Introduction to BGP

ISP/IXP 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 BGP’s fundamental operating unit
  - 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

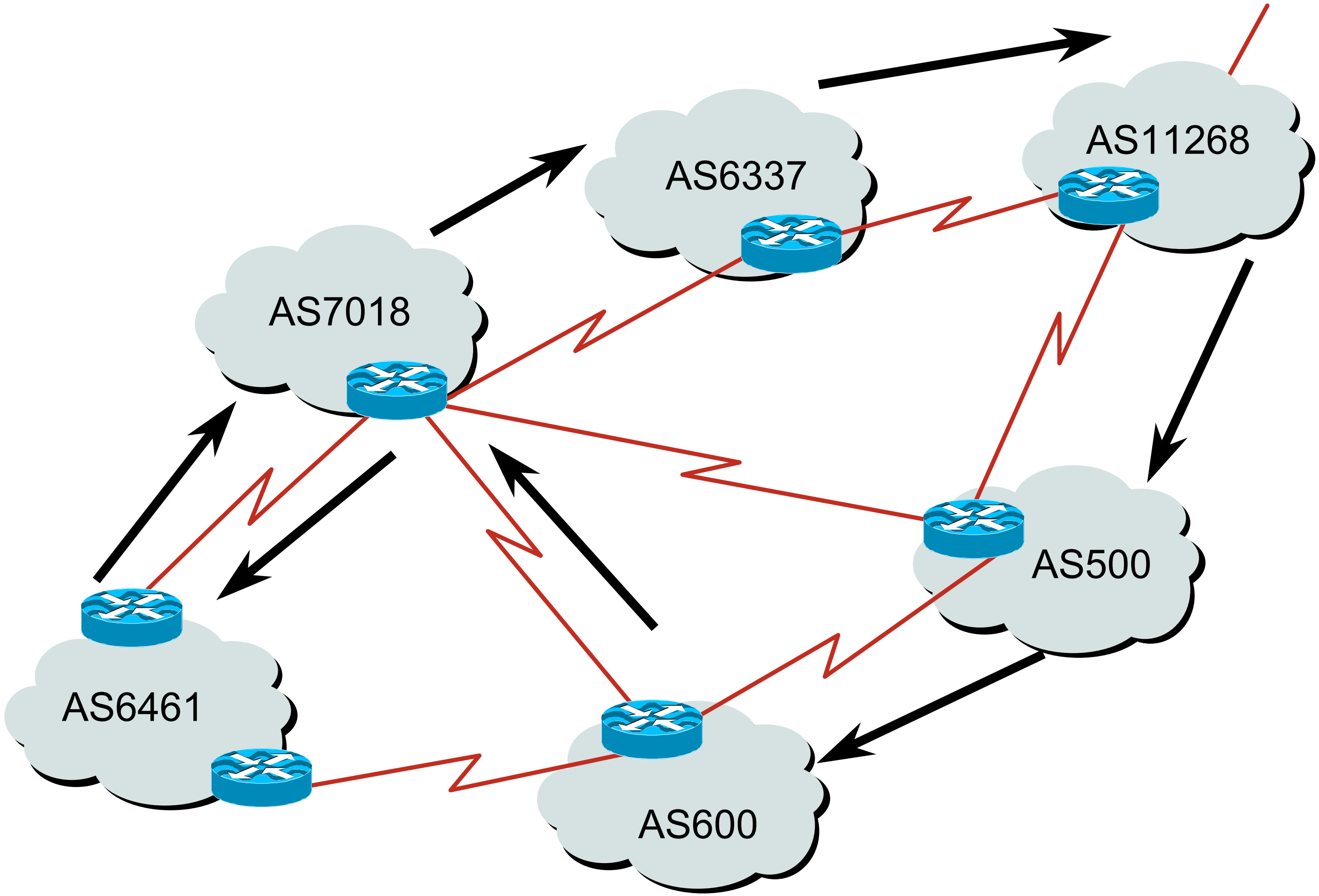
- BGP is classified as a *path vector* routing protocol (see RFC 1322)

    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



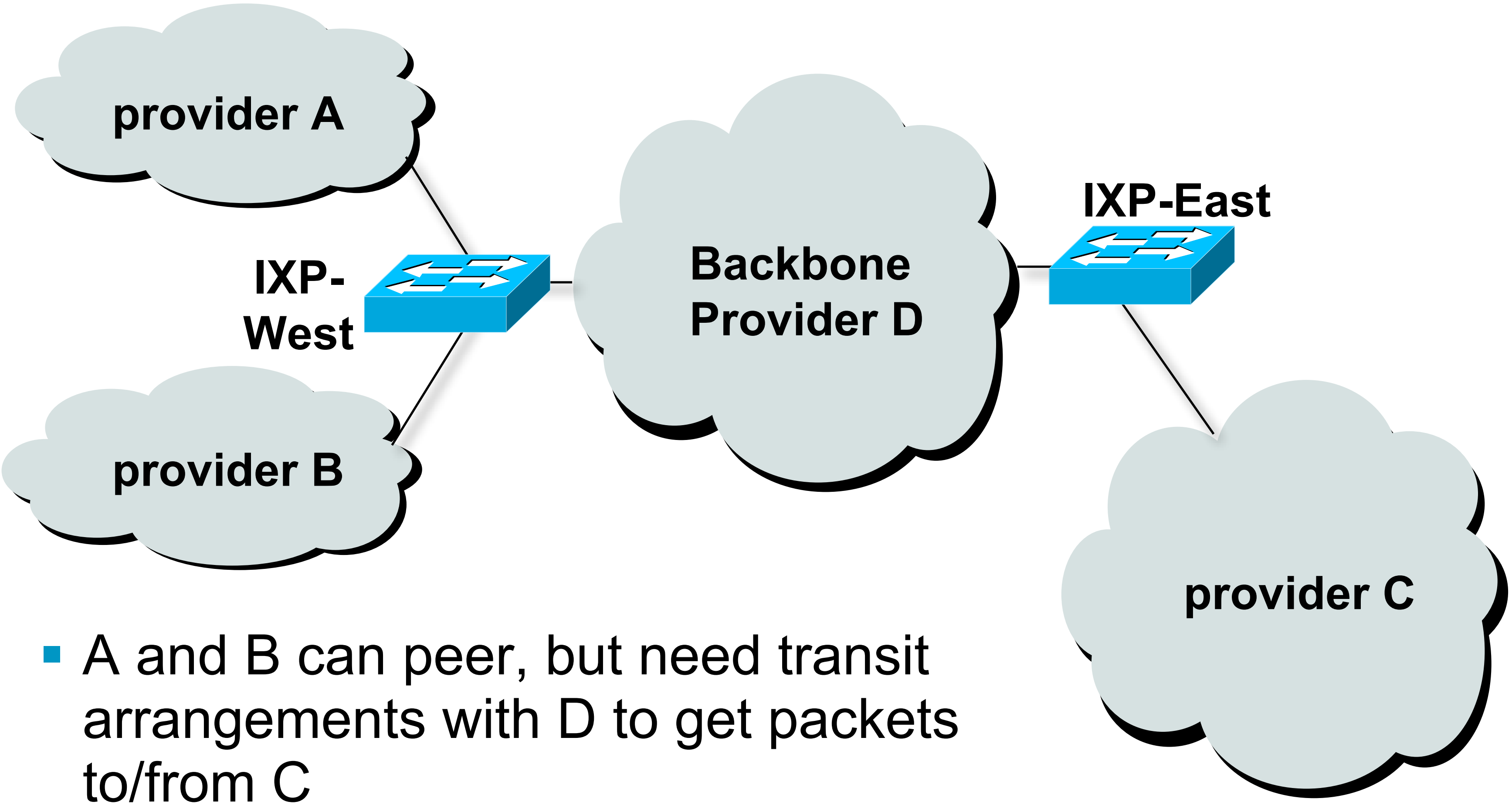
Definitions

- 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

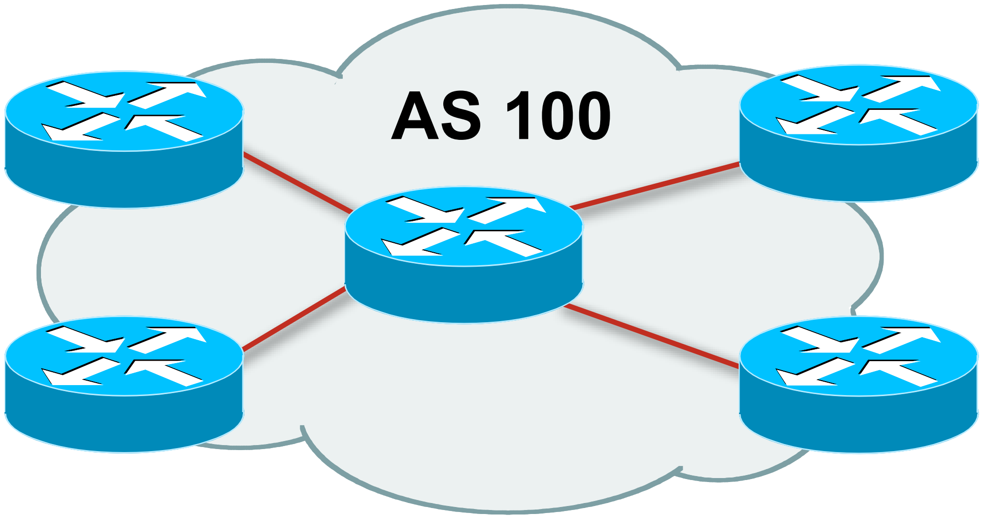
The default free zone is made up of Internet routers which have explicit routing information about the rest of the Internet, and therefore do not need to use a default route.

Peering and Transit example



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

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 number

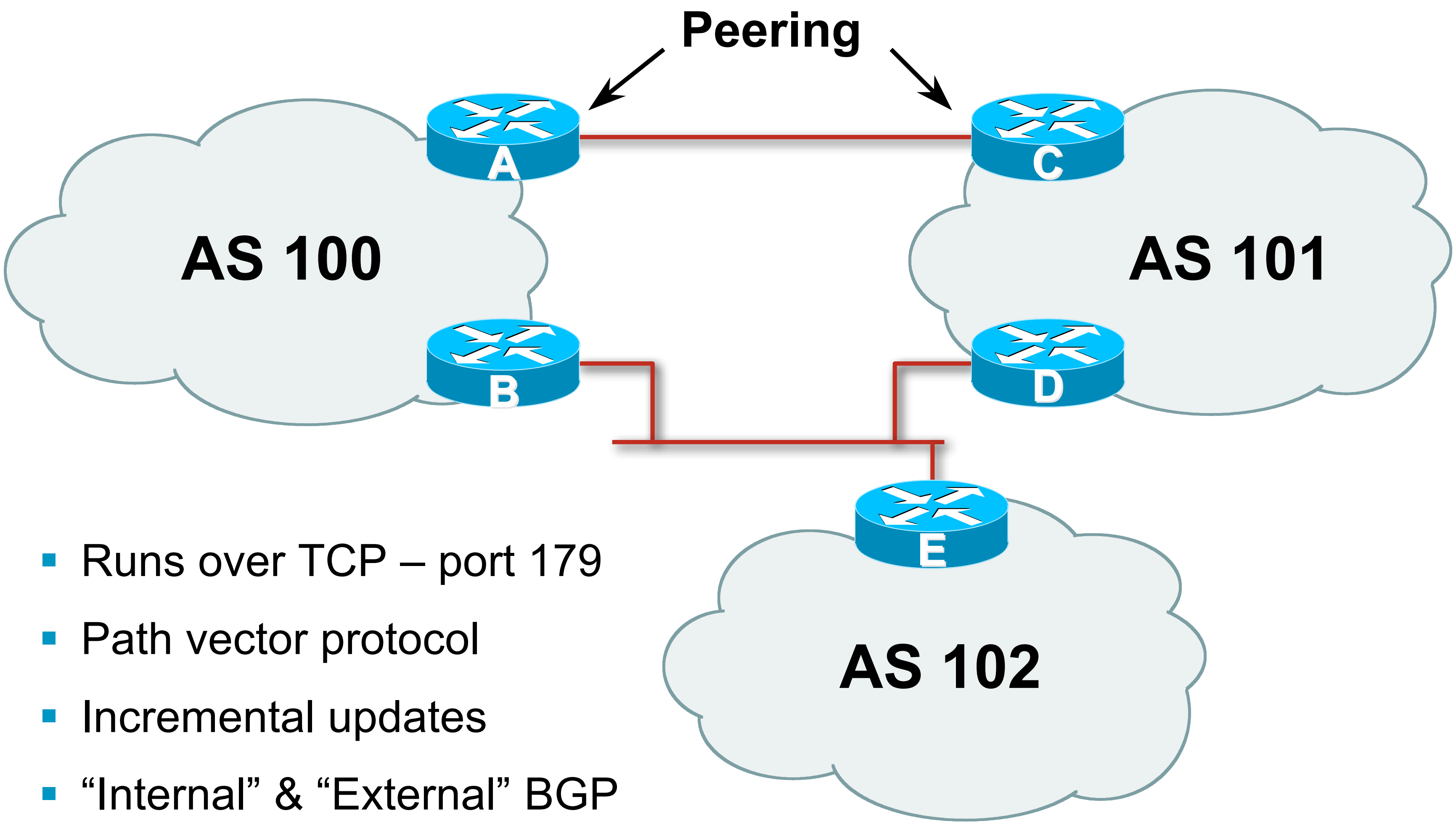
Autonomous System Number (ASN)

- An ASN is a 16 bit integer
  - 1-64511 are for use on the public Internet
  - 64512-65534 are for private use only
  - 0 and 65535 are reserved
- ASNs are now extended to 32 bit!
  - RFC4893 is standards document describing 32-bit ASNs
  - Representation still under discussion:
    - 32-bit notation or “16.16” notation
      - **draft-michaelson-4byte-as-representation-04.txt**
  - AS 23456 is used to represent 32-bit ASNs in 16-bit ASN world

Autonomous System Number (ASN)

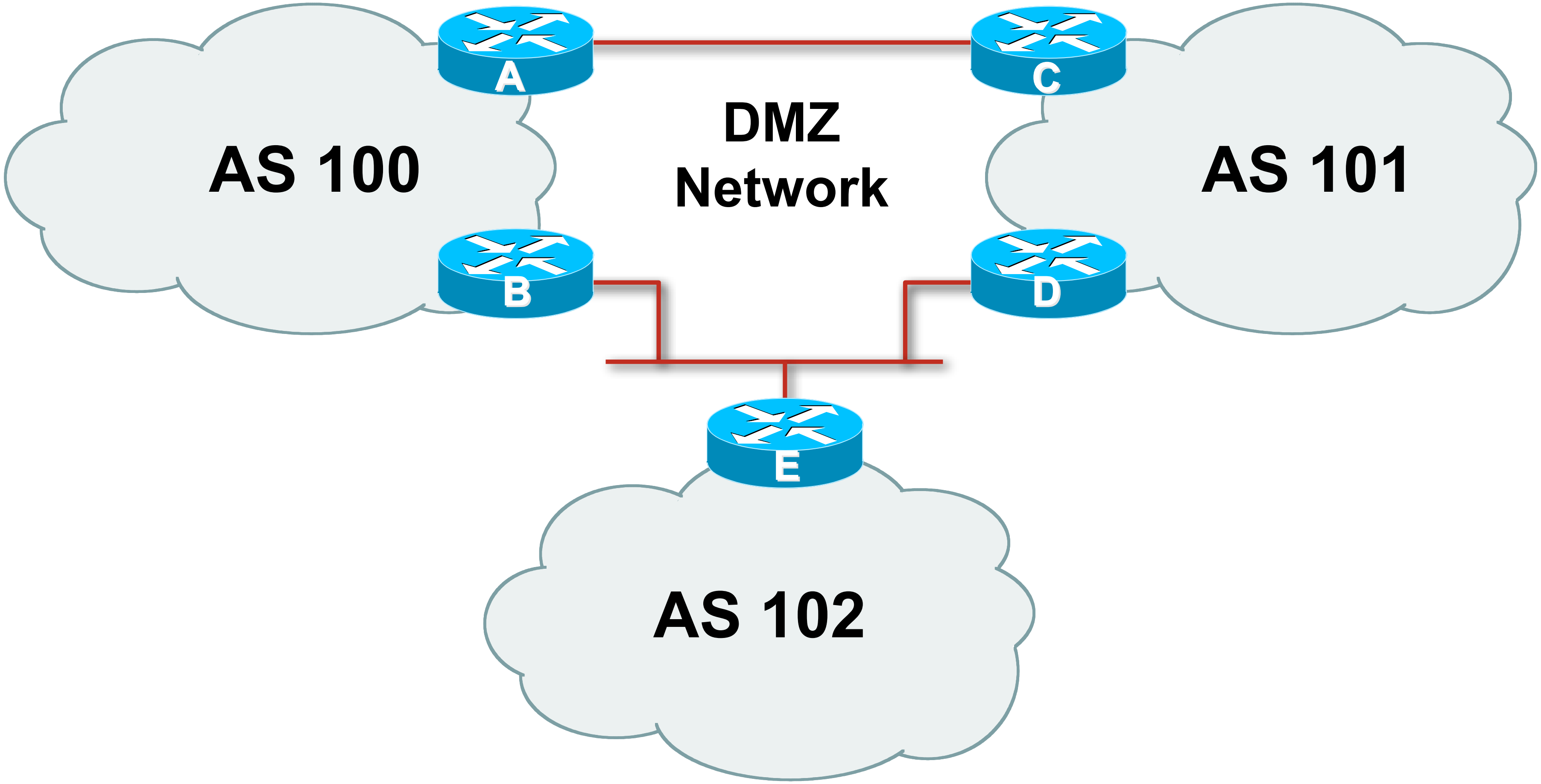
- ASNs are distributed by the Regional Internet Registries
  - They are also available from upstream ISPs who are members of one of the RIRs
- Current 16-bit ASN allocations up to 48027 have been made to the RIRs
  - Around 29000 are visible on the Internet
- The RIRs also have received 1024 32-bit ASNs each
  - Around 10 are visible on the Internet (early adopters)
- See **www.iana.org/assignments/as-numbers**

BGP Basics



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

Demarcation Zone (DMZ)



- Shared network between ASes

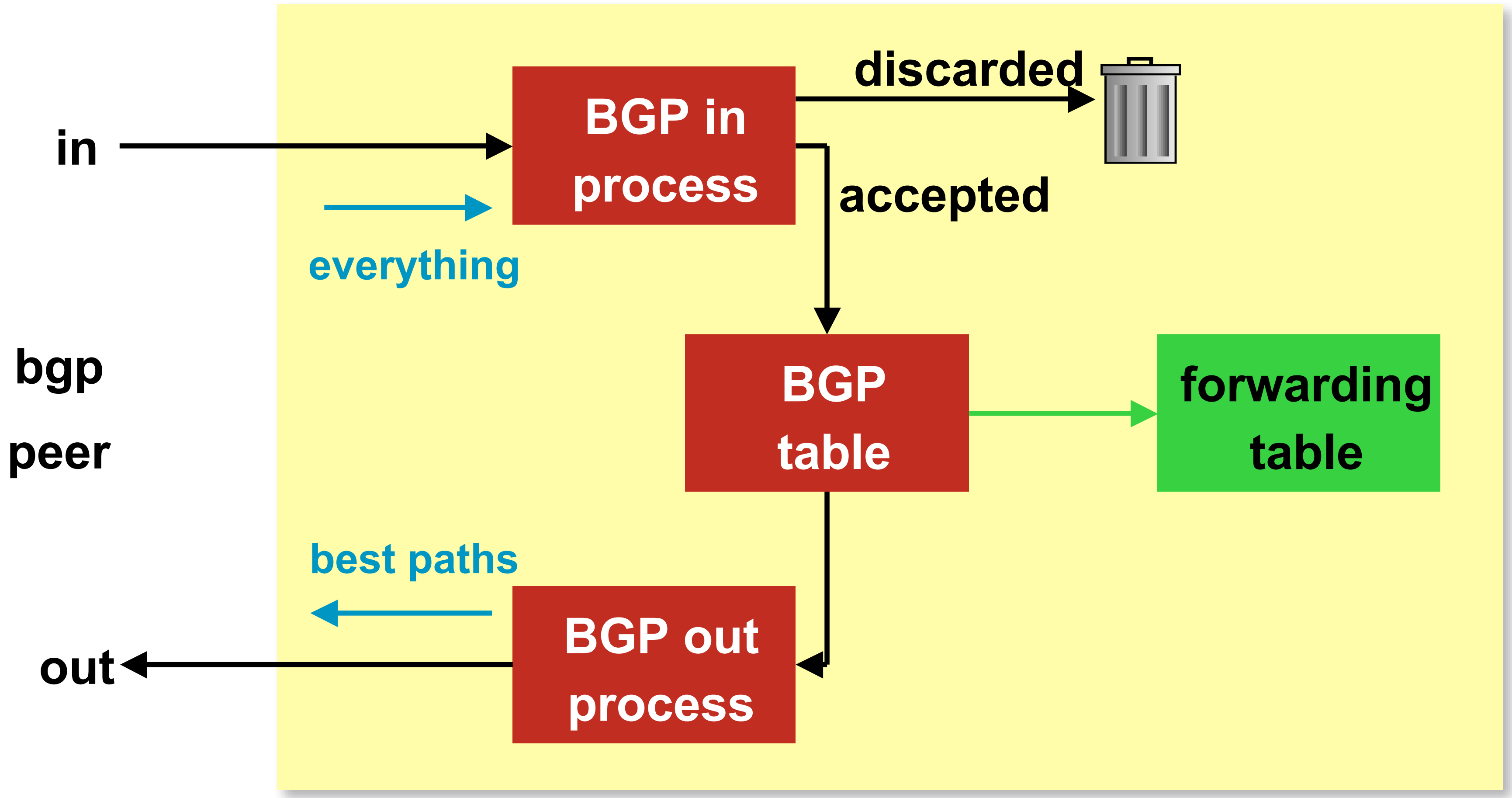
BGP General Operation

- Learns multiple paths via internal and external BGP speakers
- Picks the best path and installs in the forwarding table
- 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 paths installed in forwarding table if:
  - prefix and prefix length are unique
  - lowest "protocol distance"

Constructing the Forwarding Table

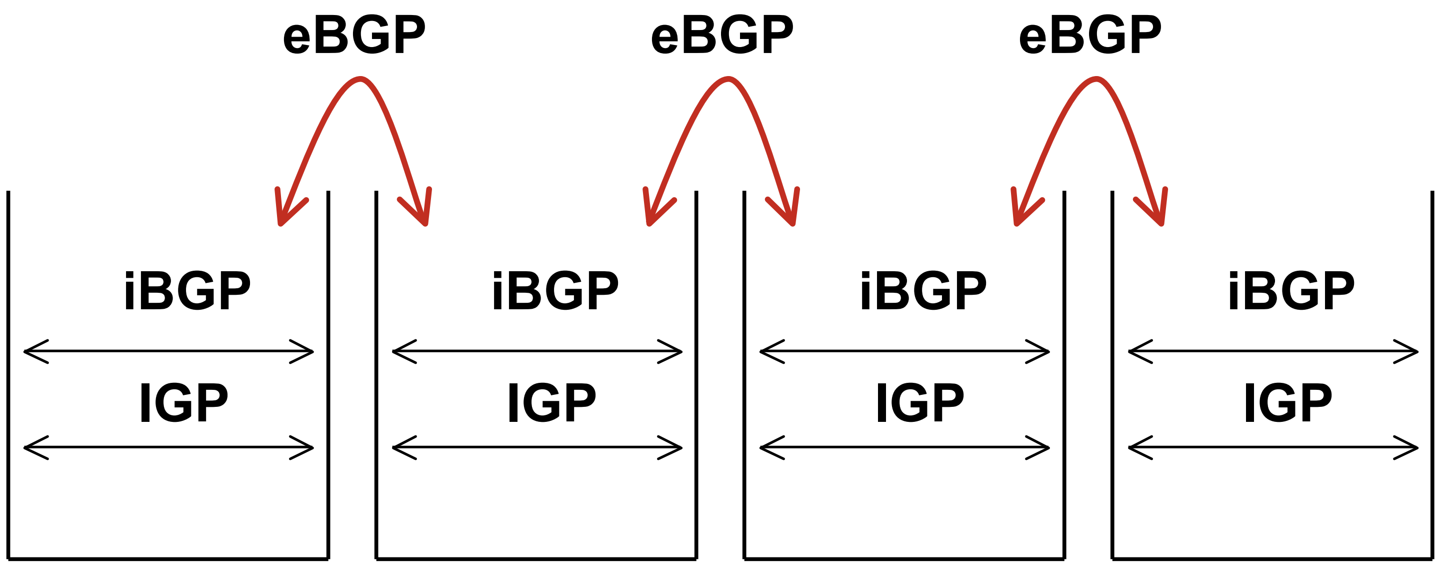


eBGP & iBGP

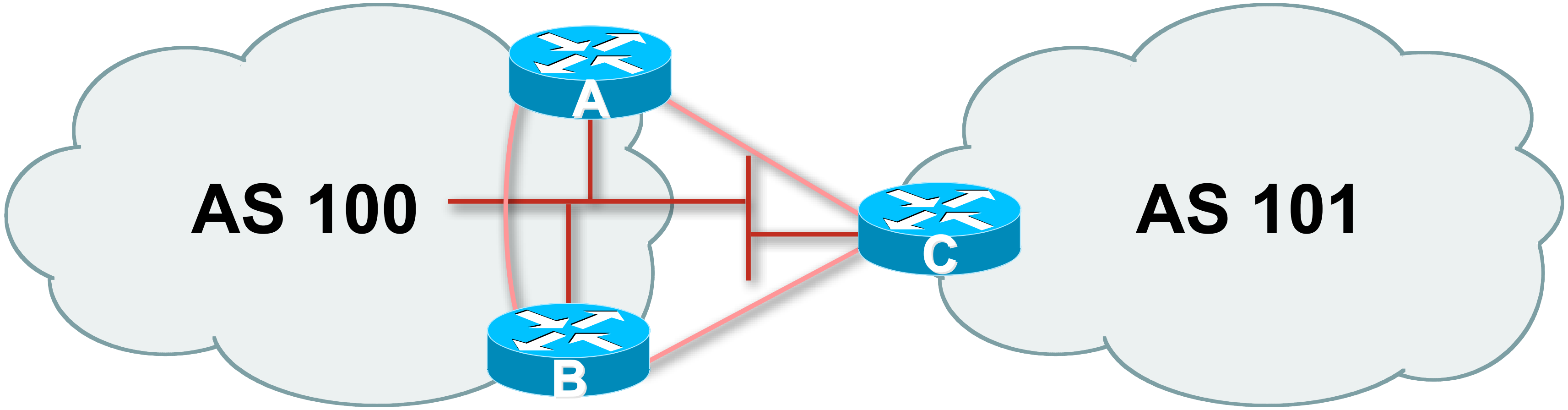
- BGP used internally (iBGP) and externally (eBGP)
- iBGP used to carry
  - some/all Internet prefixes across ISP backbone
  - ISP's customer prefixes
- eBGP used to
  - exchange prefixes with other ASes
  - implement routing policy

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

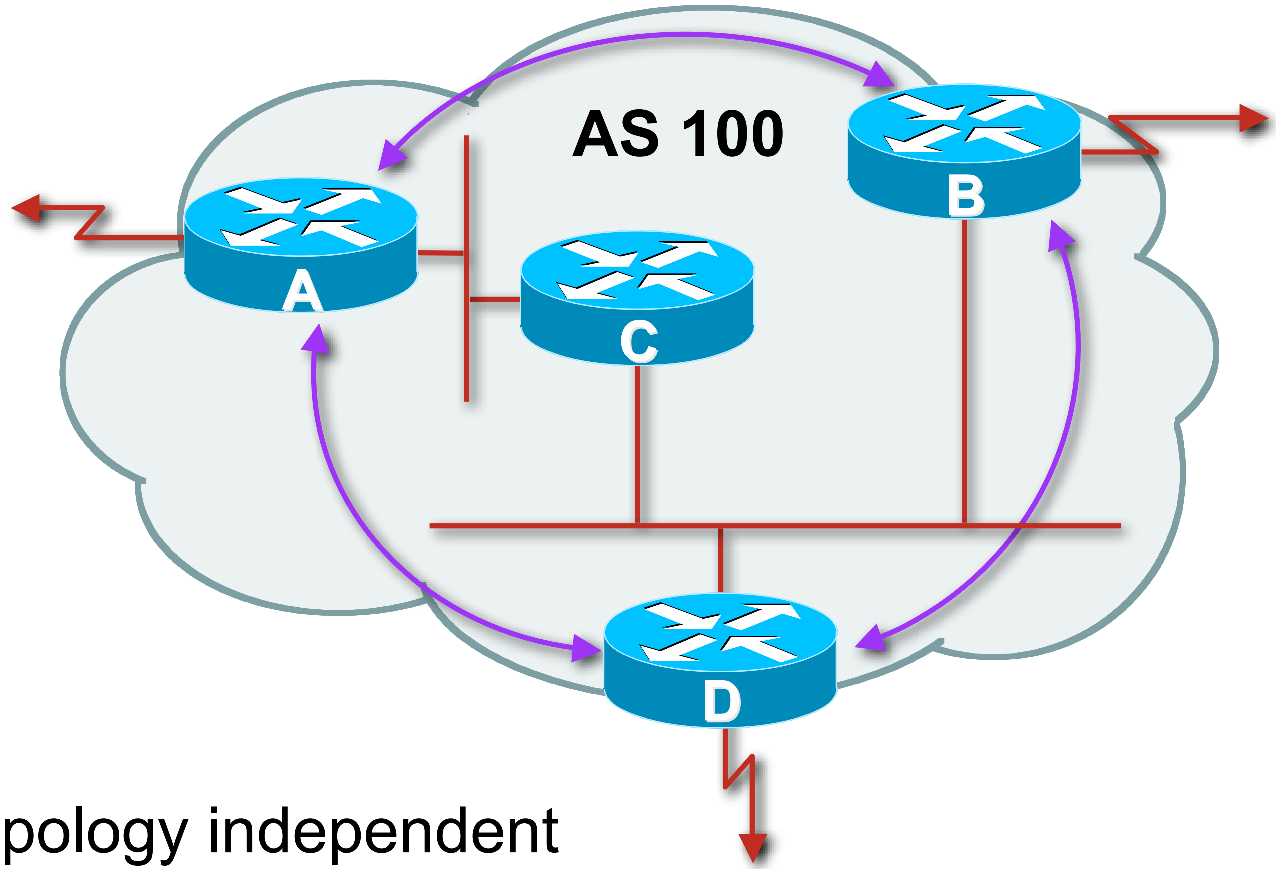
ip address of Router A ethernet interface

Inbound and outbound filters

Internal BGP (iBGP)

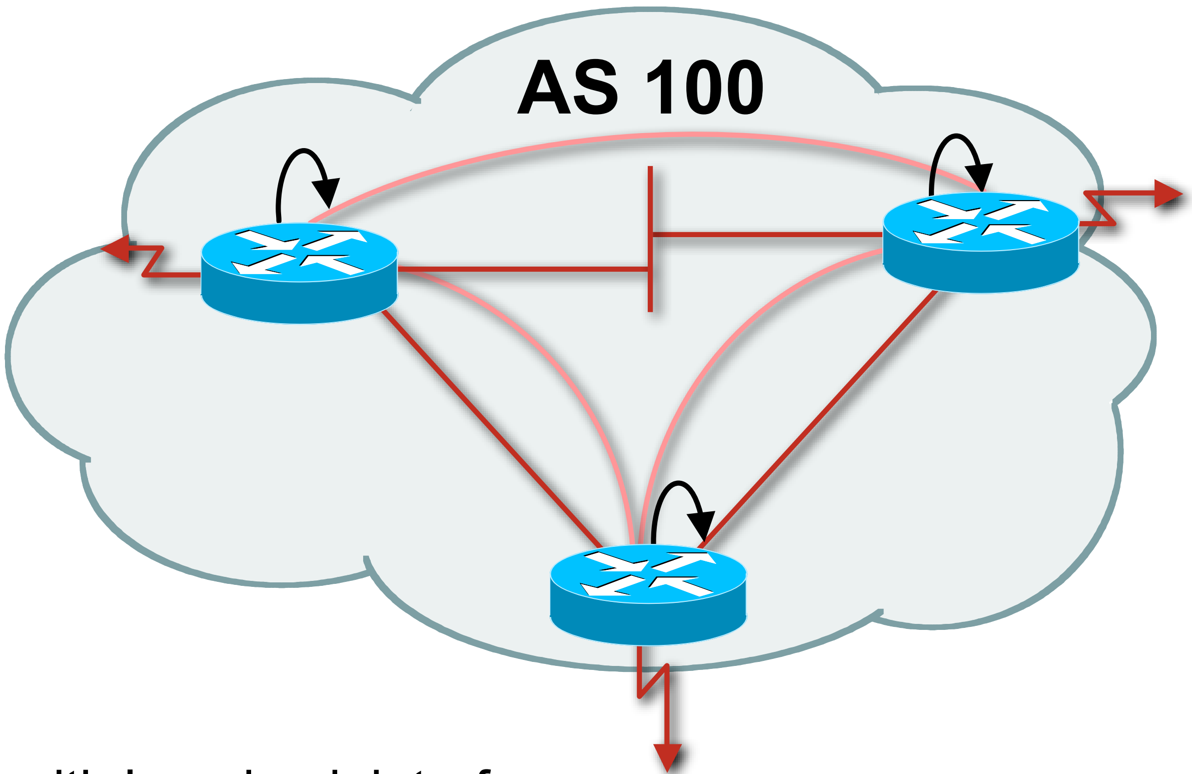
- BGP peer within the same AS
- Not required to be directly connected
  - IGP takes care of inter-BGP speaker connectivity
- iBGP speakers must be fully meshed:
  - They originate connected networks
  - They pass on prefixes learned from outside the ASN
  - They do **not** pass on prefixes learned from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

Internal BGP Peering (iBGP)



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

Peering to 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

ip address on loopback interface

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
!
```

Local ASN

Local ASN

ip address of Router B loopback interface

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

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

Historical Defaults – Auto Summarisation

- **Disable historical default 1**
- Applies to Cisco IOS prior to 12.3
- Automatically summarises subprefixes to the classful network when redistributing to BGP from another routing protocol

  Example:

  61.10.8.0/22 → 61.0.0.0/8
- Must be turned off for any Internet connected site using BGP

```
router bgp 100
 no auto-summary
```

Historical Defaults – Synchronisation

- **Disable historical default 2**
- In Cisco IOS prior to 12.3, BGP does not advertise a route before all routers in the AS have learned it via an IGP
- Disable synchronisation if:

  AS doesn’t pass traffic from one AS to another, or

  All transit routers in AS run BGP, or

  iBGP is used across backbone

```
router bgp 100
 no synchronization
```


Summary
BGP neighbour status

```
Router1>sh ip bgp sum
BGP router identifier 100.1.15.224, local AS number 10
BGP table version is 27, main routing table version 27
14 network entries using 1582 bytes of memory
14 path entries using 672 bytes of memory
3/2 BGP path/bestpath attribute entries using 324 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 2578 total bytes of memory
BGP activity 17/3 prefixes, 22/8 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
100.1.31.224    4    10     195     193       27    0    0 03:09:48        1
100.1.63.224    4    10      71      70       27    0    0 01:05:31        1
100.2.15.224    4    10      46      47       27    0    0 00:17:00        1
...
```

BGP Version

Updates sent and received

Updates waiting

Summary

- BGP4 – path vector protocol
- iBGP versus eBGP
- stable iBGP – peer with loopbacks
- announcing prefixes & aggregates
- **no synchronization** & **no auto-summary**

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