# Introduction to BGP

ISP 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

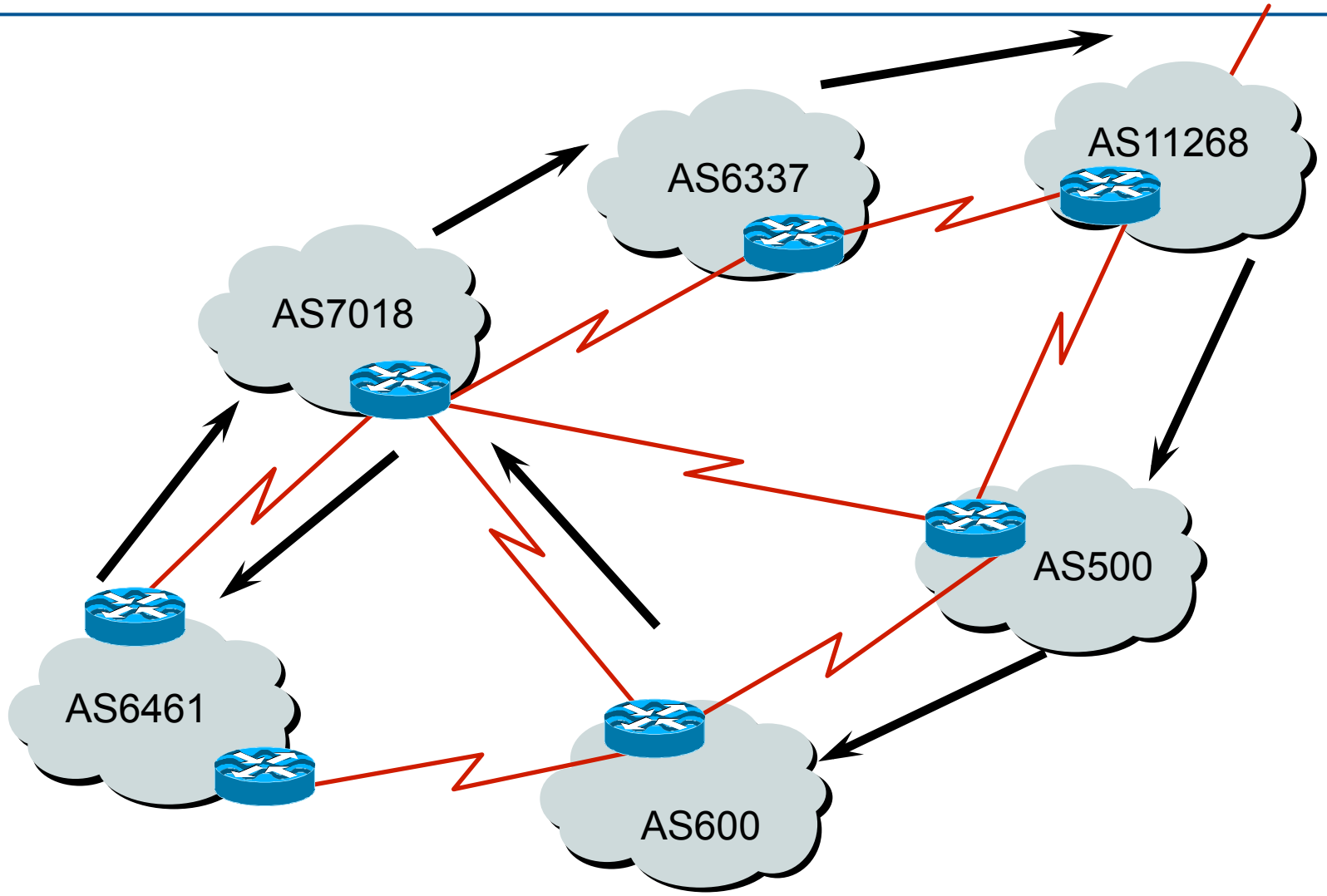
# Path Vector Protocol

- 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

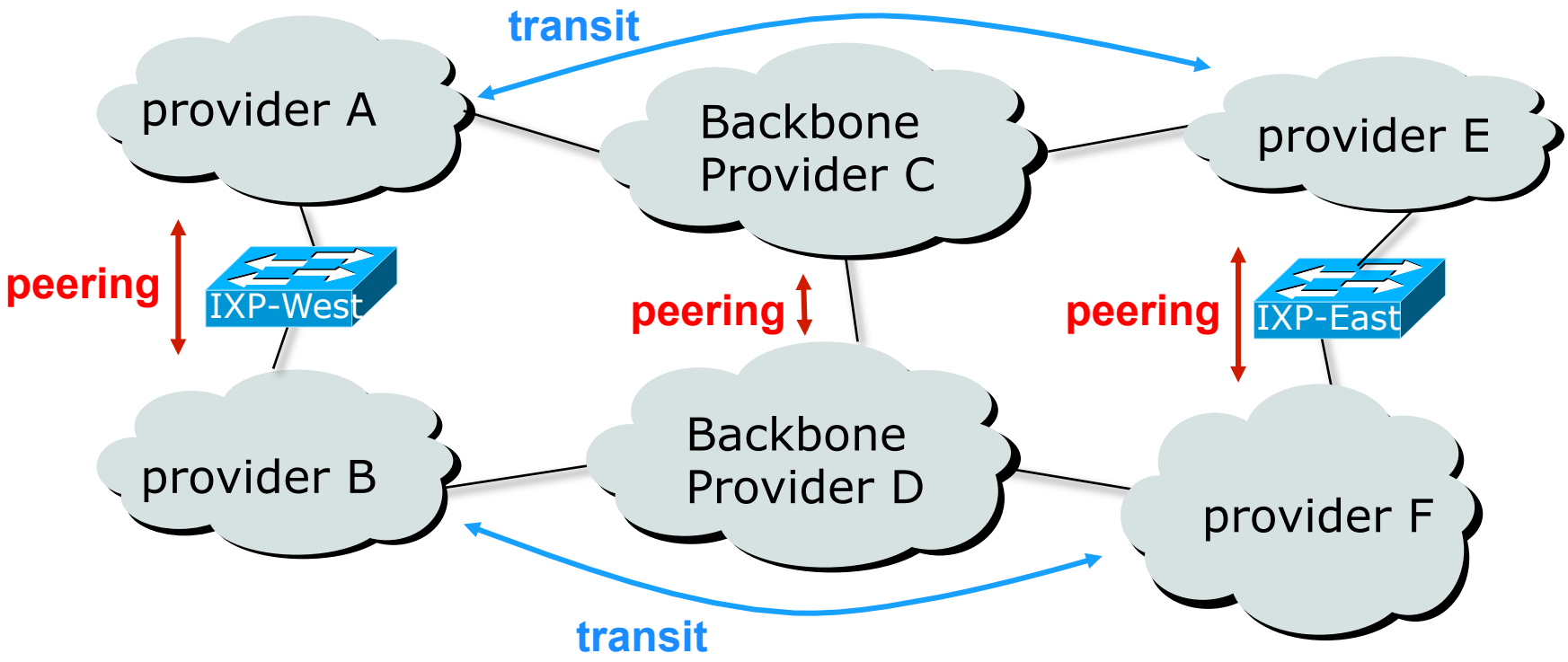
- Transit – carrying traffic across a network
  - (Commercially: for a fee)
- Peering – exchanging routing information and traffic
  - (Commercially: between similar sized networks, and for no fee)
- Default – where to send traffic when there is no explicit match in the routing table

# Default Free Zone

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

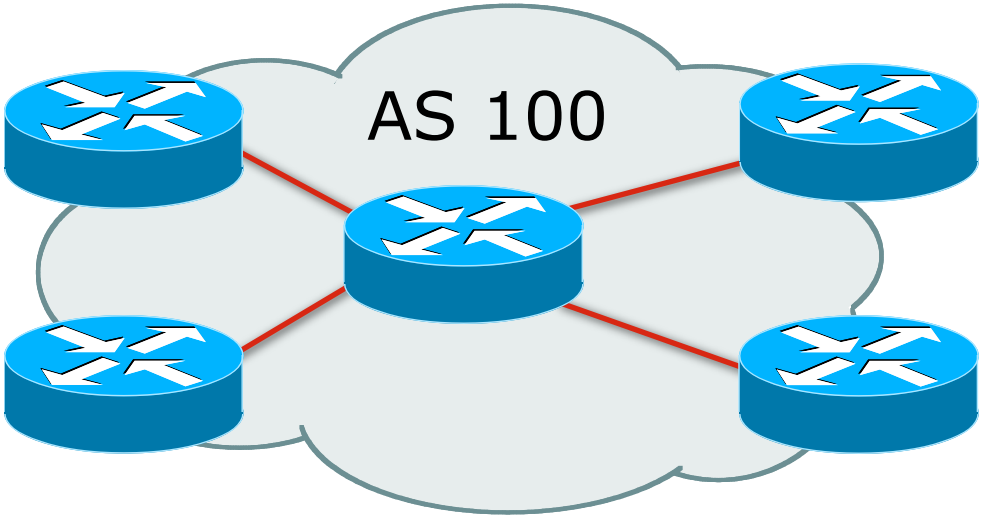
NB: is not related to where an ISP is in the hierarchy

# Peering and Transit example




A and B peer for free, but need transit arrangements with C and D to get packets to/from E and F

# Autonomous System (AS)




- 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 – RFC6793) |

- 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) |
| 65552-4199999999 | (public Internet) |
| 4200000000-4294967295 | (private use only – RFC6996) |

- 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
- The entire 16-bit ASN pool has been assigned to the RIRs
  - Around 43000 16-bit ASNs are visible on the Internet
- Each RIR has also received a block of 32-bit ASNs
  - Out of 15300 assignments, around 11800 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
```

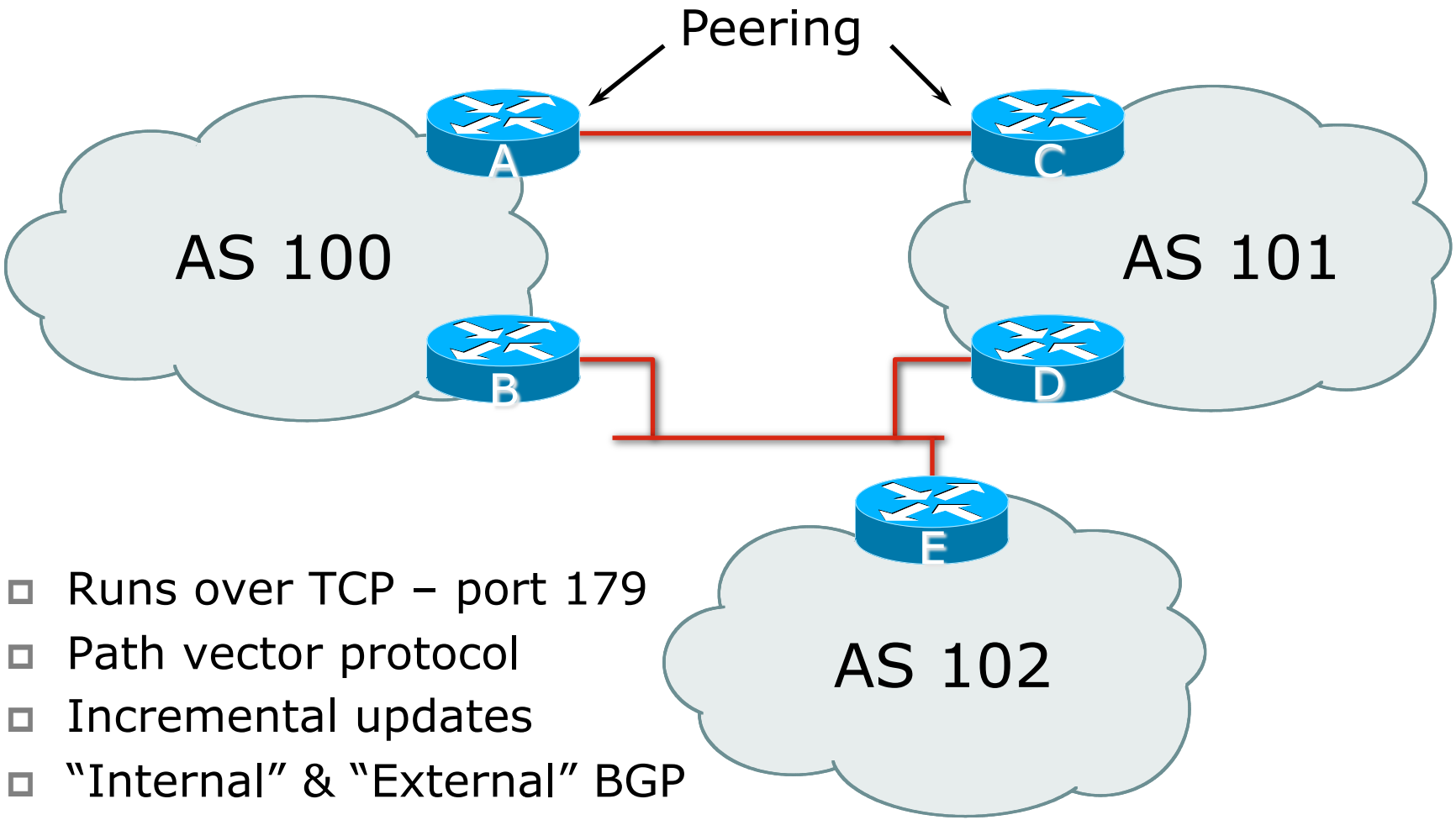
  - Or

```
router bgp 2.4
```

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

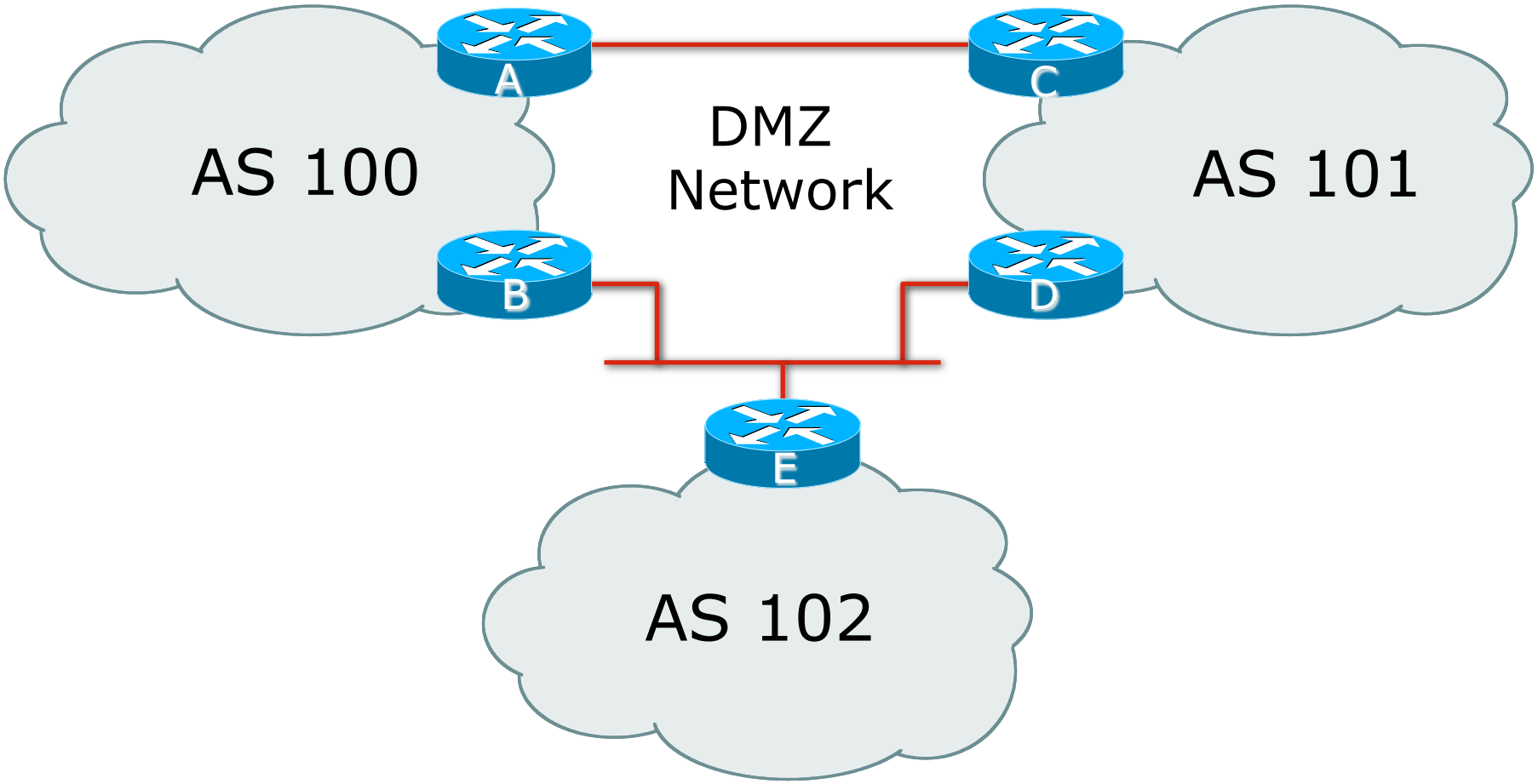
```
router bgp 2.4
 bgp asnotation dot
```

# BGP Basics




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

# Demarcation Zone (DMZ)




- DMZ is the link or network shared between ASes

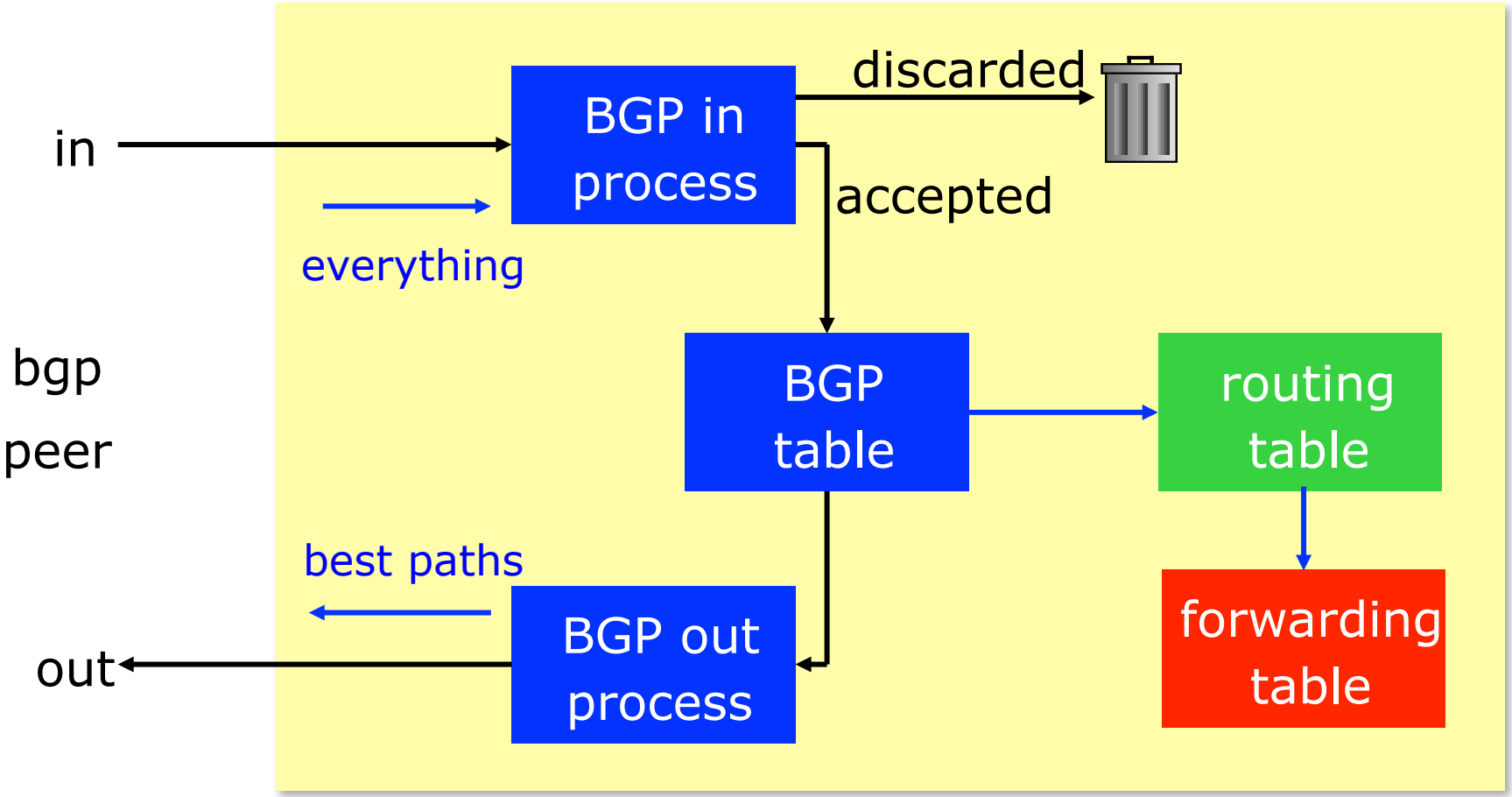
# BGP General Operation

- 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) if:
  - Prefix and prefix length are unique, and
  - Lowest “protocol distance”
- Best paths in the RIB are installed in forwarding table (FIB)

# Constructing the Forwarding Table

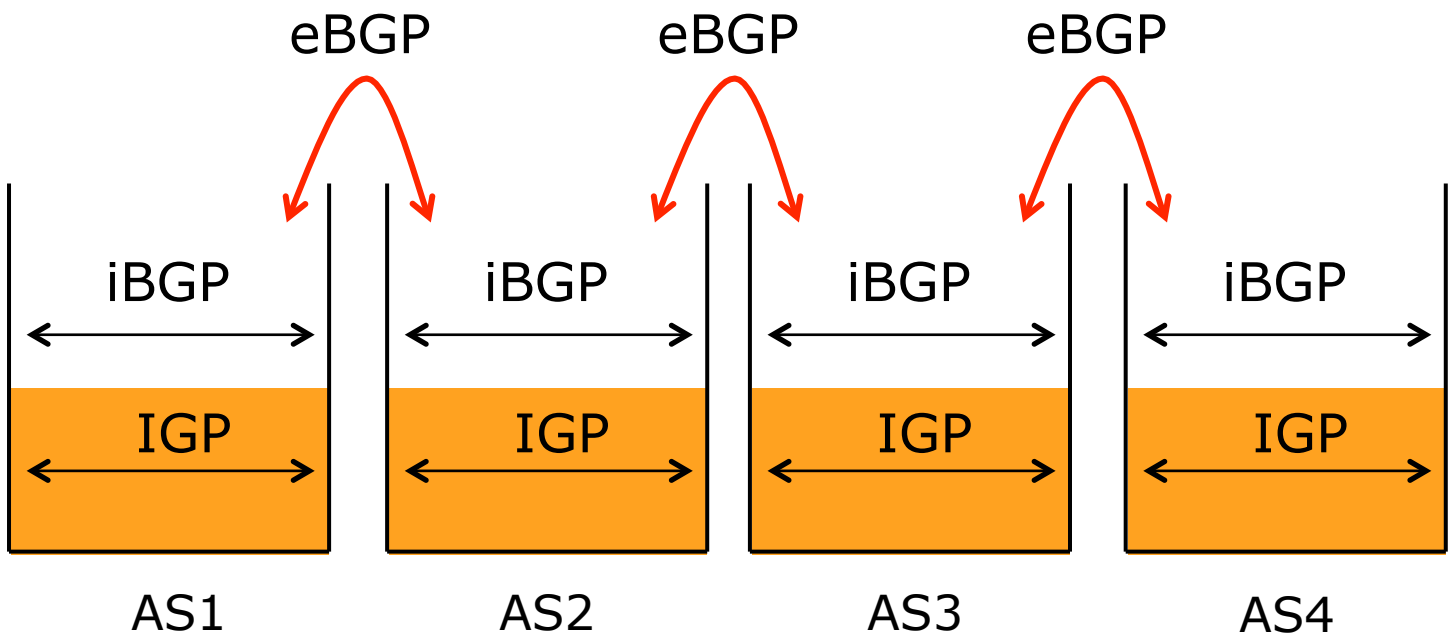


# eBGP & iBGP

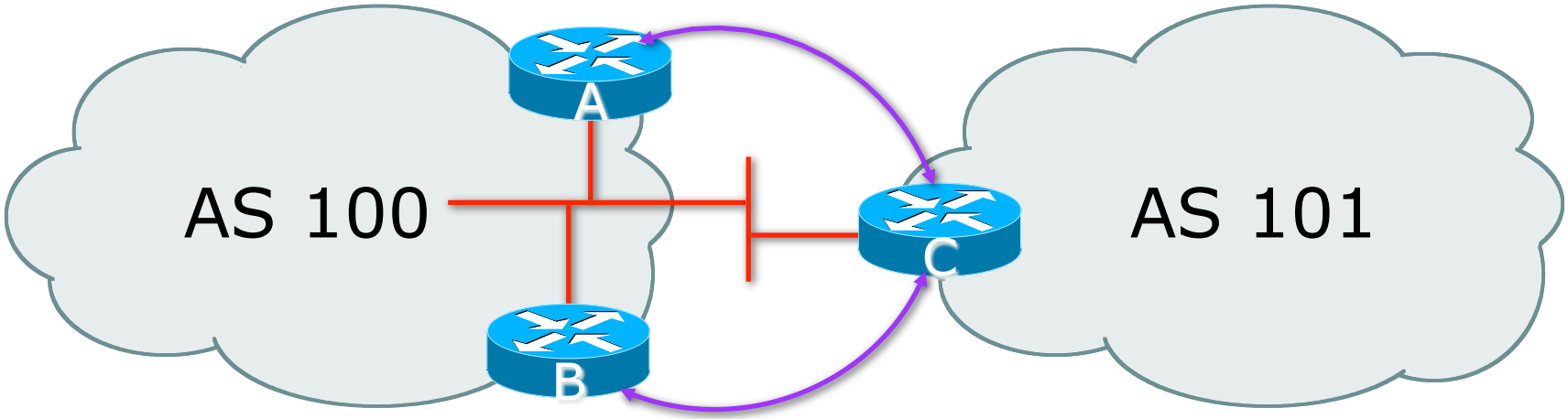
- BGP is used
  - Internally (iBGP)
  - Externally (eBGP)
- iBGP used to carry
  - Some/all Internet prefixes across ISP backbone
  - ISP's customer prefixes
- eBGP used to
  - Exchange prefixes with other ASes
  - Implement routing policy

# BGP/IGP model used in ISP networks

- Model representation



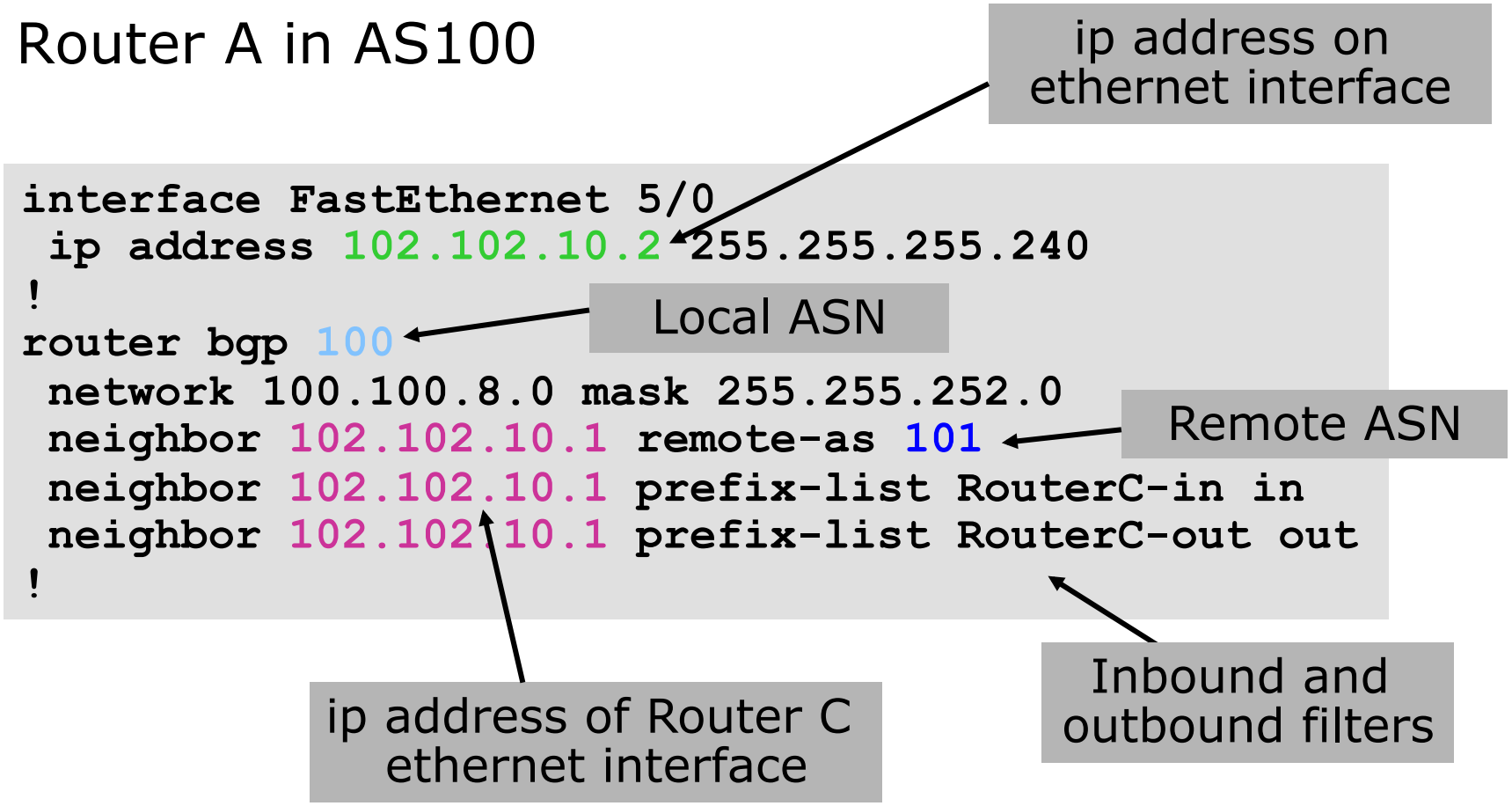
# External BGP Peering (eBGP)




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

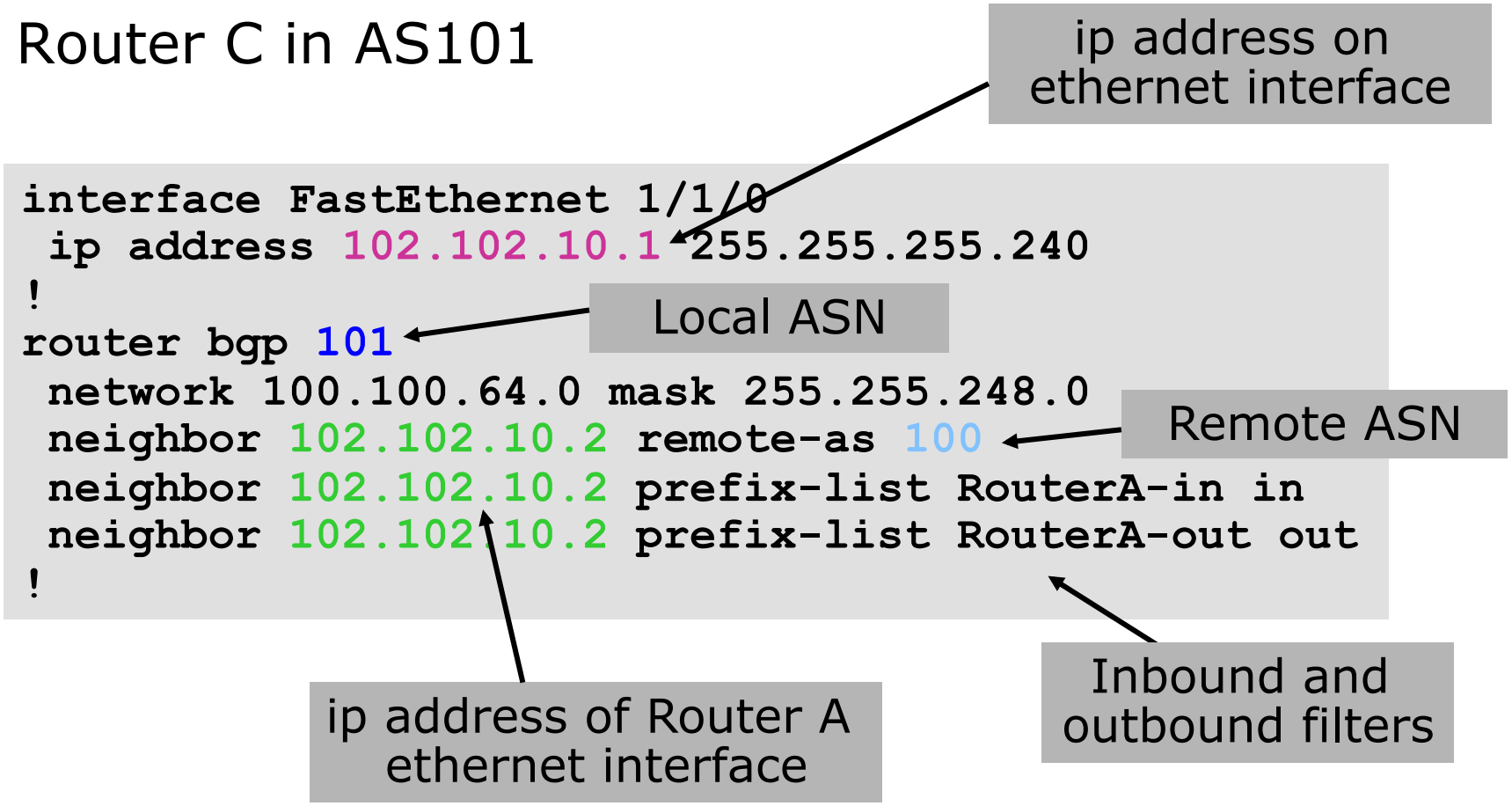
# Configuring External BGP

- Router A in AS100



# Configuring External BGP

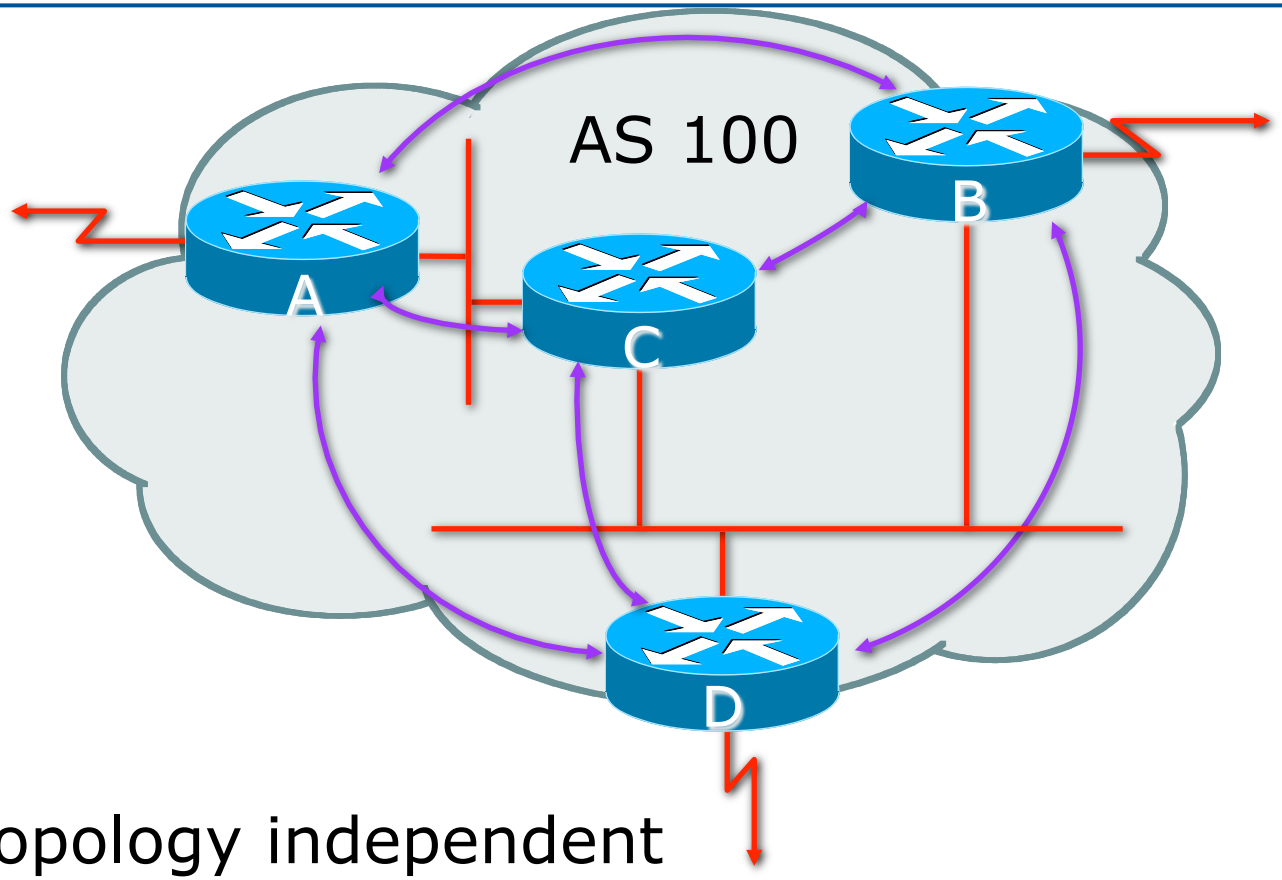
- Router C in AS101



# Internal BGP (iBGP)

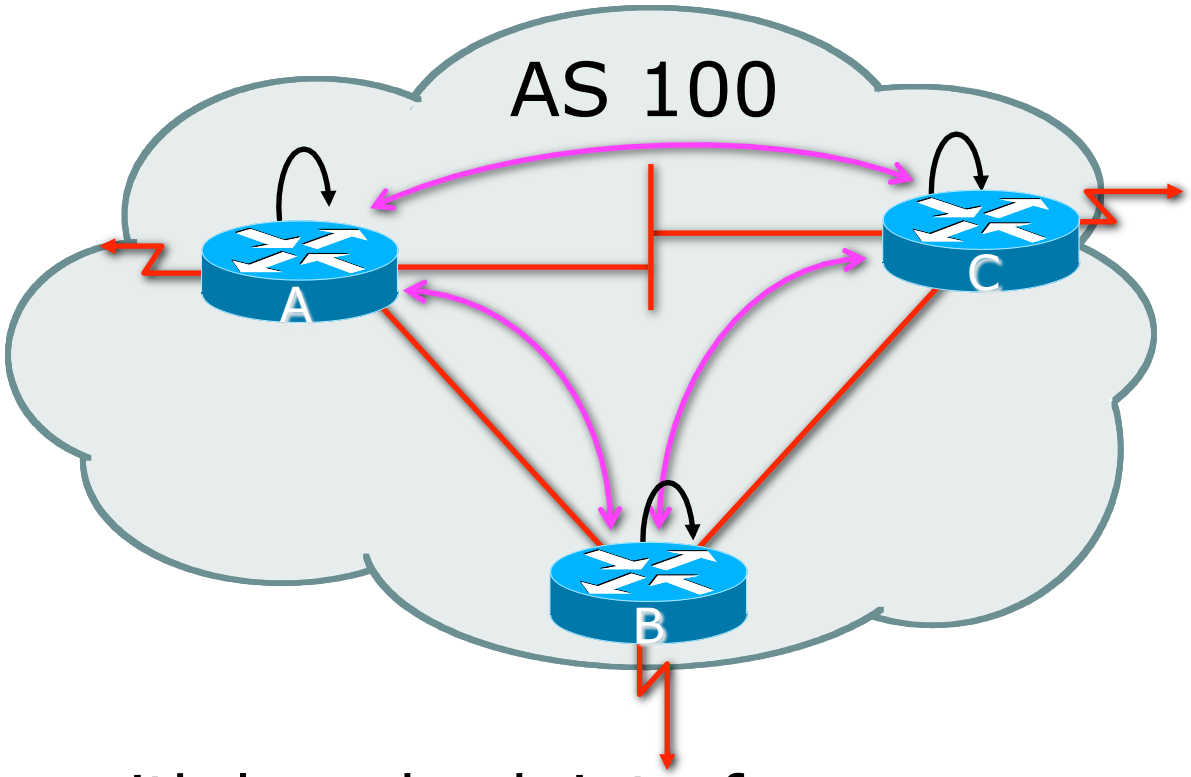
- BGP peer within the same AS
- Not required to be directly connected
  - IGP takes care of inter-BGP speaker connectivity
- iBGP speakers must be fully meshed:
  - They originate connected networks
  - They pass on prefixes learned from outside the ASN
  - They do not pass on prefixes learned from other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

# Internal BGP Peering (iBGP)




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

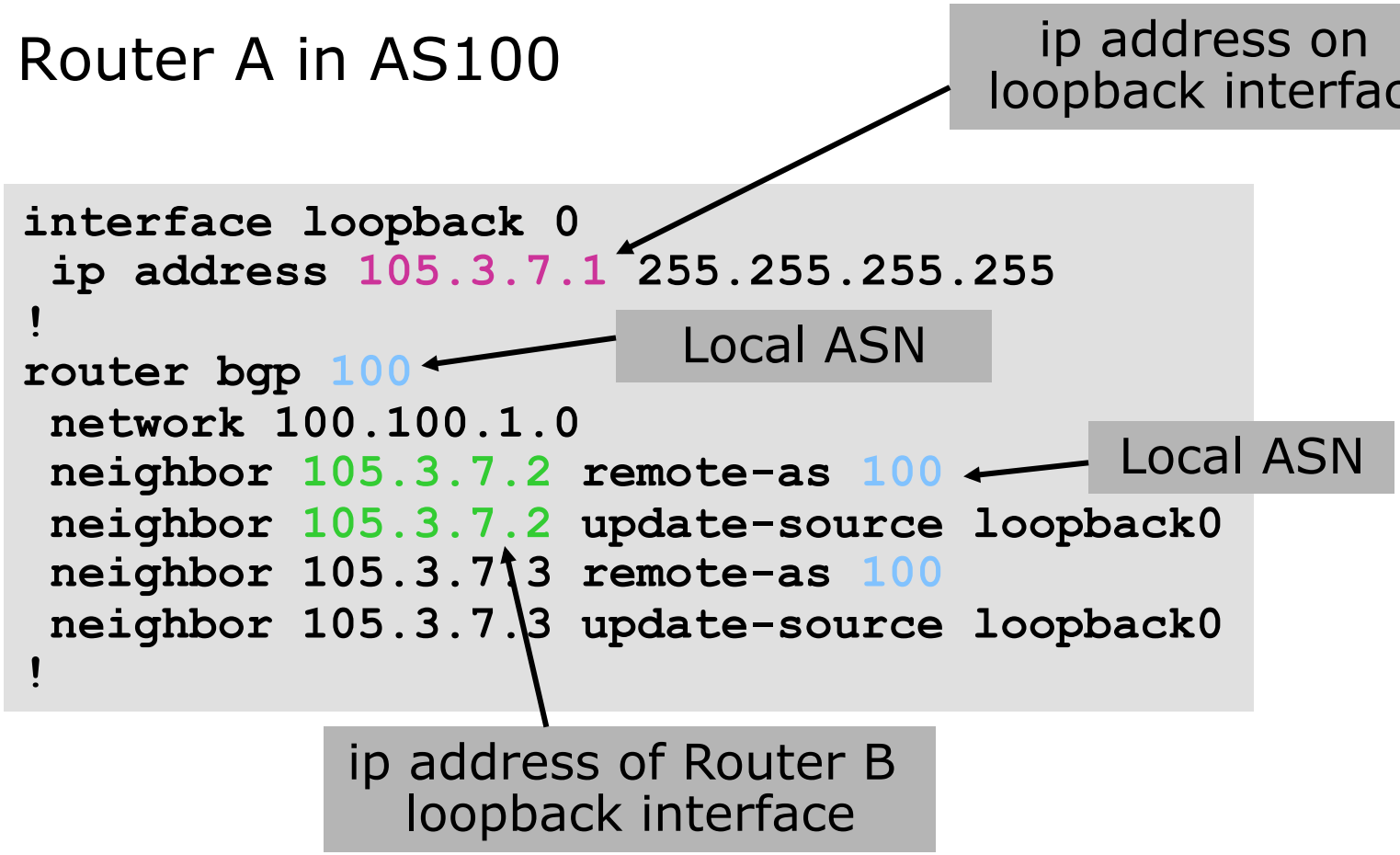
# Peering between Loopback Interfaces




- 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

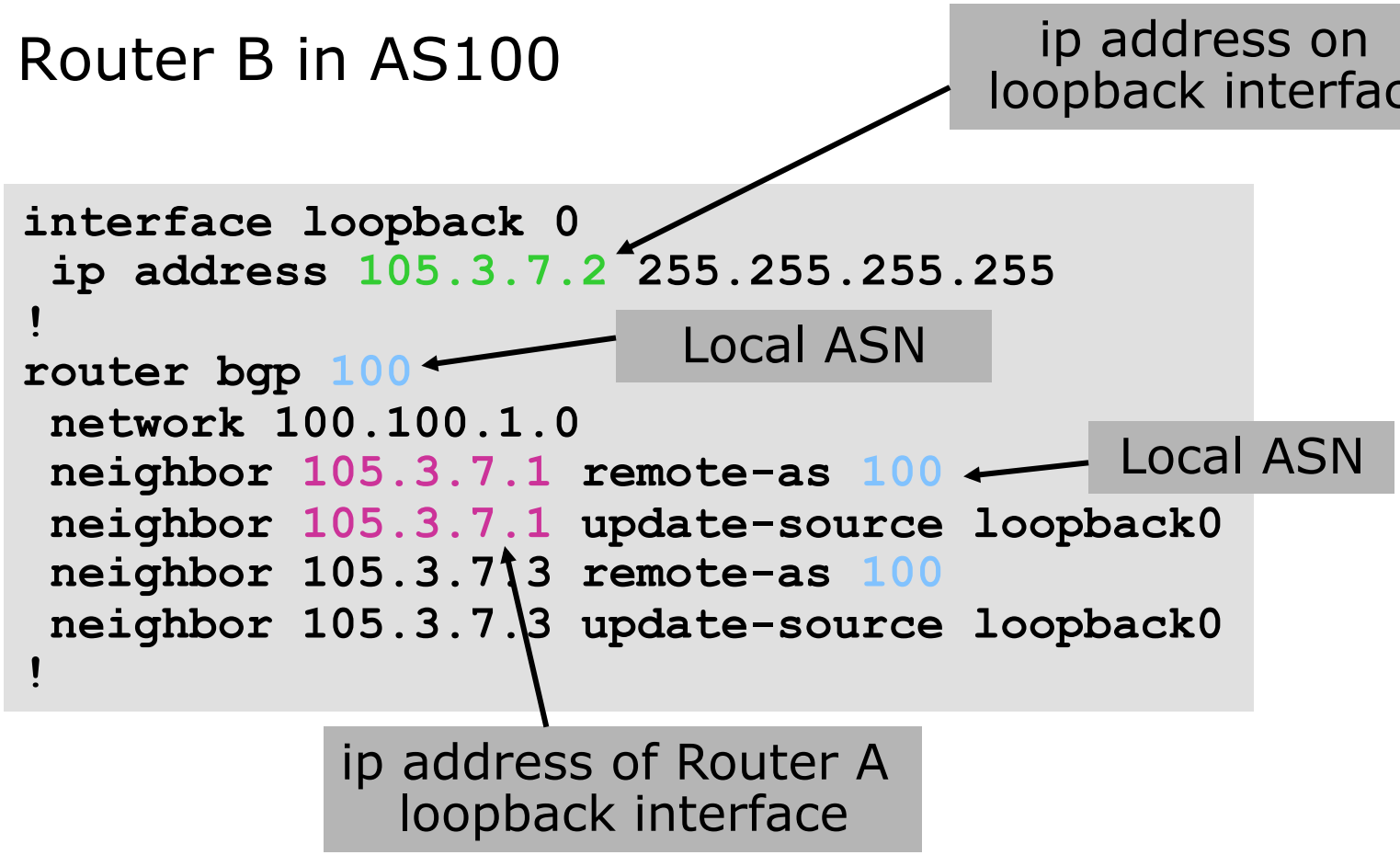
# Configuring Internal BGP

- Router A in AS100



# Configuring Internal BGP

- Router B in AS100



# 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 – Redistributing Static

- Configuration Example:

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

- 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
  - 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
```

- 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]
!
ip route 102.10.32.0 255.255.252.0 null 0
```

- Requires more specific prefix in BGP table before aggregate is announced
- `summary-only` keyword
  - Optional keyword which ensures that only the summary is announced (the more specific routes are suppressed)

# 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 and received

Updates waiting

# Summary
# BGP Table

```
Router6>sh ip bgp
BGP table version is 16, 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, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>i 10.0.0.0/26      10.0.15.241              0    100      0 i
 *>i 10.0.0.64/26     10.0.15.242              0    100      0 i
 *>i 10.0.0.128/26    10.0.15.243              0    100      0 i
 *>i 10.0.0.192/26    10.0.15.244              0    100      0 i
 *>i 10.0.1.0/26      10.0.15.245              0    100      0 i
 *>  10.0.1.64/26     0.0.0.0                  0         32768 i
 *>i 10.0.1.128/26    10.0.15.247              0    100      0 i
 *>i 10.0.1.192/26    10.0.15.248              0    100      0 i
 *>i 10.0.2.0/26      10.0.15.249              0    100      0 i
 *>i 10.0.2.64/26     10.0.15.250              0    100      0 i
...
```

# Summary

- BGP4 – path vector protocol
- iBGP versus eBGP
- Stable iBGP – peer with loopbacks
- Announcing prefixes & aggregates

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ISP Workshops