BGP Policy Control

ISP Workshops

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

Overview

- Organisations tend to have particular non-technical routing policies
  - A circuit may be preferred because it is cheaper
  - A circuit may be preferred because the traffic by regulation must stay within a certain jurisdiction or country
- BGP in this case is more of a policy tool than the typical routing protocol which just tries to find the best technical route

Overview: Applying Policy with BGP

- You can accept a prefix announcement, meaning that traffic to that destination will flow towards whoever advertised it to you
- You can reject a prefix announcement, meaning that traffic to that destination will not flow towards whoever advertised it to you
- Similarly for prefixes you announce, if they are accepted then traffic to those destinations will flow towards you

Overview: Applying Policy with BGP

- In addition to the prefix itself you can make similar filtering decisions based on the AS_PATH attribute or which communities have been applied to the prefix announcements
- Once you have decided to accept a prefix you can optionally set other BGP attributes that will affect how preferred the announcement will be in your network
- This can be complex or simple and the goal is to influence the router based on the BGP path selection algorithm

Overview: Applying Policy with BGP

- Tools to do this are:
  - Cisco's "prefix-list" for filtering BGP prefixes
  - Juniper also has prefix-lists but the direct equivalent would be the "route-filter"
  - Cisco's filter lists for filtering AS-PATHs
  - Juniper has AS-PATH regular expressions
- For more advanced policy requirements:
  - Route-maps for Cisco IOS
  - BGP Policy statements for Juniper

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!**

- Note: JunOS equivalent is called “route-filter”

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
 address-family ipv4
  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
 address-family ipv4
  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

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

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
 address-family ipv4
  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
 address-family ipv4
  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
 address-family ipv4
  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
 address-family ipv4
  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

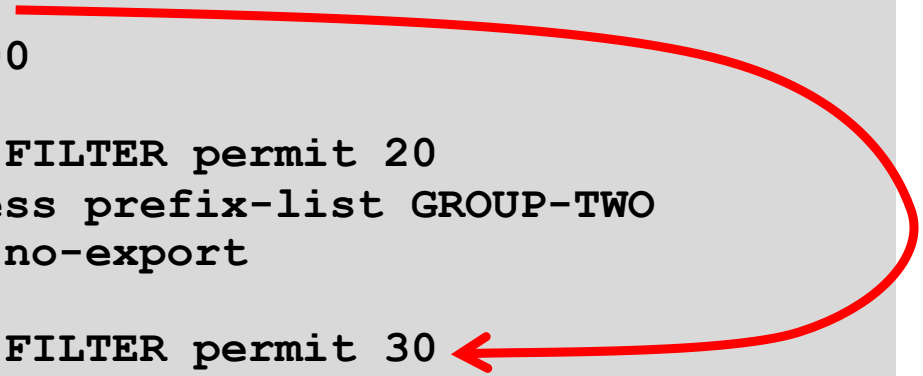
- Example Configuration

```
router bgp 100
 address-family ipv4
  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
- **Note:** Cisco IOS does not automatically apply policy changes after they are added to the configuration
  - Most other router operating systems will implement the route-refresh once the policy change has been committed

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

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