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## Principles

### Traffic Class Identifier

Before optimizing traffic, PfR has to determine the traffic classes from the traffic flowing through the border routers. To optimize traffic routing, subsets of the total traffic must be identified, and these traffic subsets are named traffic classes.

The list of Traffic Class entries can be profiled either by automatically learning the traffic flowing through the device or by manually configuring the traffic classes. Traffic Classes can be based on layer3 information such as prefixes, or layer4 such as port number, on DSCP values or application by using Network Based Application Recognition (NBAR).

Each Traffic Class (TC) has its own Identifier. This 'Traffic-Class ID' is encoded into the 'application tag' export field as follows:

Classification Engine ID (1 Byte)	Type (1 Byte)	Traffic Class Id (4 Bytes)
<b>Classification Engine ID: 17</b>	<b>Type:</b> Type=1: Passive Update, Type=2: Passive Performance, Type=3: Active Update, Type=4: Active Performance, Type=5: Traffic-Class Event,	

### Export Process Summary

PfR uses NetFlow v9 to export configuration parameters, statistics and events.

The PfR NetFlow v9 Export feature won't export configuration and statistics data from Border Routers (BR) to collectors, but from Master Controller (MC) to collectors.

The Performance Routing (PfR) NetFlow v9 Export feature defines several Template FlowSets that are described in the following sections.

## AVC-Export:PfR

When PfR NetFlow Export is enabled:

- MC exports all ?TC Config?, ?Exit Config?, ?Internal Interface Config?, ?Policy Config? and ?Reason Config? Option Data FlowSet to collectors.
- Re-export on PfR configuration change, MC failover or router reload.

When a BR is UP or DOWN

- Exports a ?BR UP/DOWN? Data FlowSet.

When MC receives a NetFlow update from a BR

- Export a ?Passive Update? Data FlowSet.
- Exports a ?Passive Performance? Data FlowSet for InPolicy/Out-Of-Policy decision. Includes short-term/long-term performance updates and thresholds.
- If the decision is Out-Of-Policy, MC makes the periodic timer expire immediately

When MC receives an IP SLA update from a BR

- Exports an ?Active Update? Data FlowSet
- Exports an ?Active Performance? Data FlowSet for InPolicy/ Out-Of-Policy decision. Includes short-term/long-term performance updates and thresholds.
- MC might export multiple ?Active Performance? Data FlowSets for a single IP SLA update.
- If the decision is Out-Of-Policy, MC makes the periodic timer expire immediately.

When MC receives a link update

- Exports a ?External Link Update? and ?Internal Link Update? Data FlowSets. ?Internal Link Update? will be exported for inside prefixes only. Otherwise, ?External Link Update? will be exported normally.
- Includes InPolicy or Out-Of-Policy decision, if either Cost-Minimization, Load (utilization) or Range feature is configured.

When the periodic timer expires

- According to the configured mode, priorities and variances, MC tries to find the best Exits, and then makes InPolicy, RouteChange or Uncontrol decision.
- If the decision is RouteChange or Uncontrol, MC exports a ?TC Event? Data FlowSet, which includes the following data: Thresholds, Priorities and Variances.

When the cost rollup timer expires

Export Process Summary

- When the rollup timer is expired, MC exports a ?Cost Minimization Performance? Data FlowSet.

The Option FlowSets are exported periodically (every 10 minutes by default). The customer can modify the period by the following hidden commands in "pfr master" submode:

- exporter <name> option-period <minute>

this periodical export can also be disabled with the following command

- exporter <name> option-period 0

## Configuration templates Definition

### Traffic Class Config

Description	Field Type	Value	Len (bytes)	Type	Invalid Data
Encoded Traffic-Class ID	CLASSIFICATION TAG	95	6	int	0
Source prefix	PV4_SRC_ADDR	8	4	IPv4 Address	0
Source Mask	IPV4_SRC_MASK	9	1	IPv4 Mask	0
Destination prefix	IPV4_DST_ADDR	12	4	IPv4 Address	0
Destination mask	IPV4_DST_MASK	13	1	IPv4 Mask	0
Protocol	PROTOCOL	4	1	Int	0
DSCP	ipDiffServCodePoint	195	1	Int	0
Source port min	L4_SRC_PORT_MIN	39012	2	Int	0
Source port max	L4_SRC_PORT_MAX	39013	2	Int	0
Destination port min	L4_DST_PORT_MIN	39014	2	Int	0
Destination port max	L4_DST_PORT_MAX	39015	2	Int	0
Application name	CLASSIFICATION NAME	96	N	string	0
Policy id	POLICY_ID	32775	2	int	0

### Notes

- {Encoded Traffic-Class ID}: see [Traffic Class Identifier Encoding](#) for details. The Classification Tag is basically the Application Tag with Engine Id 17 for PfR.
- {Protocol}: if Traffic Classes are not based on protocol, then this field will not be included.
- {Port min} and {port max}: PfR uses either a port or a range of port numbers. If a single port number is used, then {port min} = {Port max} = port#. If a port range is used, then it can specify a port number or bigger than the port number by including only ?port\_min?. It can specify a port number or smaller than the port number by including only ?port\_max?.
- {Policy id}: The corresponding policy configuration template for this Traffic Class is described [here](#).

## Template Usage Description

- This Option template is used to give all the configuration parameters of a specific Traffic Class.
- This template is exported
  - ◆ When PfR NetFlow Export is enabled
  - ◆ When PfR configuration is changed
  - ◆ On MC or router reload
  - ◆ Periodically

## External Interface Config

Description	Field Type	Value	Len (bytes)	Type	Invalid Data
BR address	IPV4_BR_ADDR	39000	4	IPv4 Addr	
External interface id	OUTPUT_SNMP	14	2	Int	
BR interface name	IF_NAME	82	N	String	
Link capacity (kbps)	CAPACITY	39016	8	Int	0
RSVP reserved bandwidth pool (kbps)	RSVPBandWidthPool	39008	8	Int	0
Maximum ingress bandwidth (kbps)	MAX_INGRESS_BW	39018	8	Int	0
Maximum egress bandwidth (kbps)	MAX_EGRESS_BW	39020	8	Int	0
BGP Community	BGP_COMMUNITY	39025	4	int	0
Link group name	LINK_GROUP_NAME	39024	48	String	
Cost nickname	SAMPLER_NAME	84	N	String	
Cost type	SAMPLING_ALGORITHM	49	1	Int	
Cost discard rollup count	DISCARD_ROLLUP_COUNT	39028	2	int	

## Notes

- {Link capacity}: Interface physical bandwidth. Egress link capacity.
- {RSVP reserved bandwidth pool}: is the configured RSVP pool bandwidth size.
- {Maximum ingress bandwidth}: Available ingress bandwidth for PfR.
- {Maximum egress bandwidth}: Available egress bandwidth for PfR.
- {Link group name}: If the link group feature is not configured then the ?link group name? field will be empty. If configured, then the {link group name} will contain the name defined in the master controller configuration.
- If cost minimization is used:
  - ◆ {Cost nickname} = a string corresponding to the name
  - ◆ {Cost type} =

- ◇ 0: separate,
- ◇ 1: sum,
- ◇ 2: combined
- ◇ If cost minimization feature is not used then:
  - ◆ {Cost nickname} = null
  - ◆ {Cost type} = 0

### Template Usage Description

This template gives the configuration of an exit interface and is exported:

- When PfR NetFlow Export is enabled
- When PfR configuration is changed
- On MC or router reload
- Periodically

## Internal Interface Config

Description	Field Type	Value	Len (bytes)	Type	Invalid Data
BR address	IPV4_BR_ADDR	39000	4	IPv4 Addr	
Internal interface id	INPUT_SNMP	10	2	Int	
BR interface name	IF_NAME	82	N	String	

### Template Usage Description

This template gives the configuration of an ingress interface and is exported:

- When PfR NetFlow Export is enabled
- When PfR configuration is changed
- On MC or router reload
- Periodically

## Policy Config

### Field Descriptions

Description	Field Type	Value	Len (bytes)	Type	Invalid Data
-------------	------------	-------	-------------	------	--------------

## AVC-Export:PfR

Policy id	POLICY_ID	32775	2	Int	
pfr-map name	scAccessString	32789	128, 256, 512, 1024	String	
State	PFR_STATUS	39001	2	Int	
Threshold	THRESHOLD	39003	4	Int	0
Priority	PRIORITY	39004	2	Int	
Variance	VARIANCE	69	4	Int	
MOS	rtpMosQuality	42123	4	Int	
Link group name	LINK_GROUP_NAME	39024	48	String	

Notes:

- In a pfr-map sequence, we can have multiple resolvers (defined or by default inherited from the global configuration).
- {pfr-map name}: is the pfr-map sequence number from 0 to 0xFFFFE, while the Policy id of the default policy is 0xFFFFF.
- {Policy name}: the default policy name is ?default?. The other policy names are the pfr-map name followed by sequence number. For example, if the pfr-map name is ?pfrmap? and the sequence number is ?10?, the policy name will be ?pfrmap10?.
- {State}: State Type is Config (0x00). See chapter [State Encoding](#) for coding details.
- {Link group name}: If the link group feature is not configured then the ?link group name? field will be empty. If configured, then the {link group name} will contain the name defined in the master controller configuration. When the link-group feature is used, it has the following meanings based on ?state?:

State		Link Group ID
state_type	state_id	
0x00	0x90	Primary link group id
	0x91	Fallback link group id

So, if {link group id} = 1 and {state} = 0x0090, then link group number 1 is the primary link group in this policy.

### Threshold, Priority and Variance definitions

The fields ?threshold?, ?priority? and ?variance? have the following meanings, based on ?state?:

State		Threshold	Priority	Variance
state_type	state_id			
	0x10	unreachable relative percentage (%)	unreachable priority	unreachable variance
	0x11	unreachable absolute threshold (fpm)	unreachable priority	unreachable variance
	0x20	loss relative percentage (%)	loss priority	loss variance
	0x21	loss absolute threshold (ppm)	loss priority	loss variance

Field Descriptions

0x00

## AVC-Export:PfR

0x30	round-trip-time relative percentage (%)	round-trip-time priority	round-trip-time variance
0x31	round-trip-time absolute threshold (ms)	round-trip-time priority	round-trip-time variance
0x40	jitter threshold (ms)	jitter priority	jitter variance
0x50	MOS below threshold (%)	MOS priority	MOS variance
0x6x	(not included)	utilization priority	utilization variance
0x70	maximum range ingress bandwidth (%)	range priority	range variance
0x71	maximum range egress bandwidth (%)	range priority	range variance
0x80	(not included)	cost priority	cost variance

### Template Usage Description

This template is used to define the policies associated to the specified Traffic Class.

No matter how many resolvers are configured, each policy export will have at least 7 exports for each policy configured (each pfr-map, including the default one):

- Unreachable
- Loss
- Delay
- Jitter
- MOS
- Utilization
- Range

Only in the case link-groups/cost being configured extra templates along with the above 7 exported templates will be exported.

This template is exported:

- When PfR NetFlow Export is enabled
- When PfR configuration is changed
- On MC or router reload
- Periodically

### Example

Let's see an example with the following configuration:

```
!  
flow exporter pfr_exp  
  destination 25.25.25.2  
  transport udp 2500  
!  
pfr master  
  policy-rules PREFIXMAP
```

Threshold, Priority and Variance definitions



## AVC-Export:PfR

```
port 7777
max-range-utilization percent 44 ? line 7 of policy export
!
border 1.1.1.2 key-chain key2
  interface Ethernet0/2 internal
  interface Tunnel50 external
!
border 1.1.1.1 key-chain key1
  interface Ethernet3/1 external
  interface Ethernet0/2 internal
!
border 1.1.1.3 key-chain key3
  interface Ethernet0/2 internal
  interface Ethernet1/0 external
loss relative 1000
holddown 90
backoff 90 90
mode route protocol pbr
mode route control
!
pfr-map PREFIXMAP 45
match traffic-class prefix-list LIST3
set delay threshold 140
set mode monitor active
set resolve delay priority 1 variance 20
set resolve utilization priority 3 variance 13
no set resolve range
set active-probe echo 13.13.13.13
!
ip prefix-list LIST3 seq 1 permit 100.2.1.1/32
ip prefix-list LIST3 seq 2 permit 100.2.2.1/32
ip prefix-list LIST3 seq 3 permit 100.2.3.1/32
!
```

### Collector output extract:

```
[option data set,id=334] scopes: observationDomainId data: Threshold|VARIANCE|rtpMosQuality|scPack
[option data] 421075201 50|0|0|65535|0x0010|0|default|0 [Unreach]
[option data] 421075201 1000|0|0|65535|0x0020|0|default|0 [Loss]
[option data] 421075201 50|20|0|65535|0x0030|11|default|0 [Delay]
[option data] 421075201 20|0|0|65535|0x0040|0|default|0 [Jitter]
[option data] 421075201 30|0|360|65535|0x0050|0|default|0 [MOS]
[option data] 421075201 0|20|0|65535|0x0060|13|default|0 [Util]
[option data] 421075201 44|0|0|65535|0x0070|12|default|0 [Range]

[option data] 421075201 50|0|0|45|0x0010|0|PREFIXMAP|0 [Unreach]
[option data] 421075201 1000|0|0|45|0x0020|0|PREFIXMAP|0 [Loss]
[option data] 421075201 140|20|0|45|0x0031|11|PREFIXMAP|0 [Delay]
[option data] 421075201 20|0|0|45|0x0040|0|PREFIXMAP|0 [Jitter]
[option data] 421075201 30|0|360|45|0x0050|0|PREFIXMAP|0 [MOS]
[option data] 421075201 0|13|0|45|0x0060|3|PREFIXMAP|0 [Util]
[option data] 421075201 44|0|0|45|0x0070|0|PREFIXMAP|0 [Range]
```

### The default policy and the active policy each export 7 lines

```
[option data] 421075201 50|0|0|65535|0x0010|0|default|0 [Unreach]
```

- 65535 = default policy number
- default: default policy

### Example

## AVC-Export:PfR

```
[option data] 421075201 50|0|0|45|0x0010|0|PREFIXMAP|0
```

[Unreach]

- 45 = pfr-map sequence number
- PREFIXMAP = name of the configured policy

This export is verified by using "show oer master policy" and ?show run | sec pfr? output

```
pfr master
policy-rules PREFIXMAP
port 7777
max-range-utilization percent 44 <-- line 7 of export
!
```

This export matching the output of ?sh oer master policy?:

```
show oer master policy
```

```
Default Policy Settings:
backoff 90 90 90
delay relative 50 ? line 3 of export
holddown 90
periodic 0
probe frequency 56
number of jitter probe packets 100
mode route control
mode monitor both
mode select-exit good
loss relative 1000 ? line 2 of export
jitter threshold 20 ? line 4 of export
mos threshold 3.60 percent 30 ? line 5 of export
unreachable relative 50 -? line 1 of export
resolve delay priority 11 variance 20 ? line 3 of export
resolve range priority 12 variance 0 ? line 7 of export
resolve utilization priority 13 variance 20 ? line 6 of export
```

## Reason Config

### Field Descriptions

Description	Field Type	Value	Len (bytes)	Type
Reason id	pfrReason	39002	4	Int
Reason text	scInfoString	32790	N	String

Notes:

Reason Config

## AVC-Export:PfR

- The Reason Id is encoded with one-byte ?Reason Class?, one-byte ?Reason Group? and two-byte id.
- Check chapter [Reason ID Encoding](#) for more information.

### Template Usage Description

This template gives the reason of a change, for a Traffic Class or for an interface. This template is exported:

- When PfR NetFlow Export is enabled
- When PfR configuration is changed
- On MC or router reload
- Periodically

## Passive Reports Definitions

### Passive Update

Description	Field Type	Value	Len (bytes)	Type	Invalid Data
Encoded Traffic-Class ID	CLASSIFICATION_TAG	95	6	Int	0
BR Address	IPV4_BR_ADDR	39000	4	IPv4 Addr	0
External interface ID	OUTPUT_SNMP	14	2	Int	0
Direction	DIRECTION	61	1	Int	
State	PFR_STATUS	39001	2	Int	
First switched time	FIRST_SWITCH	22	4	Int	
Last switched time	LAST_SWITCH	21	4	Int	
Sum of round-trip-time (ms)	LATENCY	67	4	Int	
Samples	DATA_POINTS	68	4	Int	
Loss (ppm)	OER_PKT_LOSS	65	4	Int	
Unreachable (fpm)	OER_UNREACH	66	4	Int	
Bytes	IN_BYTES	1	4	Int	
Packets	IN_PKTS	2	4	Int	
Flows	FLOWS	3	4	Int	
Next hop address	NEXT_HOP	15	4	IPv4 Addr	

### Notes

- Raw measurement data received by the MC from the BRs
- {Encoded Traffic-Class ID } : see [Traffic Class Identifier Encoding](#)
- {Direction}: ingress=0 and egress=1

- {State}: see see [State Encoding](#)

### Template Usage Description

This template gives the raw statistics for a specific Traffic Class. As soon as the Master Controller receives an update from a Border Router for a Traffic Class, it exports the record with all the statistics. This is NOT the metrics computed by the Master Controller.

This template is exported:

- When MC receives a NetFlow update from a BR

### Passive Performance

Description	Field Type	Value	Len (bytes)	Type	Invalid Data
Encoded Traffic-Class ID	CLASSIFICATION_TAG	95	6	Int	
BR Address	IPV4_BR_ADDR	39000	4	IPv4 Addr	
External interface ID	OUTPUT_SNMP	14	2	Int	
Direction	DIRECTION	61	1	Int	
Routing protocol	PROTOCOL	4	1	Int	
State	PFR_STATUS	39001	2	Int	
Reason ID	REASON_ID	39002	4	Int	
Timestamp	flowEndMilliSeconds	153	8	Int	
Left time	FLOW_ACTIVE_TIMEOUT	36	2	Int	
Passive short-term unreachable (fpm)	CNT_PKTS_DROP	37000	4	Int	0xFFFFFFFF
Passive short-term loss (ppm)	TRANS_PKTS_LOST	37019	4	Int	0xFFFFFFFF
Passive short-term round-trip-time (ms)	ShortTermRTT	37016	4	Int	0xFFFFFFFF
Passive long-term unreachable (fpm)	CNT_PKTS_DROP_PERM	37001	4	Int	0xFFFFFFFF
Passive long-term loss (ppm)	TRANS_PKTS_LOST_PERM	37020	4	Int	0xFFFFFFFF
Passive long-term round-trip-time (ms)	LongTermRTT	39006	4	Int	0xFFFFFFFF
Ingress bandwidth (kbps)	INGRESS_BW	39017	4	Int	0xFFFFFFFF
Egress bandwidth (kbps)	EGRESS_BW	39019	4	Int	0xFFFFFFFF
BGP Prepend	BGP_PREPEND	39026	1	Int	
BGP Community	BGP_COMMUNITY	39025	1	Int	

## Notes

- Computed metrics from the MC
- Short and long-term performance data
- {Encoded Traffic-Class ID}: see [Traffic Class Identifier Encoding](#)
- {Direction}: ingress=0 and egress=1
- {State}: see [State Encoding](#)
- {Reason}: see [Reason Encoding](#)
- {BGP Prepend} and {BGP Community} are used for ingress load-balancing with BGP.

## Template Usage Description

When the Master Controller receives an update from a Master Control, it computes the short term (5 min) and long term (60 minutes) statistics, makes a policy decision and then exports all passive statistics for this Traffic Class. This is the metrics you would see on the Master Controller with the 'show pfr master traffic-class' command.

This template is exported:

- When MC receives a NetFlow update from a BR and makes an InPolicy/ Out-Of-Policy decision.
- If the decision is Out-Of-Policy, MC makes the periodic timer expire immediately, which leads to a [Traffic Class Event?](#) export.

## Active Reports Definitions

### Active Update

Description	Field Type	Value	Len (bytes)	Type	Invalid Data
Encoded Traffic-Class ID	CLASSIFICATION TAG	95	6	Int	
BR Address	IPV4_BR_ADDR	39000	4	IPv4 Addr	
External Interface ID	OUTPUT_SNMP	14	2	Int	
State	PFR_STATUS	39001	2	Int	
Average round-trip-time (ms)	DELAY_SUM	67	4	Int	
Minimum round-trip-time (ms)	transport_round_trip-time_min	37052	4	Int	
Maximum round-trip-time (ms)	transport_round_trip-time_max	37053	4	Int	

## AVC-Export:PfR

Sum of round-trip-time (ms)	transport_round-trip-time_sum	37050	4	Int
Unreachable (fpm)	OER_UNREACH	66	4	Int
Loss (ppm)	CNT_PKTS_LOSS	65	4	Int
Jitter (ms)	VARIANCE	69	4	Int
MOS below counts	MosBelow	39007	4	Int
MOS total counts	rtpConnCountTotal	42124	4	Int
Initiations	OUT_PKTS	24	4	Int
Completes	IN_PKTS	2	4	Int

### Notes

- Raw measurement data
- {Encoded Traffic-Class ID}: see [Traffic Class Identifier Encoding](#)
- {State}: see [State Encoding](#)

### Template Usage Description

This template gives the raw statistics for a specific Traffic Class. As soon as the Master Controller receives an update (probe results) from a Border Router for a Traffic Class, it exports the record with all the statistics. This is NOT the metrics computed by the Master Controller but the raw data as measured by a Border Router.

This template is exported:

- When MC receives an IP SLA update from a BR

## Active Performance

Description	Field Type	Value	Len (bytes)	Type	Invalid Data
Encoded Traffic-Class ID	CLASSIFICATION TAG	95	6	Int	
BR Address	IPV4_BR_ADDR	39000	4	IPv4 Addr	
External interface ID	OUTPUT_SNMP	14	2	Int	
Routing protocol	PROTOCOL	4	1	Int	
State	PFR_STATUS	39001	2	Int	
Reason ID	REASON_ID	39002	4	Int	
Timestamp	flowEndMilliSeconds	153	8	Int	
Left time	FLOW_ACTIVE_TIMEOUT	36	2	Int	
Active short-term unreachable (fpm)	CNT_PKTS_DROP	37000	4	Int	0xFFFFFFFF

## AVC-Export:PfR

Active short-term loss (ppm)	TRANS_PKTS_LOST	37019	4	Int	0xFFFFFFFF
Active short-term round-trip-time (ms)	ShortTermRTT	37016	4	Int	0xFFFFFFFF
Active short-term jitter (ms)	RTP_JITTER	37023	4	Int	0xFFFFFFFF
Active short-term MOS (%)	rtpWorstMos100	42115	4	Int	0xFFFFFFFF
Active long-term unreachable (fpm)	CNT_PKTS_DROP_PERM	37001	4	Int	0xFFFFFFFF
Active long-term loss (ppm)	TRANS_PKTS_LOST_PERM	37020	4	Int	0xFFFFFFFF
Active long-term round-trip-time (ms)	LongTermRTT	39006	4	Int	0xFFFFFFFF

### Notes

- Computed metrics from the MC
- Short and long-term performance data
- {Encoded Traffic-Class ID}: see see [Traffic Class Identifier Encoding](#)
- {State}: see see [State Encoding](#)
- {Reason}: see [Reason Encoding](#)
- Active short-term jitter (RTP\_JITTER, ID 37023) is encoded in micro secondes

### Template Usage Description

When the Master Controller receives an update from a Master Control, it computes the short term and long term statistics, makes a policy decision and then exports all active statistics for all Traffic Classes impacted by these results. Indeed, an IP SLA probe result impacts multiple Traffic Classes that all use the same probe. For example a group of voice traffic has a jitter probe defined to a specific remote branch, All Traffic Classes under that group will use the same probe results. This is the metrics you would have with the *show pfr master traffic-class* command on the Master Controller.

This template is exported:

- When MC receives an IP SLA update from a BR and makes an InPolicy/Out-Of-Policy decision.
- MC might export multiple ?Active Performance? Data FlowSets for a single IP SLA update because this IP SLA update can impact multiple Traffic Classes.
- If the decision is Out-Of-Policy, MC makes the periodic timer expire immediately, which leads to a [Traffic Class Event](#) export.

## Interface Update Definitions

### External Interface Update

Description	Field Type	Value	Len (bytes)	Type	Invalid Data
BR Address	IPV4_BR_ADDR	39000	4	IPv4 Addr	
External interface ID	OUTPUT_SNMP	14	2	Int	
State	PFR_STATUS	39001	2	Int	
Reason ID	REASON_ID	39002	4	Int	
Egress bandwidth (kbps)	EGRESS_BW_LONG	39019	8	Int	0xFFFFFFFF
Ingress bandwidth (kbps)	INGRESS_BW_LONG	39017	8	Int	0xFFFFFFFF
Cost target bandwidth (kbps)	KTH_ROLLUP_BW	39023	8	Int	
RSVP bandwidth pool (kbps)	CONNECTION_RSVP_BW_POOL	39008	8	Int	
TC total counts	FLows	3	4	Int	
Controlled TC counts	CNT_PKTS_RATE_FLOW	37028	4	Int	
In Policy TC counts	CNT_PKTS_RATE_FLOW_MIN	37029	4	Int	
Controlled bandwidth (kbps)	CAPACITY	39016	8	Int	

## Notes

- Raw measurement data
- {State}: see see [State Encoding](#)
- {RSVP bandwidth pool}: is the current remaining RSVP pool size. If a connection is set up by RSVP, the RSVP pool size will be decreased, and the updated ?External Link Update? will be exported.

## Template Usage Description

This template gives the statistics for a specific external interface. This type of statistics is typically used when a policy is based on interface usage or load-balancing between multiple external interfaces.

This template is exported:

- When MC receives a link update.
- Includes InPolicy or Out-Of-Policy decision, if Cost-Minimization, Load (utilization) or Range feature is configured.

## Internal Interface Update



Description	Field Type	Value	Len (bytes)	Type	Invalid Data
BR Address	IPV4_BR_ADDR	39000	4	IPv4 Addr	
Internal interface ID	INPUT_SNMP	10	2	Int	
State	PFR_STATUS	39001	2	Int	
Reason ID	REASON_ID	39002	4	Int	

### Notes

- {State}: see see [State Encoding](#)

### Template Usage Description

This template is exported:

- When MC receives a link update.
- For inside prefixes only.

## Traffic Class Performance Definitions

### Traffic Class Event

Description	Field Type	Value	Len (bytes)	Type	Invalid Data
Encoded Traffic-Class ID	CLASSIFICATION TAG	95	6	Int	
BR address	IPV4_BR_ADDR	39000	4	IPv4 Addr	
External interface ID	OUTPUT_SNMP	14	2	Int	
Direction	DIRECTION	61	1	Int	
Routing protocol	PROTOCOL	4	1	Int	
State	PFR_STATUS	39001	2	Int	
Reason ID	REASON_ID	39002	4	Int	
Timestamp	flowEndMilliseconds	153	8	Int	
Left time	FLOW_ACTIVE_TIMEOUT	36	2	Int	
BGP Prepend	BGP_PREPEND	39026	1	Int	
BGP Community	BGP_COMMUNITY	39025	1	Int	

### Notes

- {Encoded Traffic-Class ID}: see [Traffic Class Identifier Encoding](#)

- {Direction}: ingress=0 and egress=1
- {State}: see [State Encoding](#)
- {Reason}: see [Reason Encoding](#)
- {BGP Prepend} and {BGP Community} are used for ingress load-balancing with BGP.

### Template Usage Description

This template is exported:

- When the periodic timer expires and the decision is RouteChange or Uncontrol.
- Includes the following data: Thresholds, Priorities and Variances

## Cost Minimization Definitions

### Cost Minimization

Description	Field Type	Value	Len (bytes)	Type	Invalid Data
BR Address	IPV4_BR_ADDR	39000	4	IPv4 Addr	
External interface ID	OUTPUT_SNMP	14	2	Int	
State	PFR_STATUS	39001	2	Int	
Timestamp	flowEndMilliseconds	153	8	Int	
Counter of left rollup	RollupCounter	39009	2	Int	
Ingress rollup bandwidth (kbps)	INGRESS_ROLLUP_BW	39021	8	Int	
Egress rollup bandwidth (kbps)	EGRESS_ROLLUP_BW	39022	8	Int	
k-th rollup bandwidth (kbps)	KTH_ROLLUP_BW	39023	8	Int	
k-th tier percentage (%)	BandwidthPercentage	39010	2	Int	
k-th fee	BandwidthFee	39011	4	Int	

### Notes

- Raw measurement data
- {State}: see [State Encoding](#)

### Template Usage Description

This template is exported:

- When the cost rollup timer expires.

## PfR System Up/Down Definitions

### BR Up/Down Alert

Description	Field Type	Value	Len (bytes)	Type	Invalid Data
BR address	IPV4_BR_ADDR	39000	4	IPv4 Addr	
State	PFR_STATUS	39001	2	Int	

#### Notes

- {State}: see [State Encoding](#)

#### Template Usage Description

This template is exported:

- When a BR is going UP or DOWN

### MC Up/Down Alert

Description	Field Type	Value	Len (bytes)	Type	Invalid Data
State	PFR_STATUS	39001	2	Int	
Timestamp	flowEndMilliseconds	153	8	Int	

#### Notes

- {State}: see [State Encoding](#)

#### Template Usage Description

This template is exported:

- When a MC is going UP or DOWN

## State Encoding

State Type Meaning	State Type Value (1 Byte)	State id (1 Byte)	Meaning
Config	0x00	0x1x	Unreachable policy configuration (See note1)
		0x2x	Loss policy configuration (See note1)
		0x3x	Round-trip-time policy configuration (See note1)
		0x4x	Jitter policy configuration (See note1)
		0x5x	MOS policy configuration (See note1)
		0x6x	Utilization policy configuration (See note1)
		0x7x	Range policy configuration (See note1)
		0x8x	Cost minimization policy configuration (See note1)
		0x9x	Link group policy configuration (See note1)
MC up/down	0x01	0x0	MC: going down
		0x1	MC: going up
BR up/down	0x02	0x00	BR: down
		0x01	BR: up
Exit up/down	0x10	0x00	Exit: down
		0x01	Exit: up
		0x02	Exit: an RSVP connection set up
		0x03	Exit: an RSVP connection disconnected
Exit state	0x11	0x00	Exit: InPolicy
		0x01	Exit: cost-minimization OOP
		0x02	Exit: range OOP
		0x03	Exit: utilization OOP
Internal Interface up/down	0x20	0x00	Internal Interface: down
		0x01	Internal Interface: up
Passive Update	0x30	0x00	Passive Update: Not Current Interface
		0x01	

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			Passive Update: Current Interface
Passive Performance	0x31	0x00	Passive Performance: InPolicy
		0x01	Passive Performance: round-trip-time
		0x02	Passive Performance: loss
		0x03	Passive Performance: unreachable
Active Update	0x40	0x00	Active Update: Not Current Interface
		0x01	Active Update: Current Interface
Active Performance	0x41	0x00	Active Performance: InPolicy
		0x01	Active Performance: round-trip-time
		0x02	Active Performance: loss
		0x03	Active Performance: unreachable
		0x0E	Active Performance: jitter
		0x0F	Active Performance: MOS
TC Uncontrol	0x50	0x01	TC Uncontrol: round-trip-time
		0x02	TC Uncontrol: loss
		0x03	TC Uncontrol: unreachable
		0x04	TC Uncontrol: cost-minimization
		0x05	TC Uncontrol: utilization
		0x06	TC Uncontrol: range
		0x0E	TC Uncontrol: jitter
		0x0F	TC Uncontrol: MOS
TC Choose	0x51	0x00	TC is in Choose State
TC HoldDown	0x52	0x00	TC is in Holddown State
TC InPolicy	0x53	0x00	TC is in InPolicy State
TC OOP	0x54	0x01	TC OOP round-trip-time
		0x02	TC OOP loss
		0x03	TC OOP unreachable
		0x04	TC OOP cost-minimization
		0x05	TC OOP utilization
		0x06	TC OOP range
		0x0E	TC OOP jitter
		0x0F	TC OOP MOS
		0x00	Cost-Minimization: re-start

## AVC-Export:PfR

	0x01	Cost-Minimization: update
	0x02	Cost-Minimization: rollup update
	0x03	Cost-Minimization: end-of-month update

Note1: in 0x1x, ?, 0x8x, The last "x" means any hex digit; x=0x0, 0x1, ... 0xF. So, 0x8x means 0x80, 0x81, ... 0x8F.

## Reason Id Encoding

The Reason Id is encoded with one-byte ?Reason Class?, one-byte ?Reason Group? and two-byte id as follows:

Reason Class (1 byte)	Reason Group (1 byte)	ID (2 bytes)
0: Traffic Class	0: In Policy 1: Uncontrol 2: Route Change and OOP	values
1: Interface	0: Status 1: Out Of Policy	values

TC/Uncontrol

```

0x00010000    "",
0x00010001    "Activating unused forced targets",
0x00010002    "Interface down",
0x00010003    "Uncontrol: new probe target assigned",
0x00010004    "Uncontrol: new target assigned",
0x00010005    "Border down",
0x00010006    "Uncontrol non-optimized prefix",
0x00010007    "Recontrol Null0 prefix",
0x00010008    "Recontrol sinkhole prefix",
0x00010009    "Mode route change",
0x0001000a    "Prefix Enabled",
0x0001000b    "Uncontrol due to mode monitor change",
0x0001000c    "Inside",
0x0001000d    "Forced next hop",
0x0001000e    "Forward to Null0",
0x0001000f    "Clear one prefix",
0x00010010    "Clear one traffic-class",
0x00010011    "Grant Updated",
0x00010012    "Traffic-class in fast mode",
0x00010013    "PBR BR topology changed",
0x00010014    "PBR requirement not met",
0x00010015    "Probe frequency changed",
0x00010016    "Forced target assigned/removed/modified",
0x00010017    "Policy changed: added a new forced probe target",
0x00010018    "Using forced assign target now",
0x00010019    "First target with dscp added",
0x0001001a    "Using longest match target now",

```

## AVC-Export:PfR

```
0x0001001b "Last target with dscp removed",
0x0001001c "Couldn't monitor",
0x0001001d "Couldn't control",
0x0001001e "Application control on border router failed",
0x0001001f "Tried all protocols but couldn't control",
0x00010020 "Exclude prefix failed",
0x00010021 "ipflow_reset failed on %u borders",
0x00010022 "Couldn't exclude",
0x00010023 "Don't downgrade all entrances",
0x00010024 "Max downgrade",
0x00010025 "Can't select entrances",
0x00010026 "Unhandled OOP reason in Choose Exit",
0x00010027 "OOP, mode select-exit good",
0x00010028 "Couldn't find the best exit in all link groups",
0x00010029 "Couldn't find the best exit",
0x0001002a "Failed to control route",
0x0001002b "End of probing",
0x0001002c "Retry forced next hop",
0x0001002d "No status in prefix timeout",
0x0001002e "Couldn't choose exit in prefix timeout",
0x0001002f "Inconsistent view",
0x00010030 "Unable to send control message",
0x00010031 "NBAR id state updated",
0x00010032 "Controlled exit is not current",
0x00010033 "Exit mismatch",
0x00010034 "Controlled exit is not current for update",
0x00010035 "Unknown exit",
0x00010036 "New exit while INPOLICY",
0x00010037 "Couldn't control passive prefix in special mode",
0x00010038 "Remote stats not found",
0x00010039 "NBAR Internal interface added/removed",
0x0001003a "No Passive Data",
0x0001003b "Probe number of packets changed",
0x0001003c "Unknown"
```

### TC/RouteChange and OOP

```
0x00020000 "None",
0x00020001 "Delay",
0x00020002 "Loss",
0x00020003 "Unreachable",
0x00020004 "Cost",
0x00020005 "Utilization",
0x00020006 "Range",
0x00020007 "Random due to Tie",
0x00020008 "Monitor",
0x00020009 "Discover",
0x0002000a "Non-OER",
0x0002000b "Timer Expired",
0x0002000c "Inpolicy Found",
0x0002000d "Unable to probe",
0x0002000e "Jitter",
0x0002000f "MOS",
0x00020010 "RSVP recomp excl",
0x00020011 "RSVP recomp incl",
0x00020012 "Round-Robin due to Tie",
0x00020013 "unknown"
```

### Interface/Status

```
0x01000000 OER_STR_DOWN,
0x01000001 "Going Down",
0x01000002 "Init",
0x01000003 "Testing",
0x01000004 "Reset",
```

## AVC-Export:PfR

```
0x01000005 "Admin Down",
0x01000006 "Deleted",
0x01000007 "Unverified",
0x01000008 "Invalid",
0x01000009 OER_STR_UP,
0x0100000a ""
```

### Interface/OOP

```
0x01010000 "InPolicy",
0x01010001 "Cost OOP",
0x01010002 "Range OOP",
0x01010003 "Utilization OOP",
0x01010004 "Entrance Cost OOP",
0x01010005 "Entrance Range OOP",
0x01010006 "Entrance Utilization OOP",
0x01010007 "unknown",
```

## PfR NetFlow Export CLI

The configuration is the following:

```
flow exporter MYEXPORTER
 destination 10.151.1.131
 source Loopback0
 transport udp 9991
 export-protocol netflow-v9
 option interface-table timeout 300
 option sampler-table timeout 300
 option application-table timeout 300
!
!
pfr master
 export MYEXPORTER
!
```

To check the records exported by the router, use can use this show command:

```
R3#sh flow exporter templates
Flow Exporter MYEXPORTER:
```

[SNIP]

```
Client: Option TC Config (without protocol)
Exporter Format: NetFlow Version 9
Template ID      : 259
Source ID       : 0
Record Size     : 51
Template layout
```

Field	Type	Offset	Size
v9-scope system	1	0	4
ipv4 source address	8	4	4
ipv4 destination address	12	8	4



## AVC-Export:PfR

flow class wide	95	12	6	
transport source-port min	39012	18	2	
transport source-port max	39013	20	2	
transport destination-port min	39014	22	2	
transport destination-port max	39015	24	2	
package id	32775	26	2	
ipv4 source mask	9	28	1	
ipv4 destination mask	13	29	1	
ip dscp	195	30	1	
application name	96	31	20	

-----

Client: Option TC Config  
 Exporter Format: NetFlow Version 9  
 Template ID : 260  
 Source ID : 0  
 Record Size : 52  
 Template layout

Field	Type	Offset	Size
v9-scope system	1	0	4
ipv4 source address	8	4	4
ipv4 destination address	12	8	4
flow class wide	95	12	6
transport source-port min	39012	18	2
transport source-port max	39013	20	2
transport destination-port min	39014	22	2
transport destination-port max	39015	24	2
package id	32775	26	2
ipv4 source mask	9	28	1
ipv4 destination mask	13	29	1
ip protocol	4	30	1
ip dscp	195	31	1
application name	96	32	20

-----

Client: Option External Config  
 Exporter Format: NetFlow Version 9  
 Template ID : 261  
 Source ID : 0  
 Record Size : 179  
 Template layout

Field	Type	Offset	Size
v9-scope system	1	0	4
capacity	39016	4	8
rsvp bw pool	39008	12	8
max ingress bw	39018	20	8
max egress bw	39020	28	8
pfr br ipv4 address	39000	36	4
bgp community	39025	40	4
discard rollup count	39028	44	4
interface output snmp short	14	48	2
interface name	82	50	48
link group name	39024	98	48
flow sampler name	84	146	32
flow sampler algorithm export	49	178	1

-----

Client: Option Internal Config  
 Exporter Format: NetFlow Version 9  
 Template ID : 262  
 Source ID : 0  
 Record Size : 58  
 Template layout

## AVC-Export:PfR

Field	Type	Offset	Size
v9-scope system	1	0	4
pfr br ipv4 address	39000	4	4
interface input snmp short	10	8	2
interface name	82	10	48

Client: Option Policy Config  
 Exporter Format: NetFlow Version 9  
 Template ID : 263  
 Source ID : 0  
 Record Size : 150  
 Template layout

Field	Type	Offset	Size
v9-scope system	1	0	4
threshold	39003	4	4
variance	69	8	4
mos quality	42123	12	4
package id	32775	16	2
pfr status	39001	18	2
pfr priority	39004	20	2
access string	32789	22	80
link group name	39024	102	48

Client: Option Reason Config  
 Exporter Format: NetFlow Version 9  
 Template ID : 264  
 Source ID : 0  
 Record Size : 56  
 Template layout

Field	Type	Offset	Size
v9-scope system	1	0	4
reason id	39002	4	4
info string	32790	8	48

Client: Option Passive Update  
 Exporter Format: NetFlow Version 9  
 Template ID : 265  
 Source ID : 0  
 Record Size : 55  
 Template layout

Field	Type	Offset	Size
pfr br ipv4 address	39000	0	4
timestamp sys-uptime first	22	4	4
timestamp sys-uptime last	21	8	4
transport latency	67	12	4
data points	68	16	4
transport packet loss	65	20	4
transport unreachability	66	24	4
counter bytes	1	28	4
counter packets	2	32	4
counter flows	3	36	4
routing next-hop address ipv4	15	40	4
flow class wide	95	44	6
interface output snmp short	14	50	2
pfr status	39001	52	2
flow direction	61	54	1

## AVC-Export: PfR

```

-----
Client: Option Passive Performance
Exporter Format: NetFlow Version 9
Template ID   : 266
Source ID    : 0
Record Size   : 67
Template layout
  
```

Field	Type	Offset	Size
flow end	153	0	8
pfr br ipv4 address	39000	8	4
reason id	39002	12	4
counter packets dropped	37000	16	4
transport packets lost counter	37019	20	4
transport round-trip-time	37016	24	4
counter packets dropped permanent short	37001	28	4
transport packets lost counter permanen	37020	32	4
long-term round-trip-time	39006	36	4
ingress bw	39017	40	4
egress bw	39019	44	4
bgp community	39025	48	4
flow class wide	95	52	6
interface output snmp short	14	58	2
pfr status	39001	60	2
flow active timeout	36	62	2
flow direction	61	64	1
ip protocol	4	65	1
bgp prepend	39026	66	1

```

-----
Client: Option Active Update
Exporter Format: NetFlow Version 9
Template ID   : 267
Source ID    : 0
Record Size   : 58
Template layout
  
```

Field	Type	Offset	Size
pfr br ipv4 address	39000	0	4
transport latency	67	4	4
transport round-trip-time min	37052	8	4
transport round-trip-time max	37053	12	4
transport round-trip-time sum short	37050	16	4
transport unreachability	66	20	4
transport packet loss	65	24	4
variance	69	28	4
mos below	39007	32	4
mos total count	42124	36	4
counter server packets	24	40	4
counter packets	2	44	4
flow class wide	95	48	6
interface output snmp short	14	54	2
pfr status	39001	56	2

```

-----
Client: Option Active Performance
Exporter Format: NetFlow Version 9
Template ID   : 268
Source ID    : 0
Record Size   : 61
Template layout
  
```

Field	Type	Offset	Size
-------	------	--------	------

## AVC-Export:PfR

flow end	153	0	8	
pfr br ipv4 address	39000	8	4	
reason id	39002	12	4	
counter packets dropped	37000	16	4	
transport packets lost counter	37019	20	4	
transport round-trip-time	37016	24	4	
transport rtp jitter mean	37023	28	4	
mos worst 100	42115	32	4	
counter packets dropped permanent short	37001	36	4	
transport packets lost counter permanen	37020	40	4	
long-term round-trip-time	39006	44	4	
flow class wide	95	48	6	
interface output snmp short	14	54	2	
pfr status	39001	56	2	
flow active timeout	36	58	2	
ip protocol	4	60	1	

-----  
Client: Option External Update  
Exporter Format: NetFlow Version 9  
Template ID : 269  
Source ID : 0  
Record Size : 64  
Template layout

Field	Type	Offset	Size
egress bw long	39019	0	8
ingress bw long	39017	8	8
kth rollup bw	39023	16	8
rsvp bw pool	39008	24	8
capacity	39016	32	8
pfr br ipv4 address	39000	40	4
reason id	39002	44	4
counter flows	3	48	4
counter bytes rate per-flow	37028	52	4
counter bytes rate per-flow min	37029	56	4
interface output snmp short	14	60	2
pfr status	39001	62	2

-----  
Client: Option Internal Update  
Exporter Format: NetFlow Version 9  
Template ID : 270  
Source ID : 0  
Record Size : 12  
Template layout

Field	Type	Offset	Size
pfr br ipv4 address	39000	0	4
reason id	39002	4	4
interface input snmp short	10	8	2
pfr status	39001	10	2

-----  
Client: Option TC Event  
Exporter Format: NetFlow Version 9  
Template ID : 271  
Source ID : 0  
Record Size : 35  
Template layout

Field	Type	Offset	Size
flow end	153	0	8
pfr br ipv4 address	39000	8	4

## AVC-Export:PfR

reason id	39002	12	4	
bgp community	39025	16	4	
flow class wide	95	20	6	
interface output snmp short	14	26	2	
pfr status	39001	28	2	
flow active timeout	36	30	2	
flow direction	61	32	1	
ip protocol	4	33	1	
bgp prepend	39026	34	1	

-----

Client: Option Cost  
 Exporter Format: NetFlow Version 9  
 Template ID : 272  
 Source ID : 0  
 Record Size : 48  
 Template layout

	Field		Type		Offset		Size	
	flow end		153		0		8	
	ingress rollup bw		39021		8		8	
	egress rollup bw		39022		16		8	
	kth rollup bw		39023		24		8	
	pfr br ipv4 address		39000		32		4	
	bw fee		39011		36		4	
	interface output snmp short		14		40		2	
	pfr status		39001		42		2	
	flow left time		39009		44		2	
	bw percentage		39010		46		2	

-----

Client: Option BR Alert  
 Exporter Format: NetFlow Version 9  
 Template ID : 273  
 Source ID : 0  
 Record Size : 6  
 Template layout

	Field		Type		Offset		Size	
	pfr br ipv4 address		39000		0		4	
	pfr status		39001		4		2	

-----

Client: Option MC Alert  
 Exporter Format: NetFlow Version 9  
 Template ID : 274  
 Source ID : 0  
 Record Size : 10  
 Template layout

	Field		Type		Offset		Size	
	flow end		153		0		8	
	pfr status		39001		8		2	

R3#