Introduction

This document describes the methods used in Performance Routing version 2 (PfRv2) to monitor the performance of the Wide Area Network (WAN) links on the branch routers.

Prerequisites

Requirements

Cisco recommends that you have basic knowledge of Performance Routing (PfR).

Components Used

This document is not restricted to specific software and hardware versions.

The information in this document was created from the devices in a specific lab environment. All of the devices used in this document started with a cleared (default) configuration. If your network is live, make sure that you understand the potential impact of any command.

Background Information

PfRv2 uses three methods for measuring performance of the Border Routers (BR) links. The information collected is used by Master Controller (MC) for PfR policy implementation. The three methods are:
**Passive Monitoring**

In this mode, Netflow enabled (by default with PfR) on Border Router collects following information regarding the traffic class and sends it back to the Master controller.

Following is applicable for TCP flows passing through BR:

- **Reachability**: This is calculated based on TCP SYN for which corresponding TCP ACK have not being received.
- **Delay**: Time calculated between TCP SYN and TCP ACK messages during TCP 3-way handshake. The total value is then divided by 2.
- **Loss**: Measured on the basis of TCP sequence numbers. For example: when received TCP sequence number is higher or lower than the expected, loss is reported.

Following is applicable for all flows (including TCP) passing through BR:

- **Egress Bandwidth**: Throughput for traffic class egressing the BRs (calculated in bits per second using Netflow).
- **Ingress Bandwidth**: Throughput for traffic class ingressing the BRs (calculated in bits per second using Netflow).

**Active Monitoring**

In this mode, BR sends out IP SLA probes over its WAN interface to measure several parameters regarding the traffic class. Information collected is sent back to the Master controller. Following parameters are measured:

- Reachability
- Delay
- Loss
- Egress Bandwidth
- Ingress Bandwidth

These probes are generated automatically when monitoring method configured on Master controller.

While the Exit BR selection is ongoing, all the BRs will send active probes for the Netflow-learned prefixes. Upon selection of the Exit BR, other BRs will stop sending active probes. The selected BR will continue to send active probes.

**Hybrid Mode**

Hybrid modes uses both the Netflow statistics and IP Service Level Agreement (SLA) to decide on exit point (Border router) and link monitoring. In this mode, IP SLA probe information is used to select the exit point and then Netflow statistics are used to monitor that Border router's WAN connection towards the destination.

While PfR is in learning state and has not yet moved into “INPOLICY” state, all the BRs will send active probes for the prefixes collected from netflow. This is to determine respective link conditions. When on MC state changes to “INPOLICY”, all the BRs will stop sending active probes and now monitoring will be done passively (using Netflow).
Configure

Following image would be used as a sample topology for rest of the document:

Network Diagram

Relevant Configuration

Following basic configuration is required for using different modes. R3 is configured as MC so these configuration will have to be done on R3:

Passive Mode:

Active Mode:

Hybrid mode:

This is the default mode. If no mode command is mentioned, Hybrid mode will be activated or command "mode monitor both" can be used to enable it.

Note: If command "mode monitor both" is given manually then it will not be shown in configuration as it is a default command.
Verify

Most verification commands are executed on MC. Following commands can be used to verify working of different modes:

### Passive Mode

```
R3#show pfr master
<Output suppressed>
```

Default Policy Settings:
- backoff 90 900 90
- delay relative 50
- holddown 90
- periodic 0
- probe frequency 56
- number of jitter probe packets 100
- mode route control
- mode monitor passive
  - loss relative 10
  - jitter threshold 20
  - mos threshold 3.60 percent 30
  - unreachable relative 50
  - trigger-log percentage 30

**Test 1 - Initiate TCP stream from server**

```
R3#show 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 (percent/10000), 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

<table>
<thead>
<tr>
<th>DstPrefix</th>
<th>Appl_ID</th>
<th>Dscp</th>
<th>Prot</th>
<th>SrcPort</th>
<th>DstPort</th>
<th>SrcPrefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>PasSDly</td>
<td>PasLDly</td>
<td>PasSUn</td>
<td>PasLUn</td>
<td>PasSlos</td>
<td>PasLLos</td>
<td>EBw</td>
</tr>
<tr>
<td>ActSDly</td>
<td>ActLDly</td>
<td>ActSUn</td>
<td>ActLUn</td>
<td>ActSJit</td>
<td>ActPMOS</td>
<td>ActSlos</td>
</tr>
<tr>
<td>------------</td>
<td>---------</td>
<td>-------</td>
<td>-------</td>
<td>---------</td>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>10.20.0.24</td>
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<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>INPOLICY</td>
<td>0</td>
<td>10.4.4.4 Et0/1</td>
<td>BGP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>46</td>
<td>0</td>
<td>0</td>
<td>35502</td>
<td>35502</td>
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<tr>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>10.30.0.34</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>INPOLICY</td>
<td>0</td>
<td>10.5.5.5 Et0/1</td>
<td>BGP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<tr>
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<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

**Test 2 - Initiate UDP stream from server**

```
R3#show 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 (percent/10000), 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
As shown above, for TCP traffic, you can see Delay and Unreachable counters also getting populated but in case of UDP stream you can only see Bandwidth counters getting populated.

Active Mode

R3#show pfr master

Default Policy Settings:
- backoff 90 900 90
- delay relative 50
- holddown 90
- periodic 0
- probe frequency 56
- number of jitter probe packets 100
- mode route control
- mode monitor active
  - loss relative 10
  - jitter threshold 20
  - mos threshold 3.60 percent 30
  - unreachable relative 50
  - trigger-log percentage 30

Test - Initiate TCP stream from server

On Master Controller:

R3#show pfr master traffic-class

OER Prefix Statistics:
- P = Percentage below threshold, Jit = Jitter (ms),
- MOS = Mean Opinion Score
- Los = Packet Loss (percent/10000), 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
### On BR1:

```plaintext
R4# show 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

<table>
<thead>
<tr>
<th>Type</th>
<th>Target</th>
<th>TPort</th>
<th>Source</th>
<th>Interface</th>
<th>Att</th>
<th>Comps</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSCP</td>
<td>echo</td>
<td></td>
<td>10.10.20.11</td>
<td>Et0/1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>0</td>
<td>echo</td>
<td></td>
<td>10.30.30.12</td>
<td>Et0/1</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
```

### On BR2:

```plaintext
R5# show 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

<table>
<thead>
<tr>
<th>Type</th>
<th>Target</th>
<th>TPort</th>
<th>Source</th>
<th>Interface</th>
<th>Att</th>
<th>Comps</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSCP</td>
<td>echo</td>
<td></td>
<td>10.10.20.11</td>
<td>Et0/1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>0</td>
<td>echo</td>
<td></td>
<td>10.30.30.12</td>
<td>Et0/1</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
```

Once the Traffic classes on MC move into “INPOLICY” state and BR1 is selected as the BR for sending all traffic, BR2 will stop sending probes:

```plaintext
R4# show 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

<table>
<thead>
<tr>
<th>Type</th>
<th>Target</th>
<th>TPort</th>
<th>Source</th>
<th>Interface</th>
<th>Att</th>
<th>Comps</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSCP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

echo 10.10.20.11 N 192.168.1.1 Et0/1 10 10
0
echo 10.30.30.12 N 192.168.1.1 Et0/1 10 10
0
R5#show 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

<table>
<thead>
<tr>
<th>Type</th>
<th>Target</th>
<th>TPort</th>
<th>Source</th>
<th>Interface</th>
<th>Att</th>
<th>Comps</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSCP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<No Active Probes>

Hybrid Mode

R3#show pfr master
OER state: ENABLED and ACTIVE
<Output Suppressed>

Default Policy Settings:
  backoff 90 900 90
  delay relative 50
  holddown 90
  periodic 0
  probe frequency 56
  number of jitter probe packets 100
  mode route control
  mode monitor both
  loss relative 10
  jitter threshold 20
  mos threshold 3.60 percent 30
  unreachable relative 50
  trigger-log percentage 30

Test - Initiate TCP stream from server

While Traffic Class (TC) are being measured and the state is not yet “INPOLICY”, Both the border routers will send active probes to the prefixes collected from netflow. This is to determine respective link conditions.

On MC:

R3#show pfr mas 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 (percent/10000), 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

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<th>Prot</th>
<th>SrcPort</th>
<th>DstPort</th>
<th>SrcPrefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flags</td>
<td>State</td>
<td>Time</td>
<td>CurrrBR</td>
<td>Currl/F</td>
<td>Protocol</td>
<td></td>
</tr>
<tr>
<td>PasSDly</td>
<td>PasLDly</td>
<td>PasSUn</td>
<td>PasLUn</td>
<td>PasSLos</td>
<td>PasLLos</td>
<td>EBw</td>
</tr>
<tr>
<td>ActSDly</td>
<td>ActLDly</td>
<td>ActSUn</td>
<td>ActLUn</td>
<td>ActS</td>
<td>ActS</td>
<td>ActPMSOS</td>
</tr>
</tbody>
</table>
10.20.20.0/24  N N N N  N N N  HOLDDOWN  61  10.5.5.5  Et0/1  BGP
1 1 0 0 0 0 16 1
1 1 0 0 N N N N

10.30.30.0/24  N N N N  N N N  HOLDDOWN  61  10.5.5.5  Et0/1  BGP
1 1 0 0 0 0 16 1
4 4 0 0 N N N N

On BR1:

R4#show 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

<table>
<thead>
<tr>
<th>Type</th>
<th>Target</th>
<th>TPort</th>
<th>Source</th>
<th>Interface</th>
<th>Att</th>
<th>Comps</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSCP</td>
<td>10.20.20.1</td>
<td>N 192.168.1.1</td>
<td>Et0/1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>echo</td>
<td>10.20.20.1</td>
<td>N 192.168.1.1</td>
<td>Et0/1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>10.30.30.1</td>
<td>N 192.168.1.1</td>
<td>Et0/1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

On BR2:

R5#show 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

<table>
<thead>
<tr>
<th>Type</th>
<th>Target</th>
<th>TPort</th>
<th>Source</th>
<th>Interface</th>
<th>Att</th>
<th>Comps</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSCP</td>
<td>10.20.20.1</td>
<td>N 192.168.2.1</td>
<td>Et0/1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>echo</td>
<td>10.20.20.1</td>
<td>N 192.168.2.1</td>
<td>Et0/1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>10.30.30.1</td>
<td>N 192.168.2.1</td>
<td>Et0/1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

When on MC the state changes to “INPOLICY”, both the BRs will stop sending active probes and the respective monitoring will switch to passive mode(using Netflow).

R3#show 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 (percent/10000), 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
As shown above, you can see counters for both the Passive and Active components. Also, the probes will stop on BRs once the TCs move to "INPOLICY" state.

Troubleshoot

There is currently no specific troubleshooting information available for this configuration.