Introduction to BGP

ISP Training Workshops

Border Gateway Protocol

- A Routing Protocol used to exchange routing information between different networks
  - Exterior gateway protocol
- Described in RFC4271
  - RFC4276 gives an implementation report on BGP
  - RFC4277 describes operational experiences using BGP
- The Autonomous System is the cornerstone of BGP
  - It is used to uniquely identify networks with a common routing policy

BGP

- Path Vector Protocol
- Incremental Updates
- Many options for policy enforcement
- Classless Inter Domain Routing (CIDR)
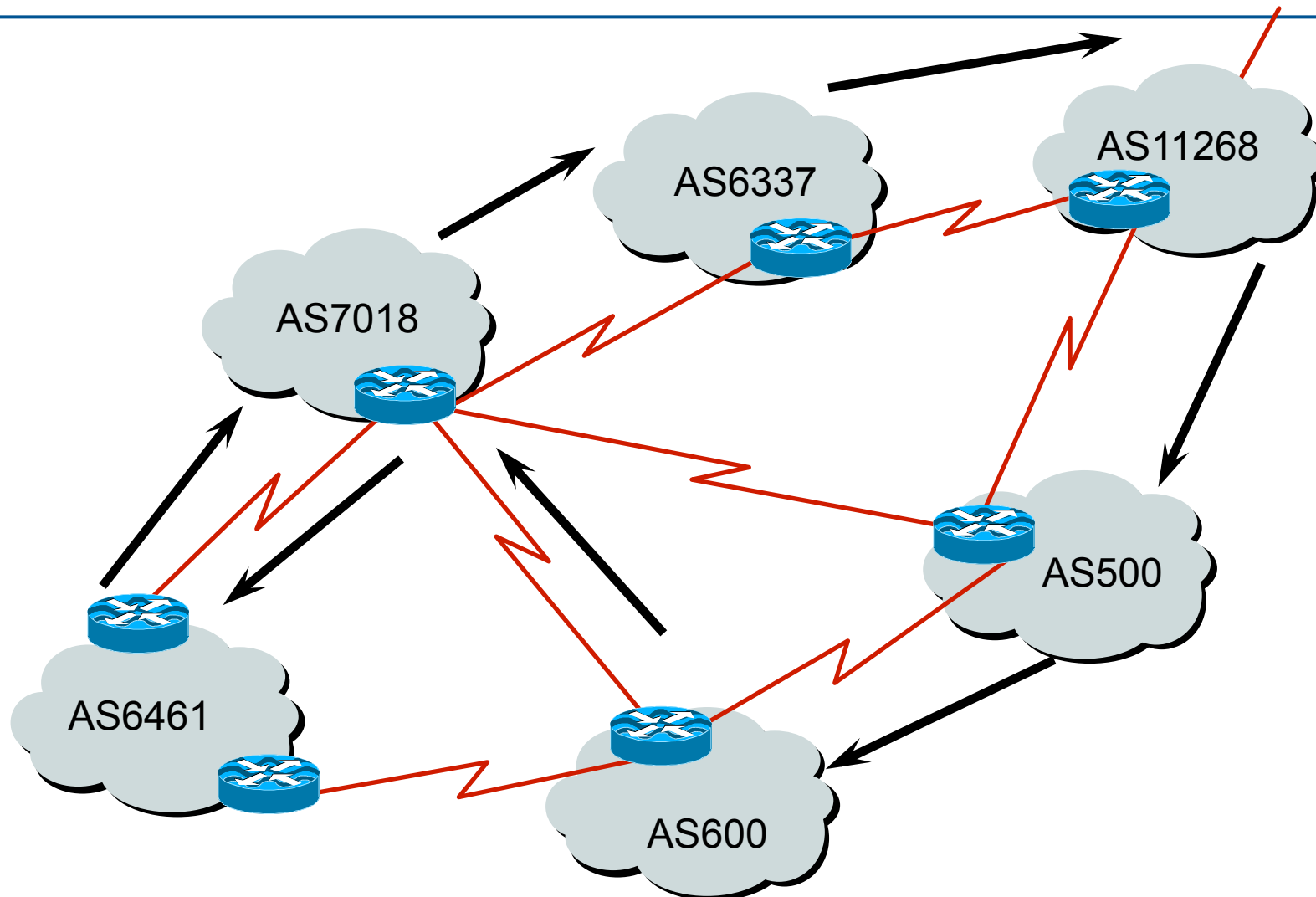- Widely used for Internet backbone
- Autonomous systems

Path Vector Protocol

- BGP is classified as a *path vector* routing protocol (see RFC 1322)
  - A path vector protocol defines a route as a pairing between a destination and the attributes of the path to that destination.

```
12.6.126.0/24 207.126.96.43   1021   0 6461 7018 6337 11268 i
```
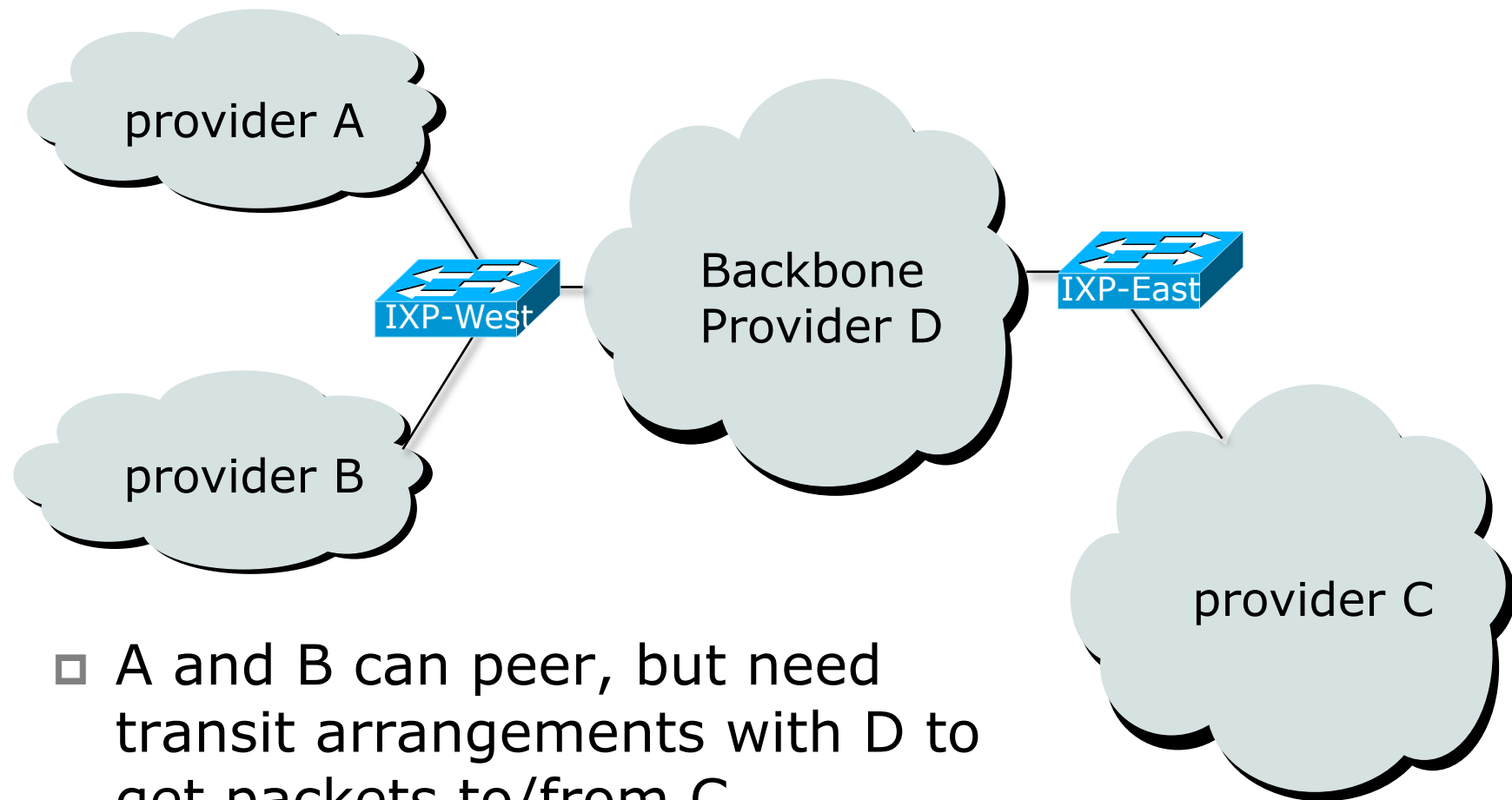
AS Path

Path Vector Protocol

Definitions

- Transit – carrying traffic across a network, usually for a fee
- Peering – exchanging routing information and traffic
- Default – where to send traffic when there is no explicit match in the routing table
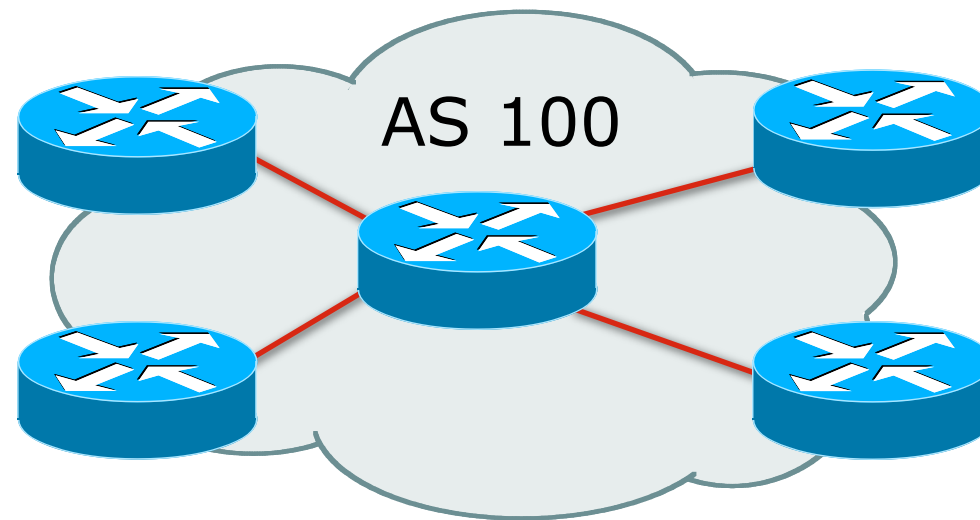
Default Free Zone

The default free zone is made up of Internet routers which have explicit routing information about the rest of the Internet, and therefore do not need to use a default route

Peering and Transit example

provider A

provider B

IXP-West

Backbone
Provider D

IXP-East

provider C

- ❑ A and B can peer, but need transit arrangements with D to get packets to/from C

Autonomous System (AS)

AS 100

- Collection of networks with same routing policy
- Single routing protocol
- Usually under single ownership, trust and administrative control
- Identified by a unique 32-bit integer (ASN)

Autonomous System Number (ASN)

- Two ranges
    - 0-65535   (original 16-bit range)
    - 65536-4294967295   (32-bit range – RFC4893)
- Usage:
    - 0 and 65535   (reserved)
    - 1-64495   (public Internet)
    - 64496-64511   (documentation – RFC5398)
    - 64512-65534   (private use only)
    - 23456   (represent 32-bit range in 16-bit world)
    - 65536-65551   (documentation – RFC5398)
    - 65552-4294967295   (public Internet)
- 32-bit range representation specified in RFC5396
    - Defines "asplain" (traditional format) as standard notation

Autonomous System Number (ASN)

- ASNs are distributed by the Regional Internet Registries
  - They are also available from upstream ISPs who are members of one of the RIRs
- Current 16-bit ASN allocations up to 59391 have been made to the RIRs
  - Around 39300 are visible on the Internet
- Each RIR has also received a block of 32-bit ASNs
  - Out of 2000 assignments, around 1700 are visible on the Internet
- See www.iana.org/assignments/as-numbers

Configuring BGP in Cisco IOS

□ This command enables BGP in Cisco IOS:

   `router bgp 100`

□ For ASNs > 65535, the AS number can be entered in either plain or dot notation:
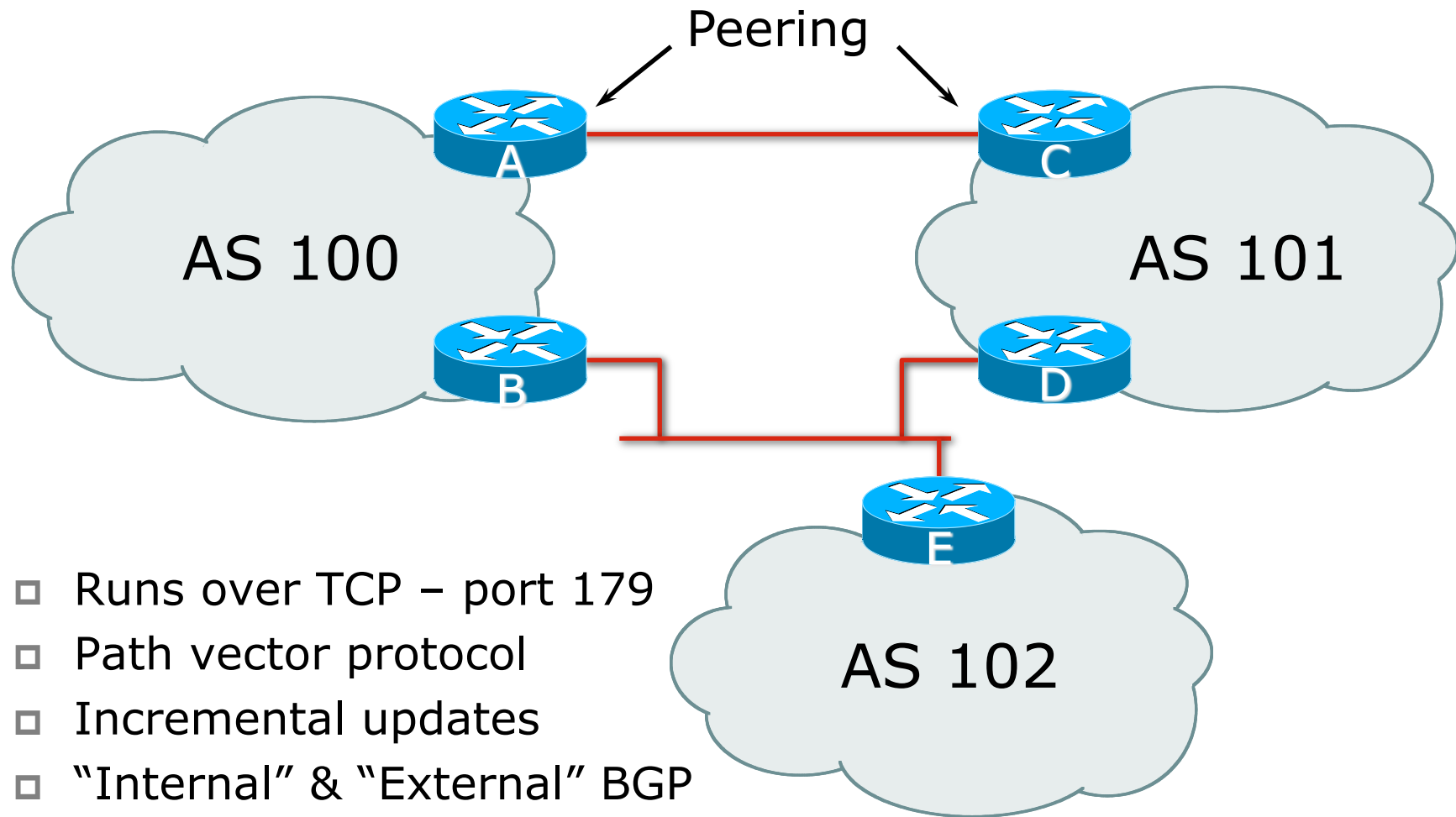
   `router bgp 131076`

     or

   `router bgp 2.4`

□ IOS will display ASNs in plain notation by default
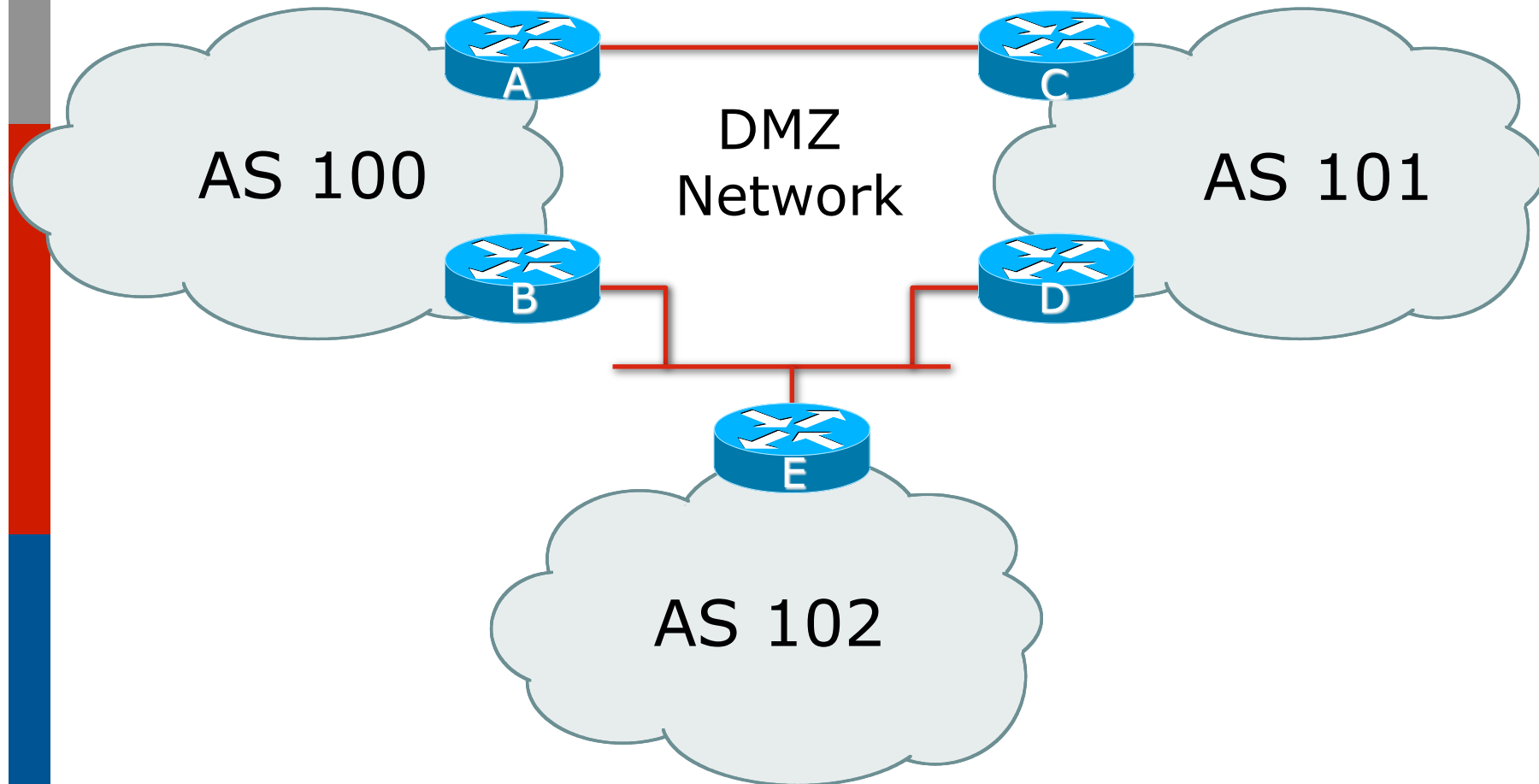
  ■ Dot notation is optional:

   `router bgp 2.4`

    `bgp asnotation dot`

BGP Basics

Peering

- Runs over TCP – port 179
- Path vector protocol
- Incremental updates
- "Internal" & "External" BGP

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Demarcation Zone (DMZ)

AS 100

DMZ Network

AS 101

AS 102

A   B   C   D   E
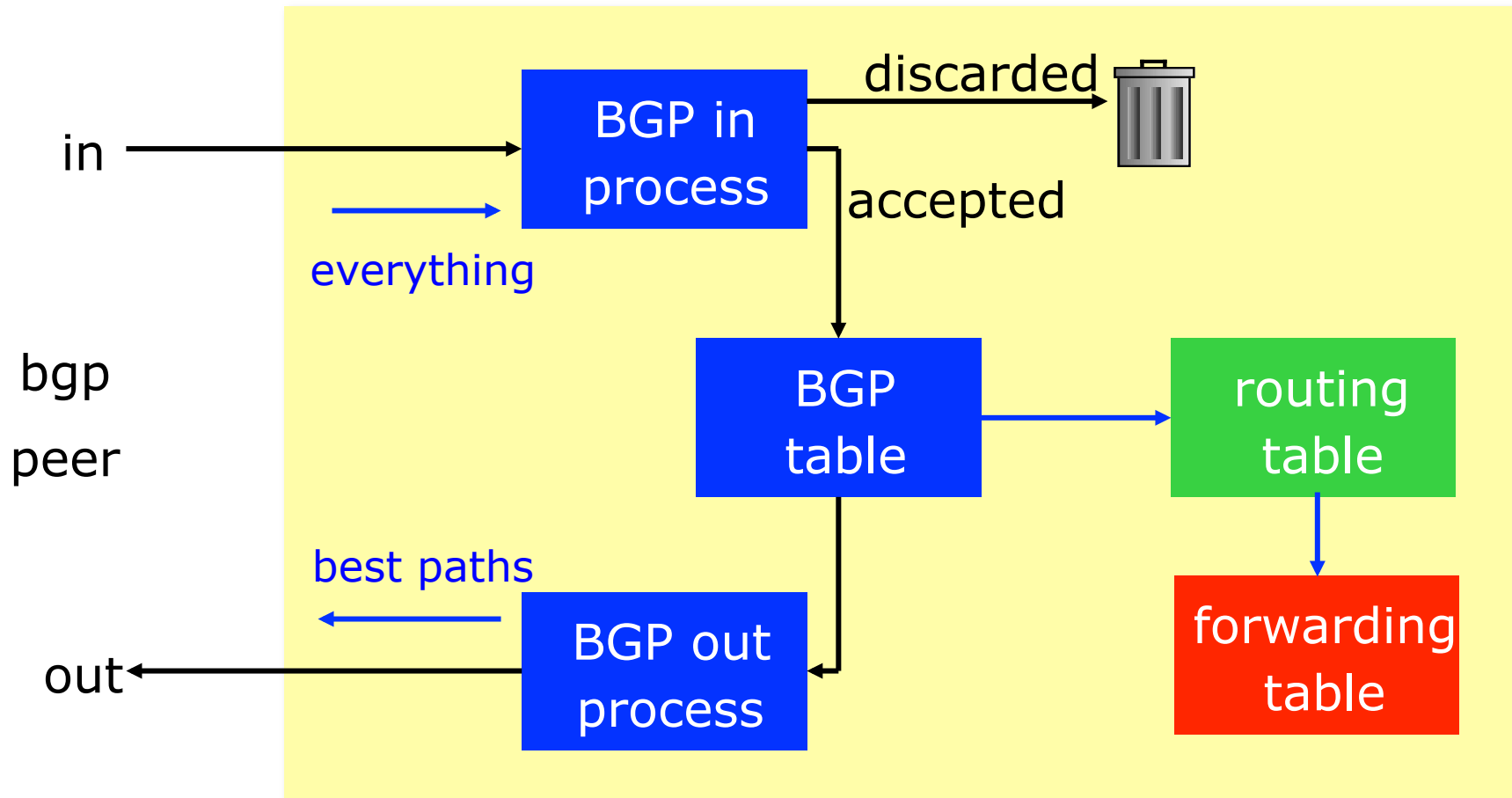
- DMZ is the link or network shared between ASes

BGP General Operation

- Learns multiple paths via internal and external BGP speakers
- Picks the best path and installs it in the routing table (RIB)
- Best path is sent to external BGP neighbours
- Policies are applied by influencing the best path selection

Constructing the Forwarding Table

- BGP "in" process
  - receives path information from peers
  - results of BGP path selection placed in the BGP table
  - "best path" flagged
- BGP "out" process
  - announces "best path" information to peers
- Best path stored in Routing Table (RIB)
- Best paths in the RIB are installed in forwarding table (FIB) if:
  - prefix and prefix length are unique
  - lowest "protocol distance"

Constructing the Forwarding Table

in → **BGP in process**

BGP in process → discarded 🗑

everything →

BGP in process → accepted → **BGP table**

BGP table → **routing table**

routing table → **forwarding table**

BGP table → **BGP out process**

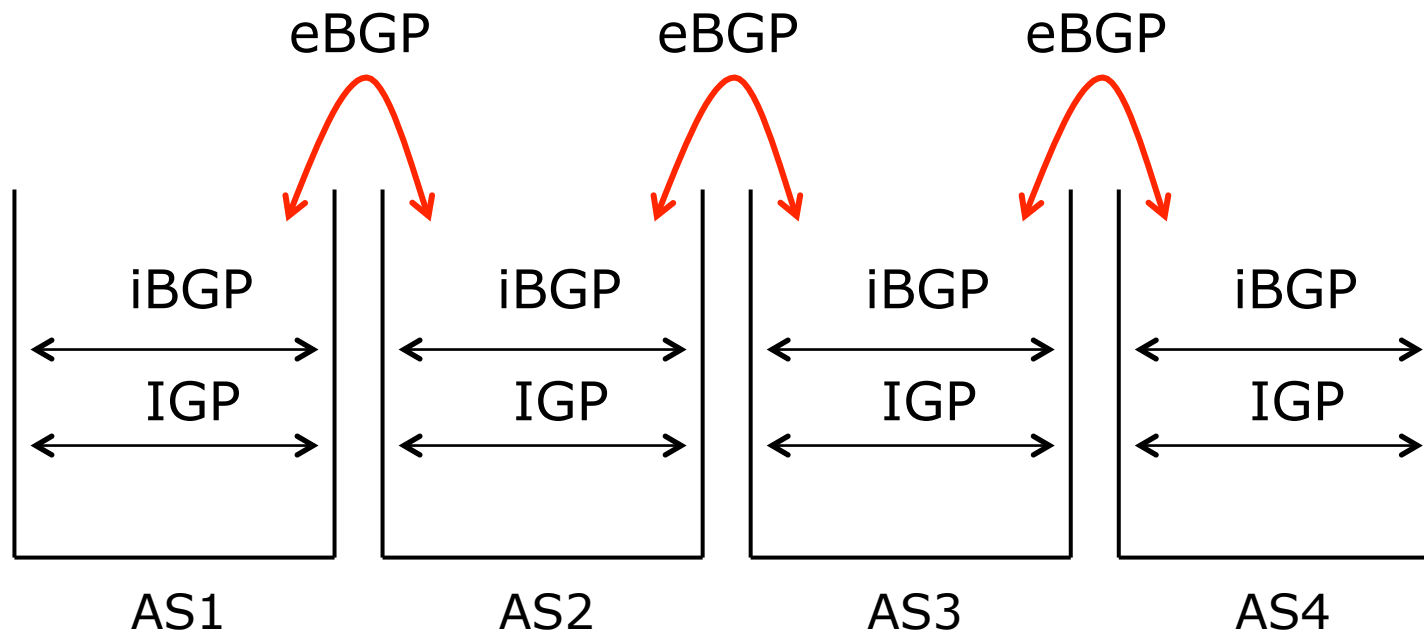**BGP out process** → out
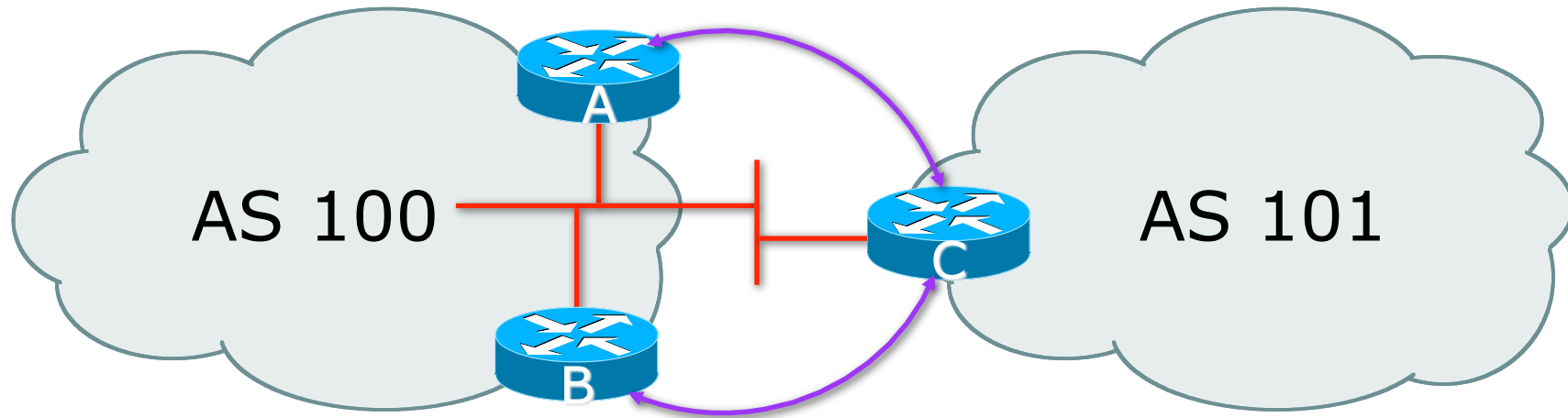
best paths ←

in

bgp

peer

out

eBGP & iBGP

- BGP used internally (iBGP) and externally (eBGP)
- iBGP used to carry
  - Some/all Internet prefixes across ISP backbone
  - ISP's customer prefixes
- eBGP used to
  - Exchange prefixes with other ASes
  - Implement routing policy

BGP/IGP model used in ISP networks

□ Model representation

External BGP Peering (eBGP)

- Between BGP speakers in different AS
- Should be directly connected
- **Never** run an IGP between eBGP peers

Configuring External BGP

Router A in AS100

```
    interface ethernet 5/0
     ip address 102.102.10.2 255.255.255.240
    !
   router bgp 100
     network 100.100.8.0 mask 255.255.252.0
     neighbor 102.102.10.1 remote-as 101
     neighbor 102.102.10.1 prefix-list RouterC in
     neighbor 102.102.10.1 prefix-list RouterC out
    !
```

ip address on ethernet interface

Local ASN

Remote ASN

ip address of Router C ethernet interface

Inbound and outbound filters

Configuring External BGP

Router C in AS101

```
    interface ethernet 1/0/0
     ip address 102.102.10.1 255.255.255.240
    !
    router bgp 101
     network 100.100.8.0 mask 255.255.252.0
     neighbor 102.102.10.2 remote-as 100
     neighbor 102.102.10.2 prefix-list RouterA in
     neighbor 102.102.10.2 prefix-list RouterA out
    !
```

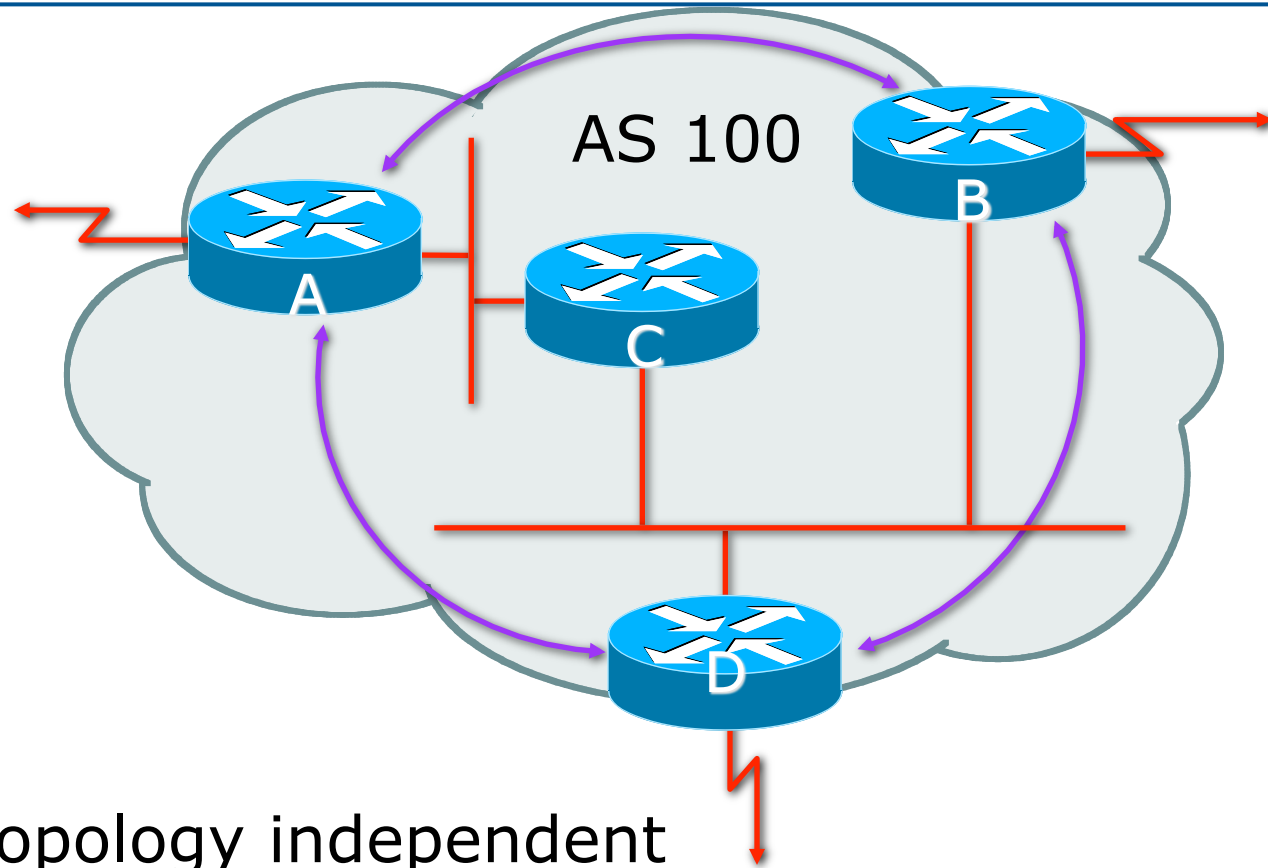ip address on ethernet interface

Local ASN

Remote ASN

ip address of Router A ethernet interface

Inbound and outbound filters

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Internal BGP (iBGP)

- BGP peer within the same AS
- Not required to be directly connected
  - IGP takes care of inter-BGP speaker connectivity
- iBGP speakers must be fully meshed:
  - They originate connected networks
  - They pass on prefixes learned from outside the ASN
  - They do not pass on prefixes learned from other iBGP speakers

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Internal BGP Peering (iBGP)

AS 100

A

B

C

D

- Topology independent
- Each iBGP speaker must peer with every other iBGP speaker in the AS

Peering between Loopback Interfaces

AS 100

□ Peer with loop-back interface
  ■ Loop-back interface does not go down – ever!
□ Do not want iBGP session to depend on state of a single interface or the physical topology

Configuring Internal BGP

Router A in AS100

```
    interface loopback 0
      ip address 105.3.7.1 255.255.255.255
    !
    router bgp 100
      network 100.100.1.0
      neighbor 105.3.7.2 remote-as 100
      neighbor 105.3.7.2 update-source loopback0
      neighbor 105.3.7.3 remote-as 100
      neighbor 105.3.7.3 update-source loopback0
    !
```

ip address on loopback interface

Local ASN

Local ASN

ip address of Router B loopback interface

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Configuring Internal BGP

Router B in AS100

```
interface loopback 0
  ip address 105.3.7.2 255.255.255.255
!
router bgp 100
  network 100.100.1.0
  neighbor 105.3.7.1 remote-as 100
  neighbor 105.3.7.1 update-source loopback0
  neighbor 105.3.7.3 remote-as 100
  neighbor 105.3.7.3 update-source loopback0
!
```

ip address on loopback interface

Local ASN

Local ASN

ip address of Router A loopback interface

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Inserting prefixes into BGP

- Two ways to insert prefixes into BGP
  - **`redistribute static`**
  - **`network`** command

Inserting prefixes into BGP – redistribute static

- Configuration Example:

```
router bgp 100
  redistribute static
ip route 102.10.32.0 255.255.254.0 serial0
```

- Static route must exist before redistribute command will work
- Forces origin to be "incomplete"
- Care required!

Inserting prefixes into BGP – redistribute static

- ☐ Care required with redistribute!
    - `redistribute <routing-protocol>` means everything in the *<routing-protocol>* will be transferred into the current routing protocol
    - Will not scale if uncontrolled
    - Best avoided if at all possible
    - **redistribute** normally used with "route-maps" and under tight administrative control

Inserting prefixes into BGP – network command

- ❑ Configuration Example

```
router bgp 100
  network 102.10.32.0 mask 255.255.254.0
  ip route 102.10.32.0 255.255.254.0 serial0
```

- ❑ A matching route must exist in the routing table before the network is announced
- ❑ Forces origin to be "IGP"

Configuring Aggregation

- Three ways to configure route aggregation
  - **`redistribute static`**
  - **`aggregate-address`**
  - **`network`** command

Configuring Aggregation

- Configuration Example:

```
router bgp 100
  redistribute static
ip route 102.10.0.0 255.255.0.0 null0 250
```

- static route to "null0" is called a pull up route

  - packets only sent here if there is no more specific match in the routing table
  - distance of 250 ensures this is last resort static
  - care required – see previously!

Configuring Aggregation – Network Command

- Configuration Example

  ```
  router bgp 100
    network 102.10.0.0 mask 255.255.0.0
    ip route 102.10.0.0 255.255.0.0 null0 250
  ```

- A matching route must exist in the routing table before the network is announced
- Easiest and best way of generating an aggregate

Configuring Aggregation – aggregate-address command

- Configuration Example:

  ```
  router bgp 100
    network 102.10.32.0 mask 255.255.252.0
    aggregate-address 102.10.0.0 255.255.0.0 [summary-only]
  ```

- Requires more specific prefix in BGP table before aggregate is announced

- summary-only keyword
  - Optional keyword which ensures that only the summary is announced if a more specific prefix exists in the routing table

Summary
BGP neighbour status

```
Router6>sh ip bgp sum

BGP router identifier 10.0.15.246, local AS number 10

BGP table version is 16, main routing table version 16

7 network entries using 819 bytes of memory

14 path entries using 728 bytes of memory

2/1 BGP path/bestpath attribute entries using 248 bytes of memory

0 BGP route-map cache entries using 0 bytes of memory

0 BGP filter-list cache entries using 0 bytes of memory

BGP using 1795 total bytes of memory

BGP activity 7/0 prefixes, 14/0 paths, scan interval 60 secs


Neighbor         V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down State/PfxRcd
10.0.15.241      4    10       9       8       16    0    0 00:04:47           2
10.0.15.242      4    10       6       5       16    0    0 00:01:43           2
10.0.15.243      4    10       9       8       16    0    0 00:04:49           2
...
```

BGP Version   Updates sent   Updates waiting
                 and received

Summary
BGP Table

```
Router6>sh ip bgp
BGP table version is 30, local router ID is 10.0.15.246
Status codes: s suppressed, d damped, h history, * valid, > best, i -
   internal,
             r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network            Next Hop           Metric LocPrf Weight Path
*>i10.0.0.0/26        10.0.15.241             0    100      0 i
*>i10.0.0.64/26       10.0.15.242             0    100      0 i
*>i10.0.0.128/26      10.0.15.243             0    100      0 i
*>i10.0.0.192/26      10.0.15.244             0    100      0 i
*>i10.0.1.0/26        10.0.15.245             0    100      0 i
*> 10.0.1.64/26       0.0.0.0                 0          32768 i
*>i10.0.1.128/26      10.0.15.247             0    100      0 i
*>i10.0.1.192/26      10.0.15.248             0    100      0 i
...
```

Summary

- BGP4 – path vector protocol
- iBGP versus eBGP
- stable iBGP – peer with loopbacks
- announcing prefixes & aggregates

Introduction to BGP

ISP Training Workshops