Using Communities for Multihoming

ISP/IXP Workshops

Multihoming and Communities

- The BGP community attribute is a very powerful tool for assisting and scaling BGP Multihoming
- Most major ISPs make extensive use of BGP communities:
    - Internal policies
    - Inter-provider relationships (MED replacement)
    - Customer traffic engineering

Using BGP Communities

- Four scenarios are covered:
  - Use of RFC1998 traffic engineering
  - Extending RFC 1998 ideas for even greater customer policy options
  - Community use in ISP backbones
  - Customer Policy Control (aka traffic engineering)

RFC1998

An example of how ISPs use communities…

RFC1998

- Informational RFC
- Describes how to implement loadsharing and backup on multiple inter-AS links

  BGP communities used to determine local preference in upstream's network

- Gives control to the customer

  Means the customer does not have to phone upstream's technical support to adjust traffic engineering needs

- Simplifies upstream's configuration

  simplifies network operation!

RFC1998

- RFC1998 Community values are defined to have particular meanings
- *ASx*:100 set local preference 100
  - Make this the preferred path
- *ASx* :90 set local preference 90
  - Make this the backup if dualhomed on *ASx*
- *ASx* :80 set local preference 80
  - The main link is to another ISP with same AS path length
- *ASx* :70 set local preference 70
  - The main link is to another ISP

RFC1998

- Upstream ISP defines the communities mentioned
- Their customers then attach the communities they want to use to the prefix announcements they are making
- For example:
  - If upstream is AS 100
  - To declare a particular path as a backup path, their customer would announce the prefix with community 100:70 to AS100
  - AS100 would receive the prefix with the community 100:70 tag, and then set local preference to be 70

RFC1998

- Sample Customer Router Configuration

```
router bgp 130
 neighbor x.x.x.x remote-as 100
 neighbor x.x.x.x description Backup ISP
 neighbor x.x.x.x route-map as100-out out
 neighbor x.x.x.x send-community
!
ip as-path access-list 20 permit ^$
!
route-map as100-out permit 10
 match as-path 20
 set community 100:70
!
```

RFC1998

- Sample ISP Router Configuration

```
router bgp 100
 neighbor y.y.y.y remote-as 130
 neighbor y.y.y.y route-map customer-policy-in in
!
! Homed to another ISP
ip community-list 7 permit 100:70
! Homed to another ISP with equal ASPATH length
ip community-list 8 permit 100:80
! Customer backup routes
ip community-list 9 permit 100:90
!
```

RFC1998

```
route-map customer-policy-in permit 10
 match community 7
 set local-preference 70
!
route-map customer-policy-in permit 20
 match community 8
 set local-preference 80
!
route-map customer-policy-in permit 30
 match community 9
 set local-preference 90
!
route-map customer-policy-in permit 40
 set local-preference 100
!
```

RFC1998

- RFC1998 was the inspiration for a large variety of differing community policies implemented by ISPs worldwide
- There are no “standard communities” for what ISPs do
- But best practices today consider that ISPs should use BGP communities extensively for multihoming support of traffic engineering
- Look in the ISP AS Object in the IRR for documented community support

Service Provider use of Communities

RFC1998 was so inspiring…

Background

- RFC1998 is okay for “simple” multihoming situations
- ISPs create backbone support for many other communities to handle more complex situations
  - Simplify ISP BGP configuration
  - Give customer more policy control

ISP BGP Communities

- There are no recommended ISP BGP communities apart from
  - RFC1998
  - The five standard communities
    - www.iana.org/assignments/bgp-well-known-communities
- Efforts have been made to document from time to time
  - totem.info.ucl.ac.be/publications/papers-elec-versions/draft-quoitin-bgp-comm-survey-00.pdf
  - But so far… nothing more… ☹
  - Collection of ISP communities at www.onesc.net/communities
  - www.nanog.org/meetings/nanog40/presentations/BGPcommunities.pdf
- ISP policy is usually published
  - On the ISP’s website
  - Referenced in the AS Object in the IRR

Typical ISP BGP Communities

- X:80 set local preference 80
  - Backup path
- X:120 set local preference 120
  - Primary path (over ride BGP path selection default)
- X:1 set as-path prepend X
  - Single prepend when announced to X’s upstreams
- X:2 set as-path prepend X X
  - Double prepend when announced to X’s upstreams
- X:3 set as-path prepend X X X
  - Triple prepend when announced to X’s upstreams
- X:666 set ip next-hop 192.0.2.1
  - Blackhole route - very useful for DoS attack mitigation

Sample Router Configuration (1)

```
router bgp 100
 neighbor y.y.y.y remote-as 130
 neighbor y.y.y.y route-map customer-policy-in in
 neighbor z.z.z.z remote-as 200
 neighbor z.z.z.z route-map upstream-out out
!
ip community-list 1 permit 100:1
ip community-list 2 permit 100:2
ip community-list 3 permit 100:3
ip community-list 4 permit 100:80
ip community-list 5 permit 100:120
ip community-list 6 permit 100:666
!
ip route 192.0.2.1 255.255.255.255 null0
```

Customer BGP

Upstream BGP

Black hole route (on all routers)

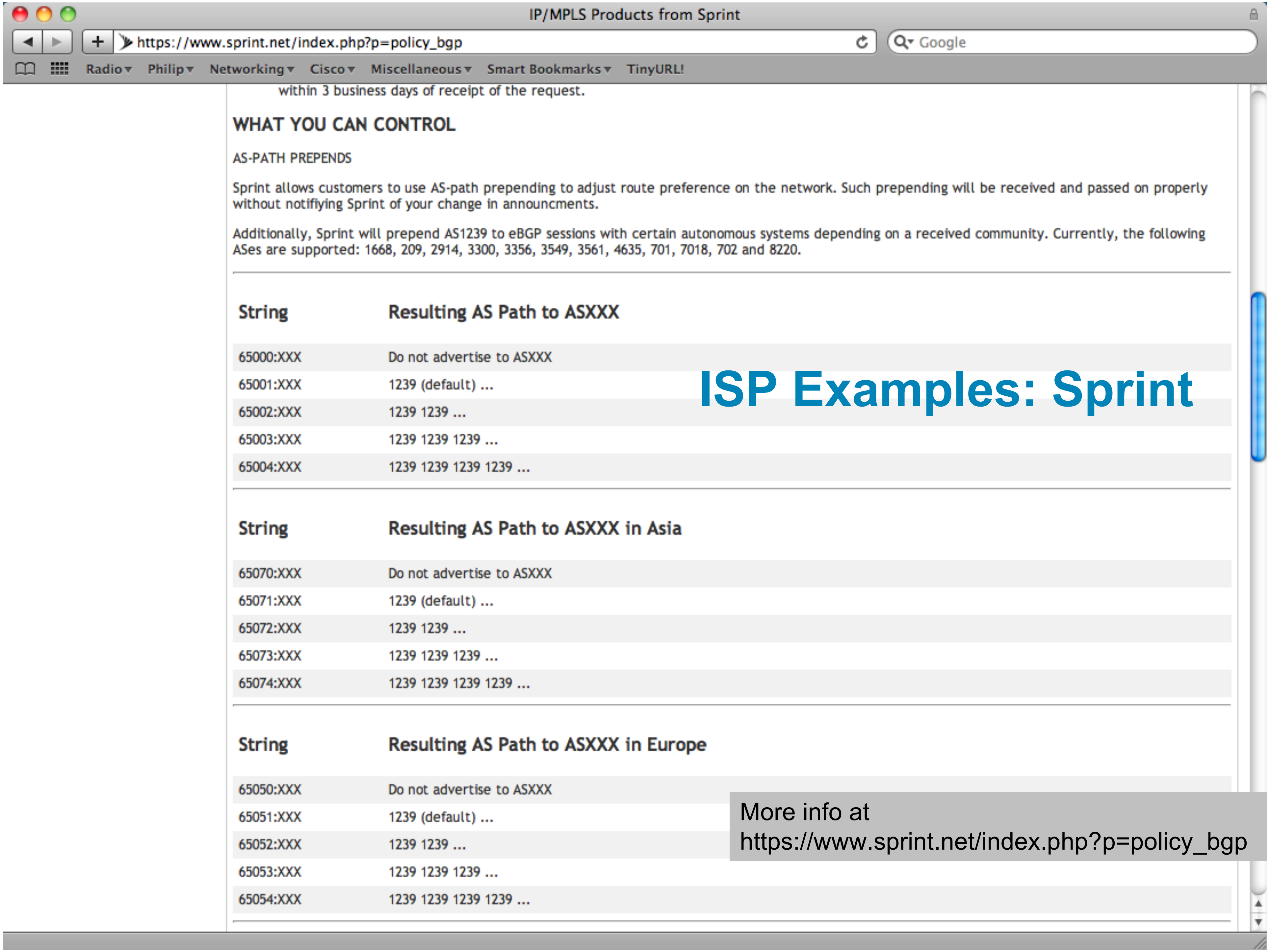
Sample Router Configuration (2)

```
route-map customer-policy-in permit 10
 match community 4
 set local-preference 80
!
route-map customer-policy-in permit 20
 match community 5
 set local-preference 120
!
route-map customer-policy-in permit 30
 match community 6
 set ip next-hop 192.0.2.1
!
route-map customer-policy-in permit 40
...etc...
```

Sample Router Configuration (3)

```
route-map upstream-out permit 10
 match community 1
 set as-path prepend 100
!
route-map upstream-out permit 20
 match community 2
 set as-path prepend 100 100
!
route-map upstream-out permit 30
 match community 3
 set as-path prepend 100 100 100
!
route-map upstream-out permit 40
...etc...
```

ISP Examples: Sprint


IP/MPLS Products from Sprint
https://www.sprint.net/index.php?p=policy_bgp
Google
Radio
Philip
Networking
Cisco
Miscellaneous
Smart Bookmarks
TinyURL!

within 3 business days of receipt of the request.

WHAT YOU CAN CONTROL

AS-PATH PREPENDS

Sprint allows customers to use AS-path prepending to adjust route preference on the network. Such prepending will be received and passed on properly without notifying Sprint of your change in announcments.

Additionally, Sprint will prepend AS1239 to eBGP sessions with certain autonomous systems depending on a received community. Currently, the following ASes are supported: 1668, 209, 2914, 3300, 3356, 3549, 3561, 4635, 701, 7018, 702 and 8220.

String	Resulting AS Path to ASXXX
65000:XXX	Do not advertise to ASXXX
65001:XXX	1239 (default) ...
65002:XXX	1239 1239 ...
65003:XXX	1239 1239 1239 ...
65004:XXX	1239 1239 1239 1239 ...

String	Resulting AS Path to ASXXX in Asia
65070:XXX	Do not advertise to ASXXX
65071:XXX	1239 (default) ...
65072:XXX	1239 1239 ...
65073:XXX	1239 1239 1239 ...
65074:XXX	1239 1239 1239 1239 ...

String	Resulting AS Path to ASXXX in Europe
65050:XXX	Do not advertise to ASXXX
65051:XXX	1239 (default) ...
65052:XXX	1239 1239 ...
65053:XXX	1239 1239 1239 ...
65054:XXX	1239 1239 1239 1239 ...

More info at
https://www.sprint.net/index.php?p=policy_bgp

ISP Examples:
Verizon Business Europe

```
aut-num: AS702
descr:   Verizon Business EMEA - Commercial IP service provider in Eur
remarks: VzBi uses the following communities with its customers:
         702:80    Set Local Pref 80 within AS702
         702:120   Set Local Pref 120 within AS702
         702:20    Announce only to VzBi AS'es and VzBi customers
         702:30    Keep within Europe, don't announce to other VzBi AS
         702:1     Prepend AS702 once at edges of VzBi to Peers
         702:2     Prepend AS702 twice at edges of VzBi to Peers
         702:3     Prepend AS702 thrice at edges of VzBi to Peers
         Advanced communities for customers
         702:7020  Do not announce to AS702 peers with a scope of
                   National but advertise to Global Peers, European
                   Peers and VzBi customers.
         702:7001  Prepend AS702 once at edges of VzBi to AS702
                   peers with a scope of National.
         702:7002  Prepend AS702 twice at edges of VzBi to AS702
                   peers with a scope of  National.
(more)
```

ISP Examples: Verizon Business Europe

```
(more)
         702:7003 Prepend AS702 thrice at edges of VzBi to AS702
                  peers with a scope  of National.
         702:8020 Do not announce to AS702 peers with a scope of
                  European but advertise to Global Peers, National
                  Peers and VzBi  customers.
         702:8001 Prepend AS702 once at edges of VzBi to AS702
                  peers with a scope of European.
         702:8002 Prepend AS702 twice at edges of VzBi to AS702
                  peers with a scope of  European.
         702:8003 Prepend AS702 thrice at edges of VzBi to AS702
                  peers with a scope  of European.
         ---------------------------------------------------------------
         Additional details of the VzBi communities are located at:
         http://www.verizonbusiness.com/uk/customer/bgp/
         ---------------------------------------------------------------
mnt-by:  WCOM-EMEA-RICE-MNT
source:  RIPE
```

Some ISP Examples
BT Ignite

```
aut-num:      AS5400
descr:        BT Ignite European Backbone
remarks:
remarks:      Community to                           Community to
remarks:      Not announce      To peer:             AS prepend 5400
remarks:
remarks:      5400:1000 All peers & Transits         5400:2000
remarks:
remarks:      5400:1500 All Transits                 5400:2500
remarks:      5400:1501 Sprint Transit (AS1239)      5400:2501
remarks:      5400:1502 SAVVIS Transit (AS3561)      5400:2502
remarks:      5400:1503 Level 3 Transit (AS3356)     5400:2503
remarks:      5400:1504 AT&T Transit (AS7018)        5400:2504
remarks:      5400:1506 GlobalCrossing Trans(AS3549) 5400:2506
remarks:
remarks:      5400:1001 Nexica (AS24592)             5400:2001
remarks:      5400:1002 Fujitsu (AS3324)             5400:2002
remarks:      5400:1004 C&W EU (1273)                5400:2004
<snip>
notify:       notify@eu.bt.net
mnt-by:       CIP-MNT
source:       RIPE
```

And many many more!

Some ISP Examples
Level 3

```
aut-num:      AS3356
descr:        Level 3 Communications
<snip>
remarks:      -------------------------------------------------------
remarks:      customer traffic engineering communities - Suppression
remarks:      -------------------------------------------------------
remarks:      64960:XXX - announce to AS XXX if 65000:0
remarks:      65000:0   - announce to customers but not to peers
remarks:      65000:XXX - do not announce at peerings to AS XXX
remarks:      -------------------------------------------------------
remarks:      customer traffic engineering communities - Prepending
remarks:      -------------------------------------------------------
remarks:      65001:0   - prepend once  to all peers
remarks:      65001:XXX - prepend once  at peerings to AS XXX
<snip>
remarks:      3356:70   - set local preference to 70
remarks:      3356:80   - set local preference to 80
remarks:      3356:90   - set local preference to 90
remarks:      3356:9999 - blackhole (discard) traffic
<snip>
mnt-by:       LEVEL3-MNT
source:       RIPE
```

And many many more!

Creating your own community policy

- Consider creating communities to give policy control to customers
  - Reduces technical support burden
  - Reduces the amount of router reconfiguration, and the chance of mistakes
  - Use previous ISP and configuration examples as a guideline

Using Communities for Backbone Scaling

Scaling BGP in the ISP backbone…

Communities for iBGP

- ISPs tag prefixes learned from their BGP and static customers with communities
  - To identify services the customer may have purchased
  - To identify prefixes which are part of the ISP’s PA space
  - To identify PI customer addresses
  - To control prefix distribution in iBGP
  - To control prefix announcements to customers and upstreams
  - (amongst several other reasons)

Service Identification

- ISP provides:
  - Transit via upstreams
  - Connectivity via major IXP
  - Connectivity to private peers/customers
- Customers can buy all or any of the above access options
  - Each option is identified with a unique community
- ISP identifies whether address space comes from their PA block or is their customers' own PI space
  - One community for each

Community Definitions

100:1000	AS100 aggregates
100:1001	AS100 aggregate subprefixes
100:1005	Static Customer PI space
100:2000	Customers who get Transit
100:2100	Customers who get IXP access
100:2200	Customers who get BGP Customer access
100:3000	Routes learned from the IXP

```
ip community-list 10 permit 100:1000
ip community-list 11 permit 100:1001
ip community-list 12 permit 100:1005
ip community-list 13 permit 100:2000
ip community-list 14 permit 100:2100
ip community-list 15 permit 100:2200
ip community-list 16 permit 100:3000
```

Aggregates and Static Customers into BGP

```
router bgp 100
 network 100.10.0.0 mask 255.255.224.0 route-map as100-prefixes
 redistribute static route-map static-to-bgp
!
ip prefix-list as100-block permit 100.10.0.0/19 le 32
!
route-map as100-prefixes permit 10
 set community 100:1000
!
route-map static-to-bgp permit 10
 match ip address prefix-list as100-block
 set community 100:1001
route-map static-to-bgp permit 20
 set community 100:1005
```

Aggregate community set

Aggregate subprefixes community set

PI community is set

Service Identification

- AS100 has four classes of BGP customers
  - Full transit (upstream, IXP and BGP customers)
  - Upstream only
  - IXP only
  - BGP Customers only
- For BGP support, easiest IOS configuration is to create a peer-group for each class (can also use peer-templates to simplify further)
  - Customer is assigned the peer-group of the service they have purchased
  - Simple for AS100 customer installation engineer to provision

BGP Customers - creating peer-groups

```
router bgp 100
 neighbor full-transit peer-group
 neighbor full-transit route-map customers-out out
 neighbor full-transit route-map full-transit-in in
 neighbor full-transit default-originate
 neighbor transit-up peer-group
 neighbor transit-up route-map customers-out out
 neighbor transit-up route-map transit-up-in in
 neighbor transit-up default-originate
 neighbor ixp-only peer-group
 neighbor ixp-only route-map ixp-routes out
 neighbor ixp-only route-map ixp-only-in in
 neighbor bgpcust-only peer-group
 neighbor bgpcust-only route-map bgp-cust-out out
 neighbor bgpcust-only route-map bgp-cust-in in
```

BGP Customers - creating route-maps

```
route-map customers-out permit 10
 match ip community 10
route-map full-transit-in permit 10
 set community 100:2000 100:2100 100:2200
route-map transit-up-in permit 10
 set community 100:2000
route-map ixp-routes permit 10
 match ip community 10 12 13 14 16
route-map ixp-only-in permit 10
 set community 100:2100
route-map bgp-cust-out permit 10
 match ip community 10 12 13 15
route-map bgp-cust-in permit 10
 set community 100:2200
```

Customers only get AS100 aggregates and default route

Full transit go everywhere

Customers buying IXP access only get aggregates, static & full transit customers and IXP routes

Customers buying BGP customer access only get aggregates, static & full transit customers and other BGP customers

BGP Customers - configuring customers

```
router bgp 100
 neighbor a.a.a.a remote-as 200
 neighbor a.a.a.a peer-group full-transit
 neighbor a.a.a.a prefix-list as200cust-in
 neighbor b.b.b.b remote-as 300
 neighbor b.b.b.b peer-group transit-up
 neighbor b.b.b.b prefix-list as300cust-in
 neighbor c.c.c.c remote-as 400
 neighbor c.c.c.c peer-group ixp-only
 neighbor c.c.c.c prefix-list as400cust-in
 neighbor d.d.d.d remote-as 500
 neighbor d.d.d.d peer-group bgpcust-only
 neighbor d.d.d.d prefix-list as500cust-in
```

Customers are simply dropped into the appropriate peer-group depending on the service they paid for

Note the specific per-customer inbound filters

BGP Customers - configuring upstream

```
router bgp 100
 neighbor x.x.x.x remote-as 130
 neighbor x.x.x.x prefix-list full-routes in
 neighbor x.x.x.x route-map upstream-out out
!
route-map upstream-out permit 10
 match ip community 10 12 13
!
! IP prefix-list full-routes is the standard bogon
! prefix filter - or use a reputable bogon route-service such
! as that offered by Team Cymru
```

Aggregates, PI customers and full transit customers are announced to upstream

BGP Customers - configuring IXP peers

```
router bgp 100
 neighbor y.y.y.1 remote-as 901
 neighbor y.y.y.1 route-map ixp-peers-out out
 neighbor y.y.y.1 route-map ixp-peers-in in
 neighbor y.y.y.1 prefix-list AS901-peer in
 neighbor y.y.y.2 remote-as 902
 neighbor y.y.y.2 route-map ixp-peers-out out
 neighbor y.y.y.2 route-map ixp-peers-in in
 neighbor y.y.y.2 prefix-list AS902-peer in
!
route-map ixp-peers-out permit 10
 match ip community 10 12 13 14
!
route-map ixp-peers-in permit 10
 set community 100:3000
```

Aggregates, PI customers full transit and IXP customers are announced to the IXP

Service Identification

- While the community set up takes a bit of thought and planning, once it is implemented:
  - eBGP configuration with customers is simply a case of applying the appropriate peer-group
  - eBGP configuration with IXP peers is simply a case of announcing the appropriate community members to the peers
  - eBGP configuration with upstreams is simply a case of announcing the appropriate community members to the upstreams
- All BGP policy internally is now controlled by communities
  - No prefix-lists, as-path filters, route-maps or other BGP gymnastics are required

What about iBGP itself?

- We've made good use of communities to handle customer requirements
  - But what about iBGP
- Most ISPs deploy Route Reflectors as a means of scaling iBGP
- In transit networks:
  - Core routers (the Route Reflectors) carry the full BGP table
  - Edge/Aggregation routers carry domestic prefixes & customers

iBGP core router/route reflector

```
router bgp 100
 neighbor rrc peer-group
 neighbor rrc descr Route Reflector Clients
 neighbor rrc remote-as 100
 neighbor rrc route-map ibgp-filter out
 neighbor rrc send-community
 neighbor ibgp-peer peer-group
 neighbor ibgp-peer Standard iBGP peers
 neighbor ibgp-peer remote-as 100
 neighbor ibgp-peer send-community
 neighbor n.n.n.a peer-group ibgp-peer
 neighbor n.n.n.b peer-group rrc
!
route-map ibgp-filter permit 10
 match community 10 11 12 13 14 15 16
!
```

The filter to restrict client iBGP to just domestic prefixes

Must NOT forget to send community to iBGP peers

Allow all prefixes coming from the domestic network & IXP

iBGP in the core

- Notice that the filtering of iBGP from the core to the edge is again achieved by a simple route-map applying a community match
    - No prefix-lists, as-path filters or any other complicated policy
    - Once the prefix belongs to a certain community, it has the access across the backbone determined by the community policy in force

Using Communities for Customers Policy

Giving policy control to customers…

Customer Policy Control

- ISPs have a choice on how to handle policy control for customers
- No delegation of policy options:
  - Customer has no choices
  - If customer wants changes, ISP Technical Support handles it
- Limited delegation of policy options:
  - Customer has choices
  - ISP Technical Support does not need to be involved
- BGP Communities are the only viable way of offering policy control to customers

Policy Definitions

- Typical definitions:

Nil	No community set, just announce everywhere
X:1	1x prepend to all BGP neighbours
X:2	2x prepend to all BGP neighbours
X:3	3x prepend to all BGP neighbours
X:80	Local pref 80 on customer prefixes
X:120	Local pref 120 on customer prefixes
X:666	Black hole this route please!
X:5000	Don’t announce to any BGP neighbour
X:5AA0	Don’t announce to BGP neighbour AA
X:5AAB	Prepend B times to BGP neighbour AA

Policy Implementation

- The BGP configuration for the initial communities was discussed at the start of this slide set
- But the new communities, X:5MMN, are worth covering in more detail
  - The ISP in AS X documents the BGP transits and peers that they have (MM can be 01 to 99)
  - The ISP in AS X indicates how many prepends they will support (N can be 1 to 9, but realistically 4 prepends is usually enough on today's Internet)
  - Customers then construct communities to do the prepending or announcement blocking they desire
- If a customer tags a prefix announcement with:
  - 100:5030 don't send prefix to BGP neighbour 03
  - 100:5102 2x prepend prefix announcement to peer 10

Community Definitions

- Example: ISP in AS 100 has two upstreams. They create policy based on previously slide to allow no announce and up to 3 prepends for their customers

```
ip community-list 100 permit 100:5000
ip community-list 101 permit 100:5001
ip community-list 102 permit 100:5002
ip community-list 103 permit 100:5003
ip community-list 110 permit 100:5010
ip community-list 111 permit 100:5011
ip community-list 112 permit 100:5012
ip community-list 113 permit 100:5013
ip community-list 120 permit 100:5020
ip community-list 121 permit 100:5021
ip community-list 122 permit 100:5022
ip community-list 123 permit 100:5023
```

Don’t announce anywhere

Single prepend to all

Don’t announce to peer 1

Single prepend to peer 2

Creating route-maps - neighbour 1

```
route-map bgp-neigh-01 deny 10
 match ip community 100 110
!
route-map bgp-neigh-01 permit 20
 match ip community 101 111
 set as-path prepend 100
!
route-map bgp-neigh-01 permit 30
 match ip community 102 112
 set as-path prepend 100 100
!
route-map bgp-neigh-01 permit 40
 match ip community 103 113
 set as-path prepend 100 100 100
!
route-map bgp-neigh-01 permit 50
```

Don’t announce these prefixes to neighbour 01

Single prepend of these prefixes to neighbour 01

Double prepend of these prefixes to neighbour 01

Triple prepend of these prefixes to neighbour 01

All other prefixes remain untouched

Creating route-maps - neighbour 2

```
route-map bgp-neigh-02 deny 10
 match ip community 100 120
!
```

Don’t announce these prefixes to neighbour 02

```
route-map bgp-neigh-02 permit 20
 match ip community 101 121
 set as-path prepend 100
!
```

Single prepend of these prefixes to neighbour 02

```
route-map bgp-neigh-02 permit 30
 match ip community 102 122
 set as-path prepend 100 100
!
```

Double prepend of these prefixes to neighbour 02

```
route-map bgp-neigh-02 permit 40
 match ip community 103 123
 set as-path prepend 100 100 100
!
```

Triple prepend of these prefixes to neighbour 02

```
route-map bgp-neigh-02 permit 50
```

All other prefixes remain untouched

ISP’s BGP configuration

```
router bgp 100
 neighbor a.a.a.a remote-as 200
 neighbor a.a.a.a route-map bgp-neigh-01 out
 neighbor a.a.a.a route-map policy-01 in
 neighbor b.b.b.b remote-as 300
 neighbor b.b.b.b route-map bgp-neigh-02 out
 neighbor b.b.b.b route-map policy-02 in
```

- The route-maps are then applied to the appropriate neighbour
- As long as the customer sets the appropriate communities, the policy will be applied to their prefixes

Customer BGP configuration

```
router bgp 600
 neighbor c.c.c.c remote-as 100
 neighbor a.a.a.a route-map upstream out
 neighbor a.a.a.a prefix-list default in
!
route-map upstream permit 10
 match ip address prefix-list blockA
 set community 100:5010 100:5023
route-map upstream permit 20
 match ip address aggregate
```

- This will:
  - 3x prepend of blockA towards their upstream's 2nd BGP neighbour
  - Not announce blockA towards their upstream's 1st BGP neighbour
  - Let the aggregate through with no specific policy

Customer Policy Control

- Notice how much flexibility a BGP customer could have with this type of policy implementation
- Advantages:
  - Customer has flexibility
  - ISP Technical Support does not need to be involved
- Disadvantages
  - Customer could upset ISP loadbalancing tuning
- Advice
  - This kind of policy control is very useful, but should only be considered if appropriate for the circumstances

Conclusion

Communities

- Communities are fun! ☺
- And they are extremely powerful tools
- Think about community policies, e.g. like the additions described here
- Supporting extensive community usage makes customer configuration easy
- Watch out for routing loops!

Using Communities for Multihoming

ISP/IXP Workshops