Chapter 4:
Routing Protocols
Revised by
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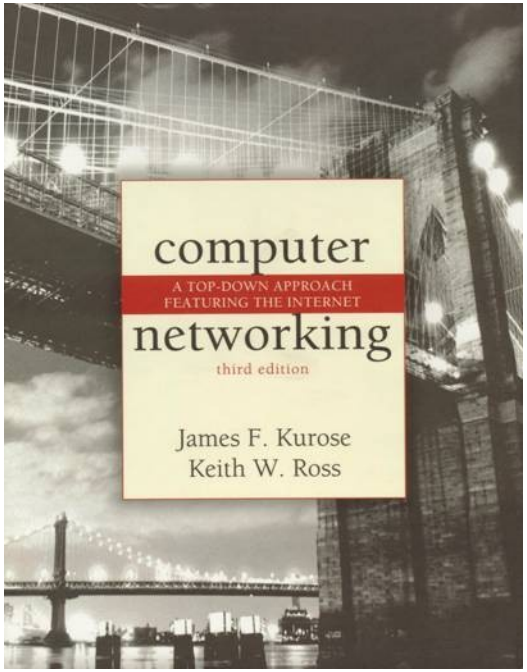
http://sites.google.com/site/quanletrung/



Computer Networking: A Top Down Approach Featuring the Internet, 3rd edition.
Jim Kurose, Keith Ross
Addison-Wesley, July 2004.

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Thanks and enjoy! JFK/KWR

Routing in the Internet

- RIP
- OSPF
- BGP

Intra-AS Routing

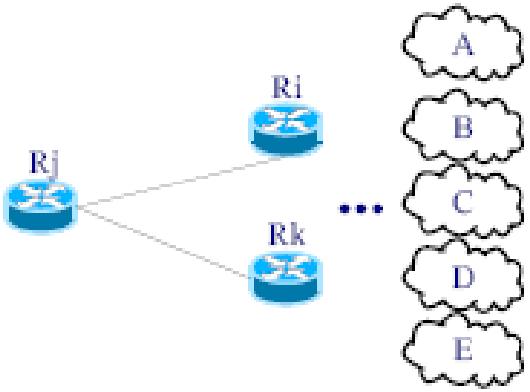
- Also known as Interior Gateway Protocols (IGP)
- Most common Intra-AS routing protocols:
  - RIP: Routing Information Protocol
  - OSPF: Open Shortest Path First
  - IGRP: Interior Gateway Routing Protocol (Cisco proprietary)

Routing Information Protocol, RIP (RFC 2453)

- The metric (distance) to a destination is the number of hops (i.e. transmissions) to reach the destination: 1 if the destination is attached to a directly connected network, 2 if 1 additional router is needed ...
- Routers send updates every 30 seconds to the neighbors.
- RIP messages use UDP, src./dst. port = 520, broadcast dst. IP addr.
- RIP updates include destinations and metrics tuples.
- A neighbor is considered down if no RIP messages are seen during 180 seconds.
- Infinite metric is 16.
- Two versions of RIP: Version 2 allows variable masks ans uses the multicast dst. address 244.0.0.9 (all RIPv2 routers).

RIP – Routing Table (RT) Update Example

- When an update message from Rj is received:
  - Increase the message metrics.
  - Add new destinations.
  - Change entries with other routers with larger metrics.
  - Update metrics using Rj's gateway.



D	G	M
A	Rk	4
B	Rj	3
C	Rk	5
D	Rj	2

Ri's RT

D	M
A	1
B	4
C	5
D	1
E	3

Ri receives Rj's update message

D	M
A	2
B	5
C	6
D	2
E	4

Rj's metrics increased

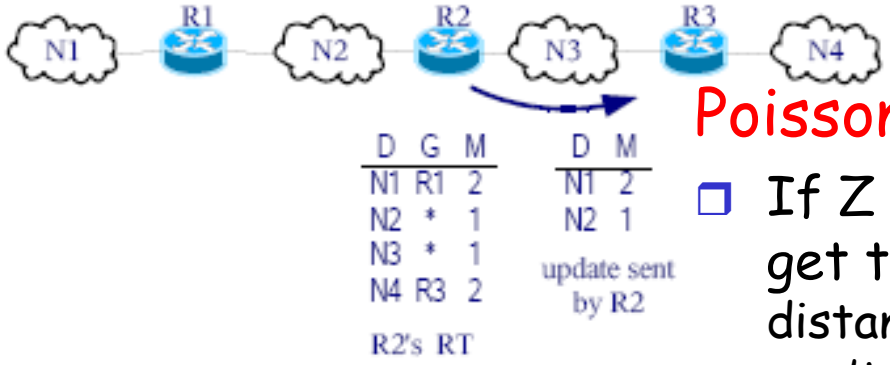
D	G	M
A	Rj	2
B	Rj	5
C	Rk	5
D	Rj	2
E	Rj	4

Ri's RT updated

http://tools.ietf.org/html/rfc1058

RIP – Count to Infinity Solutions

- Split horizon: When the router sends the update, removes the entries having a gateway in the interface where the update is sent:



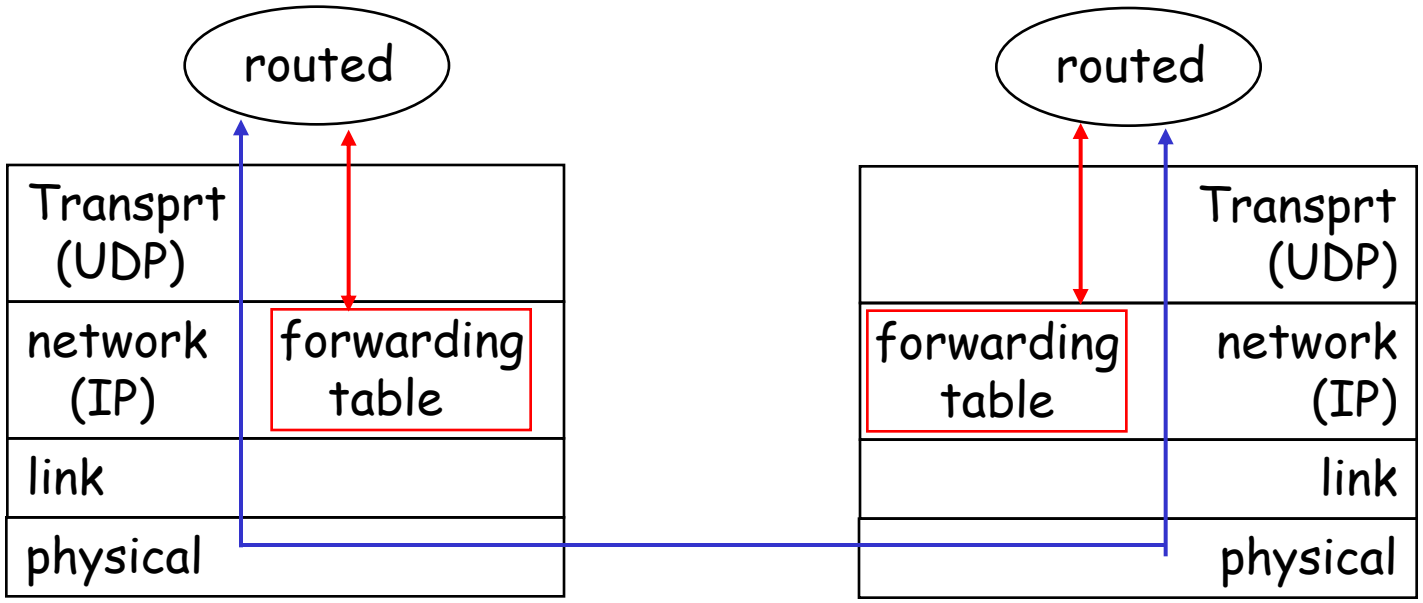
Poissoned reverse:

- If Z routes through Y to get to X : Z tells Y its (Z's) distance to X is infinite (so Y won't route to X via Z)

- Split horizon with Poisoned Reverse: Consists of adding the entries having a gateway with M=16.
- Triggered updates: Consists of sending the update before the 30 seconds timer expires when a metric change in the routing table.
- Hold down timer (CISCO): When a route becomes unreachable (metric = 16), the entry is placed in *holddown* during 280 seconds. During this time, the entry is not updated.

RIP Table processing

- RIP routing tables managed by **application-level** process called route-d (daemon)
- advertisements sent in UDP packets, periodically repeated



RIP Table example (continued)

Router: *giroflee.eurocom.fr*

Destination	Gateway	Flags	Ref	Use	Interface
127.0.0.1	127.0.0.1	UH	0	26492	lo0
192.168.2.	192.168.2.5	U	2	13	fa0
193.55.114.	193.55.114.6	U	3	58503	le0
192.168.3.	192.168.3.5	U	2	25	qaa0
224.0.0.0	193.55.114.6	U	3	0	le0
default	193.55.114.129	UG	0	143454	

- Three attached class C networks (LANs)
- Router only knows routes to attached LANs
- Default router used to "go up"
- Route multicast address: 224.0.0.0
- Loopback interface (for debugging)

route, routed, zebra

- Static routing
  - Windows ()
    - route PRINT/ADD/CHANGE/DELETE
  - Linux/Unix
    - route
- Dynamic routing
  - RIP
    - routed
  - RIP, OSPF, BGP, etc
    - zebra (ripd, ospfd, bgpd, etc)
- Further information
  - Linux networking
- Demo
  - Netkit
    - http://wiki.netkit.org/

CCNA: Cisco Certified Network Associate Study Guide

CHAPTER 5:

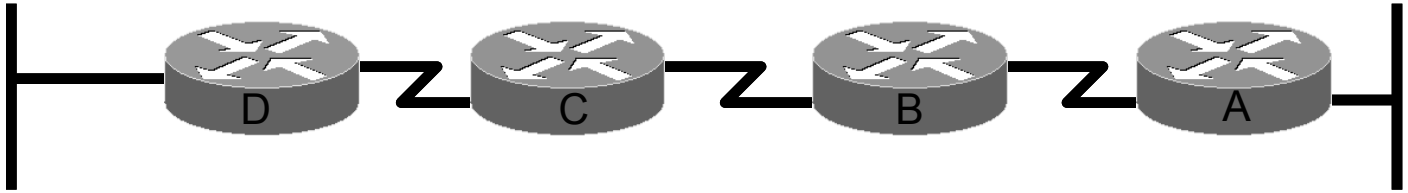
IP Routing

SYBEX

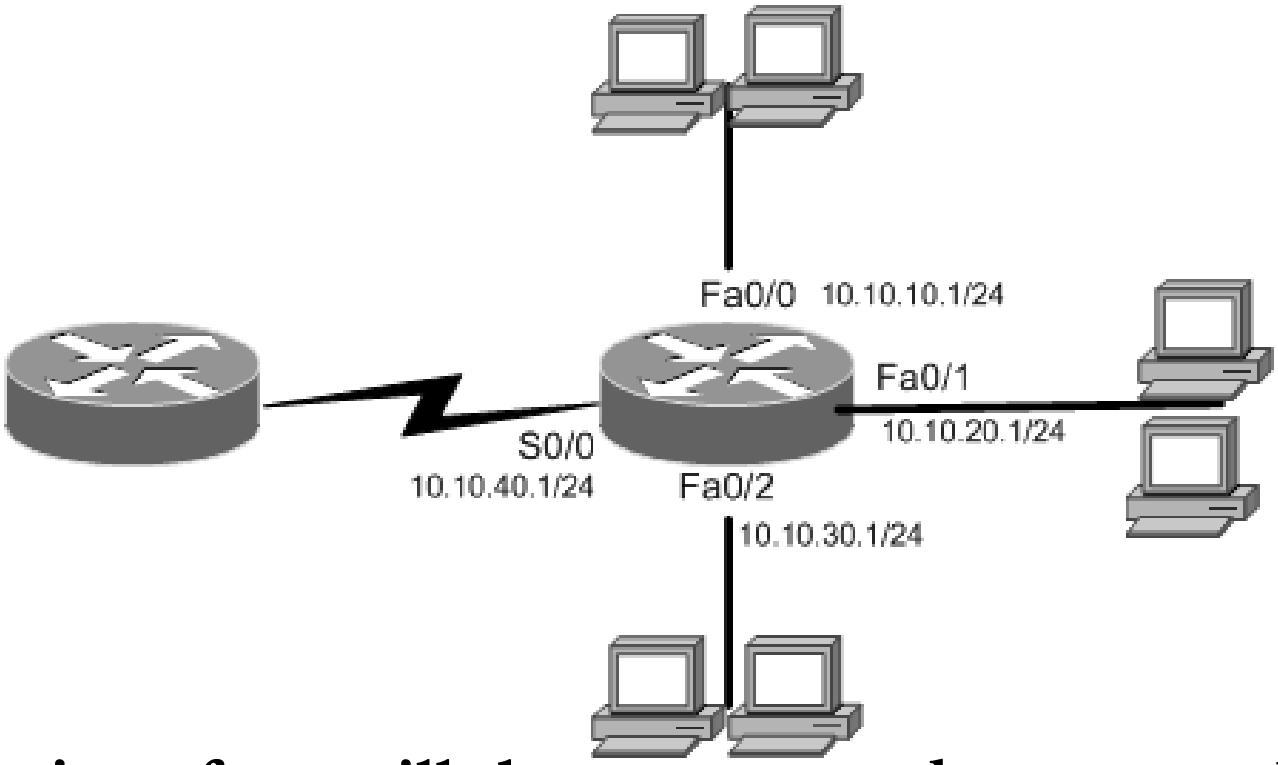
What is Routing?

To route a router need to know:

- Remote Networks
- Neighbor Routers
- All Possible routes to remote network
- The absolute best route to all remote networks
- Maintain and verify the routing information

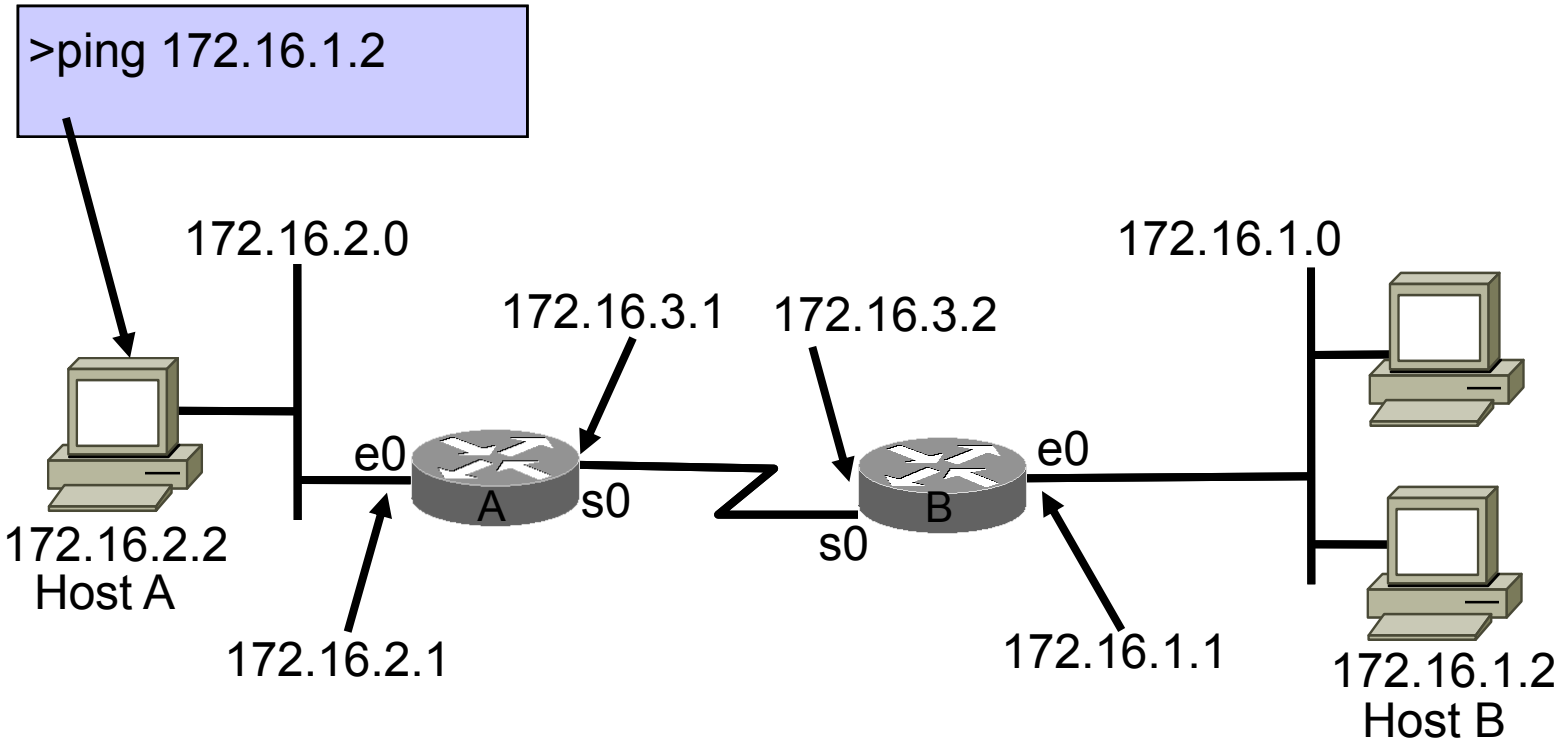


Basic Path Selection

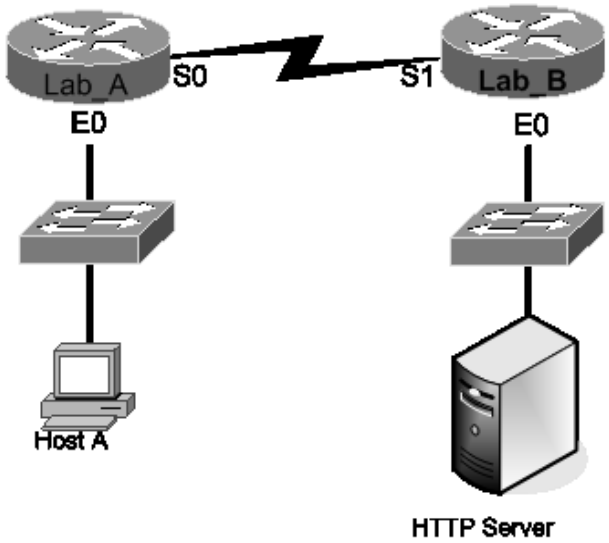


What interface will the router send out a packet if it has destination address of 10.10.10.18?

Simple IP Routing



Routing/PDU Example: Host A Web browses to the HTTP Server….

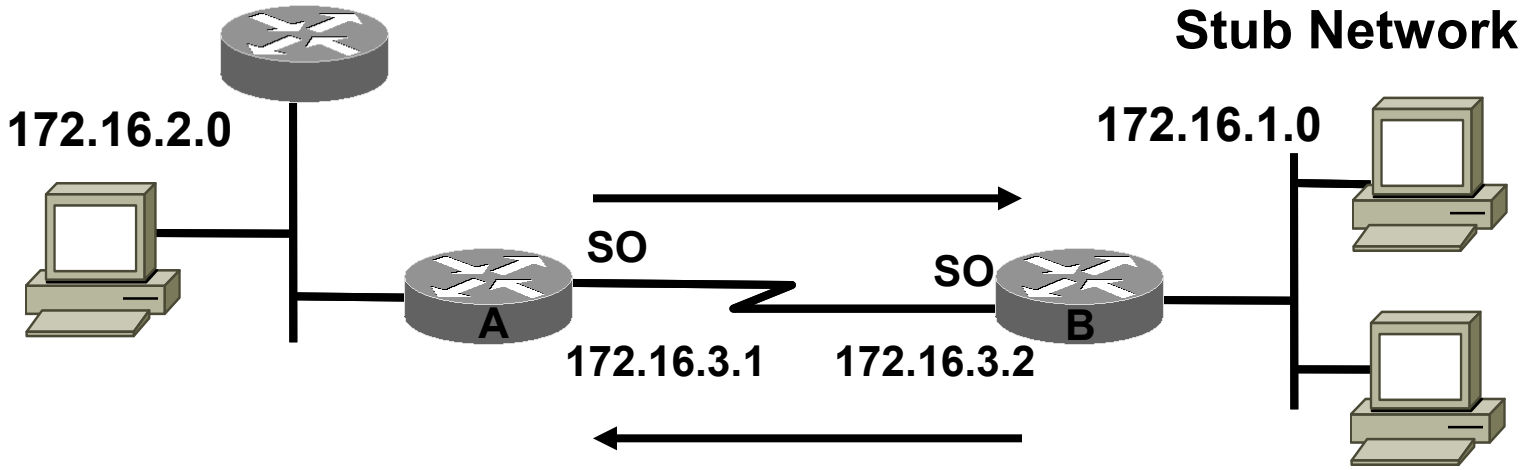


1. The destination address of a frame will be the _____

2. The destination IP address of a packet will be the IP address of the _____

3. The destination port number in a segment header will have a value of __

Static Routes



Routes must be unidirectional

Static Route Configuration

ip route *remote network*

[*mask*]

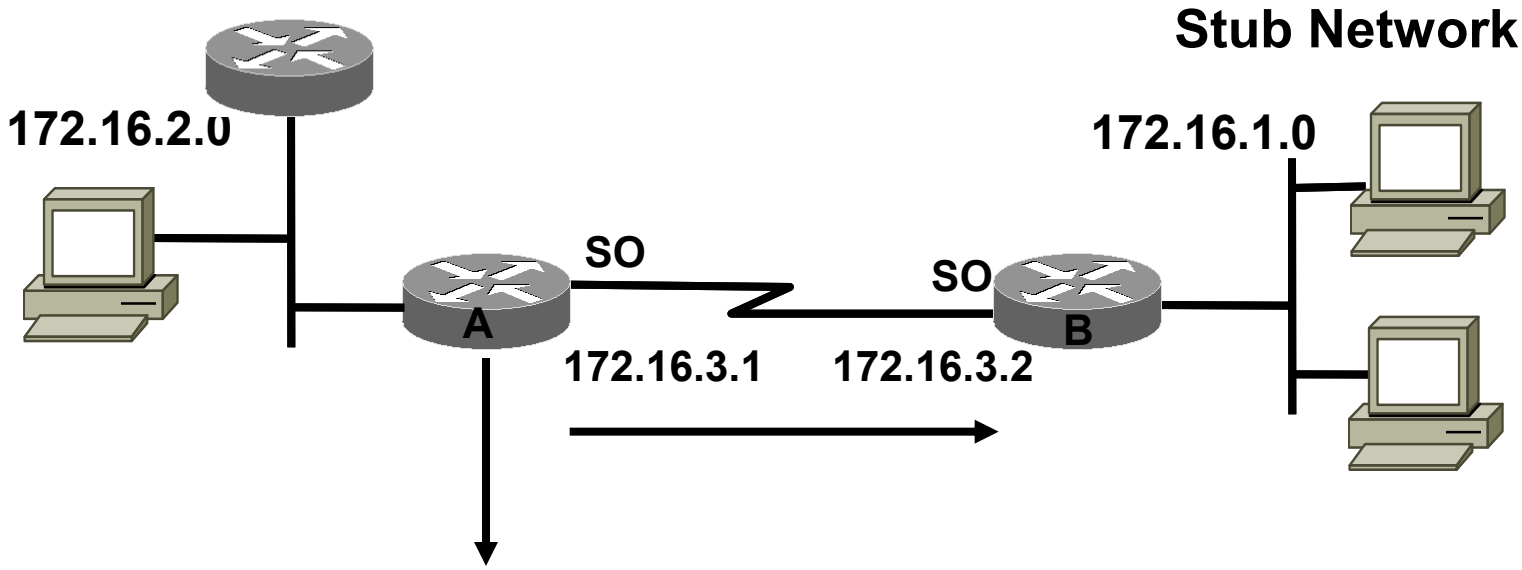
{*address* | *interface*}

[*distance*]

[permanent]

Router(config)#**ip route *remote_network mask next_hop***

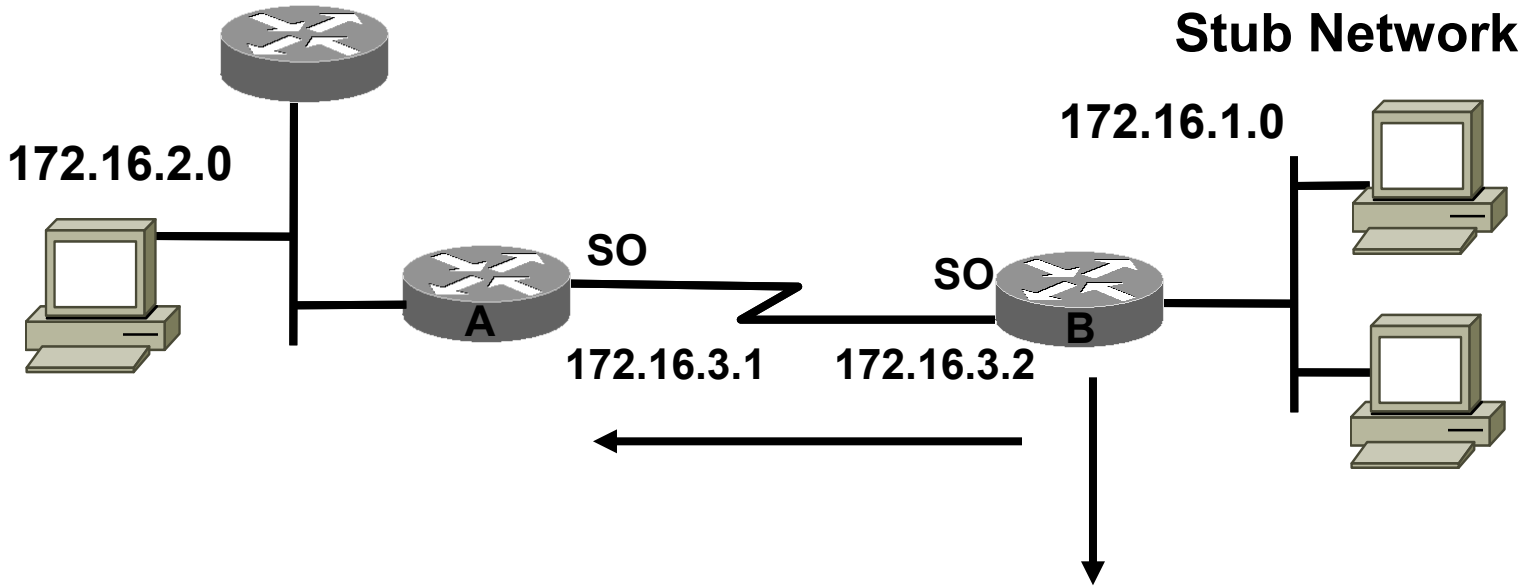
Static Route Example



ip route 172.16.1.0 255.255.255.0 172.16.3.2
or

ip route 172.16.1.0 255.255.255.0 s0

Default Routes



ip route 0.0.0.0 0.0.0.0 172.16.3.1

ip classless [means that subnet mask will be included in routing packets exchange]

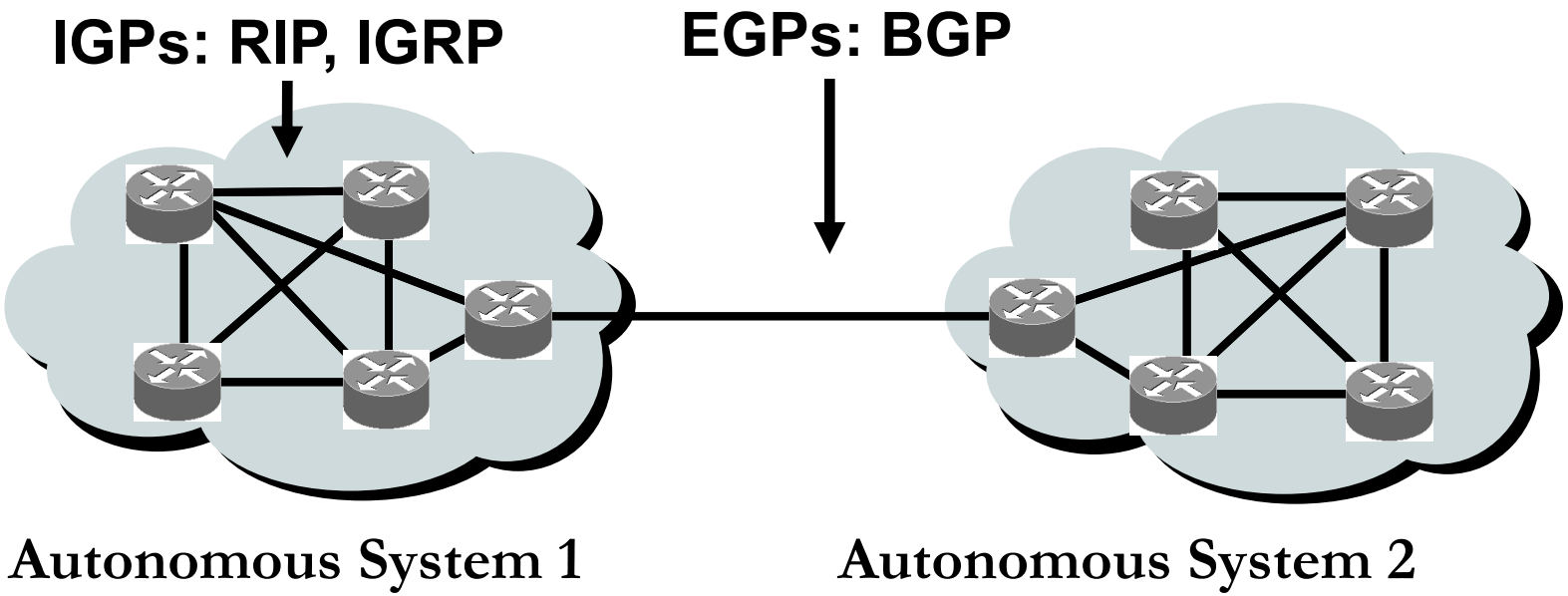
Routing vs. Routed

- **Routing protocols are used between routers to:**
  - Determine the path of a packet through a network
  - Maintain routing tables
  - Examples?
  - RIP, OSPF

- **Routed protocols are:**
  - Assigned to an interface
  - Once the path is determined by the Routing protocol, determines method of delivery
  - Examples?
  - IP

SYBEX

Routing Protocols



- An autonomous system is a collection of networks under a common administrative domain.
- IGPs operate within an autonomous system.
- EGPs connect different autonomous systems.

Classful Routing Overview

Classful routing protocols do not include the subnet mask with the route advertisement.

- Within the same network, consistency of the subnet masks is assumed.
- Summary routes are exchanged between foreign networks.
- Examples of classful routing protocols:
  - RIP Version 1 (RIPv1)
  - IGRP

SYBEX

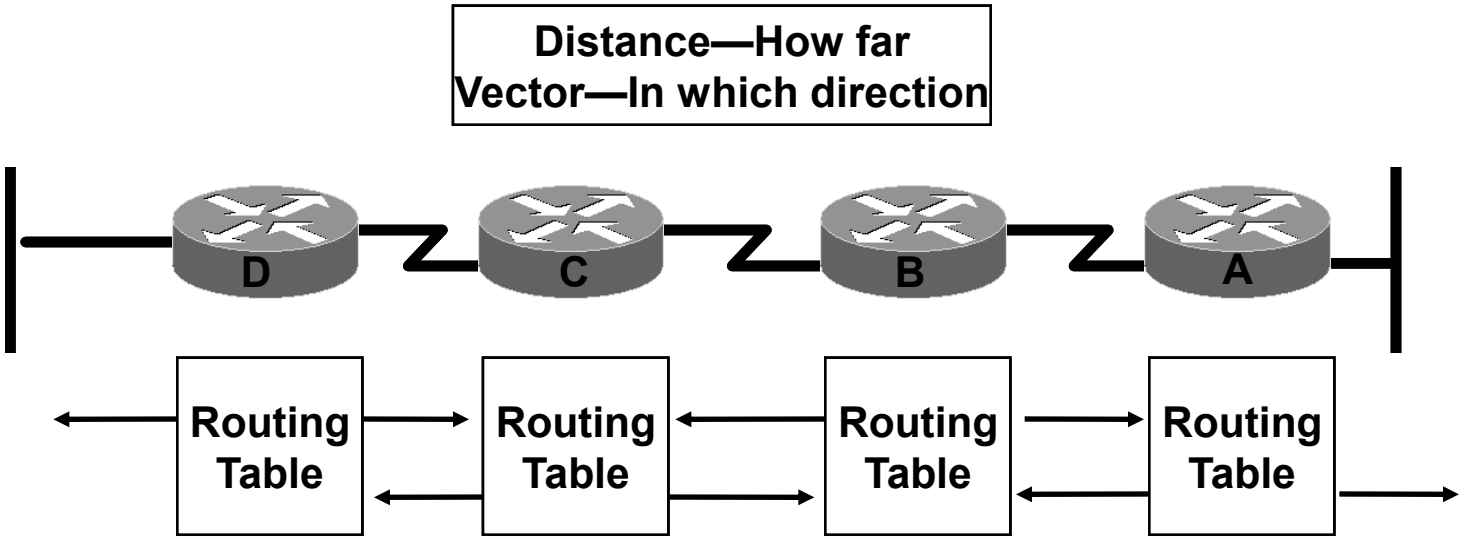
Classless Routing Overview

Classless routing protocols include the subnet mask with the route advertisement.

- Classless routing protocols support variable-length subnet masking (VLSM).
- Summary routes can be manually controlled within the network.
- Examples of classless routing protocols:
  - RIP Version 2 (RIPv2)
  - EIGRP
  - OSPF
  - IS-IS

SYBEX

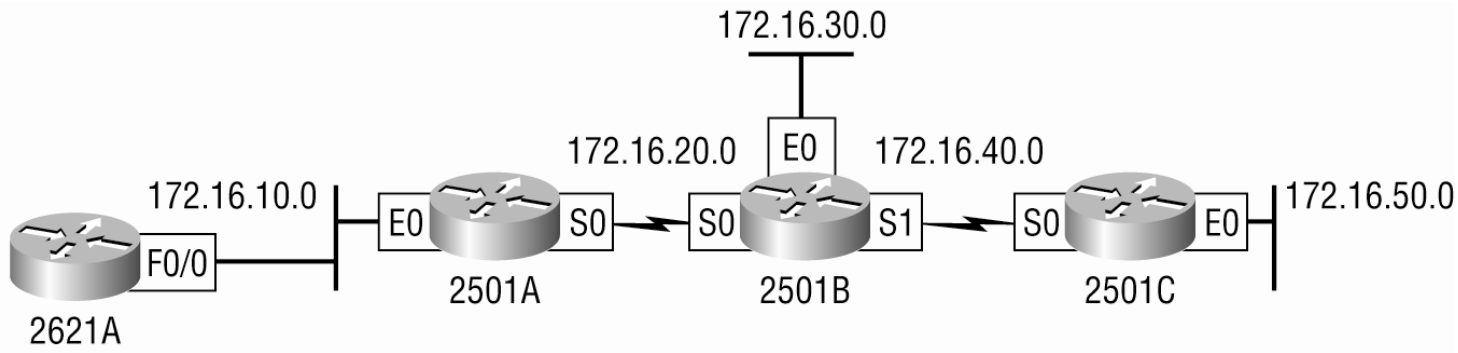
Distance Vector



Distance vector algorithms do not allow a router to know the exact topology of an internetwork.

All routers just broadcast their entire routing table out all active interfaces on periodic time intervals

Discovering Routes



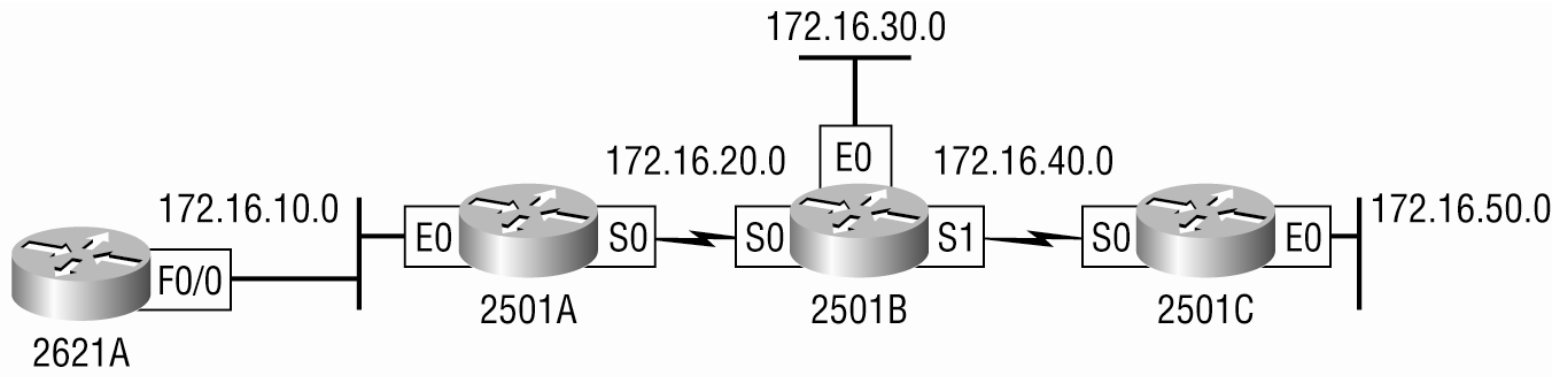
Routing Table		
172.16.10.0	F0/0	0

Routing Table		
172.16.10.0	E0	0
172.16.20.0	S0	0

Routing Table		
172.16.20.0	S0	0
172.16.30.0	E0	0
172.16.40.0	S1	0

Routing Table		
172.16.40.0	S0	0
172.16.50.0	E0	0

Discovering Routes



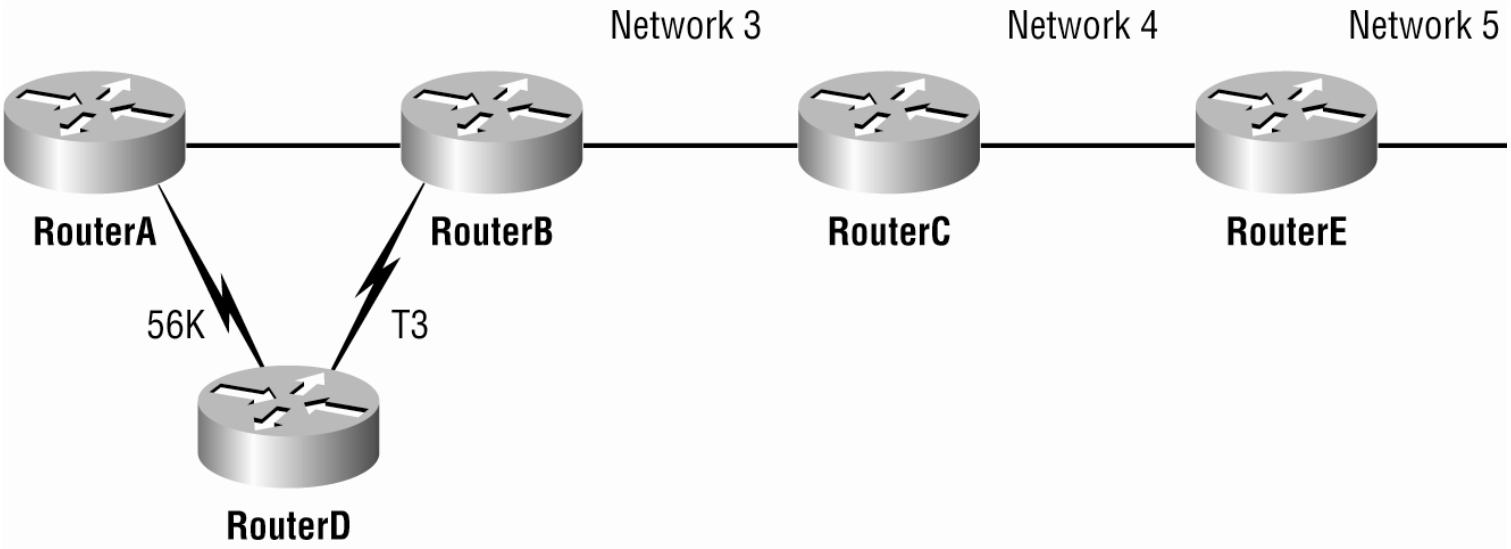
Routing Table		
172.16.10.0	F0/0	0
172.16.20.0	F0/0	1
172.16.30.0	F0/0	2
172.16.40.0	F0/0	2
172.16.50.0	F0/0	3

Routing Table		
172.16.10.0	E0	0
172.16.20.0	S0	0
172.16.30.0	S0	1
172.16.40.0	S0	1
172.16.50.0	S0	2

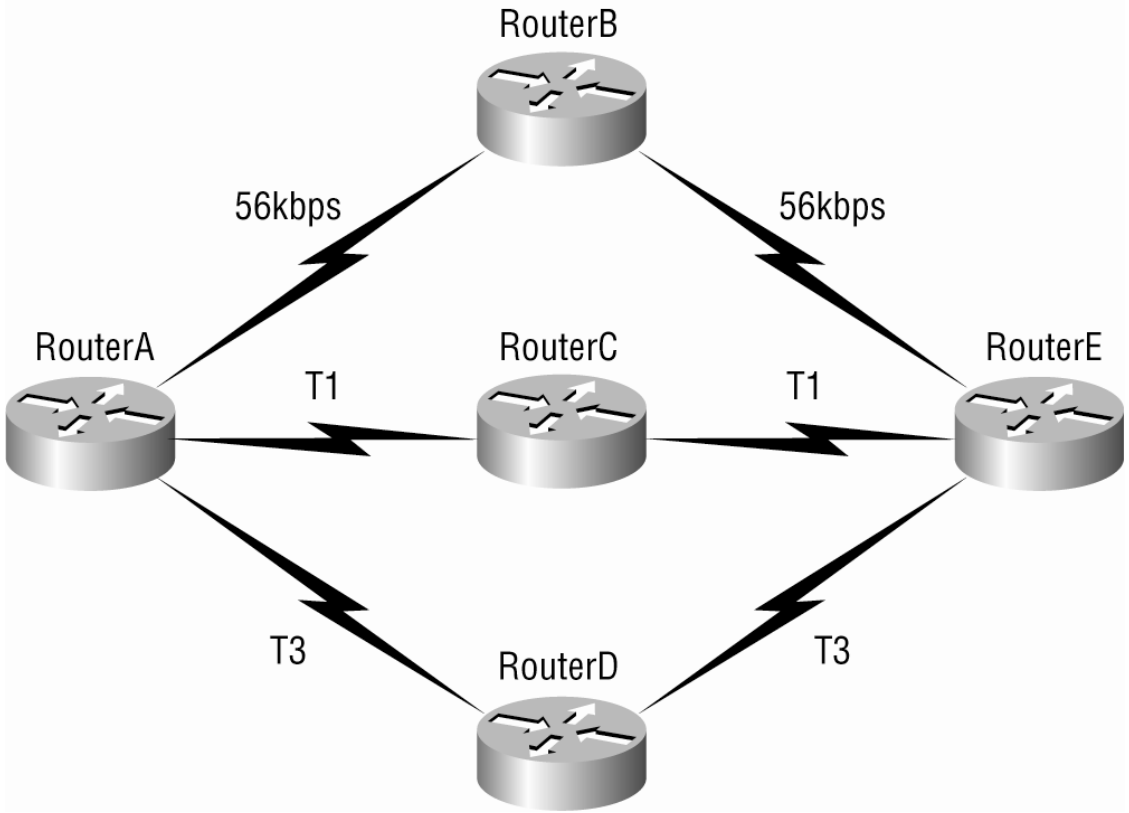
Routing Table		
172.16.20.0	S0	0
172.16.30.0	E0	0
172.16.40.0	S1	0
172.16.10.0	S0	1
172.16.50.0	S1	1

Routing Table		
172.16.40.0	S0	0
172.16.50.0	E0	0
172.16.10.0	S0	2
172.16.20.0	S0	1
172.16.30.0	S0	1

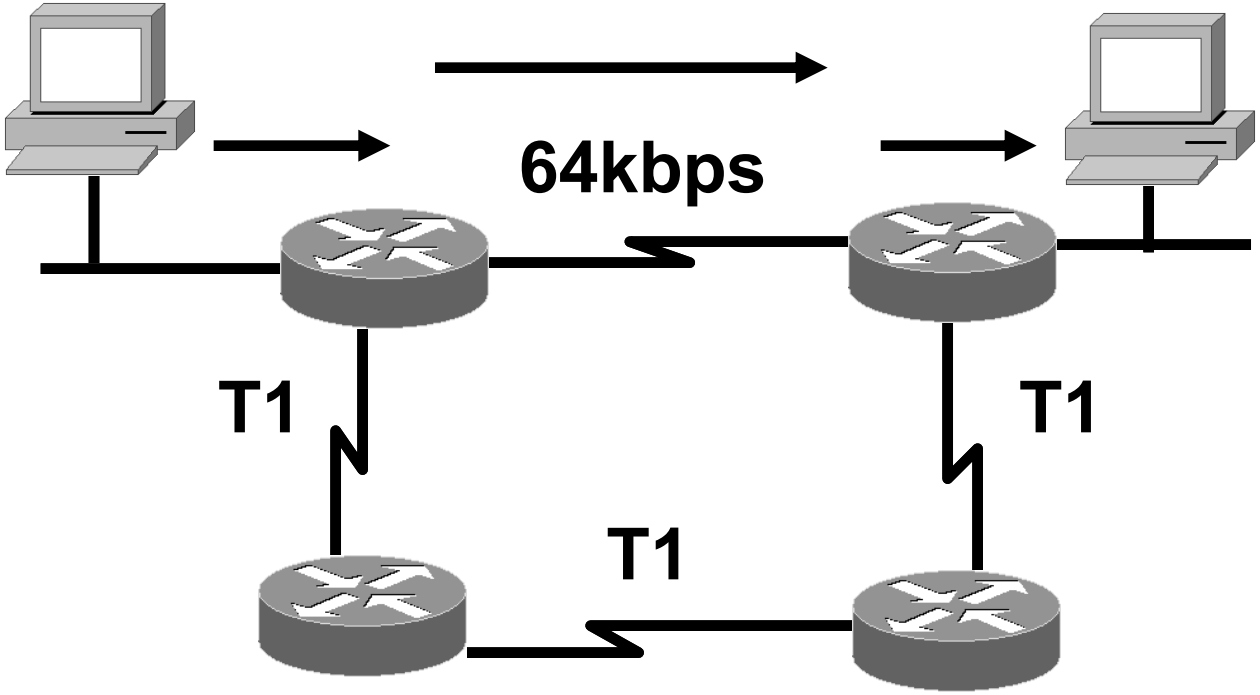
Routing Loops



Router Loops



RIP Overview

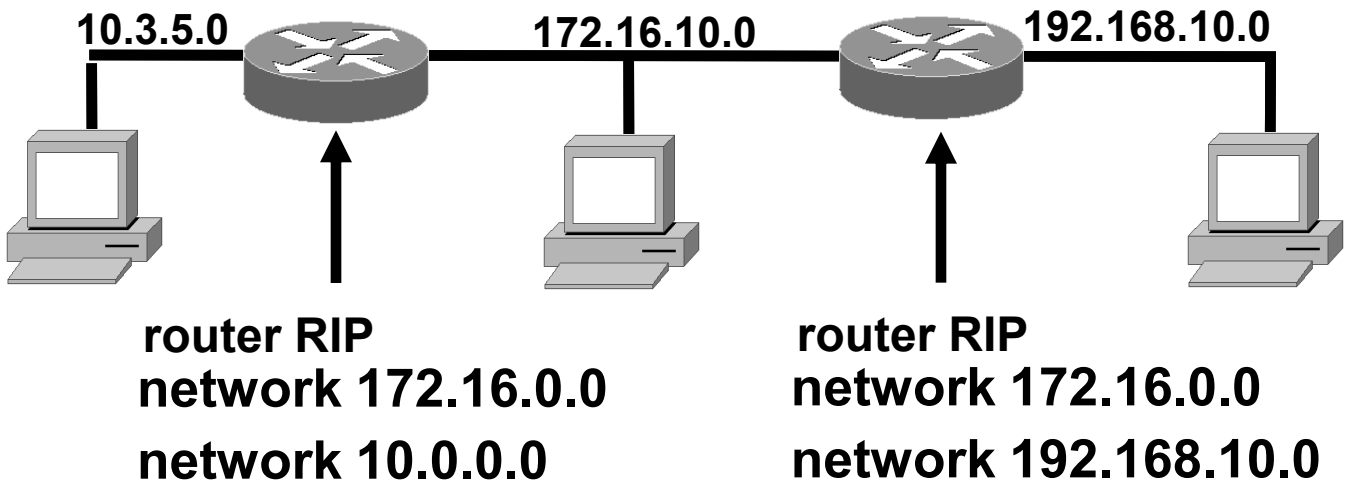


- Hop count metric selects the path, 16 is unreachable
- Full route table broadcast every 30 seconds
- Load balance maximum of 6 equal cost paths (default = 4)
- RIPv2 supports VLSM and Discontiguous networks

RIP Routing Configuration

Router(config)#**router rip**

Router(config-router)#**network** ***network-number****



*Network is a classful network address.

Every device on network uses the same subnet mask

RIP Version 2

- Allows the use of variable length subnet masks (VLSM) by sending subnet mask information with each route update
- Distance Vector – same AD, and timers.
- Easy configuration, just add the command "version 2" under the router rip configuration

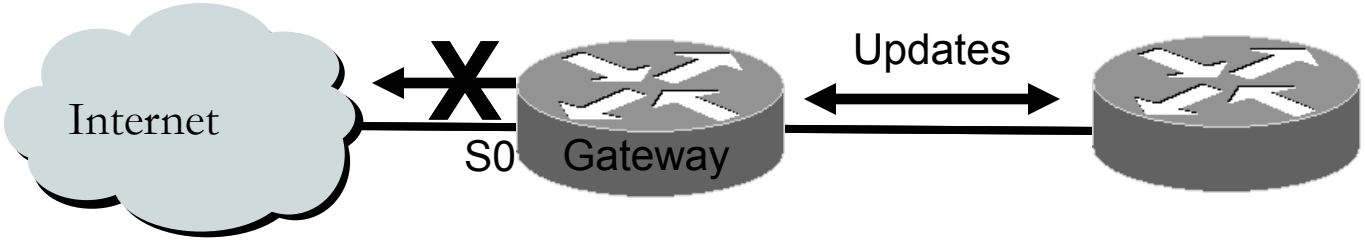
```
router rip
network 10.0.0.0
version 2
```

Passive Interface

Maybe you don't want to send RIP updates out your router interface connected to the Internet. Use the passive-interface command:

Router(config)#**router rip**

Router(config-router)#**passive-interface serial0**



This allows a router to receive route updates on an interface, but not send updates via that interface

Verifying RIP

Router#**show ip protocols**

Router#**show protocols**

Router#**show ip route**

Router#**debug ip rip**

Router#**undebug all (un all)**

http://www.ietf.org/rfc/rfc2328.txt

Open Shortest Path First, OSPF (RFC 2328)

- IETF standard for high performance IGP routing protocol.
- *Link State* protocol: Routers monitor neighbor routers and networks and send this information to all OSPF routers (*Link State Advertisements*, LSA).
- LSA are encapsulated into IP datagrams with multicast destination address 224.0.0.5, and routed using *flooding*.
- LSA are only sent when changes in the neighborhood occur, or when a LSA Request is received.
- Neighbor routers are monitored using a *hello protocol*.
- OSPF routers maintain a LS database with the information received with LSA. The Shortest Path First algorithm (Dijkstra algorithm) is used to optimal build routing table entries.
- The metric is computed taking into account link bitrates, delays etc.
- The infinite metric is the maximum metric value.
- There is no count to infinity problem.

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

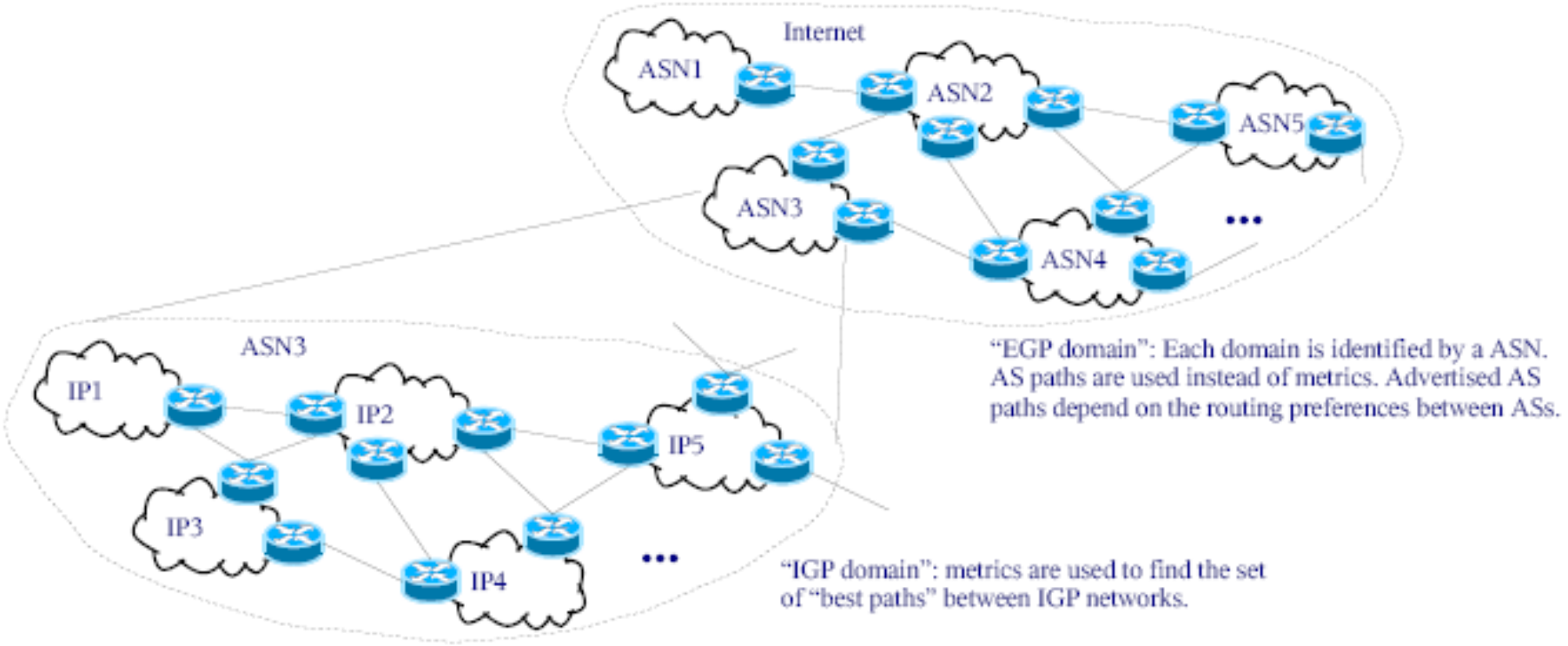
- OSPF advertisement carries one entry per neighbor router
- Advertisements disseminated to entire AS (via flooding)
  - Carried in OSPF messages directly over IP (rather than TCP or UDP

http://www.ietf.org/rfc/rfc1772.txt

Border Gateway Protocol, BGP (RFC 1771, 1772)

- BGP is the routing protocol used among ASs in Internet:

http://www.ietf.org/rfc/rfc1772.txt

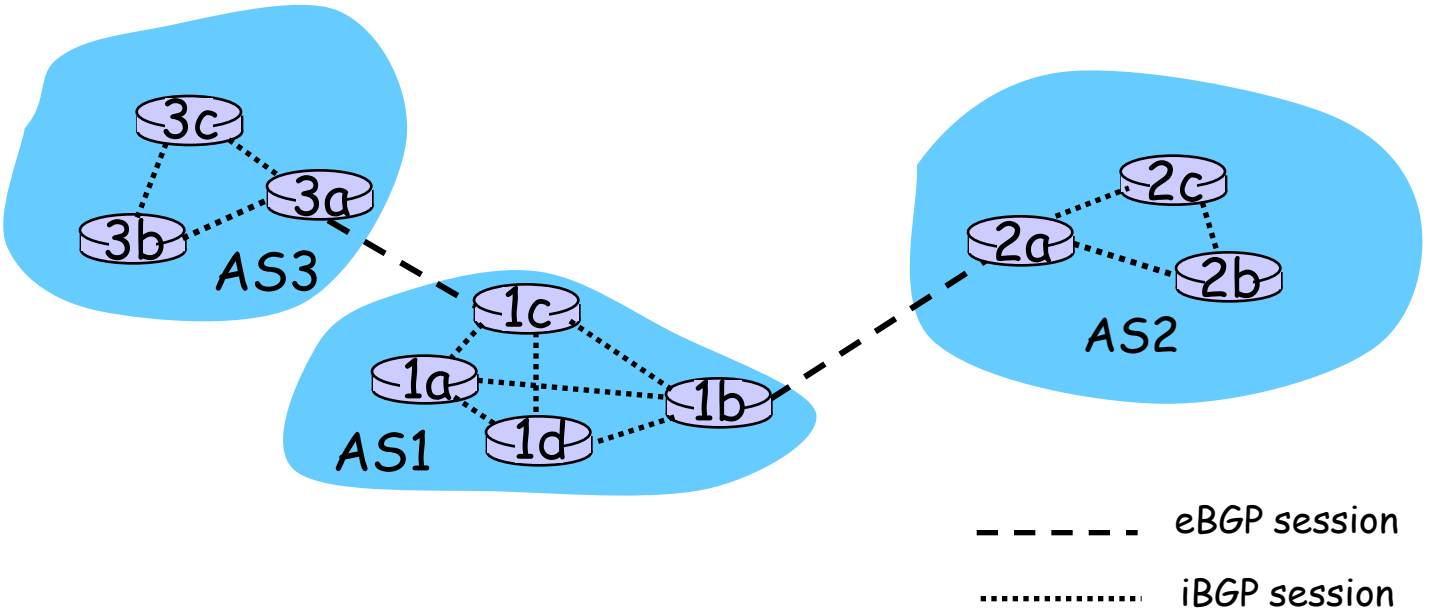


Internet inter-AS routing: BGP

- BGP (Border Gateway Protocol): *the* de facto standard
- BGP provides each AS a means to:
  1. Obtain subnet reachability information from neighboring ASs.
  2. Propagate the reachability information to all routers internal to the AS.
  3. Determine "good" routes to subnets based on reachability information and policy.
- Allows a subnet to advertise its existence to rest of the Internet: *"I am here"*

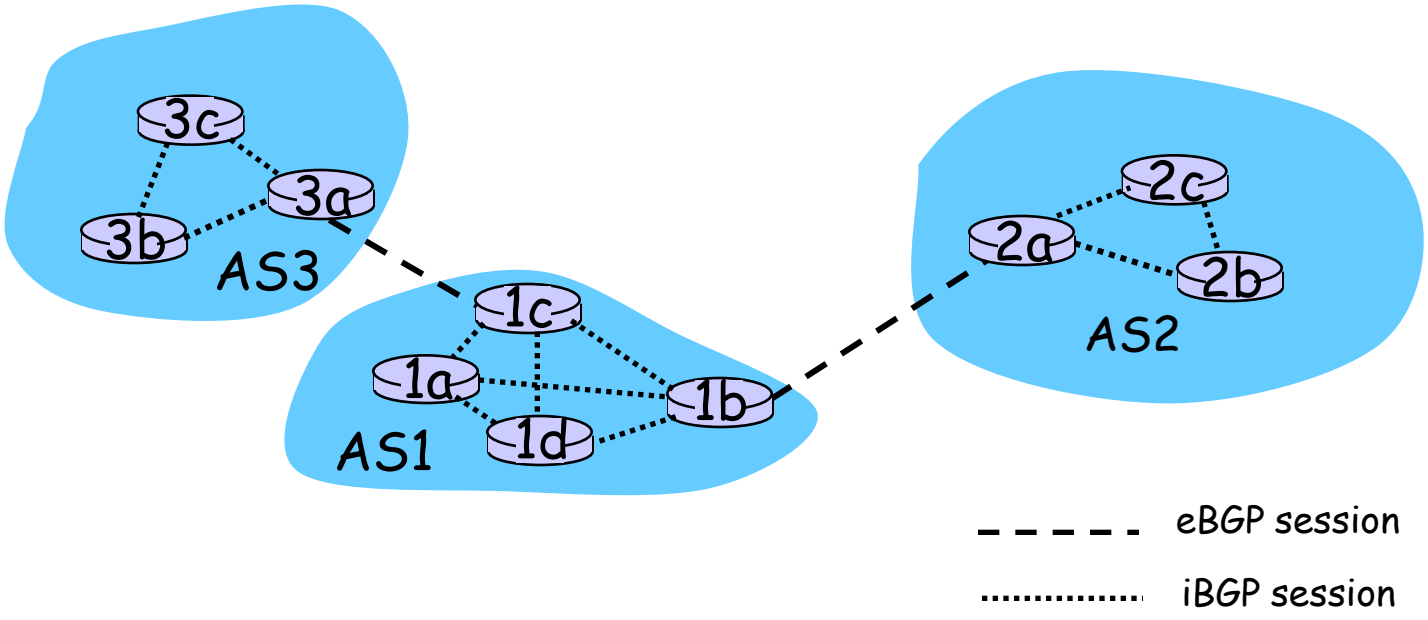
BGP basics

- Pairs of routers (BGP peers) exchange routing info over semi-permanent TCP conctns: BGP sessions
- Note that BGP sessions do not correspond to physical links
- When AS2 advertises a prefix to AS1, AS2 is *promising* it will forward any datagrams destined to that prefix towards the prefix
  - AS2 can aggregate prefixes in its advertisement



Distributing reachability info

- With eBGP session between 3a and 1c, AS3 sends prefix reachability info to AS1.
- 1c can then use iBGP do distribute this new prefix reach info to all routers in AS1
- 1b can then re-advertise the new reach info to AS2 over the 1b-to-2a eBGP session
- When router learns about a new prefix, it creates an entry for the prefix in its forwarding table.



Why different Intra- and Inter-AS routing ?

Policy

- Inter-AS: admin wants control over how its traffic routed, who routes through its net.
- Intra-AS: single admin, so no policy decisions needed

Scale

- hierarchical routing saves table size, reduced update traffic

Performance

- Intra-AS: can focus on performance
- Inter-AS: policy may dominate over performance