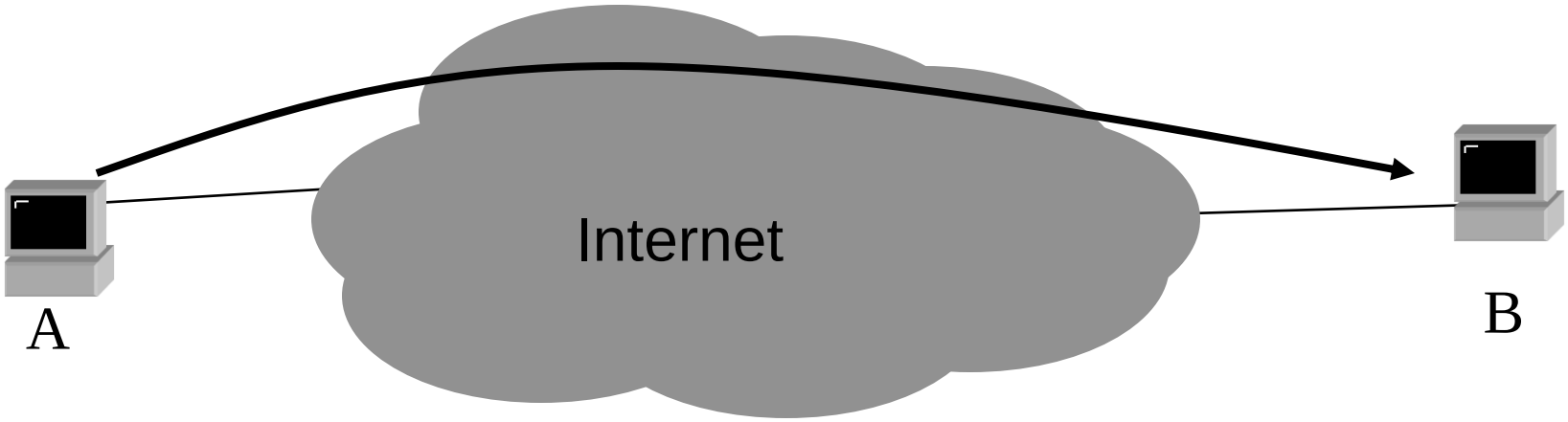
# Introduction to IP Routing

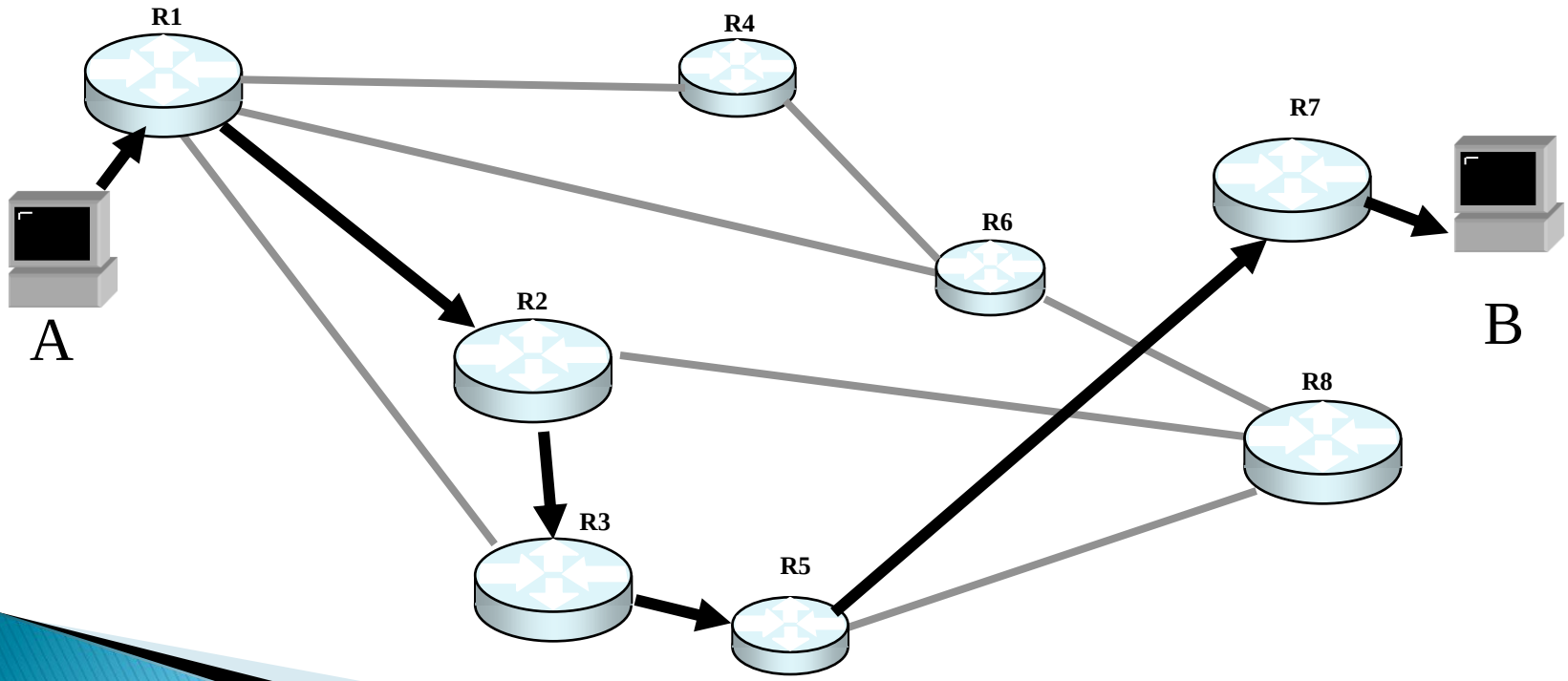
# Routing

- How do packets get from A to B in the Internet?



# Connectionless Forwarding

- Each router (switch) makes a LOCAL decision to forward the packet towards B



# Connectionless Forwarding

- This is termed *destination-based connectionless forwarding*
- How does each router know the *correct* local forwarding decision for any possible destination address?
  - Through knowledge of the *topology state* of the network
  - This knowledge is maintained by a *routing protocol*

# Routing Protocols

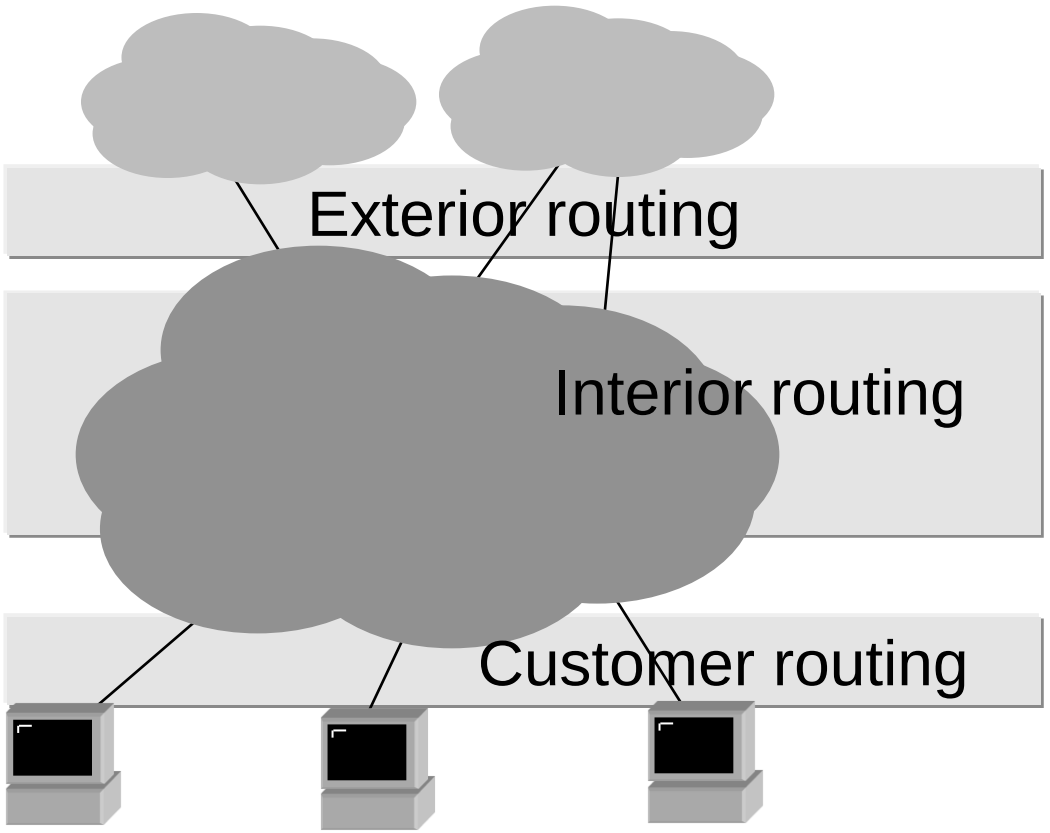
- Distribute the knowledge of the current *topology state* of the network to all routers
- This knowledge is used by each router to generate a *forwarding table*, which contains the local switching decision for each known destination address

# Routing Protocols

- correct operation of the routing state of a network is essential for the management of a *quality* network service
  - accuracy of the routing information
  - dynamic adjustment of the routing information
  - matching aggregate traffic flow to network capacity

# ISP Routing Tasks

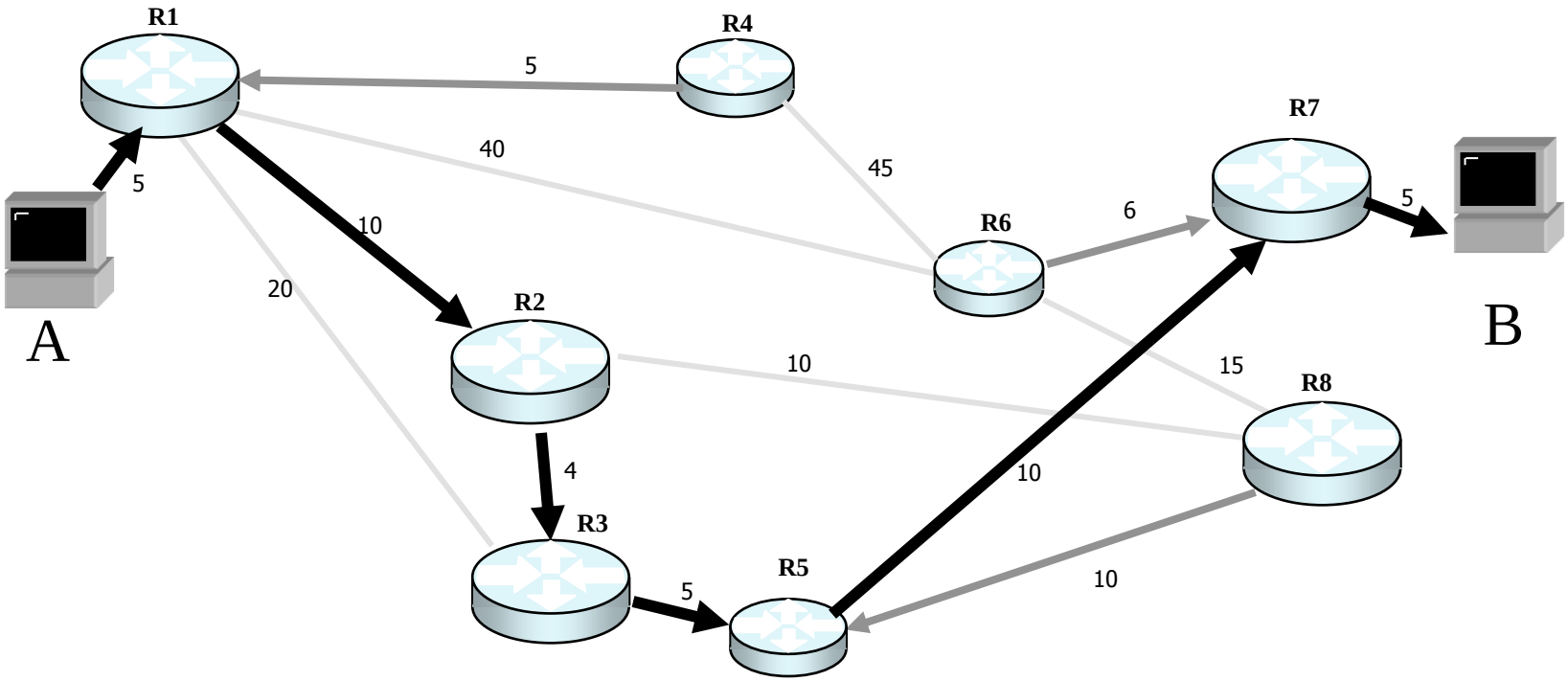
- customers
- internal
- peer / upstream



# Interior Routing

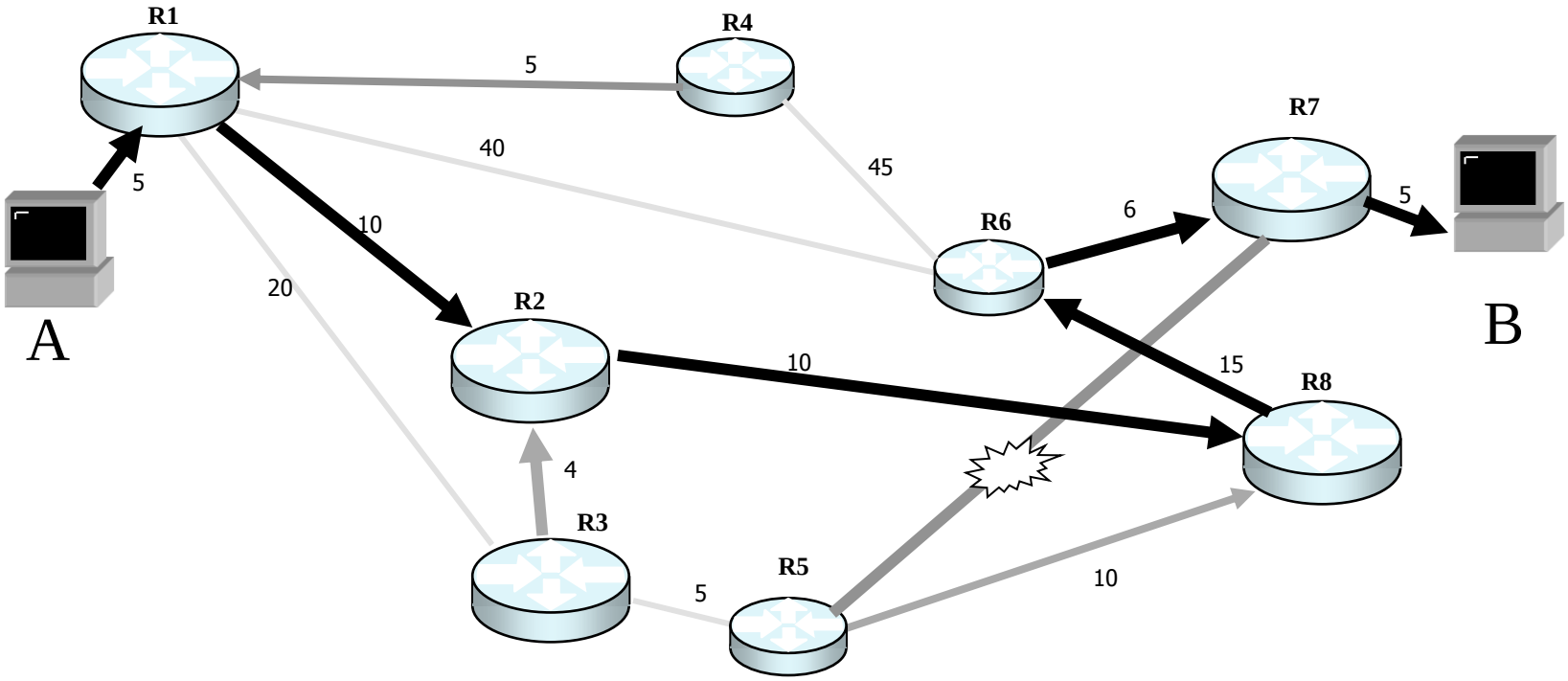
- discovers the *topology* of a network through the operation of a *distributed routing protocol*

# Path Selection




Minimum cost from A to B is 39 units

# Dynamic Path Adjustment




If R5 – R7 breaks, minimum cost path from A to B is Now 46 units

# Interior Routing Protocols

- describe the current network topology
- Routing protocols distribute **how** to reach address prefix groups
- Routing protocols function through either
  - distributed computing model (distance vector)
  - parallel computing model (link state)

# Routing Protocols

- Distance Vector Routing Protocols
  - Each node sends its routing table (dest, distance) to all neighbors every 30 seconds
  - Lower distances are updated with the neighbor as next hop
  - cannot scale
  - cannot resolve routing loops quickly

  - RIP is the main offender

# Routing Protocols

- Link State Routing Protocols
  - Each link, the connected nodes and the metric is flooded to all routers
  - Each link up/down status change is incrementally flooded
  - Each router re-computes the routing table in parallel using the common link state database
  - OSPF is the main protocol in use today

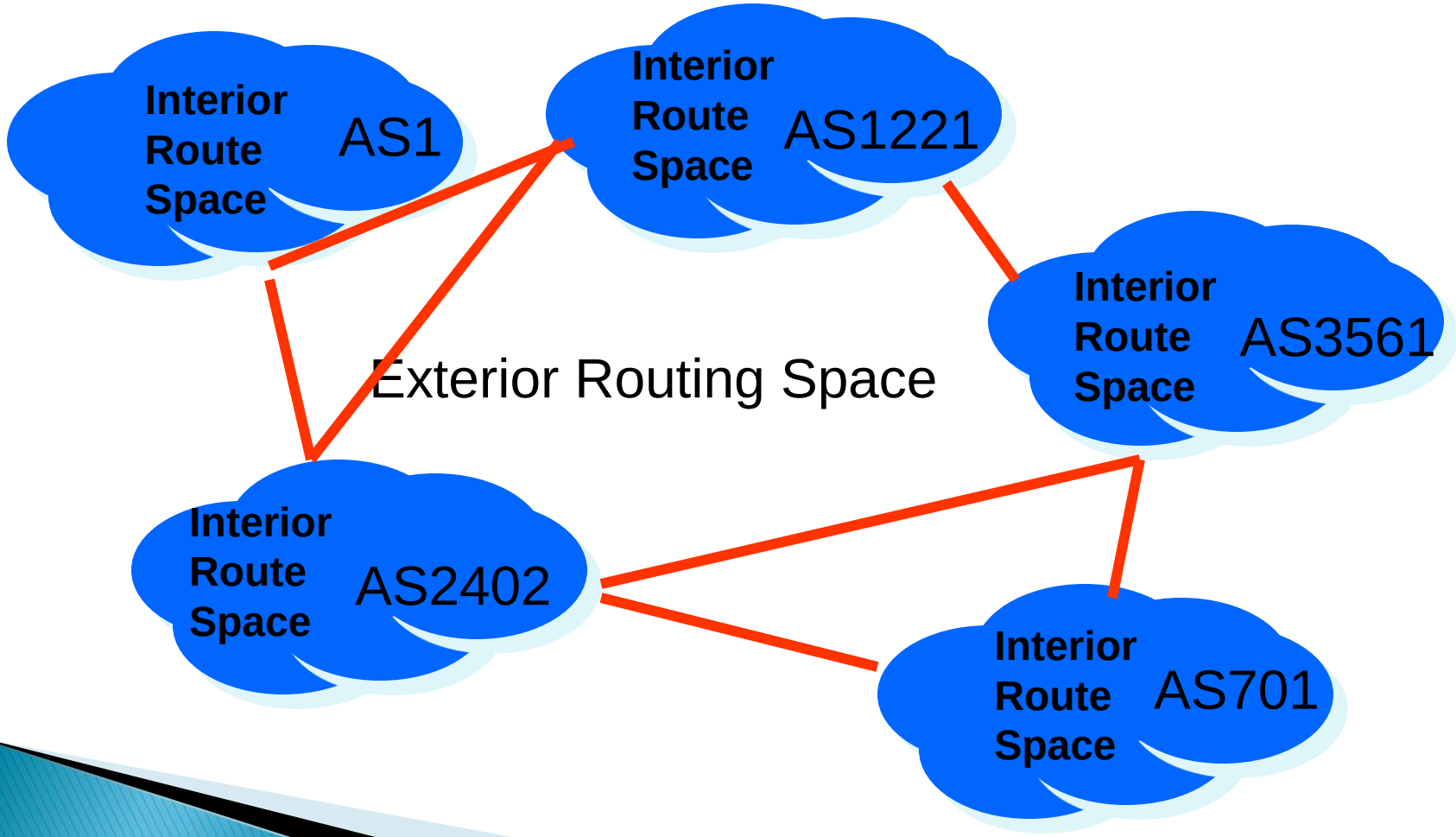
# Suggestions

- Just engineering a physical link does not ensure that  traffic will flow
  - some system somewhere must provide routing information about how to reach the newly connected network
- Installing backup circuits is easy, making the routing work may not be

# Suggestions

- need a clear understanding of how the client networks want their traffic to flow before you can start making routing configuration changes

# Interior and Exterior Routing Protocols



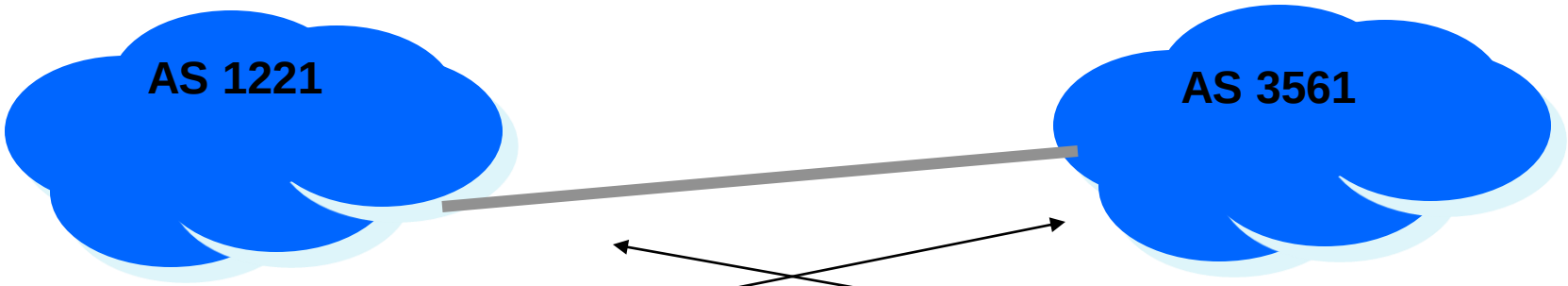
# Exterior Routing Protocols

- You tell me all the address prefixes you can reach, but don't tell me the path you use to get there
  - I'll tell you the same
- If anything changes, please let me know
- If you tell me an address I'll send you traffic destined to that address.
  - If I tell you an address I will accept traffic destined to that address

# Exterior Routing Protocols

- Border Gateway Protocol version 4 (BGP4)
- Each interior route collection is described by an Autonomous System (AS) number
- Internal topology is hidden
- Routes are announced with associated AS value
  - 139.130.0.0/16 + AS 1221

# BGP example



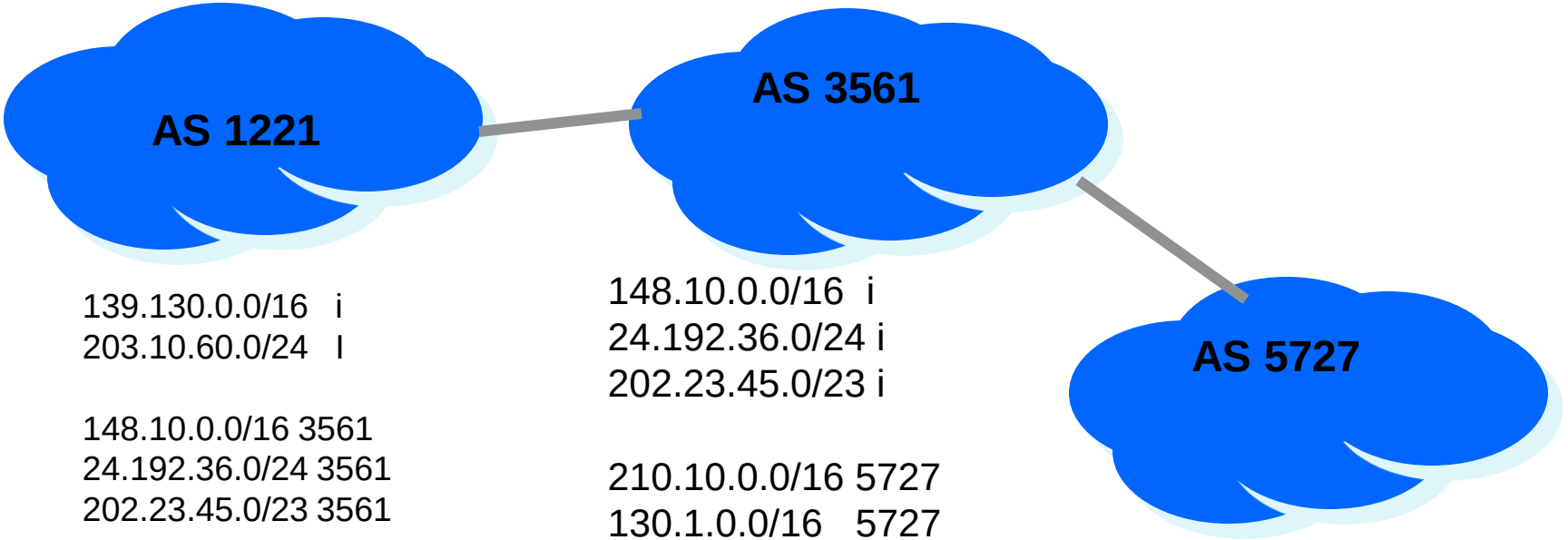

139.130.0.0/16
203.10.60.0/24

148.10.0.0/16 3561
24.192.36.0/24 3561
202.23.45.0/23 3561

148.10.0.0/16
24.192.36.0/24
202.23.45.0/23

139.130.0.0/16 1221
203.10.60.0/24 1221

# BGP Example of TRANSIT




139.130.0.0/16 i
203.10.60.0/24 I

148.10.0.0/16 3561
24.192.36.0/24 3561
202.23.45.0/23 3561

210.10.0.0/16 3561,5727
139.1.0.0/16 3561,5727

148.10.0.0/16 i
24.192.36.0/24 i
202.23.45.0/23 i

210.10.0.0/16 5727
130.1.0.0/16 5727

139.130.0.0/16 1221
203.10.60.0/24 1221

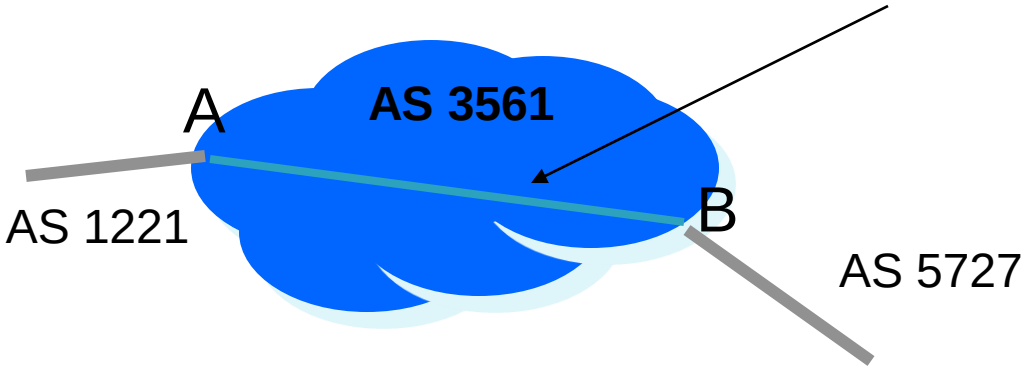
210.10.0.0/16 i
130.1.0.0/16 I

148.10.0.0/16 3561
24.192.36.0/24 3561
202.23.45.0/23 3561

139.130.0.0/16 3561,1221
203.10.60.0/24 3561,1221

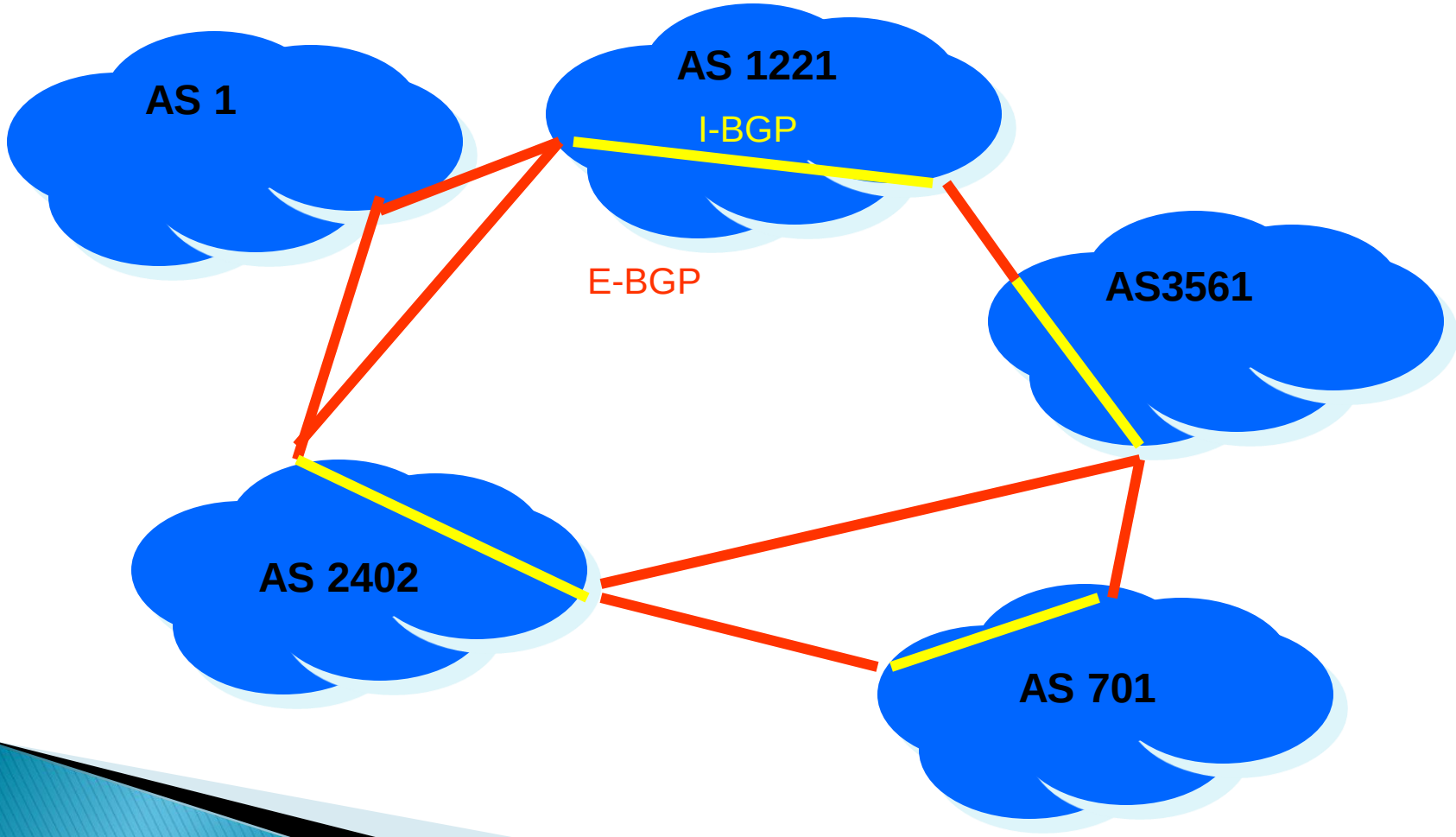
# Exterior Routing Protocols

- Internal transit paths use I-BGP




Q: How does router A tell router B about AS1221 addresses?
A: Router A sets un an INTERIOR BGP session with router B

# Exterior Routing Protocols



# Exterior Routing Protocols

- Normally chose minimal AS path length

203.10.60.0/24 701,3561,1221
→ 203.10.60.0/24 5727,1221

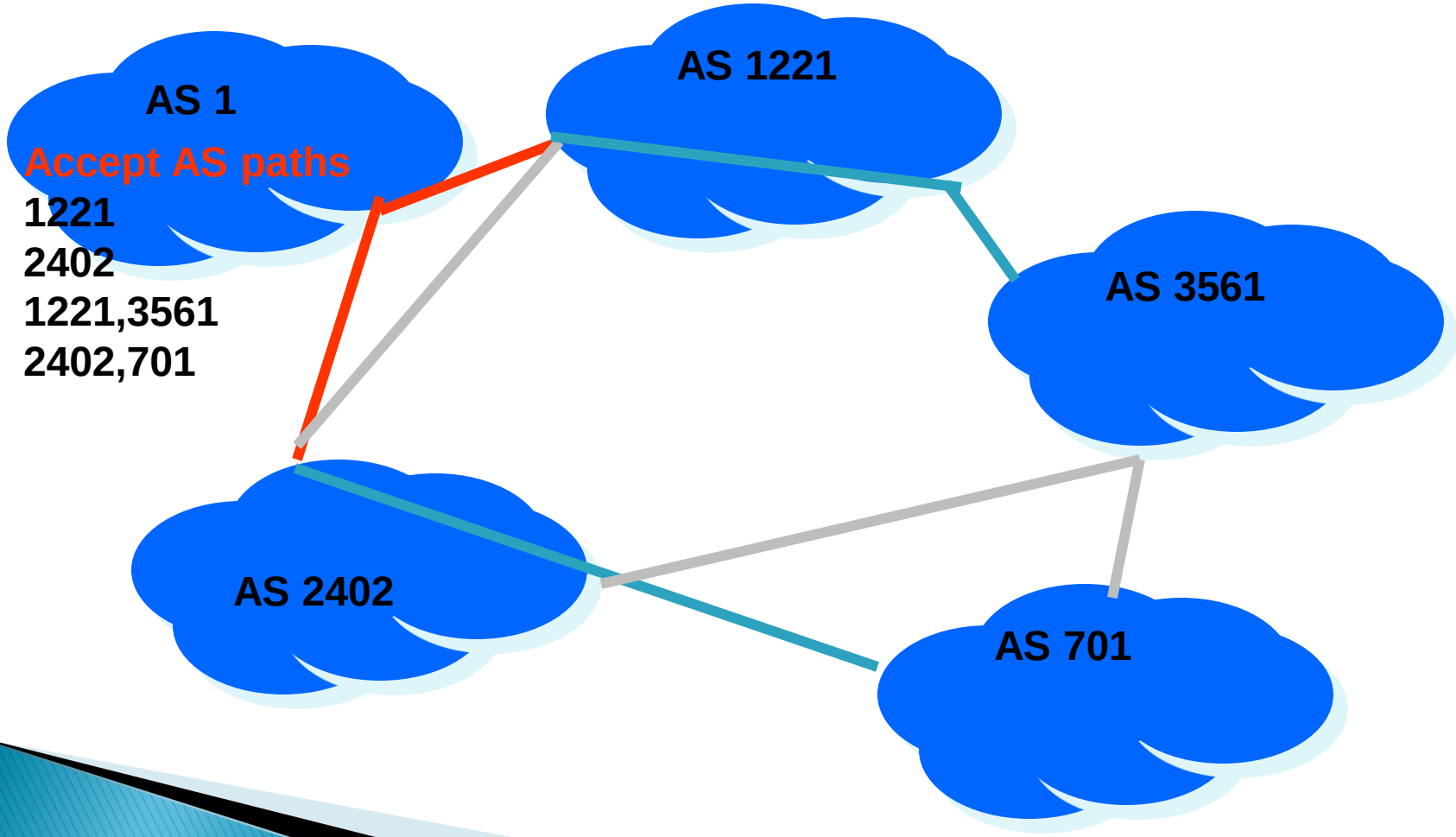
Selected path is via peer session to AS 5727 as this
Is 1 AS shorter that the other path

# Exterior POLICY

- How can I share the traffic load between 2 or moreexterior providers?
- How can I create a backup link to support my main exterior link?

- You can bias minimal path selection by **AS path filter lists** or **community attributes** or **local preferences**

# Exterior Routing Protocols plus Policy



# Exterior Routing Protocols plus Policy

- policy settings control
  - what you advertise to your immediate peers
  - What you accept from your immediate peers
  - What transits you will accept (send traffic)
- you **cannot** control
  - transit path of received traffic
  - symmetry of transit policy