# BGP Policy Control

ISP Workshops

Last updated 15th July 2015

# Acknowledgements

- This material originated from the Cisco ISP/IXP Workshop Programme developed by Philip Smith & Barry Greene

- Use of these materials is encouraged as long as the source is fully acknowledged and this notice remains in place

- Bug fixes and improvements are welcomed
  - Please email *workshop (at) bgp4all.com*

Philip Smith

# Applying Policy with BGP

- Policy-based on AS path, community or the prefix
- Rejecting/accepting selected routes
- Set attributes to influence path selection
- Tools:
  - Prefix-list (filters prefixes)
  - Filter-list (filters ASes)
  - Route-maps and communities

# Policy Control – Prefix List

- Incremental configuration
- Applies Inbound or Outbound
- Based upon network numbers (using familiar IP address/mask format)
- Prefix-list ends with an implicit default deny

- Using access-lists in Cisco IOS for filtering prefixes was deprecated long ago
  - **Strongly discouraged!**

# Prefix Lists – Command Syntax

- Syntax:

```
[no] ip[v6] prefix-list list-name [seq value]
  permit|deny network/len [ge value] [le value]
```

| | |
|---|---|
| ***network/len***: | The prefix and its length |
| **ge *value***: | “greater than or equal to” |
| **le *value***: | “less than or equal to” |

- Both “ge” and “le” are optional
  - Used to specify the range of the prefix length to be matched for prefixes that are more specific than network/len

- Sequence number is also optional
  - **`no ip[v6] prefix-list sequence-number`** to disable display of sequence numbers

# Prefix Lists – Examples

- Deny default route in IPv4

```
ip prefix-list EG deny 0.0.0.0/0
```

- Deny default route in IPv6

```
ipv6 prefix-list EG-v6 deny ::/0
```

- Permit the prefix 35.0.0.0/8

```
ip prefix-list EG permit 35.0.0.0/8
```

- Permit the IPv6 prefix 2001:DB8::/32

```
ipv6 prefix-list EG-v6 permit 2001:DB8::/32
```

# Prefix Lists – Examples

- Deny the prefix 172.16.0.0/12

```
ip prefix-list EG deny 172.16.0.0/12
```

- Deny the IPv6 prefix 3FFE::/16

```
ipv6 prefix-list EG-v6 deny 3FFE::/16
```

- In 192/8 allow up to /24

```
ip prefix-list EG permit 192.0.0.0/8 le 24
```

  - This allows all prefix sizes in the 192.0.0.0/8 address block, apart from /25, /26, /27, /28, /29, /30, /31 and /32.

- In 2000::/3 allow up to /48

```
ipv6 prefix-list EG-v6 permit 2000::/3 le 48
```

# Prefix Lists – Examples

- In 192/8 deny /25 and above

```
ip prefix-list EG deny 192.0.0.0/8 ge 25
```

  - This denies all prefix sizes /25, /26, /27, /28, /29, /30, /31 and /32 in the address block 192.0.0.0/8.
  - It has the same effect as the previous example

- In 193/8 permit prefixes between /12 and /20

```
ip prefix-list EG permit 193.0.0.0/8 ge 12 le 20
```

  - This denies all prefix sizes /8, /9, /10, /11, /21, /22, … and higher in the address block 193.0.0.0/8.

- Permit all prefixes

```
ip prefix-list EG permit 0.0.0.0/0 le 32
```

  - 0.0.0.0 matches all possible addresses, “0 le 32” matches all possible prefix lengths

# Prefix Lists – Full Example

- Example Configuration

```
router bgp 100
 network 105.7.0.0 mask 255.255.0.0
 neighbor 102.10.1.1 remote-as 110
 neighbor 102.10.1.1 prefix-list AS110-IN in
 neighbor 102.10.1.1 prefix-list AS110-OUT out
!
ip prefix-list AS110-IN deny 218.10.0.0/16
ip prefix-list AS110-IN permit 0.0.0.0/0 le 32
!
ip prefix-list AS110-OUT permit 105.7.0.0/16
ip prefix-list AS110-OUT deny 0.0.0.0/0 le 32
```

# Policy Control – Filter List

- Filter routes based on AS path
  - Inbound or Outbound
- Referenced in BGP neighbour configuration as:

```
neighbor <addr> filter-list <N> [in|out]
```

- Referenced in main configuration as:

```
ip as-path access-list <N> [permit|deny] ...
```

- The as-path access-list finishes with an implicit default deny

# Filter List – Example

- Example Configuration:

```
router bgp 100
 network 105.7.0.0 mask 255.255.0.0
 neighbor 102.10.1.1 filter-list 5 out
 neighbor 102.10.1.1 filter-list 6 in
!
ip as-path access-list 5 permit ^200$
!
ip as-path access-list 6 permit ^150$
```

# Policy Control – Regular Expressions

- Like Unix regular expressions

<table>
<tr><td>.</td><td>Match one character</td></tr>
<tr><td>*</td><td>Match any number of preceding expression</td></tr>
<tr><td>+</td><td>Match at least one of preceding expression</td></tr>
<tr><td>^</td><td>Beginning of line</td></tr>
<tr><td>$</td><td>End of line</td></tr>
<tr><td>\</td><td>Escape a regular expression character</td></tr>
<tr><td>_</td><td>Beginning, end, white-space, brace</td></tr>
<tr><td>|</td><td>Or</td></tr>
<tr><td>()</td><td>brackets to contain expression</td></tr>
<tr><td>[]</td><td>brackets to contain number ranges</td></tr>
</table>

# Policy Control – Regular Expressions

- Simple Examples

| | |
|---|---|
| .* | match anything |
| .+ | match at least one character |
| ^$ | match routes local to this AS |
| _1800$ | originated by AS1800 |
| ^1800_ | received from AS1800 |
| _1800_ | via AS1800 |
| _790_1800_ | via AS1800 and AS790 |
| _(1800_)+ | multiple AS1800 in sequence (used to match AS-PATH prepends) |
| _\(65530\)_ | via AS65530 (confederations) |

# Policy Control – Regular Expressions

- Not so simple Examples

| | |
|---|---|
| ^[0-9]+$ | Match AS_PATH length of one |
| ^[0-9]+_[0-9]+$ | Match AS_PATH length of two |
| ^[0-9]*_[0-9]+$ | Match AS_PATH length of one or two |
| ^[0-9]*_[0-9]*$ | Match AS_PATH length of one or two (will also match zero) |
| ^[0-9]+_[0-9]+_[0-9]+$ | Match AS_PATH length of three |
| _(701\|1800)_ | Match anything which has gone through AS701 or AS1800 |
| _1849(_.+_)12163$ | Match anything of origin AS12163 and passed through AS1849 |

# Policy Control – Route Maps

- A route-map is like a "programme" for IOS
- Has "line" numbers, like programmes
- Each line is a separate condition/action
- Concept is basically:

  if *match* then do *expression* and exit

  else

  if *match* then do *expression* and exit

  else etc

- Route-map "continue" lets ISPs apply multiple conditions and actions in one route-map

# Route Maps – Rules

- Lines can have multiple set statements
  - All set statements are implemented

```
route-map SAMPLE permit 10
 set community 300:1
 set local-preference 120
!
```

- Lines can have multiple match statements
  - All conditions must match

```
route-map SAMPLE permit 10
 match community 1
 match ip address prefix-list MY-LIST
 set local-preference 300
!
```

# Route Maps – Rules

- A match statement can have multiple commands
  - At least one command must match

```
route-map SAMPLE permit 10
 match ip address prefix-list MY-LIST OTHER-LIST
 set community 300:10
!
```

- Route-map with only a match statement
  - Only prefixes matching go through, the rest are dropped

```
route-map SAMPLE permit 10
 match ip address prefix-list MY-LIST
!
```

# Route Maps – Rules

- Line with only a set statement
  - All prefixes are matched and set
  - Any following lines are ignored

```
route-map SAMPLE permit 10
 set local-preference 120
!
route-map SAMPLE permit 20
 remark This line is ignored
 set community 300:5
!
```

# Route Maps – Rules

- Line with a match/set statement and no following lines
  - Only prefixes matching the condition are set, the rest are dropped

```
route-map SAMPLE permit 10
 match ip address prefix-list MY-LIST
 set local-preference 120
!
```

# Route Maps – Caveats

- Example
  - Omitting the third line below means that prefixes not matching list-one or list-two are dropped

```
route-map SAMPLE permit 10
 match ip address prefix-list LIST-ONE
 set local-preference 120
!
route-map SAMPLE permit 20
 match ip address prefix-list LIST-TWO
 set local-preference 80
!
route-map SAMPLE permit 30
 remark Don’t forget this
!
```

# Route Maps – Matching prefixes

- Example Configuration:

```
router bgp 100
 neighbor 1.1.1.1 route-map INFILTER in
!
route-map INFILTER permit 10
 match ip address prefix-list HIGH-PREF
 set local-preference 120
!
route-map INFILTER permit 20
 match ip address prefix-list LOW-PREF
 set local-preference 80
!
ip prefix-list HIGH-PREF permit 10.0.0.0/8
ip prefix-list LOW-PREF permit 20.0.0.0/8
```

# Route Maps – Matching prefixes

- Commentary:
  - If address matches HIGH-PREF set local-pref 120, and then exit
  - Otherwise if address matches LOW-PREF, set local-pref 80, and then exit
  - No other condition, so all other prefixes are dropped

# Route Maps – AS-PATH filtering

- Example Configuration

```
router bgp 100
 neighbor 102.10.1.2 remote-as 200
 neighbor 102.10.1.2 route-map FILTER-ON-ASPATH in
!
route-map FILTER-ON-ASPATH permit 10
 match as-path 1
 set local-preference 80
!
route-map FILTER-ON-ASPATH permit 20
 match as-path 2
 set local-preference 200
!
ip as-path access-list 1 permit _150$
ip as-path access-list 2 permit _210_
```

# Route Maps – AS-PATH filtering

- Commentary:
  - If prefix originated from AS150, then set local-pref to 80, and exit
  - Otherwise if prefix transited AS210 (ie AS210 appears in the path), then set local-pref to 200, and exit
  - No other condition, so all other prefixes are dropped

# Route Maps – AS-PATH prepends

- Example configuration of AS-PATH prepend

```
router bgp 100
 network 105.7.0.0 mask 255.255.0.0
 neighbor 102.10.1.2 remote-as 300
 neighbor 102.10.1.2 route-map SETPATH out
!
route-map SETPATH permit 10
 set as-path prepend 100 100
!
```

- Use your **own** AS number when prepending
  - Otherwise BGP loop detection may cause disconnects
  - Deliberate insertion of other ASNs is called “AS PATH poisoning”

# Route Maps – Matching Communities

- Example Configuration

```
router bgp 100
 neighbor 102.10.1.2 remote-as 200
 neighbor 102.10.1.2 route-map FILTER-ON-COMMUNITY in
!
route-map FILTER-ON-COMMUNITY permit 10
 match community 1
 set local-preference 50
!
route-map FILTER-ON-COMMUNITY permit 20
 match community 2 exact-match
 set local-preference 200
!
ip community-list 1 permit 150:3 200:5
ip community-list 2 permit 88:6
```

# Route Maps – Matching Communities

- Commentary:
  - If prefix belongs to communities 150:3 AND 200:5, then set local-pref to 50, and exit
  - Otherwise if prefix belongs to ONLY community 88:6, then set local-pref to 200, and exit
  - No other condition, so all other prefixes are dropped

# Community-List Processing

- Note:
  - When multiple values are configured in the same community list statement, a logical AND condition is created. All community values must match to satisfy an AND condition

```
ip community-list 1 permit 150:3 200:5
```

  - When multiple values are configured in separate community list statements, a logical OR condition is created. The first list that matches a condition is processed

```
ip community-list 1 permit 150:3
ip community-list 1 permit 200:5
```

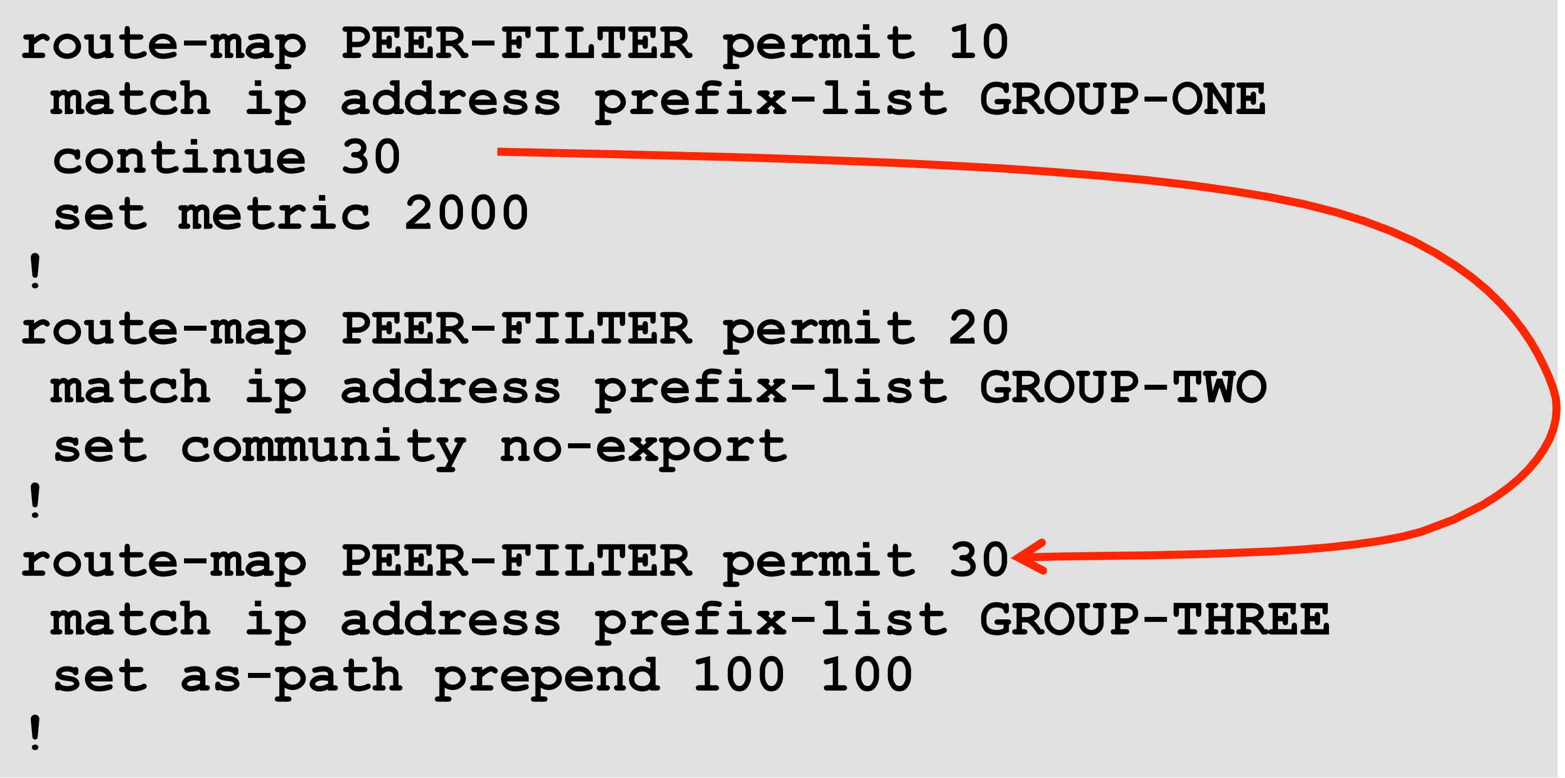
# Route Maps – Setting Communities

- Example Configuration

```
router bgp 100
 network 105.7.0.0 mask 255.255.0.0
 neighbor 102.10.1.1 remote-as 200
 neighbor 102.10.1.1 send-community
 neighbor 102.10.1.1 route-map SET-COMMUNITY out
!
route-map SET-COMMUNITY permit 10
 match ip address prefix-list NO-ANNOUNCE
 set community no-export
!
route-map SET-COMMUNITY permit 20
 match ip address prefix-list AGGREGATE
!
ip prefix-list NO-ANNOUNCE permit 105.7.0.0/16 ge 17
ip prefix-list AGGREGATE permit 105.7.0.0/16
```

# Route Map Continue

- Handling multiple conditions and actions in one route-map (for BGP neighbour relationships only)



```
route-map PEER-FILTER permit 10
 match ip address prefix-list GROUP-ONE
 continue 30
 set metric 2000
!
route-map PEER-FILTER permit 20
 match ip address prefix-list GROUP-TWO
 set community no-export
!
route-map PEER-FILTER permit 30
 match ip address prefix-list GROUP-THREE
 set as-path prepend 100 100
!
```

# Order of processing BGP policy

- For policies applied to a specific BGP neighbour, the following sequence is applied:
  - For inbound updates, the order is:
    1. Route-map
    2. Filter-list
    3. Prefix-list
  - For outbound updates, the order is:
    1. Prefix-list
    2. Filter-list
    3. Route-map

# Managing Policy Changes

- New policies only apply to the updates going through the router AFTER the policy has been introduced or changed
- To facilitate policy changes on the entire BGP table the router handles the BGP peerings need to be “refreshed”
  - This is done by clearing the BGP session either in or out, for example:

```
clear ip bgp <neighbour-addr> in|out
```

- Do NOT forget in or out — forgetting results in a hard reset of the BGP session

# Managing Policy Changes

- Ability to clear the BGP sessions of groups of neighbours configured according to several criteria
- **`clear ip bgp <addr> [in|out]`**

**`<addr>`** may be any of the following

| | |
|---|---|
| **`x.x.x.x`** | IP address of a peer |
| **`*`** | all peers |
| ***`ASN`*** | all peers in an AS |
| **`external`** | all external peers |
| **`peer-group <name>`** | all peers in a peer-group |

# BGP Policy Control

ISP Workshops