PfR - Enterprise Fast Failover
Using Fast Mode

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PfR Features that Enable Traffic Optimization

Link Utilization

Usage of this policy sets an upper threshold on the amount of traffic a specific link can carry. For example, if the upper threshold for a link is 90 % of total bandwidth, and it is currently running at 95 % of bandwidth, the link is Out-of-Policy (OOP). Cisco PfR will attempt to bring the link back into policy by repeatedly moving prefixes from the over-used link onto other exit links.

Range

Usage of this policy keeps all WAN links within a certain utilization range, relative to each other in order to ensure fair load-sharing across all concerned links. The range functionality allows the network administrator to instruct Cisco PfR to keep the usage on a set of exit links with in a certain percentage range of each other. If the difference between the links becomes too great, Cisco PfR will attempt to bring the link back in to policy by distributing data traffic among the available exit links.

Traffic Class Performance

Usage of this policy enables the customer to define multiple paths that a set of traffic (ie voice traffic) could use as long as all the paths maintain the performance SLA ?s that are needed forth at set of traffic. Hence, a policy that determines voice traffic to have a delay threshold of less than 250 msecs can utilize multiple paths in the network if available, as long as all the paths deliver the traffic within its performance bounds.

Enterprise Failover Needs

Critical, voice or video applications need high availability. A fast failover mechanism should be deployed to allow re-routing sensitive application traffic to a fallback link in case of a link or node failure but also in case of soft errors, brownouts or blackouts. Typical routing protocols cannot cope with soft errors.

PfR Solution Used

To achieve a fast failover when a Traffic Class is Out of Policy, PfR mode **fast** has to be used. Fast failover monitoring is designed for traffic classes that are very sensitive to performance issues or congested links, and voice or video traffic is very sensitive to any dropped links. But Fast Failover can also be used for very delay sensitive business applications.

Fast mode gives PfR the ability to re-route a sub-optimally performing application, very quickly. In best case, we have observed re-route within 3 seconds of event detection.

How does fast mode work?

- In fast monitoring mode, all exits are continuously probed using active probing. This ensures that the latest performance information is always available and it enables PfR to react instantly to a network event.
- The probe frequency can be set to a lower frequency in fast failover monitoring mode than for other monitoring modes, to allow a faster failover capability.
- Fast failover monitoring can be used with all types of active probes: ICMP echo, jitter, TCP connection, and UDP echo.
- Performance data from active probing is used for routing decisions while the throughput data from passive probing is used to load balance the links.
- PfR is not a fast re-route technology. Fast mode should be used only for performance sensitive traffic like real time communication applications.

Notes:

- In fast monitoring mode, probe targets are learned as well as learned prefixes. To avoid triggering large numbers of probes in the network, use fast monitoring mode only for real time applications and critical applications with performance sensitive traffic.
- User can configure 2 sec probe frequency in fast mode only.
- if < 4 second probe freq is configured, the user is not allowed to set any other mode. Error is displayed.

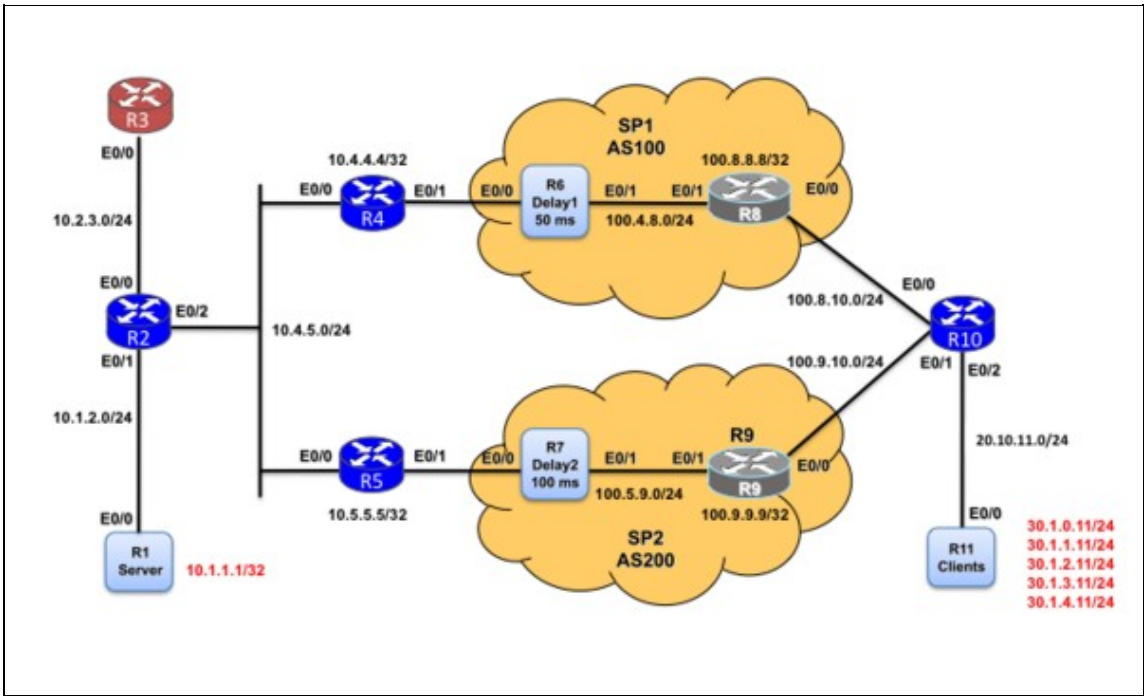
In this example, the fast failover monitoring mode is enabled and the critical traffic to be monitored is identified using DSCP AF31. To reduce some of the overhead that fast failover monitoring produces, we statically assigned a force target.

PfR Network Topology Used

The central site has two Border Routers, connected to two separate Service Providers using eBGP. R2, R4 and R5 are iBGP peers.

- R3 is the Master Controller

- R4 and R5 the Border Routers
- Traffic Simulator tool is used between R1 and R11 to emulates traffic, both TCP and UDP.
- R6 and R7 are delay generators that add delay/loss to the path through SP1 and SP2. By default, 100 ms through SP1 and 50 ms through SP2.
- R1 and R11 are packet generators that send/receive traffic (http, ssh, etc).



PfR Configuration

Master Controller Configuration

- Basic configuration to establish session between MC and BR

```
! This is the basic configuration required to establish session
! between MC and BR. It includes
! ? Key-chain configuration for authentication.
! ? Specification of BR?s IP Address and internal/external interface
!   on the BR.
! ? Specification of Maximum transmit utilization of 90%
!
<pre>
!
key chain pfr
 key 0
  key-string cisco
!
pfr master
 logging
 !
 border 10.4.5.5 key-chain pfr
```

```
  interface Ethernet0/1 external
   max-xmit-utilization percentage 90
  interface Ethernet0/0 internal
 !
 border 10.4.5.4 key-chain pfr
  interface Ethernet0/1 external
   max-xmit-utilization percentage 90
  interface Ethernet0/0 internal
 !
 !
```

- Enable logging

```
! Following configuration is
! - to enable logging. This will print PfR related syslog messages on
!   the console.
! ? to disable default policy of load balancing.
!
pfr master
 no max-range-utilization
 logging
```

- Define learning parameters, disable global learning

```
! - To enable continuous learn cycle, each 1 minute duration ?
!   configure periodic-interval value 0 and monitor-period value 1 (minutes)
!   By default each cycle is 5 minute and occurs ever 2 hrs.
!
! - Sort the traffic-class based on ?throughput? at the end of
!   each learning cycle.
!
! - Anything traffic that doesn?t match the learn list will be
!   learned under global learn and will be optimized using default policy.
!   To disable global learn configure a filter using a named access-list.
!   The goal here is to learn only branch traffic using learn list (described in the next section)
!
pfr master
 learn
  throughput
  periodic-interval 0
  monitor-period 1

  ! Disable Global learn
  !
  traffic-class filter access-list DENY_GLOBAL_LEARN_LIST
 !
! Access-list for disabling global learn.
!
ip access-list extended DENY_GLOBAL_LEARN_LIST
 deny ip any any
```

- Define learn-list for sensitive applications

```
! Following is a learn list configuration for sensitive application
! specific to one branch.
! This should be repeated for each branch. It includes
! ? Here CRITICAL (assuming it is marked as af31) is learned using
!   access-list CRITICAL and branch specific filter BRANCH1.
!
pfr master
 learn
  list seq 10 refname BRANCH1_CRITICAL
   traffic-class access-list CRITICAL filter BRANCH1
   aggregation-type prefix-length 32
   throughput
!
!
! Access-list for CRITICAL
!
ip access-list extended CRITICAL
 permit ip any any dscp af31
!
! Prefix-list for BRANCH1
!
ip prefix-list BRANCH1 seq 5 permit 30.1.0.0/16
!
```

- Policy configuration for sensitive applications and specific for a branch

```
! Following is a policy configuration sensitive application specific to one branch.
! This should be repeated for each branch. It includes
!
! ? match command is to specify that this policy should be applied
!   to all the traffic-class learned under list BRANCH1_CRITICAL
!
! - Re-evaluate exit every 90 sec (periodic 90)
!
! - holddown timer set to 90 to shorten the time needed to move to INPOLICY state
!
! ? delay threshold is configured as 300 msec. The delay measured by PfR is
!   Round-Trip-Time. For example, video conference delay higher than 150 ms one-way
!   decreases the Quality-of-Experience.
!
! ? Loss is set to 50,000 (packets-per-million). i.e 5%
!
! ? Resolver setting is configure to set the priority in the order of
!   loss and delay. Range and utilization are DISABLED for sensitive application.
!
! ? Probe packets are set to 20 to reduce the probe traffic.
!   Instead of configuring only 1 probe (with 60 probe packet) it is better to configure
!   2 or 3 probes with 20 probe packets (resulting into lower or same number of total probe packet
!
pfr-map MYMAP 10
 match pfr learn list BRANCH1_CRITICAL
 set periodic 90
 set holddown 90
 set delay threshold 300
 set mode route control
 set mode monitor fast
 set resolve loss priority 2 variance 5
 set resolve delay priority 5 variance 5
```

```
 no set resolve range
 no set resolve utilization
 set loss threshold 50000
 set active-probe echo 30.1.1.11
 set probe frequency 2
!
```

- Assign the policy to the PfR Master Controller

```
pfr master
 policy-rules MYMAP
!
```

Border Routers Configuration

Following are common PfR configuration commands in the Border Router R4 and R5.

```
! This is the minimum configuration required to BR. It includes
! ? Key-chain configuration for authentication.
! ? Specification of MC?s IP Address and Local interface. The IP address
!   of the local interface will be used as source IP address in communicating
!   with MC.
!
key chain pfr
 key 0
  key-string cisco
!
pfr border
 logging
 local Ethernet0/0
 master 10.2.3.254 key-chain pfr
!
```

PfR Configuration Verification

Master Controller

The first step is to check the master controller configuration.

- Verify the border routers, verify the parameters used (default and configured) and check the learn-list.

```
MC#sh pfr master
OER state: ENABLED and ACTIVE
  Conn Status: SUCCESS, PORT: 3949
  Version: 3.0
  Number of Border routers: 2
  Number of Exits: 2
  Number of monitored prefixes: 8 (max 5000)
  Max prefixes: total 5000 learn 2500
  Prefix count: total 8, learn 4, cfg 0
  PBR Requirements met
  Nbar Status: Inactive

Border           Status   UP/DOWN             AuthFail  Version
10.4.5.4         ACTIVE   UP       00:04:08          0  3.0
10.4.5.5         ACTIVE   UP       00:04:08          0  3.0

Global Settings:
  max-range-utilization percent 0 recv 0
  mode route metric bgp local-pref 5000
  mode route metric static tag 5000
  trace probe delay 1000
  logging
  exit holddown time 60 secs, time remaining 0

Default Policy Settings:
  backoff 300 3000 300
  delay relative 50
  holddown 300
  periodic 0
  probe frequency 56
  number of jitter probe packets 100
  mode route observe
  mode monitor both
  mode select-exit good
  loss relative 10
  jitter threshold 20
  mos threshold 3.60 percent 30
  unreachable relative 50
  resolve delay priority 11 variance 20
  resolve range priority 12 variance 0
  resolve utilization priority 13 variance 20

Learn Settings:
  current state : STARTED
  time remaining in current state : 92 seconds
  throughput
  no delay
  no inside bgp
  traffic-class filter access-list DENY_GLOBAL_LEARN_LIST
  monitor-period 1
  periodic-interval 0
  aggregation-type prefix-length 24
  prefixes 100 appls 100
  expire after time 720

  Learn-List seq 10 refname BRANCH1_CRITICAL
    Configuration:
     Traffic-Class Access-list: CRITICAL
     Filter: BRANCH1
     Aggregation-type: prefix-length 32
     Learn type: throughput
     Session count: 50 Max count: 100
     Policies assigned: 10
```

```
     Status: ACTIVE
    Stats:
     Traffic-Class Count: 4
MC#
```

What to check:

- Both Border Routers are up and running
- Number of Monitored Prefixes: 8 and 4 are automatically learned
- All default policy settings are displayed
- Learn is started (current state : STARTED)
- Then all learn-list are displayed
- For each learn-list, check the Traffic Class access-list, prefix-list and the policy number associated (which is the pfr-map it refers to).
- The Traffic Class count is also displayed which allows to check whether the learning process works well (here 4 TCs are learnt under BRANCH1_CRITICAL).

- Check the prefixes/application automatically learnt under each learn-list

```
MC#sh pfr master learn list

 Learn-List seq 10 refname BRANCH1_CRITICAL
   Configuration:
    Traffic-Class Access-list: CRITICAL
    Filter: BRANCH1
    Aggregation-type: prefix-length 32
    Learn type: throughput
    Session count: 50 Max count: 100
    Policies assigned: 10
    Status: ACTIVE
   Stats:
    Traffic-Class Count: 4
    Traffic-Class Learned:
     Appl Prefix 30.1.2.11/32 af31 256
     Appl Prefix 30.1.1.11/32 af31 256
     Appl Prefix 30.1.3.11/32 af31 256
     Appl Prefix 30.1.0.11/32 af31 256
MC#
```

- Check the policy associated

```
MC#sh pfr master policy 10
* Overrides Default Policy Setting
oer-map MYMAP 10
  sequence no. 8444249301975040, provider id 1, provider priority 30
    host priority 0, policy priority 10, Session id 0
  match oer learn list BRANCH1_CRITICAL
  backoff 300 3000 300
 *delay threshold 300
 *holddown 90
 *periodic 90
```

```
 *probe frequency 2
  number of jitter probe packets 100
 *mode route control
 *mode monitor fast
  mode select-exit good
 *loss threshold 50000
  jitter threshold 20
  mos threshold 3.60 percent 30
  unreachable relative 50
  next-hop not set
  forwarding interface not set
 *resolve loss priority 2 variance 5
 *resolve delay priority 5 variance 5

  Forced Assigned Target List:
   active-probe echo 30.1.1.11 target-port 0
MC#
```

- Check the active probes

```
MC#sh pfr master active-probes forced
        OER Master Controller active-probes
Border   = Border Router running this Probe
Policy   = Forced target is configure under this policy
Type     = Probe Type
Target   = Target Address
TPort    = Target Port
N - Not applicable

The following Forced Probes are running:

Border          State    Policy            Type     Target          TPort Dscp
10.4.5.5        ACTIVE   10                echo     30.1.1.11           N af31
10.4.5.4        ACTIVE   10                echo     30.1.1.11           N af31


MC#
```

Note: active probes use the DSCP value of the Traffic Classes in the learn-list. If there is multiple DSCP used, then multiple probes (one for each DSCP value) will be defined.

Border Routers

Active probes are defined on the Master Controller but are forged from each Border Routers. Because we are using fast mode, each Border Router generates active probes.

- On Border Router R4

```
R4#sh pfr border active-probes
        OER Border active-probes
Type      = Probe Type
Target    = Target IP Address
```

```
TPort     = Target Port
Source    = Send From Source IP Address
Interface = Exit interface
Att       = Number of Attempts
Comps   = Number of completions
N - Not applicable

Type     Target          TPort Source          Interface           Att   Comps
DSCP
echo     30.1.1.11           N 100.4.8.4       Et0/1               346     346
104

R4#
```

What to check:

- There are active probes running on the Border Router
- Att column: gives the number of attempts
- Comps column: gives the number of completed probes
- if "comps" is not equal or greater than Att then do the below command to check ip sla configuration.

- Look at the IP SLA configuration generated by PfR on R4:

```
R4#sh ip sla configuration
IP SLAs Infrastructure Engine-III
Entry number: 3267
Owner: Optimized Edge Routing (OER)
Tag:
Operation timeout (milliseconds): 1000
Type of operation to perform: icmp-echo
Target address/Source address: 30.1.1.11/100.4.8.4
Type Of Service parameter: 0x68
Request size (ARR data portion): 28
Verify data: No
Vrf Name:
Schedule:
   Operation frequency (seconds): 2  (not considered if randomly scheduled)
   Next Scheduled Start Time: Start Time already passed
   Group Scheduled : FALSE
   Randomly Scheduled : FALSE
   Life (seconds): Forever
   Entry Ageout (seconds): never
   Recurring (Starting Everyday): FALSE
   Status of entry (SNMP RowStatus): Active
Threshold (milliseconds): 1000
Distribution Statistics:
   Number of statistic hours kept: 2
   Number of statistic distribution buckets kept: 1
   Statistic distribution interval (milliseconds): 20
Enhanced History:
History Statistics:
   Number of history Lives kept: 0
   Number of history Buckets kept: 15
   History Filter Type: None


R4#
```

- Look at the IP SLA statistics on R4, and note the delay of ~50ms:

```
R4#
R4#sh ip sla statistics
IPSLAs Latest Operation Statistics

IPSLA operation id: 3267
        Latest RTT: 49 milliseconds
Latest operation start time: *13:47:44.831 MET Mon Mar 28 2011
Latest operation return code: OK
Number of successes: 420
Number of failures: 0
Operation time to live: Forever


R4#
```

- On Border Router R5

```
R5#sh pfr border active-probes
        OER Border active-probes
Type      = Probe Type
Target    = Target IP Address
TPort     = Target Port
Source    = Send From Source IP Address
Interface = Exit interface
Att       = Number of Attempts
Comps   = Number of completions
N - Not applicable

Type     Target          TPort Source          Interface           Att    Comps
DSCP
echo     30.1.1.11           N 100.5.9.5       Et0/1               364      364
104


R5#
```

What to check:

- There are active probes running on the Border Router
- Att column: gives the number of attempts
- Comps column: gives the number of completed probes
- if "comps" is not equal or greater than Att then do the below command to check ip sla configuration.

- Look at the IP SLA configuration generated by PfR on R5:

```
R5#sh ip sla configuration
IP SLAs Infrastructure Engine-III
Entry number: 3267
Owner: Optimized Edge Routing (OER)
Tag:
Operation timeout (milliseconds): 1000
Type of operation to perform: icmp-echo
Target address/Source address: 30.1.1.11/100.5.9.5
Type Of Service parameter: 0x68
Request size (ARR data portion): 28
Verify data: No
Vrf Name:
Schedule:
   Operation frequency (seconds): 2  (not considered if randomly scheduled)
   Next Scheduled Start Time: Start Time already passed
   Group Scheduled : FALSE
   Randomly Scheduled : FALSE
   Life (seconds): Forever
   Entry Ageout (seconds): never
   Recurring (Starting Everyday): FALSE
   Status of entry (SNMP RowStatus): Active
Threshold (milliseconds): 1000
Distribution Statistics:
   Number of statistic hours kept: 2
   Number of statistic distribution buckets kept: 1
   Statistic distribution interval (milliseconds): 20
Enhanced History:
History Statistics:
   Number of history Lives kept: 0
   Number of history Buckets kept: 15
   History Filter Type: None


R5#
```

- Look at the IP SLA statistics on R5 and note the delay of ~250ms:

```
R5#sh ip sla statistics
IPSLAs Latest Operation Statistics

IPSLA operation id: 3267
        Latest RTT: 251 milliseconds
Latest operation start time: *13:50:28.825 MET Mon Mar 28 2011
Latest operation return code: OK
Number of successes: 502
Number of failures: 0
Operation time to live: Forever


R5#
```

Verify Traffic Classes Statistics

As soon as you see:

```
MC#
*Mar 25 15:14:33.544: %OER_MC-5-NOTICE: Prefix Learning WRITING DATA
*Mar 25 15:14:33.618: %OER_MC-5-NOTICE: Prefix Learning STARTED
MC#
```

You should be able to see the traffic classes on the Master Controller. You will need a few cycles before having all prefixes in INPOLICY state.

Traffic Classes

On the Master Controller, you have all the Traffic Classes (in this case based on DSCP values) learnt as well as statistics:

Using show pfr master traffic-class:

```
MC#sh pfr master traffic-class
OER Prefix Statistics:
 Pas - Passive, Act - Active, S - Short term, L - Long term, Dly - Delay (ms),
 P - Percentage below threshold, Jit - Jitter (ms),
 MOS - Mean Opinion Score
 Los - Packet Loss (packets-per-million), Un - Unreachable (flows-per-million),
 E - Egress, I - Ingress, Bw - Bandwidth (kbps), N - Not applicable
 U - unknown, * - uncontrolled, + - control more specific, @ - active probe all
 # - Prefix monitor mode is Special, & - Blackholed Prefix
 % - Force Next-Hop, ^ - Prefix is denied

DstPrefix           Appl_ID Dscp Prot     SrcPort     DstPort SrcPrefix
           Flags              State     Time            CurrBR  CurrI/F Protocol
         PasSDly  PasLDly   PasSUn   PasLUn  PasSLos  PasLLos      EBw      IBw
         ActSDly  ActLDly   ActSUn   ActLUn  ActSJit  ActPMOS  ActSLos  ActLLos
------------------------------------------------------------------------------
30.1.0.11/32              N af31  256           N           N 0.0.0.0/0
                          INPOLICY       @0          10.4.5.4 Et0/1           PBR
              51       51        0        0        0        0       70        7
              53       52        0        0        N        N        N        N

30.1.1.11/32              N af31  256           N           N 0.0.0.0/0
                          INPOLICY       @0          10.4.5.4 Et0/1           PBR
              52       52        0        0        0        0       68        8
              53       52        0        0        N        N        N        N

30.1.2.11/32              N af31  256           N           N 0.0.0.0/0
                          INPOLICY       @0          10.4.5.4 Et0/1           PBR
              52       52        0        0        0        0       73        7
              53       52        0        0        N        N        N        N

30.1.3.11/32              N af31  256           N           N 0.0.0.0/0
                          INPOLICY       @0          10.4.5.4 Et0/1           PBR
              52       52        0        0        0        0       66        8
              53       52        0        0        N        N        N        N

MC#
```

A closer look at the results

Let?s have a look at a few entries.

From the command ?show oer master traffic-class, let?s focus on a specific TC: 30.1.0.11/32 dscp af31:

```
MC#sh pfr master traffic-class
OER Prefix Statistics:
 Pas - Passive, Act - Active, S - Short term, L - Long term, Dly - Delay (ms),
 P - Percentage below threshold, Jit - Jitter (ms),
 MOS - Mean Opinion Score
 Los - Packet Loss (packets-per-million), Un - Unreachable (flows-per-million),
 E - Egress, I - Ingress, Bw - Bandwidth (kbps), N - Not applicable
 U - unknown, * - uncontrolled, + - control more specific, @ - active probe all
 # - Prefix monitor mode is Special, & - Blackholed Prefix
 % - Force Next-Hop, ^ - Prefix is denied

DstPrefix           Appl_ID Dscp Prot     SrcPort     DstPort SrcPrefix
           Flags              State     Time            CurrBR  CurrI/F Protocol
         PasSDly  PasLDly   PasSUn   PasLUn  PasSLos  PasLLos      EBw      IBw
         ActSDly  ActLDly   ActSUn   ActLUn  ActSJit  ActPMOS  ActSLos  ActLLos
--------------------------------------------------------------------------------
30.1.0.11/32              N af31  256           N           N 0.0.0.0/0
                          INPOLICY       @0          10.4.5.4 Et0/1           PBR
              51       51        0        0        0        0       70        7
              53       52        0        0        N        N        N        N

[snip]
```

- Line1: prefix
- Line2: State of INPOLICY. This prefix is controlled by PfR and is currently inpolicy. PBR is used to enforce the path. Forwarding decisions based on other packet fields (such as TCP port numbers, DSCP field) cannot be done via the traditional routing table. For this reason, PfR will create a dynamic Policy Based Routing (PBR) policy and apply it to the PfR internal interfaces of the border routers.
- Line2: R4 is the exit point (WAN1) as this is the path with the lowest delay (remember that policies are based on loss then delay and remember the results from the IP SLA probes).

- **Line4: Active results**
- Line4 (ActSDly, ActLDly): short-term and long-term active delay, measured by active probes that we configured. 50 ms reported, coming from the IP SLA probe results from R4.
- Line4 (ActSUn, ActLUn): short-term and long-term Unreachable results.
- Line4 (ActSLos, ActLLoss): short-term and long-term Loss results.

How PfR modifies Paths

Forwarding decisions based on other packet fields (in this case DSCP field) cannot be done via the traditional routing table. For this reason, PfR will create a dynamic Policy Based Routing (PBR) policy and apply it to the PfR internal interfaces of the border routers. But for PBR to be successful, BRs have to be adjacent either through a direct connection or via a GRE tunnel.

As shown before, CRITICAL traffic (dscp af31) is being forced out R4 due to delay policy.

PfR creates several dynamic route-maps to enforce the path for the sensitive applications. Depending on two dynamic ACLs, PBR enforce a next-hop to WAN1 or WAN2.

Let's check on the first border router R5 where we clearly see that packets are redirected to R4:

```
R5#sh route-map dynamic
route-map OER_INTERNAL_RMAP, permit, sequence 0, identifier 4278190085
  Match clauses:
    ip address (access-lists): oer#1
  Set clauses:
    ip next-hop 10.4.5.4
    interface Ethernet0/0
  Policy routing matches: 89574 packets, 61575074 bytes
Current active dynamic routemaps = 1
R5#
```

We can also check the dynamic ACL on R5 that matches sensitive traffic with DSCP af31.

```
R5#sh ip access-lists dynamic
Extended IP access list oer#1
    134217727 permit ip any host 30.1.3.11 dscp af31 (22980 matches)
    268435455 permit ip any host 30.1.0.11 dscp af31 (22993 matches)
    536870911 permit ip any host 30.1.2.11 dscp af31 (22972 matches)
    1073741823 permit ip any host 30.1.1.11 dscp af31 (23035 matches)
R5#
```

Add Blackouts and observe how PfR reacts

Drop Test Description

We are simulating a soft error, where the bgp control packets make it through but the application traffic gets dropped. BGP still believes that the path is the best path when in reality, the application packets are getting dropped.

Drop Test Execution

- Applying filter on the WAN1 path (primary path for application traffic):

```
*17:42:31.781 MET Mon Mar 28 2011
```

You should see PfR messages, stating that AF31 TCs are Out Of Policies (OOP), due to unreachable reason. This happens 3-5 sec after the initial drop.

```
MC#
*Mar 28 17:42:35.501: %OER_MC-5-NOTICE: Active REL Unreachable OOP Appl Prefix 30.1.1.11/32 af31 2
*Mar 28 17:42:35.501: %OER_MC-5-NOTICE: Active REL Unreachable OOP Appl Prefix 30.1.0.11/32 af31 2
*Mar 28 17:42:35.501: %OER_MC-5-NOTICE: Active REL Unreachable OOP Appl Prefix 30.1.3.11/32 af31 2
MC#
*Mar 28 17:42:35.501: %OER_MC-5-NOTICE: Active REL Unreachable OOP Appl Prefix 30.1.2.11/32 af31 2
*Mar 28 17:42:35.705: %OER_MC-5-NOTICE: Route changed Appl Prefix 30.1.1.11/32 af31 256, BR 10.4.5
*Mar 28 17:42:35.705: %OER_MC-5-NOTICE: Route changed Appl Prefix 30.1.0.11/32 af31 256, BR 10.4.5
*Mar 28 17:42:35.705: %OER_MC-5-NOTICE: Route changed Appl Prefix 30.1.3.11/32 af31 256, BR 10.4.5
MC#
*Mar 28 17:42:35.705: %OER_MC-5-NOTICE: Route changed Appl Prefix 30.1.2.11/32 af31 256, BR 10.4.5
MC#
```

- Traffic has been forced out R5 due to Out of Policy. TCs are in the holddown state to avoid flapping. Holddown timer is 300sec by default and can be changed in the PfR configuration (here changed to 90sec).

```
MC#sh pfr master traffic-class
OER Prefix Statistics:
 Pas - Passive, Act - Active, S - Short term, L - Long term, Dly - Delay (ms),
 P - Percentage below threshold, Jit - Jitter (ms),
 MOS - Mean Opinion Score
 Los - Packet Loss (packets-per-million), Un - Unreachable (flows-per-million),
 E - Egress, I - Ingress, Bw - Bandwidth (kbps), N - Not applicable
 U - unknown, * - uncontrolled, + - control more specific, @ - active probe all
 # - Prefix monitor mode is Special, & - Blackholed Prefix
 % - Force Next-Hop, ^ - Prefix is denied

DstPrefix           Appl_ID Dscp Prot     SrcPort     DstPort SrcPrefix
           Flags              State     Time            CurrBR  CurrI/F Protocol
         PasSDly  PasLDly   PasSUn   PasLUn  PasSLos  PasLLos      EBw      IBw
         ActSDly  ActLDly   ActSUn   ActLUn  ActSJit  ActPMOS  ActSLos  ActLLos
-------------------------------------------------------------------------------
30.1.0.11/32              N af31  256           N           N 0.0.0.0/0
                          HOLDDOWN      @85          10.4.5.5 Et0/1           PBR
              U        U        0        0        0        0       82        5
            246      246        0        0        N        N        N        N

30.1.1.11/32              N af31  256           N           N 0.0.0.0/0
                          HOLDDOWN      @85          10.4.5.5 Et0/1           PBR
              U        U        0        0        0        0       70        8
            246      246        0        0        N        N        N        N

30.1.2.11/32              N af31  256           N           N 0.0.0.0/0
```

```
                          HOLDDOWN      @78          10.4.5.5 Et0/1           PBR
              U         U         0         0         0         0       80         5
            246       246         0         0         N         N        N         N

30.1.3.11/32              N af31  256           N           N 0.0.0.0/0
                          HOLDDOWN      @84          10.4.5.5 Et0/1           PBR
              U         U         0         0         0         0       80         7
            246       246         0         0         N         N        N         N

MC#
```

- After the holddown timer expires, Traffic Classes move to INPOLICY state:

```
MC#sh pfr master traffic-class
OER Prefix Statistics:
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DstPrefix           Appl_ID Dscp Prot     SrcPort     DstPort SrcPrefix
           Flags             State     Time            CurrBR  CurrI/F Protocol
         PasSDly  PasLDly   PasSUn   PasLUn  PasSLos  PasLLos      EBw      IBw
         ActSDly  ActLDly   ActSUn   ActLUn  ActSJit  ActPMOS  ActSLos  ActLLos
------------------------------------------------------------------------------
30.1.0.11/32              N af31  256           N           N 0.0.0.0/0
                          INPOLICY      @79          10.4.5.5 Et0/1           PBR
              252       252         0         0         0         0       24         3
              252       252         0         0         N         N        N         N

30.1.1.11/32              N af31  256           N           N 0.0.0.0/0
                          INPOLICY       @1          10.4.5.5 Et0/1           PBR
              252       252         0         0         0         0       24         3
              252       252         0         0         N         N        N         N

30.1.2.11/32              N af31  256           N           N 0.0.0.0/0
                          INPOLICY      @85          10.4.5.5 Et0/1           PBR
              252       252         0         0         0         0       26         2
              252       252         0         0         N         N        N         N

30.1.3.11/32              N af31  256           N           N 0.0.0.0/0
                          INPOLICY      @78          10.4.5.5 Et0/1           PBR
              252       252         0         0         0         0       24         3
              252       252         0         0         N         N        N         N

MC#
```

Blackout Test Conclusion

PfR is able to detect blackouts in the WAN. In this test, only Application traffic is dropped and therefore BGP still has a route through the path with blackouts.

Without PfR, the application traffic would have been dropped without further notice.

Add delay and observe how PfR reacts

Delay Test Description

This scenario is one of the worst case. This is not a failure scenario, not even a blackout condition but a scenario where soft errors or brownouts are observed in the primary WAN, leading to an increased delay. This delay increase would have a huge impact on the critical applications running over the WAN.

The initial state is that sensitive traffic is forced out R4 (WAN1), delay is 50 ms initially as measured by active probes.

Delay Test Execution

- Add delay 500 ms to R4

```
R6#sh clock
*17:29:47.731 MET Mon Mar 28 2011
```

- You should see PfR messages, stating that AF31 TCs are Out Of Policies (OOP), due to delay reason. This happens 7-10 sec after the initial delay increase.

```
MC#
*Mar 28 17:29:53.267: %OER_MC-5-NOTICE: Active ABS Delay OOP Appl Prefix 30.1.1.11/32 af31 256, de
*Mar 28 17:29:53.267: %OER_MC-5-NOTICE: Active ABS Delay OOP Appl Prefix 30.1.0.11/32 af31 256, de
*Mar 28 17:29:53.267: %OER_MC-5-NOTICE: Active ABS Delay OOP Appl Prefix 30.1.3.11/32 af31 256, de
*Mar 28 17:29:53.267: %OER_MC-5-NOTICE: Active ABS Delay OOP Appl Prefix 30.1.2.11/32 af31 256, de
MC#
*Mar 28 17:29:53.268: %OER_MC-5-NOTICE: Route changed Appl Prefix 30.1.1.11/32 af31 256, BR 10.4.5
*Mar 28 17:29:53.268: %OER_MC-5-NOTICE: Route changed Appl Prefix 30.1.0.11/32 af31 256, BR 10.4.5
*Mar 28 17:29:53.269: %OER_MC-5-NOTICE: Route changed Appl Prefix 30.1.3.11/32 af31 256, BR 10.4.5
*Mar 28 17:29:53.269: %OER_MC-5-NOTICE: Route changed Appl Prefix 30.1.2.11/32 af31 256, BR 10.4.5
MC#
```

- Traffic has been forced out R5 due to Out of Policy. TCs are in the holddown state to avoid flapping. Holddown timer is 300sec by default and can be changed in the PfR configuration (here changed to 90sec).

```
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 Los - Packet Loss (packets-per-million), Un - Unreachable (flows-per-million),
 E - Egress, I - Ingress, Bw - Bandwidth (kbps), N - Not applicable
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 # - Prefix monitor mode is Special, & - Blackholed Prefix
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DstPrefix           Appl_ID Dscp Prot     SrcPort     DstPort SrcPrefix
          Flags              State     Time            CurrBR  CurrI/F Protocol
         PasSDly  PasLDly   PasSUn   PasLUn  PasSLos  PasLLos      EBw      IBw
         ActSDly  ActLDly   ActSUn   ActLUn  ActSJit  ActPMOS  ActSLos  ActLLos
------------------------------------------------------------------------------
30.1.0.11/32              N af31  256           N           N 0.0.0.0/0
                          HOLDDOWN      @35           10.4.5.5 Et0/1           PBR
             127      127         0         0         0         0       75         6
             252      251         0         0         N         N        N         N

30.1.1.11/32              N af31  256           N           N 0.0.0.0/0
                          HOLDDOWN      @34           10.4.5.5 Et0/1           PBR
             144      144         0         0         0         0       69         6
             252      251         0         0         N         N        N         N

30.1.2.11/32              N af31  256           N           N 0.0.0.0/0
                          HOLDDOWN      @34           10.4.5.5 Et0/1           PBR
             145      145         0         0         0         0       80         6
             252      251         0         0         N         N        N         N

30.1.3.11/32              N af31  256           N           N 0.0.0.0/0
                          HOLDDOWN      @38           10.4.5.5 Et0/1           PBR
             144      144         0         0         0         0       75         6
             252      251         0         0         N         N        N         N

MC#
```

- After the holddown timer expires, Traffic Classes move to INPOLICY state:

```
MC#sh pfr master traffic-class
OER Prefix Statistics:
 Pas - Passive, Act - Active, S - Short term, L - Long term, Dly - Delay (ms),
 P - Percentage below threshold, Jit - Jitter (ms),
 MOS - Mean Opinion Score
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 E - Egress, I - Ingress, Bw - Bandwidth (kbps), N - Not applicable
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 # - Prefix monitor mode is Special, & - Blackholed Prefix
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DstPrefix           Appl_ID Dscp Prot     SrcPort     DstPort SrcPrefix
          Flags              State     Time            CurrBR  CurrI/F Protocol
```

```
         PasSDly  PasLDly   PasSUn   PasLUn  PasSLos  PasLLos      EBw      IBw
         ActSDly  ActLDly   ActSUn   ActLUn  ActSJit  ActPMOS  ActSLos  ActLLos
-------------------------------------------------------------------------------
30.1.0.11/32              N af31  256          N           N 0.0.0.0/0
                          INPOLICY      @61          10.4.5.5 Et0/1           PBR
              252      252        0        0        0        0       24        2
              253      252        0        0        N        N        N        N

30.1.1.11/32              N af31  256          N           N 0.0.0.0/0
                          INPOLICY      @55          10.4.5.5 Et0/1           PBR
              252      252        0        0        0        0       26        2
              253      252        0        0        N        N        N        N

30.1.2.11/32              N af31  256          N           N 0.0.0.0/0
                          INPOLICY      @56          10.4.5.5 Et0/1           PBR
              252      252        0        0        0        0       25        2
              253      252        0        0        N        N        N        N

30.1.3.11/32              N af31  256          N           N 0.0.0.0/0
                          INPOLICY      @63          10.4.5.5 Et0/1           PBR
              252      252        0        0        0        0       24        3
              253      252        0        0        N        N        N        N

MC#
```

Delay Test Conclusion

Using PfR allows soft errors and brownout detection. In this test, there is no way BGP can re-reroute based on a delay increase which can deeply impact the critical applications. PfR can detect this kind of soft errors and can re-route based on user policies.

Possible Optimization

Use jitter probes to get more accurate statistics on loss, delay and jitter. Configure 3 probes instead of only one for better reachability.

- Policy configuration for sensitive applications and specific for a branch

```
! Following is a policy configuration sensitive application specific to one branch.
! This should be repeated for each branch. It includes
!
! ? match command is to specify that this policy should be applied
!   to all the traffic-class learned under list BRANCH1_CRITICAL
!
! ? delay threshold is configured as 300 msec. The delay measured by PfR is
!   Round-Trip-Time. For example, video conference delay higher than 150 ms one-way
!   decreases the Quality-of-Experience.
!
```

```
! ? Loss is set to 50,000 (packets-per-million). i.e 5%
!
! ? Resolver setting is configure to set the priority in the order of
!   loss and delay. Range and utilization are DISABLED for sensitive application.
!
! ? Probe packets are set to 20 to reduce the probe traffic.
!   Instead of configuring only 1 probe (with 60 probe packet) it is better to configure
!   2 or 3 probes with 20 probe packets (resulting into lower or same number of total probe packet
!
pfr-map MYMAP 10
 match pfr learn list BRANCH1_CRITICAL
 set delay threshold 300
 set mode route control
 set mode monitor fast
 set resolve loss priority 2 variance 5
 set resolve delay priority 5 variance 5
 no set resolve range
 no set resolve utilization
 set loss threshold 50000
 set active-probe udp-jitter 30.1.1.11 target-port 2001 codec g729a
 set active-probe udp-jitter 30.1.1.11 target-port 2002 codec g729a
 set active-probe udp-jitter 30.1.1.11 target-port 2003 codec g729a
 set probe frequency 2
!
```