

APNIC eLearning: BGP Basics

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Contact: training@apnic.net

What is BGP?

- 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

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Overview

- What is BGP?
- BGP Features
- Path Vector Routing Protocol
- Peering and Transit
- BGP General Operation
- BGP Terminology
- BGP Attributes
- Inserting Prefixes into BGP

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BGP Features

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

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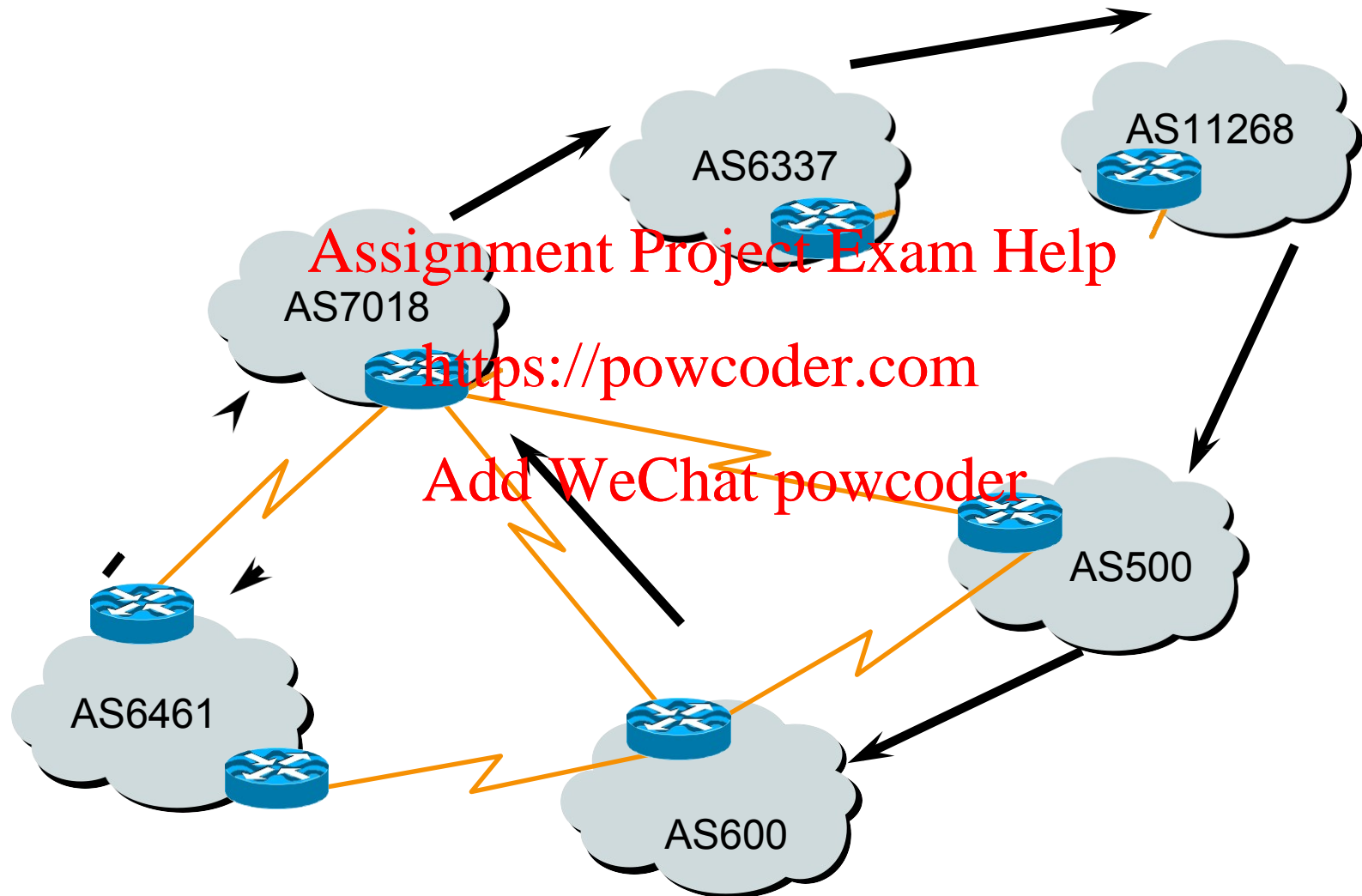
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What is Path Vector Routing Protocol

- A path vector routing protocol is used to span different autonomous systems
- It defines a route as a collection of a number of AS that it passes through from source AS to destination AS
- This list of ASes are called AS path and used to avoid routing loop
- AS path is also used to select path to destination
- RFC 1322
 - “A path vector protocol defines a route as a pairing between a destination and the attributes of the path to that destination.”

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

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Default Free Zone

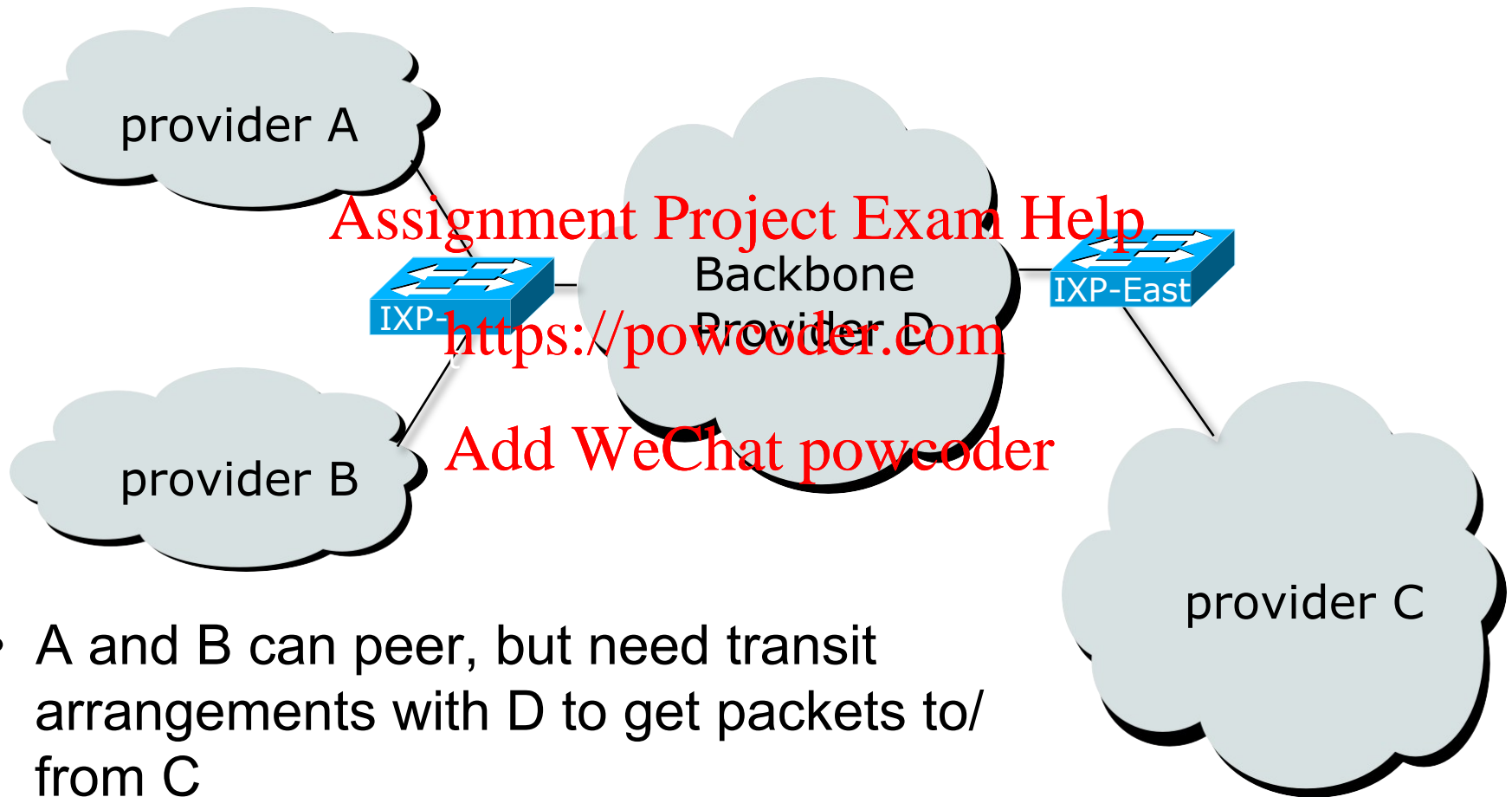
The default free zone is made up of Internet routers which explicitly have routing information about the Internet, and therefore do not need to use a default route

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Peering and Transit example



What Is An Autonomous System?

- Group of Internet Protocol-based networks with the same routing policy
 - Usually under single ownership, trust or administrative control
- The AS is used both in the exchange of exterior routing information (between neighboring ASes) and as an identifier of the AS itself
- The Autonomous System is the cornerstone of BGP
 - It is used to uniquely identify networks with a common routing policy

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Autonomous System Number (ASN)

- globally unique identifiers for IP networks
- ASN uniquely identifies each network on the Internet
- allocated to each Autonomous System (AS) for use in BGP routing
- 2-byte only AS number range : 0 – 65535
- 4-byte only AS number range – represented in two ways
 - AS PLAIN: 65,536 - 4,294,967,295
 - AS DOT: 1.0 - 65535.65535

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BGP General Operation

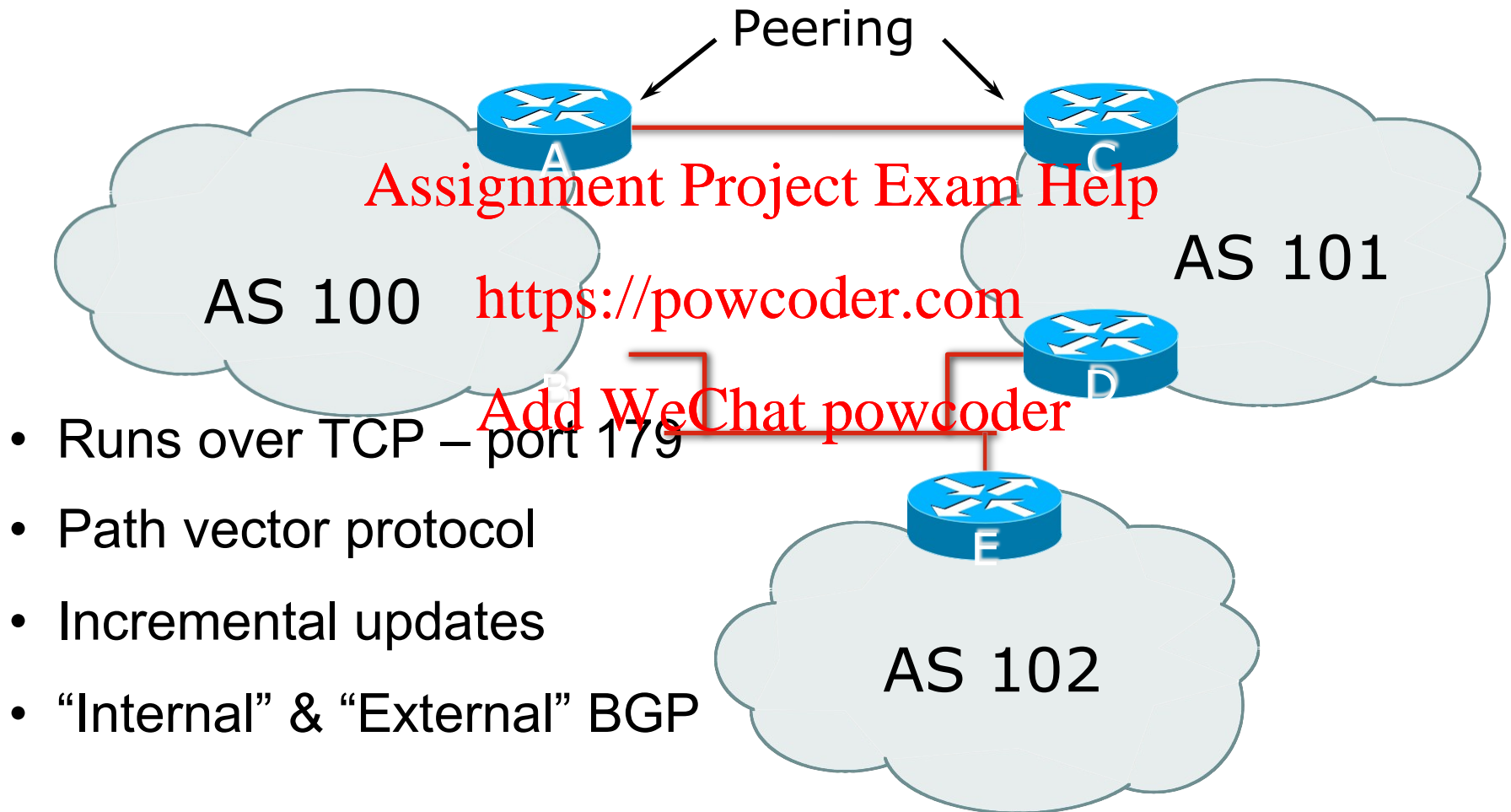
- Learns multiple paths via internal and external BGP speakers
- Picks the best path and installs it in the routing table (RIB)
- Best path is sent to external BGP neighbours
- Policies are applied by influencing the best path selection

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BGP Basics



BGP Terminology

- Neighbor
 - Any two routers that have formed a TCP connection to exchange BGP routing information are called peers or neighbors
- iBGP
 - iBGP refers to the BGP neighbor relationship within the same AS.
 - The neighbors do not have to be directly connected.
- eBGP
 - When BGP neighbor relationship are formed between two peers belongs to different AS are called eBGP.
 - EBGP neighbors by default need to be directly connected.

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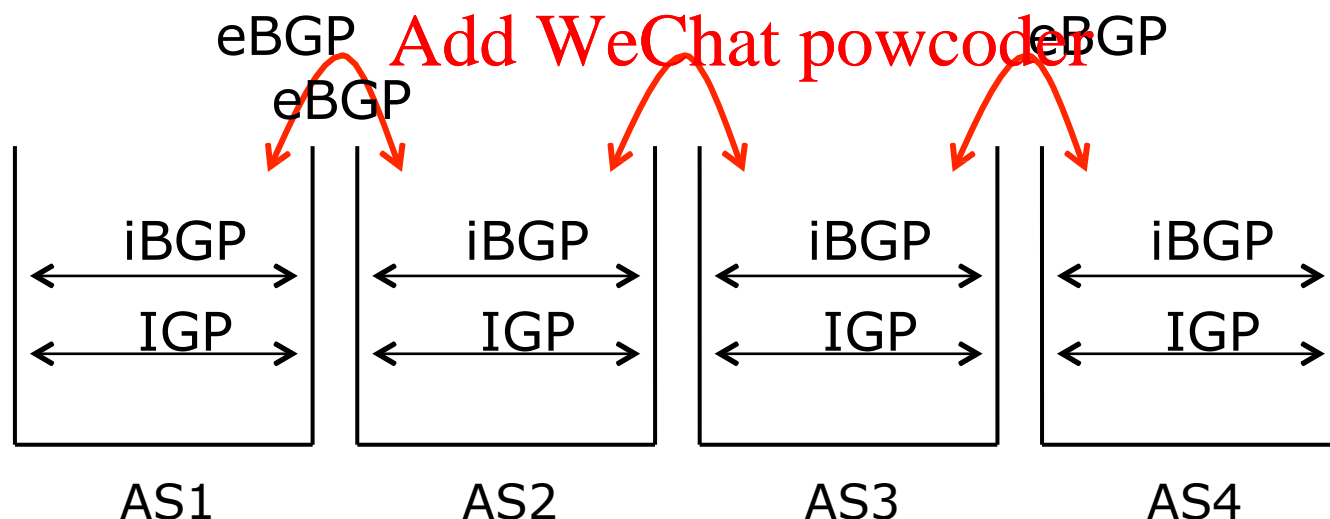
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BGP Attributes

- Well-known attributes – must be supported by every BGP implementation
- Mandatory attributes – must be included with every route entry. If one attribute is missing, it will result in an error message
 - Ex: ORIGIN, AS_PATH, NEXT_HOP, LOCAL_PREF
- Discretionary attributes – every BGP router must recognize, but they don't have to be present with every route entry
 - Ex. ATOMIC_AGGREGATE
- Optional attributes – not necessarily supported by all BGP implementations. It can be either transitive or non-transitive.
 - AGGREGATOR, COMMUNITY, MULTI_EXIT_DISC

BGP/IGP model used in ISP networks

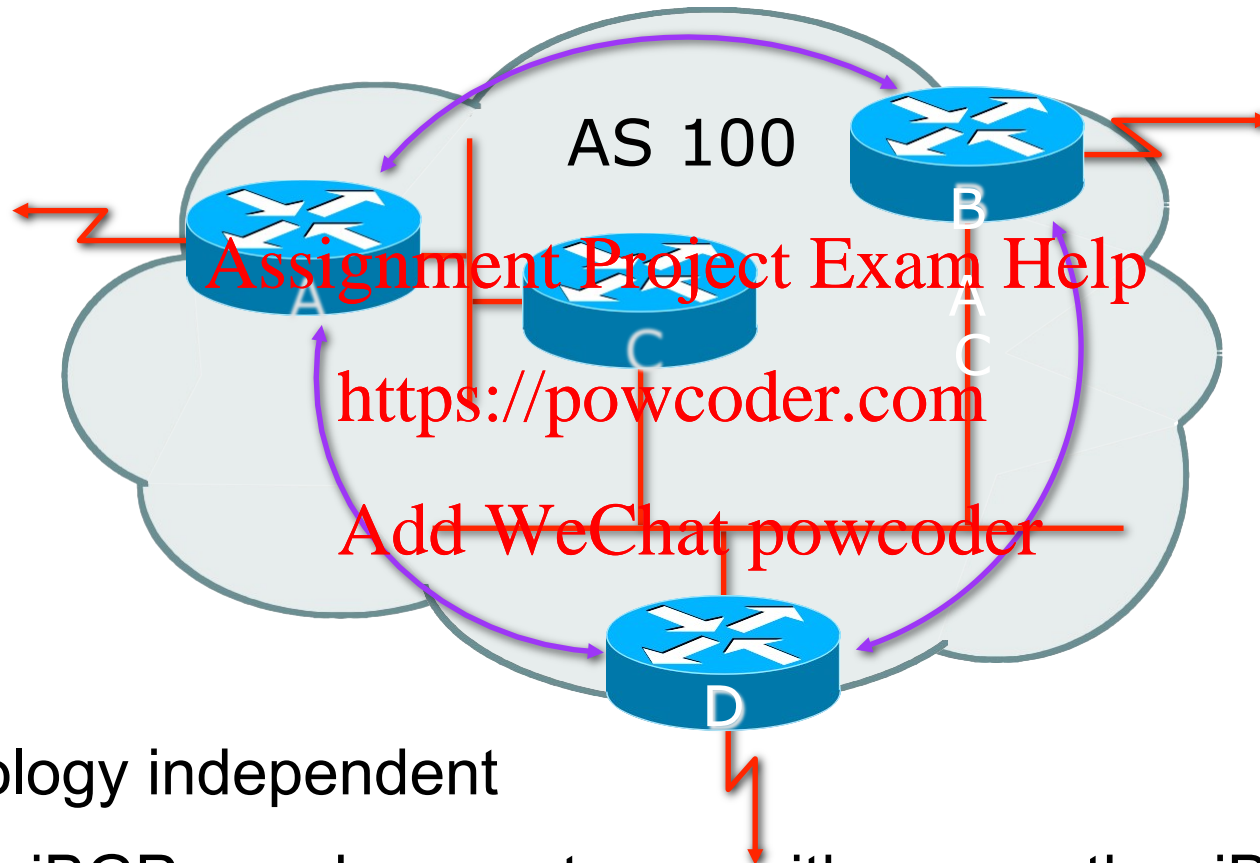
- BGP is used internally (iBGP) and externally (eBGP)
- iBGP – used to carry some/all Internet prefixes across ISP backbone and ISP's customer prefixes
- eBGP – used to exchange prefixes with other ASes and implement routing policy



Internal BGP (iBGP)

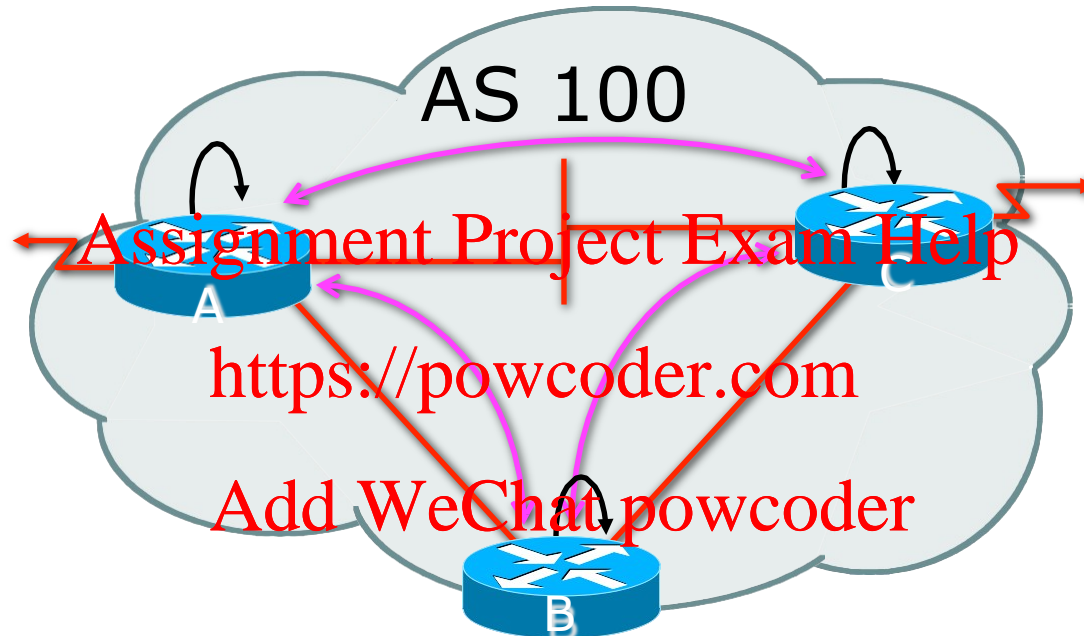
- BGP peer within the same AS
- Not required to be directly connected
 - IGP takes care of internal BGP speaker connectivity
- iBGP speakers must be fully meshed:
 - They originate connected networks
 - They pass on prefixes learned from outside the ASN
 - They do not pass on prefixes learned from other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

Constructing the Forwarding Table

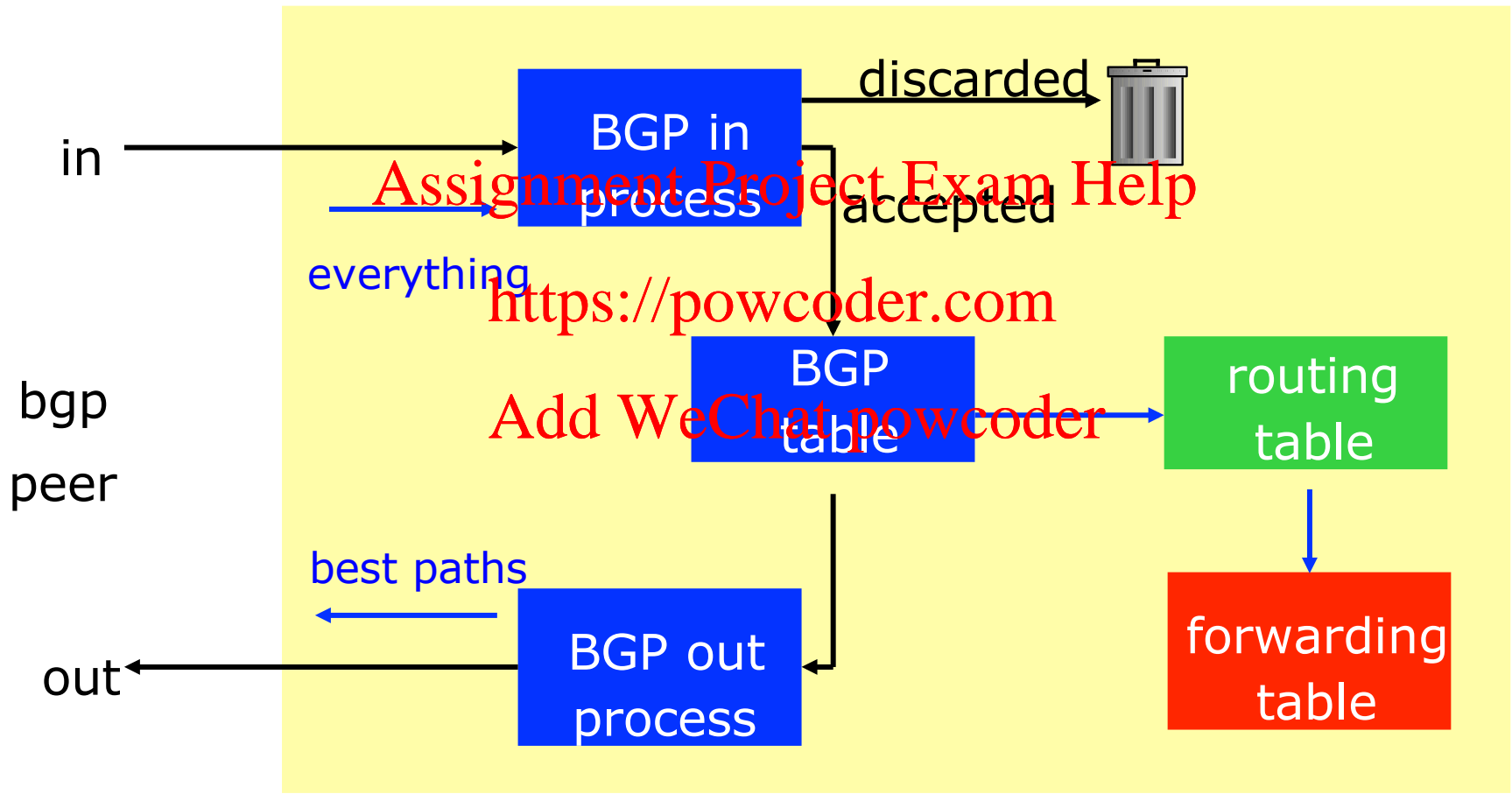
- BGP “in” process
 - receives path information from peers
 - results of BGP path selection placed in the BGP table
 - “best path” flagged
- BGP “out” process
 - announces “best path” information to peers
- Best path stored in Routing Table (RIB)
- Best paths in the RIB are installed in forwarding table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

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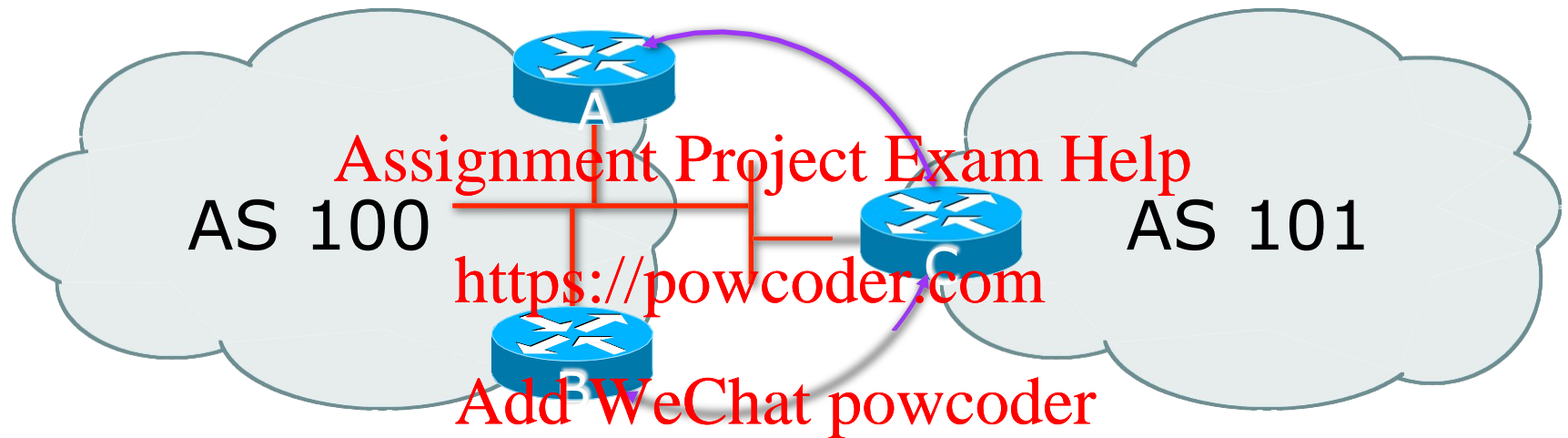
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Constructing the Forwarding Table



External BGP Peering (eBGP)



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

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 notation, or in 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
```

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

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Local ASN

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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

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Local ASN

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Remote ASN

ip address of Router
A ethernet interface

Inbound and
outbound filters

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

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Local ASN

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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

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Local ASN

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Local ASN

ip address of Router
A loopback interface

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”

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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

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Summary

BGP neighbour status

```
Router>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

```
Route6>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!
...!					

Questions

- Please remember to fill out the feedback form
- <survey-link>
- Slide handouts will be available after completing the survey

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APNIC Helpdesk Chat

The image shows a screenshot of the APNIC website with a live chat window overlay. The website header includes the APNIC logo, a user profile icon, and navigation links: Contact us, Press, Jobs, Site map. The main navigation bar has links for Home, Services, Community, Events, Publications, and About us. The Services section is expanded, showing a list of services: Registration services, Informing the community, Routing Registry, Resource certification, Training & education, Policy development, and Helpdesk (selected). The Helpdesk section is further expanded, showing options: Using VoIP, Apply for resources, Become a Member, Make a payment, Manage Internet resources, and Helpdesk. The Helpdesk chat window is titled 'APNIC Helpdesk Chat' and contains a form with fields for Name, Email, and a text area for the question. A 'Chat' button is present. The window also displays the URL 'livehelp.apnic.net/request.php?l=apphplive&x=1&deptid=1&pa...' and the text 'Welcome to our Live Chat.' Below the chat window, there is a section for 'Helpdesk queries' with a list of topics: Status of requests, Membership enquiries, Billing issues, Database enquiries, Existing members, and Public holidays. The website footer includes the APNIC logo and a list of APNIC offices and Helpdesk locations.

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- > Informing the community
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- > Resource certification
- > Training & education
- > Policy development
- ▼ Helpdesk
 - Using VoIP

- ▶ Apply for resources
- ▶ Become a Member
- ▶ Make a payment
- ▶ Manage Internet resources
- ▶ Helpdesk

Helpdesk

Monday - Friday
09:00 to 21:00 (UTC +10)

Email
helpdesk@apnic.net

Phone
+61 7 3858 3188

VoIP
helpdesk@voip.apnic.net

Fax
+ 61 7 3858 3199

Multi-language phone support
Bahasa Indonesia, Bengali, Cantonese, English, Filipino (Tagalog), Hindi, and Mandarin.

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Name

Email

What is your question?

Chat

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▶ A-Z Glossary

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Helpdesk queries

APNIC's Member Services
Helpdesk can assist you receive faster responses for:

- Status of requests
- Membership enquiries
- Billing issues
- Database enquiries

Existing members
Please use MyAPNIC to apply for resources.

Public holidays

APNIC offices and Helpdesk

Frequently asked questions

Thank you!

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End of Session

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