
    Serial0/0/0
    GigabitEthernet0/0
  Redistribution:
    None
R1#
```

Verifying Routes on R1

```
R1# show ipv6 route
IPv6 Routing Table - default - 8 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user
Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP,
       EX - EIGRP external, ND - ND Default,
       NDp - ND Prefix, DCE - Destination, NDr - Redirect,
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1,
       OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1,
       ON2 - OSPF NSSA ext 2
C   2001:DB8:CAFE:1::/64 [0/0]
     via GigabitEthernet0/0, directly connected
L   2001:DB8:CAFE:1::1/128 [0/0]
     via GigabitEthernet0/0, receive
R   2001:DB8:CAFE:2::/64 [120/2]
     via FE80::FE99:47FF:FE71:78A0, Serial0/0/0
R   2001:DB8:CAFE:3::/64 [120/3]
     via FE80::FE99:47FF:FE71:78A0, Serial0/0/0
C   2001:DB8:CAFE:A001::/64 [0/0]
     via Serial0/0/0, directly connected
L   2001:DB8:CAFE:A001::1/128 [0/0]
     via Serial0/0/0, receive
R   2001:DB8:CAFE:A002::/64 [120/2]
```

Configuring the RIPng Protocol

Examining the RIPng Configuration (cont.)

Verifying RIPng Routes on R1

```
R1# show ipv6 route rip
IPv6 Routing Table - default - 8 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user
Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP,
       EX - EIGRP external, ND - ND Default,
       NDp - ND Prefix, DCE - Destination, NDr - Redirect,
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1,
       OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1,
       ON2 - OSPF NSSA ext 2
R   2001:DB8:CAFE:2::/64 [120/2]
     via FE80::FE99:47FF:FE71:78A0, Serial0/0/0
R   2001:DB8:CAFE:3::/64 [120/3]
     via FE80::FE99:47FF:FE71:78A0, Serial0/0/0
R   2001:DB8:CAFE:A002::/64 [120/2]
     via FE80::FE99:47FF:FE71:78A0, Serial0/0/0
R1#
```