Transport Network Performance Metrics

USER DESCRIPTION

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1 Overview of LTE RBS Transport Interfaces

This section describes the RBS transport interfaces for the eNodeB.

The LTE RBS transport interfaces are implemented on the Digital Unit (DU) and micro RBS (mRBS). There are two different DU versions: the Digital Unit LTE (DUL) and the Digital Unit Service (DUS). There are two different mRBS versions: the RBS 6302 and the RBS 6501. The DUL and RBS 6501 are equipped with two Gigabit Ethernet (GE) physical interfaces labeled TN A and TN B. The DUS and RBS 6302 are equipped with three Gigabit Ethernet (GE) physical interfaces labeled TN A, TN B and TN C.

The interface ports and configurations are described in Table 1.

Table 1 DU and mRBS Transport Port Configurations

Interface	Description	Required Configuration
TN A	Electrical Ethernet interface equipped with an RJ-45 female connector	To select the TN A electrical interface, the `portNo` attribute of the `GigabitEthernet` MO(1) instance must be configured to 2.
TN B	Optical Ethernet interface equipped with a slot for a compatible optical SFP(2) module	To select the TN B optical interface, the `portNo` attribute of the `GigabitEthernet` MO instance must be configured to 1.
TN C	Optical Ethernet interface equipped with a slot for a compatible optical SFP module	To select the TN C optical interface, the `portNo` attribute of the `GigabitEthernet` MO instance must be configured to 3.

(1) Managed Object
(2) Small Form-factor Pluggable

Only one GE transport network port can be activated through configuration. The `portNo` attribute indicates the active port.

The statistics associated with the active GE interface are denoted as Link1 counters regardless of the configuration of the `portNo` attribute.

An IP interface is the logical representation of a connection to the IP network (identified by a particular IP network address or address prefix). It is connected to a GE interface. An IP interface is also defined as the interface between an IP access host and a GE interface. An IP interface may contain multiple IP access hosts. Each IP access host is identified with an IPv4 or IPv6 host address. The S1-U interface refers to IP host acting as the S1-U endpoint within an IP interface.

A minimum of two host IP addresses is required for each DU or mRBS. The first IP address is intended for O&M traffic while the other IP address is for the remaining traffic (S1, X2 and synchronization over IP). This pair of host addresses can be either defined in the same IP interface (subnet) or in different IP interfaces (subnet).

Virtual Local Area Network (VLAN) configuration is required when deploying more than one IP logical interface on the same GE transport network port. When applicable, each IP interface must be configured on a separate VLAN.

The DU and mRBS support the following Internet Protocol version 4 (IPv4) logical interface configurations:

- One IPv4 interface
  - Example: O&M and traffic host IP addresses defined in the same IP interface (subnet)
- Two IPv4 interfaces
  - Example: one interface for S1, X2 and synchronization traffic and one interface for O&M traffic on two separate VLANs
  - Example: one internal interface for S1, X2, synchronization and O&M traffic and one external interface for IKEv2 and IP Encapsulating Security Payload (ESP) traffic
- Three IPv4 interfaces
  - Example: one interface for S1 and X2 traffic, one interface for synchronization traffic and one interface for O&M traffic on three separate VLANs
  - Example: one internal interface for S1, X2 and synchronization traffic, one internal interface for O&M traffic and one external interface for IKEv2 and IP Encapsulating Security Payload (ESP) traffic

The DU and mRBS support the following Internet Protocol version 6 (IPv6) logical interface configurations:

- One IPv6 interface
  - Example: O&M and traffic host IP addresses defined in the same IP interface (subnet)
- Two IPv6 interfaces
  - Example: one interface for S1, X2 and synchronization traffic and one interface for O&M traffic on two separate VLANs

2 Transport Network Performance Metrics

The DUL, DUS and mRBS support the same transport-related counters and performance metrics. The objective is to have identical counter implementation on all Digital Units. However counter implementation may differ between the DUL, DUS and mRBS in a few cases mainly due to the differences in hardware capabilities. The differences are highlighted when applicable.

The transport network performance metrics are organized in the categories listed in Table 2.

Table 2 Categories of Transport Network Performance Metrics

Category	Description	Example
Singleton performance metrics	Metric that provides a single observation or measurement Singleton performance metrics are used to produce statistical performance metrics calculated over 1 hour, 24 hours, or another defined time period. Singleton performance metrics are divided into the following groups: • GE interface singleton performance metrics • IPv4[1] interface singleton performance metrics • IPv6[2] interface singleton performance metrics • Traffic scheduler singleton performance metrics • S1/X2 control plane interface singleton performance metrics • IPSec tunnel singleton performance metrics	A single instance of the 15-minute average usage on a GE link in the receive direction is defined as a singleton metric. Singleton performance metrics may also be used for more detailed reporting showing the performance of the RBS during the busy hours.

Table 2   Categories of Transport Network Performance Metrics

Category	Description	Example
Sample performance metrics	Metric derived from a given singleton metric by combining a number of instances A sample performance metric is a sequence of singleton metrics measured over a period of time.	An hour of measurements made at regular intervals of 15 minutes is defined as sample of GE interface average usage.
Statistical performance metrics	Metric derived from a given sample metric by computing statistics of the values defined by the singleton metric on the sample The statistical performance metrics may be captured in daily reports showing an overall performance summary for each LTE RBS.	The maximum of all 15-minute average usage values on a sample defined as a statistical metric.

(1) Internet Protocol Version 4
(2) Internet Protocol Version 6

IETF specification *Framework for IP Performance Metrics (RFC 2330)* provides more information definitions.

The GE interface singleton performance metrics are described in Section 3 on page 7 . The IPv4 interface singleton performance metrics are described in Section 4 on page 11. The IPv6 interface singleton performance metrics are described in Section 5 on page 31. The traffic scheduler singleton performance metrics are described in Section 6 on page 49. The S1/X2 control interface singleton performance metrics are described in Section 7 on page 53.

2.1 Recommendations and Considerations

The recommended statistical metrics for the LTE RBS are described in Section 9 on page 71.

It is recommended to configure a TWAMP responder on the RBS and deploy a TWAMP controller (for example, IP Probe) at the main site to monitor the one-way packet loss and delay through the backhaul network. For more information about TWAMP, see *Two-Way Active Measurement Protocol Responder*.

It is recommended to limit the total number of IP flow monitors to 1,000 instances when the network is using the Ericsson Network IQ Statistics (ENIQ Stats) server (rack, single-blade or multi-blade server). This recommendation is valid for all IP flow sampling interval values. ENIQ Stats will continue to process counters if more than 1000 IP flow monitors are deployed but ENIQ performance is not guaranteed beyond this limit. IP flow monitors are supported only on the DUS and mRBS. For more information about IP flow monitors, see *IP Flow Monitoring*.

Transport-related counters are not active and are not collected to XML file by default. The configuration of a user-defined statistic scanner is required to activate the writing of measurement data into counters. This is done by configuring a statistical subscription profile at the OSS or by directly configuring a statistic scanner through the AMOS command line interface. Transport-related counters and their respective values can be displayed in real-time through the AMOS command line interface when a statistic scanner for those counters is in active state. For more information about statistic scanners and user-defined statistical subscription profiles, see *PMS Subscription Profiles and Performance Monitoring User Guide*. For more information about AMOS CLI interface, see the OSS-RC document *Advanced MO Scripting, User Guide*.

It is recommended to activate and collect all eNB-related transport counters via one or more statistic scanners or a statistical subscription profile. The RBS activates and collects all active instances of a transport counter present in a statistical subscription profile. If a counter is included in a profile but is not defined on the RBS, the counter is not written to the XML file. The transport counters provided in Table 3 are required to detect transport errors, discards and abnormal conditions.

Table 3 RBS-Detected Transport Error and Discard Counters

MOC	Counter
GigaBitEthernet	• pmIfInErrorsLink1 • pmIfInUnknownProtosLink1 • pmIfInDiscardsLink1
IpInterface	• pmIfStatsIpInHdrErrors • pmIfStatsIpAddrErrors • pmIfStatsIpUnknownProtos • pmInDiscPolicy • pmIfStatsIpInDiscards
Ipv6Interface	• pmIpIfStatsInHdrErrors • pmIpIfStatsInAddrErrors • pmIpIfStatsInUnknownProtos • pmIpIfStatsInDiscards • pmIpIfStatsReasmFails • pmUdpIfStatsInError

Table 3 RBS-Detected Transport Error and Discard Counters

MOC	Counter
IpAccessHostEt	• pmIpInHdrErrors • pmIpInAddrErrors • pmIpInUnknownProtos • pmIpInDiscards • pmIpReasmFails • pmUdpInErrors
IpSecTunnel	• pmInDiscAReFail • pmInDiscDec • pmInDiscIntCh • pmInDiscNoSa
Sctp	• pmSctpStatChecksumErrorCounter • pmSctpInNoPorts • pmSctpInErrors • pmSctpStatRecChunksDropped

3 GE Interface Singleton Performance Metrics

The GE interface singleton performance metrics consist of the following:

- 15-minutes ingress packet error ratio (%)
- 15-minute ingress average usage (Mbps)
- 15-minute egress average usage (Mbps)

The metrics are calculated from measurements made at the Ethernet Media access control (MAC) sublayer of the eNB TN interface. The counters used for the GE interface singleton performance metrics are accessible under the GigabitEthernet MO class described in `class GigaBitEthernet`.

3.1 15-Minute Ingress Packet Error Ratio

This singleton metric computes the ingress Ethernet-layer packet or frame error ratio for a GE link over a 15-minute reporting interval. It is the percentage of Ethernet-layer input packets/frames received with errors (including packets or frames of an unknown or unsupported protocol) from any source that are discarded by the RBS during a reporting period. The port number identifies the active GE interface.

The ingress Ethernet-layer packet/frame error ratio in percentage for a specific GE interface is calculated using Equation 1.

$$100 \times \frac{(A + B + C)}{(A + B + C + D + E + F + (G \times 1000))}$$

Equation 1 GE Interface 15-Minute Ingress Packet Error Ratio (%)

Where:

A	*`pmDot1qTpVlanPortInDiscardsLink1`*
B	*`pmIfInErrorsLink1`*
C	*`pmIfInUnknownProtosLink1`*
D	*`pmIfInDiscardsLink1`*
E	*`pmIfInBroadcastPktsLink1`* including ARP packets
F	*`pmIfInMulticastPktsLink1`*
G	*`pmifInUcastPktsLink1`*

3.2 15-Minute Ingress Average Usage

This singleton metric computes the average ingress Ethernet-layer usage for a GE link over a 15-minute reporting interval. It is the number of Ethernet-layer bits (including Ethernet header, VLAN tag, frame check sequence, preamble, and inter-frame gap) received in unicast, multicast, and broadcast packets (frames) from any source during a reporting interval divided by the reporting interval. It includes packets (frames) received with errors. The port number identifies the active GE interface.

The ingress Ethernet-layer average usage in Mbps for a specific GE interface is calculated using Equation 2.

$$\frac{[[(A \times 2147483648) + B] + [(C + D + E + F + G + H + (I \times 1000)) \times 20]] \times 8}{1000000 \times ROP}$$

Equation 2 GE Interface 15-Minute Ingress Average Usage (Mbps)

Where:

A	*pmIfInOctetsLink1Hi*
B	*pmIfInOctetsLink1Lo*
C	*pmDot1qTpVlanPortInDiscardsLink1*
D	*pmIfInErrorsLink1*
E	*pmIfInUnknownProtosLink1*
F	*pmIfInDiscardsLink1*
G	*pmIfInBroadcastPktsLink1* including Address Resolution Protocol (ARP) packets
H	*pmIfInMulticastPktsLink1*
I	*pmifInUcastPktsLink1*

Result Output Period (ROP)900 s

Equation 2 uses the sum of the Ethernet bits received on the link (excluding preamble and inter-frame gap) and the number of bits associated with the preamble and received Inter-Frame Gap (IFG). The `pmIfInOctetsLink1Hi` and `pmIfInOctetsLink1Lo` counters include the Ethernet header, VLAN tag, and Frame Check Sequence (FCS) but do not include the preamble and IFG.

For the purpose of GE link usage monitoring, the preamble (8 bytes) and IFG (12 bytes) are overhead that must be accounted for by multiplying the total number of received frames by the number of preamble plus IFG octets (8+12=20 octets).

The operator can also compute the ingress average GE link use in percentage by dividing the ingress average usage by 1,000.

3.3 15-Minute Egress Average Usage

This singleton metric computes the average egress Ethernet-layer usage for a GE link over a 15-minute reporting interval. It is the number of Ethernet-layer bits (including Ethernet header, VLAN tag, frame check sequence, preamble, and IFG) transmitted in unicast, multicast, and broadcast packets (frames) to any destination during a reporting interval divided by the reporting interval. The port number identifies the active GE interface.

The egress Ethernet-layer link average usage in Mbps for a specific GE interface is calculated using Equation 3.

$$\frac{[[(A \times 2147483648) + B] + [((C + D + (E \times 1000)) - (F + G)) \times 20]] \times 8}{1000000 \times ROP}$$

Equation 3 GE Interface 15-Minute Egress Average Usage (Mbps)

Where:

A	*pmIfOutOctetsLink1Hi*
B	*pmIfOutOctetsLink1Lo*
C	*pmIfOutBroadcastPktsLink1* including ARP packets
D	*pmIfOutMulticastPktsLink1*
E	*pmifOutUcastPktsLink1*
F	*pmIfOutErrorsLink1*
G	*pmIfOutDiscardsLink1*
ROP	900 s

Equation 3 uses the sum of the Ethernet bits transmitted on the link (excluding preamble and IFG) and the number of bits associated with the preamble and received IFG. The `pmIfOutOctetsLink1Hi` and `pmIfOutOctetsLink1Lo` counters include the Ethernet header, VLAN tag, and FCS but do not include the preamble and IFG.

For the purpose of GE link usage monitoring, the preamble (8 bytes) and IFG (12 bytes) are overhead that must be accounted for by multiplying the total number of transmitted frames by the number of preamble plus IFG octets (8+12=20 octets).

The operator can also computes the egress average GE link use in percentage by dividing the egress average usage by 1,000.

4 IPv4 Interface Singleton Performance Metrics

IPv4 interface singleton performance metrics consist of the following:

- 15-minute ingress packet discard ratio (%)
- 15-minute egress packet discard ratio (%)
- 15-minute IP-layer ingress average usage (Mbps)
- 15-minute IP-layer egress average usage (Mbps)
- 15-minute Ethernet-layer ingress average usage (Mbps)
- 15-minute Ethernet-layer egress average usage (Mbps)
- IP-layer ingress DSCP group usage (Mbps)
- IP-layer egress DSCP group usage (Mbps)
- Ethernet-layer ingress DSCP group usage (Mbps)
- Ethernet-layer egress DSCP group usage (Mbps)
- 15-minute IP-layer ingress multicast average usage (Mbps)
- 15-minute IP-layer egress multicast average usage (Mbps)
- 15-minute Ethernet-layer ingress multicast average usage (Mbps)
- 15-minute Ethernet-layer egress multicast average usage (Mbps)
- IP-layer ingress IP flow usage (Mbps)
- IP-layer egress IP flow usage (Mbps)
- Ethernet-layer ingress IP flow usage (Mbps)
- Ethernet-layer egress IP flow usage (Mbps)

At the exception of the ingress packet discard ratio, the metrics are calculated from measurements made at the IPv4 sublayer of the eNB TN interface. The ingress packet discard metric also includes measurements from the UDP and GTP-U sublayers. The counters used are described in *class IpInterface* and *class IPAccessHostEt* respectively.

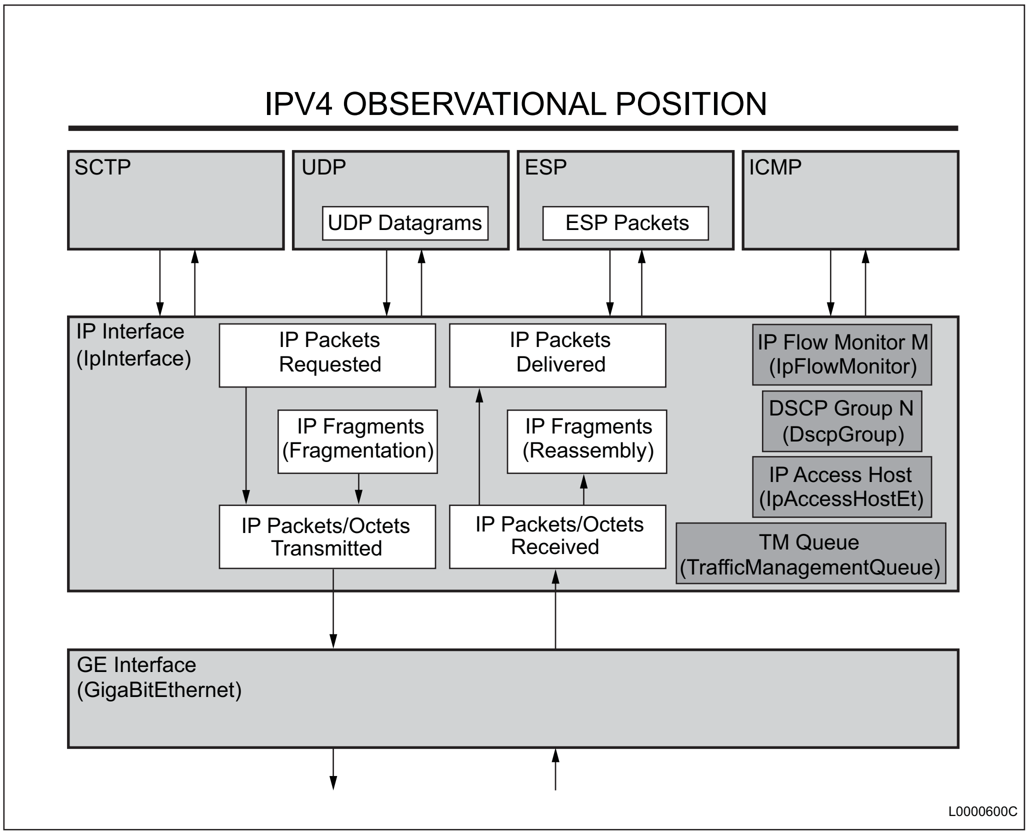

Figure 1   IPv4 Observational Position

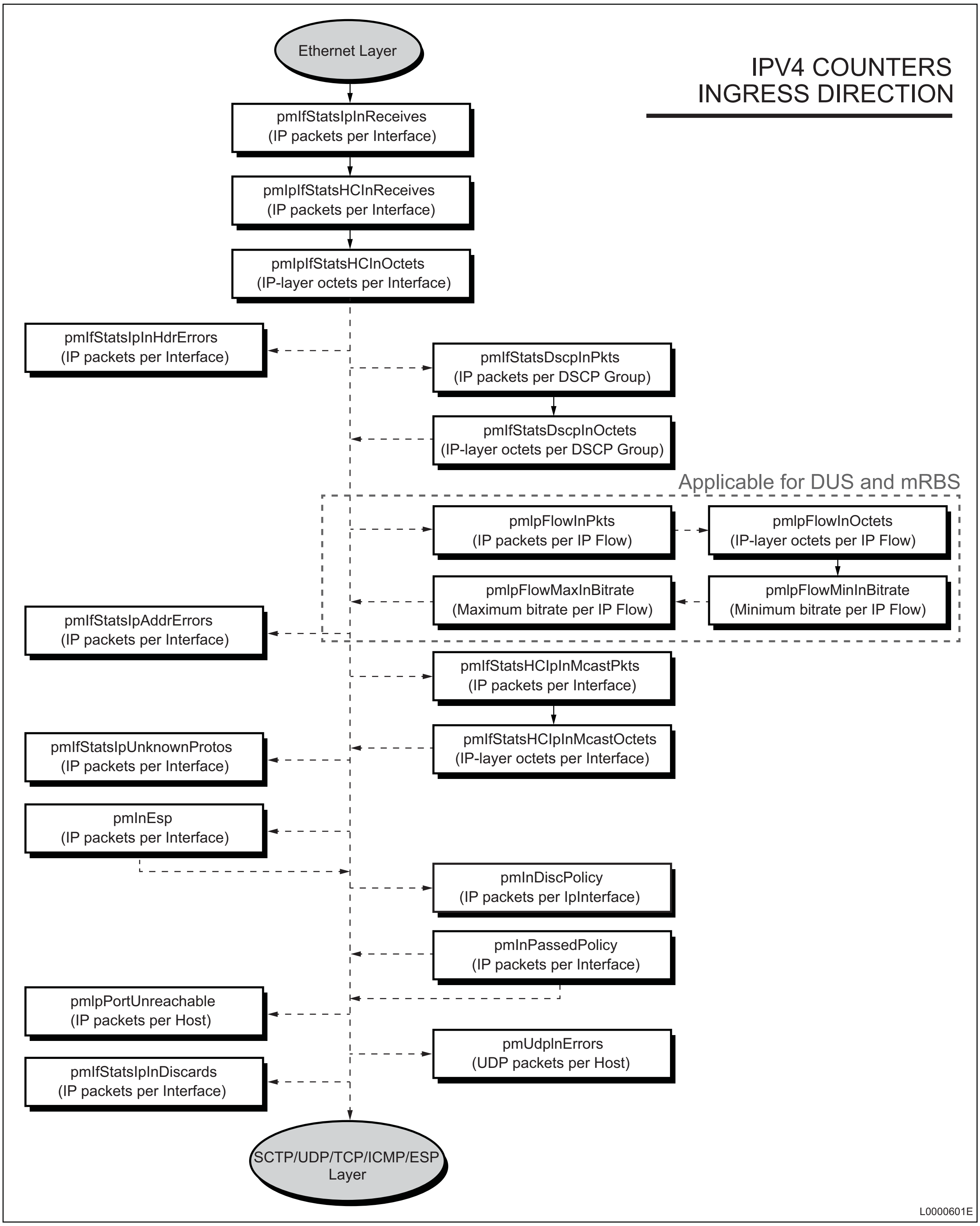

Figure 2 IPv4 Counters Ingress Direction

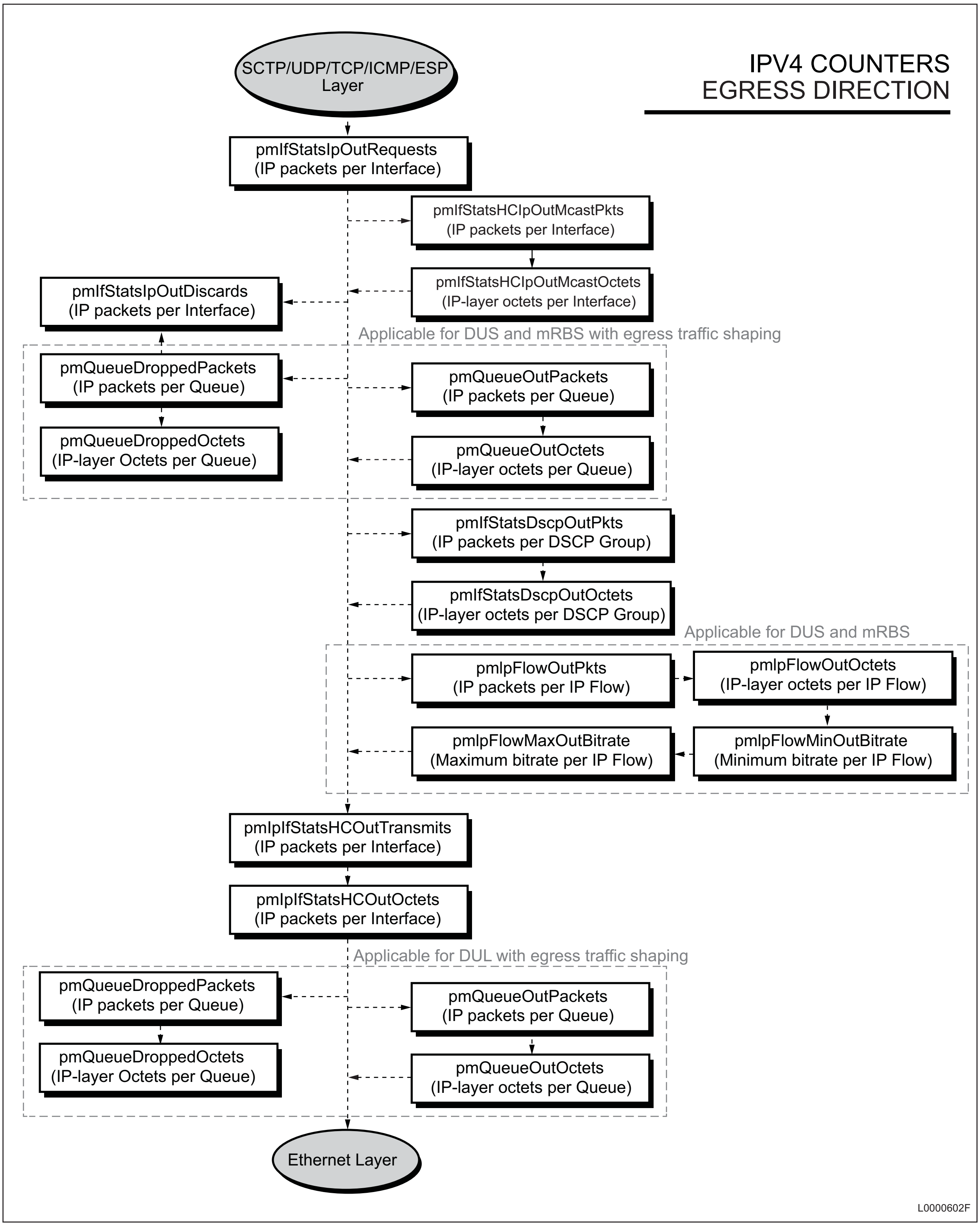

Figure 3 IPv4 Counters Egress Direction

4.1 15-Minute Ingress Packet Discard Ratio

This singleton metric computes the ingress IP-layer packet discard ratio for an IPv4 interface on a GE link over a 15-minute reporting interval. It is the percentage of IP-layer input packets received from any source for which no problem was encountered to prevent delivery to a higher-layer protocol but were discarded by the RBS during a reporting period (including IP packets discarded due to a policy rule or reassembly failure, SCTP/UDP packets discarded due to unresolved port, UDP packets discarded due to UDP buffer overflow, and TWAMP test packets discarded due to high rate). The subnet prefix identifies the IPv4 interface.

The ingress IP-layer packet discard ratio in percentage for a specific IPv4 interface is calculated using Equation 4.

$$100 \times \frac{A + B + C + D + E}{(F - (G + H + I))}$$

Equation 4   IPv4 Interface 15-Minute Ingress Packet Discard Ratio (%)

Where:

A	*`pmIfStatsIpInDiscards`*
B	*`pmInDiscPolicy`*
C	Roundup(*`pmIpReasmFails`*/2.0)
D	*`pmIpPortUnreachable`*
E	*`pmUdpInErrors`*
F	*`pmIpIfStatsHCInReceives`*
G	*`pmIfStatsIpAddrErrors`*
H	*`pmIfStatsIpInHdrErrors`*
I	*`pmIfStatsIpUnknownProtos`*

The value of the `pmIfStatsIpInDiscards` IPv4 interface counter is included in the equation because it is incremented when the ingress TWAMP test packet rate is too high.

The `pmIpReasmFails`, `pmIpPortUnreachable`, and `pmUdpInErrors` counters are counters associated with the IP access host linked to the IPv4 interface responsible for terminating the S1, X2, and SoIP traffic. The IP access host is identified with an IP address that belongs to the subnet prefix of the IPv4 interface. The `pmIpReasmFails`, `pmIpPortUnreachable`, and `pmUdpInErrors` counters are not used for the IPv4 interface dedicated to Operation and Maintenance (O&M) traffic.

The `pmUdpInErrors` IP access host counter is incremented when the ingress UDP queue is full. It is also incremented when UDP packets are received with errors including incorrect UDP checksum.

`Roundup(pmIpReasmFails/2.0)` is `pmIpReasmFails` rounded up and divided by 2 to 0 decimal places. `pmIpReasmFails` counts the number of failures detected by the IPv4 reassembly algorithm.

4.2 15-Minute Egress Packet Discard Ratio

This singleton metric computes the egress IP-layer packet discard ratio for an IPv4 interface on a GE link over a 15-minute reporting interval. It is the percentage of IP-layer output packets for which no problem was encountered to prevent their transmission but were discarded by the RBS during a reporting period. The subnet prefix identifies the IPv4 interface.

This metric does not consider packets discarded because they needed to be fragmented but could not be (for example due to “Don't Fragment” flag set to 1).

The egress IP-layer packet or frame discard ratio in percentage for a specific IPv4 interface is calculated using Equation 5.

$$100 \times \frac{A}{(A + B)}$$

Equation 5 IPv4 Interface 15-Minute Egress Packet Discard Ratio (%)

Where:

A	*pmIfStatsIpOutDiscards*
B	*pmIpIfStatsHCOutTransmits*

When traffic shaping is configured on the DUS, the above singleton metric is valid. The `pmIfStatsIpOutDiscards` counter is incremented when packets are dropped due to lack of buffer space when the DUS IPv4 interface is associated with the egress traffic shaping feature.

When traffic shaping is configured on the DUL, it is recommended to ignore the above singleton metric and use the traffic scheduler egress packet discard ratio. The traffic scheduler singleton performance metrics are described in Section 6 on page 49. The `pmIfStatsIpOutDiscards` counter is not incremented when packets are dropped due to lack of buffer space if the DUL IPv4 interface is associated with the egress traffic shaping feature.

The IPv4 interface is associated with the egress traffic shaping feature when the `trafficScheduleRef` attribute is configured with a reference to a `TrafficScheduler` MO instance.

4.3 15-Minute IP-Layer Ingress Average Usage

This singleton metric computes the average ingress IP-layer usage for an IPv4 interface on a GE link. It is the number of IP-layer bits received in IPv4 unicast, multicast, and broadcast packets from any IPv4 source during a reporting interval divided by the reporting interval. It includes ICMPv4 packets, IPv4 packets received with errors, and IPv4 packets that are discarded due to policy. The subnet prefix identifies the IPv4 interface.

The ingress IP-layer average usage in Mbps for a specific IPv4 interface is calculated using Equation 6.

$$\frac{A \times 8}{1000000 \times ROP}$$

Equation 6 IPv4 Interface 15-Minute IP-Layer Ingress Average Usage (Mbps)

Where

A `pmIpIfStatsHCInOctets`

ROP 900 s

The operator can also calculate the ingress IP-layer average usage over multiple IP interfaces by adding the contribution from each interface.

4.4 15-Minute IP-Layer Egress Average Usage

This singleton metric computes the average egress IP-layer usage for an IPv4 interface on a GE link. It is the number of IP-layer bits supplied to the egress traffic shaping function (when applicable for DUL) or supplied directly to the Ethernet layer for transmission in IPv4 unicast, multicast, and broadcast packets to any IPv4 destination during a reporting interval divided by the reporting interval. It includes ICMPv4 packets. The subnet prefix identifies the IPv4 interface.

The egress IP-layer average usage in Mbps for a specific IPv4 interface is calculated using Equation 7.

$$\frac{A \times 8}{1000000 \times ROP}$$

Equation 7 IPv4 Interface 15-Minute IP-Layer Egress Average Usage (Mbps)

Where

A `pmIpIfStatsHCOutOctets`

ROP 900 s

The operator can also calculate the egress IP-layer average usage over multiple IP interfaces by adding the contribution from each interface.

When traffic shaping is configured on the DUS, the above singleton metric is valid.

When traffic shaping is configured on the DUL, it is recommended to use the traffic scheduler IP-layer egress average usage. The traffic scheduler singleton performance metrics are described in Section 6 on page 49.

The IPv4 interface is associated with the egress traffic shaping feature when the `trafficScheduleRef` attribute is configured with a reference to a `TrafficScheduler` MO instance.

4.5 15-Minute Ethernet-Layer Ingress Average Usage

This singleton metric computes the average ingress Ethernet-layer usage for an IPv4 interface on a GE link. It is the number of Ethernet-layer bits received in IPv4 unicast, multicast, and broadcast packets from any IPv4 source during a reporting interval divided by the reporting interval. It includes ICMPv4 packets, IPv4 packets received with errors, and IPv4 packets that are discarded due to policy. It does not include non-IPv4 traffic like ARP packets for IPv4 interfaces. The subnet prefix identifies the IPv4 interface.

The ingress Ethernet-layer average usage in Mbps for a specific IPv4 interface is calculated using Equation 8.

$$\frac{(A \times 8) + (B \times Ethernet\ \ Overhead)}{1000000 \times ROP}$$

Equation 8 IPv4 Interface 15-Minute Ethernet-Layer Ingress Average Usage (Mbps)

Where

A *`pmIpIfStatsHCInOctets`*

B *`pmIpIfStatsHCInReceives`*

Ethernet Overhead

Number of Ethernet bits received on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits), and inter-frame gap (96 bits)

The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

ROP 900 s

The operator can also calculate the ingress Ethernet-layer average usage over multiple IP interfaces by adding the contribution from each interface.

4.6 15-Minute Ethernet-Layer Egress Average Usage

This singleton metric computes the average egress Ethernet-layer usage for an IPv4 interface on a GE link. It is the number of Ethernet-layer bits supplied to the egress traffic shaping function (when applicable for DUL) or supplied directly to the Ethernet layer for transmission in IPv4 unicast, multicast, and broadcast packets to any IPv4 destination during a reporting interval divided by the reporting interval. It includes ICMPv4 packets. It does not include non-IPv4 traffic like ARP packets for IPv4 interfaces. The subnet prefix identifies the IPv4 interface.

The egress Ethernet-layer average usage in Mbps for a specific IPv4 interface is calculated using Equation 9.

$$\frac{(A \times 8) + (B \times Ethernet\ Overhead)}{1000000 \times ROP}$$

Equation 9 IPv4 Interface 15-Minute IP-Layer Egress Average Usage (Mbps)

Where

A *pmIpIfStatsHCOutOctets*

B *pmIpIfStatsHCOutTransmits*

Ethernet Overhead

Number of Ethernet bits received on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits), and inter-frame gap (96 bits)

The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

ROP 900 s

The operator can also calculate the egress Ethernet-layer average usage over multiple IP interfaces by adding the contribution from each interface.

When traffic shaping is configured on the DUS, the above singleton metric is valid.

When traffic shaping is configured on the DUL, it is recommended to use the traffic scheduler Ethernet-layer egress average usage. The traffic scheduler singleton performance metrics are described in Section 6 on page 49.

The IPv4 interface is associated with the egress traffic shaping feature when the `trafficScheduleRef` attribute is configured with a reference to a `TrafficScheduler` MO instance.

4.7 IP-Layer Ingress DSCP Group Usage

This singleton metric provides the ingress IP-layer DSCP aggregation group bandwidth usage for an IPv4 interface on a GE link. It is the number of IP-layer bits received in IP unicast, multicast and broadcast packets from any IP source using one of the DSCP values in a DSCP aggregation group during a configurable measurement period (samplingInterval). It includes IP packets received with errors and IP packets that are discarded due to policy. The subnet prefix identifies the IP interface instance. The DSCP values identify the DSCP group.

The IP-layer ingress bandwidth instantaneous usage for a specific DSCP aggregation group on a specific IP interface is calculated using Equation 10.

$$\frac{A \times 8}{1000000 \times samplingInterval}$$

Equation 10 IPv4 Interface IP-Layer Ingress DSCP Group Usage (Mbps)

Where

A *pmIfStatsDscpInOctets*

samplingInterval 10, 30, 60 or 300 s

The operator is responsible to configure the appropriate number of DSCP aggregation groups and the DSCP codepoint values for each DSCP aggregation group. By default, the system is not configured with any DSCP aggregation group. The operator can also calculate the IP-layer ingress QOS instantaneous usage over multiple interfaces.

4.8 IP-Layer Egress DSCP Group Usage

This singleton metric provides the egress IP-layer DSCP aggregation group bandwidth usage for an IPv4 interface on a GE link. It is the number of IP-layer bits supplied to the egress traffic shaping function (when applicable for DUL) or supplied directly to the Ethernet layer for transmission in IP unicast, multicast and broadcast packets to any IP destination using one of the DSCP values in a DSCP aggregation group during a configurable measurement period (samplingInterval). The subnet prefix identifies the IP interface instance. The DSCP values identify the DSCP group.

The IP-layer egress bandwidth instantaneous usage for a specific DSCP aggregation group on a specific IP interface is calculated using Equation 11.

$$\frac{A \times 8}{1000000 \times samplingInterval}$$

Equation 11 IPv4 Interface IP-Layer Egress DSCP Group Usage (Mbps)

Where

A *pmIfStatsDscpOutOctets*

samplingInterval 10, 30, 60 or 300 s

The operator is responsible to configure the appropriate number of DSCP aggregation groups and the DSCP codepoint values for each DSCP aggregation group. By default, the system is not configured with any DSCP aggregation group. The operator can also calculate the IP-layer egress QOS instantaneous usage over multiple interfaces.

The `pmIfStatsDscpOutOctets` counter represents the IP octets supplied to the Ethernet layer for transmission when the DUS IPv4 interface is configured with/without traffic shaping or when the DUL IPv4 interface is configured without traffic shaping. The `pmIfStatsDscpOutOctets` counter represents the IP octets supplied to the egress traffic shaping function when the DUL IPv4 interface is configured with traffic shaping.

4.9 Ethernet-Layer Ingress DSCP Group Usage

This singleton metric provides the ingress Ethernet-layer DSCP aggregation group bandwidth usage for an IPv4 interface on a GE link. It is the number of Ethernet-layer bits (including the Ethernet header, VLAN tag, frame check sequence, preamble and inter-frame gap) received in IP unicast, multicast and broadcast packets from any IP source using one of the DSCP values in a DSCP aggregation group during a configurable measurement period (samplingInterval). It includes IP packets received with errors and IP packets that are discarded due to policy. It does not include non-IP traffic like ARP packets. The subnet prefix identifies the IP interface instance. The DSCP values identify the DSCP group.

The Ethernet-layer ingress bandwidth instantaneous usage for a specific DSCP aggregation group on a specific IP interface is calculated using Equation 12

$$\frac{(A \times 8) + (B \times Ethernet\,Overhead)}{1000000 \times samplingInterval}$$

Equation 12 IPv4 Interface Ethernet-Layer Ingress DSCP Group Usage (Mbps)

Where

A *pmIfStatsDscpInOctets*

B *pmIfStatsDscpInPkts*

Ethernet Overhead

The amount of Ethernet bits received on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits) and inter-frame gap (96 bits). The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

samplingInterval 10, 30, 60 or 300 s

The operator is responsible to configure the appropriate number of DSCP aggregation groups and the DSCP codepoint values for each DSCP aggregation group. By default, the system is not configured with any DSCP aggregation group. The operator can also calculate the Ethernet-Layer ingress QOS instantaneous usage over multiple IP interfaces.

4.10 Ethernet-Layer Egress DSCP Group Usage

This singleton metric provides the ingress Ethernet-layer DSCP aggregation group bandwidth usage for an IPv4 interface on a GE link. It is the number of Ethernet-layer bits supplied to the egress traffic shaping function (when applicable for DUL) or supplied directly to the Ethernet layer for transmission in IP unicast, multicast and broadcast packets to any IP destination using one of the DSCP values in a DSCP aggregation group during a configurable measurement period (samplingInterval). The subnet prefix identifies the IP interface instance. The DSCP values identify the DSCP group.

The Ethernet-layer egress bandwidth instantaneous usage for a specific DSCP aggregation group on a specific IP interface is calculated using Equation 13

$$\frac{(A \times 8) + (B \times Ethernet\,Overhead)}{1000000 \times samplingInterval}$$

Equation 13 IPv4 Interface Ethernet-Layer Egress DSCP Group Usage (Mbps)

Where

A *pmIfStatsDscpOutOctets*

B *pmIfStatsDscpOutPkts*

Ethernet Overhead

The amount of Ethernet bits transmitted on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits) and inter-frame gap (96 bits). The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

samplingInterval 10, 30, 60, 300 s

The operator is responsible to configure the appropriate number of DSCP aggregation groups and the DSCP codepoint values for each DSCP aggregation group. By default, the system is not configured with any DSCP aggregation group. The operator can also calculate the Ethernet-layer egress QOS instantaneous usage over multiple interfaces.

The `pmIfStatsDscpOutOctets` counter represents the IP octets supplied to the Ethernet layer for transmission when the DUS IPv4 interface is configured with/without traffic shaping or when the DUL IPv4 interface is configured without traffic shaping. The `pmIfStatsDscpOutOctets` counter represents the IP octets supplied to the egress traffic shaping function when the DUL IPv4 interface is configured with traffic shaping.

4.11 15-Minute IP-Layer Ingress Multicast Average Usage

This singleton metric computes the average ingress IP-layer multicast usage for an IPv4 interface on a GE link. It is the number of IP-layer bits received in IPv4 multicast packets from multicast groups the RBS has joined or is listening to during a reporting interval divided by the reporting interval. It does not includes IPv4 multicast packets that don't belong to any of the joined multicast groups. It includes ICMPv4, DHCPv4 and IGMPv3 multicast packets. The automatically-defined interface name identifies the IPv4 interface.

The ingress IP-layer multicast average usage in Mbps for a specific IPv4 interface is calculated using Equation 14.

$$\frac{A \times 8}{1000000 \times ROP}$$

Equation 14 IPv4 Interface 15-Minute IP-Layer Ingress Multicast Average Usage (Mbps)

Where

A *`pmIfStatsHCIpInMcastOctets`*

ROP 900 s

The operator can also calculate the ingress IP-layer multicast average usage over multiple IP interfaces by adding the contribution from each interface.

4.12 15-Minute IP-Layer Egress Multicast Average Usage

This singleton metric computes the average egress IP-layer multicast usage for an IPv4 interface on a GE link. It is the number of IP-layer bits supplied to the Ethernet layer for transmission in IPv4 multicast packets to any multicast address during a reporting interval divided by the reporting interval. It includes

ICMPv4, DHCPv4, IGMPv3 multicast packets. The automatically-defined interface name identifies the IPv4 interface.

The egress IP-layer multicast average usage in Mbps for a specific IPv4 interface is calculated using Equation 15.

$$\frac{A \times 8}{1000000 \times ROP}$$

Equation 15 IPv4 Interface 15-Minute IP-Layer Egress Multicast Average Usage (Mbps)

Where

A	*pmIfStatsHCIpOutMcastOctets*
ROP	900 s

The operator can also calculate the egress IP-layer multicast average usage over multiple IP interfaces by adding the contribution from each interface.

4.13 15-Minute Ethernet-Layer Ingress Multicast Average Usage

This singleton metric computes the average ingress Ethernet-layer multicast usage for an IPv4 interface on a GE link. It is the number of Ethernet-layer bits received in IPv4 multicast packets from multicast groups the RBS has joined or is listening to during a reporting interval divided by the reporting interval. It does not includes IPv4 multicast packets that don't belong to any of the joined multicast groups. It includes ICMPv4, DHCPv4 and IGMPv3 multicast packets. The automatically-defined interface name identifies the IPv4 interface.

The ingress Ethernet-layer multicast average usage in Mbps for a specific IPv4 interface is calculated using Equation 16.

$$\frac{(A \times 8) + (B \times Ethernet\ Overhead)}{1000000 \times ROP}$$

Equation 16 IPv4 Interface 15-Minute Ethernet-Layer Ingress Multicast Average Usage (Mbps)

Where

A	*pmIfStatsHCIpInMcastOctets*
B	*pmIfStatsHCIpInMcastPkts*

Ethernet Overhead

Number of Ethernet bits received on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits) and inter-frame gap (96 bits)

The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

ROP 900 s

The operator can also calculate the ingress Ethernet-layer multicast average usage over multiple IP interfaces by adding the contribution from each interface.

4.14 15-Minute Ethernet-Layer Egress Multicast Average Usage

This singleton metric computes the average egress Ethernet-layer multicast usage for an IPv4 interface on a GE link. It is the number of Ethernet-layer bits supplied to the Ethernet layer for transmission in IPv4 multicast packets to any multicast address during a reporting interval divided by the reporting interval. It includes ICMPv4, DHCPv4, IGMPv3 multicast packets. The automatically-defined interface name identifies the IPv4 interface.

The egress IP-layer multicast average usage in Mbps for a specific IPv4 interface is calculated using Equation 17.

$$\frac{(A \times 8) + (B \times Ethernet\ Overhead)}{1000000 \times ROP}$$

Equation 17 IPv4 Interface 15-Minute IP-Layer Egress Multicast Average Usage (Mbps)

Where

A *pmIfStatsHCIpOutMcastOctets*

B *pmIfStatsHCIpOutMcastPkts*

Ethernet Overhead

Number of Ethernet bits received on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits), and inter-frame gap (96 bits)

The total Ethernet overhead is 304 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

ROP 900 s

The operator can also calculate the egress Ethernet-layer multicast average usage over multiple IP interfaces by adding the contribution from each interface.

4.15 IP-Layer Ingress IP Flow Usage

This singleton metric provides the ingress IP-layer bandwidth usage for an IP flow terminating at the IPv4 interface on a GE link. It is the number of IP-layer bits received in IPv4 unicast, multicast and broadcast packets from a specific IPv4 source address, address prefix or subnet (remoteIpAddress) using one of the specified DSCP values (dscpValue) during a configurable measurement period (samplingInterval). It includes IPv4 packets received with errors and IPv4 packets that are discarded due to policy.

The IP-layer ingress bandwidth instantaneous usage for a specific IP flow terminating on a specific IPv4 interface is calculated using Equation 18.

$$\frac{A \times 8}{1000000 \times samplingInterval}$$

Equation 18 IPv4 Interface IP-Layer Ingress IP Flow Usage (Mbps)

Where

A `pmIpFlowInOctets`

samplingInterval 1, 10, 30, 60 or 300 s

The operator is responsible to configure the appropriate number of IP flow monitors as well as the remote IP address prefix and the DSCP codepoint values for each IP flow monitor. By default, the system is not configured with any IP flow monitor. The operator can also calculate the IP-layer ingress instantaneous usage over multiple IP flows. IP flow monitor is only supported on DUS and mRBS.

4.16 IP-Layer Egress IP Flow Usage

This singleton metric provides the egress IP-layer bandwidth usage for an IP flow originating from the IPv4 interface on a GE link. It is the number of IP-layer bits supplied to the egress traffic shaping function (when applicable for DUL) or supplied directly to the Ethernet layer for transmission in IPv4 unicast, multicast and broadcast packets to a specific IPv4 destination address, address prefix or subnet (remoteIpAddress) using one of the specified DSCP values (dscpValue) during a configurable measurement period (samplingInterval).

The IP-layer egress bandwidth instantaneous usage for a specific IP flow originating from a specific IPv4 interface is calculated using Equation 19.

$$\frac{A \times 8}{1000000 \times samplingInterval}$$

Equation 19 IPv4 Interface IP-Layer Egress IP Flow Usage (Mbps)

Where

A `pmIpFlowOutOctets`

samplingInterval 1, 10, 30, 60 or 300 s

The operator is responsible to configure the appropriate number of IP flow monitors as well as the remote IP address prefix and the DSCP codepoint values for each IP flow monitor. By default, the system is not configured with any IP flow monitor. The operator can also calculate the IP-layer egress instantaneous usage over multiple IP flows.

The `pmIpFlowOutOctets` counter represents the IP octets supplied to the Ethernet layer for transmission. It is implemented after traffic shaping if configured. IP flow monitor is only supported on DUS and mRBS.

4.17 Ethernet-Layer Ingress IP Flow Usage

This singleton metric provides the ingress Ethernet-layer bandwidth usage for an IP flow terminating at the IPv4 interface on a GE link. It is the number of Ethernet-layer bits (including the Ethernet header, VLAN tag, frame check sequence, preamble and inter-frame gap) received in IPv4 unicast, multicast and broadcast packets from a specific IPv4 source address, address prefix or subnet (remoteIpAddress) using one of the specified DSCP values (dscpValue) during a configurable measurement period (samplingInterval). It includes IPv4 packets received with errors and IPv4 packets that are discarded due to policy. It does not include non-IP traffic like ARP packets.

The Ethernet-layer ingress bandwidth instantaneous usage for a specific DSCP aggregation group on a specific IPv4 interface is calculated using Equation 20

$$\frac{(A \times 8) + (B \times Ethernet\,Overhead)}{1000000 \times samplingInterval}$$

Equation 20 IPv4 Interface Ethernet-Layer Ingress IP Flow Usage (Mbps)

Where

A `pmIpFlowInOctets`

B `pmIpFlowInPkts`

Ethernet Overhead

The amount of Ethernet bits received on the link per IPv4 packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits) and inter-frame gap (96 bits). The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

samplingInterval 1, 10, 30, 60 or 300 s

The operator is responsible to configure the appropriate number of IP flow monitors as well as the remote IP address prefix and the DSCP codepoint values for each IP flow monitor. By default, the system is not configured with any IP flow monitor. The operator can also calculate the Ethernet-layer ingress instantaneous usage over multiple IP flows. IP flow monitor is only supported on DUS and mRBS.

4.18 Ethernet-Layer Egress IP Flow Usage

This singleton metric provides the ingress Ethernet-layer bandwidth usage for an IP flow originating from the IPv4 interface on a GE link. It is the number of Ethernet-layer bits supplied to the egress traffic shaping function (when applicable for DUL) or supplied directly to the Ethernet layer for transmission in IPv4 unicast, multicast and broadcast packets to a specific IPv4 destination address, address prefix or subnet (remoteIpAddress) using one of the specified DSCP values (dscpValue) during a configurable measurement period (samplingInterval).

The Ethernet-layer egress bandwidth instantaneous usage for a specific IP flow originating from a specific IPv4 interface is calculated using Equation 21

$$\frac{(A \times 8) + (B \times Ethernet\ Overhead)}{1000000 \times samplingInterval}$$

Equation 21 IPv4 Interface Ethernet-Layer Egress IP Flow Usage (Mbps)

Where

A *pmIpFlowOutOctets*

B *pmIpFlowOutPkts*

Ethernet Overhead

The amount of Ethernet bits transmitted on the link per IPv4 packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits) and inter-frame gap (96 bits). The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

samplingInterval 1, 10, 30, 60, 300 s

The operator is responsible to configure the appropriate number of IP flow monitors as well as the remote IP address prefix and the DSCP codepoint values for each IP flow monitor. By default, the system is not configured with any IP flow monitor. The operator can also calculate the Ethernet-layer egress instantaneous usage over multiple IP flows.

The `pmIpFlowOutPkts` counter represents the IP octets supplied to the Ethernet layer for transmission. It is implemented after traffic shaping if configured. IP flow monitor is only supported on DUS and mRBS.

5 IPv6 Interface Singleton Performance Metrics

IPv6 interface singleton performance metrics consist of the following:

- 15-minute ingress packet discard ratio (%)
- 15-minute egress packet discard ratio (%)
- 15-minute IP-layer ingress average usage (Mbps)
- 15-minute IP-layer egress average usage (Mbps)
- 15-minute Ethernet-layer ingress average usage (Mbps)
- 15-minute Ethernet-layer egress average usage (Mbps)
- IP-layer ingress DSCP group usage (Mbps)
- IP-layer egress DSCP group usage (Mbps)
- Ethernet-layer ingress DSCP group usage (Mbps)
- Ethernet-layer egress DSCP group usage (Mbps)
- 15-minute IP-layer ingress multicast average usage (Mbps)
- 15-minute IP-layer egress multicast average usage (Mbps)
- 15-minute Ethernet-layer ingress multicast average usage (Mbps)
- 15-minute Ethernet-layer egress multicast average usage (Mbps)
- IP-layer ingress IP flow usage (Mbps)
- IP-layer egress IP flow usage (Mbps)
- Ethernet-layer ingress IP flow usage (Mbps)
- Ethernet-layer egress IP flow usage (Mbps)

The metrics are calculated from measurements made at the IPv6 sublayer of the eNB TN interface. The counters used for the IPv6 interface singleton performance metrics are accessible under the Ipv6Interface MO class described in *class Ipv6Interface*.

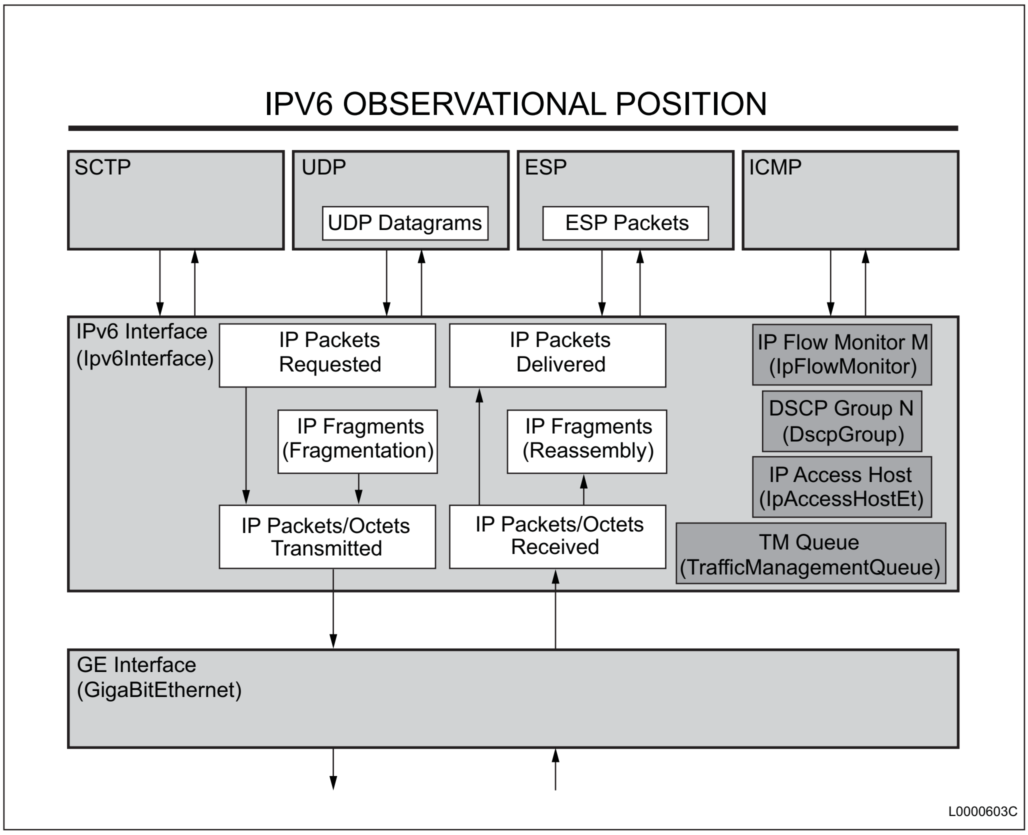

Figure 4 IPv6 Observational Position

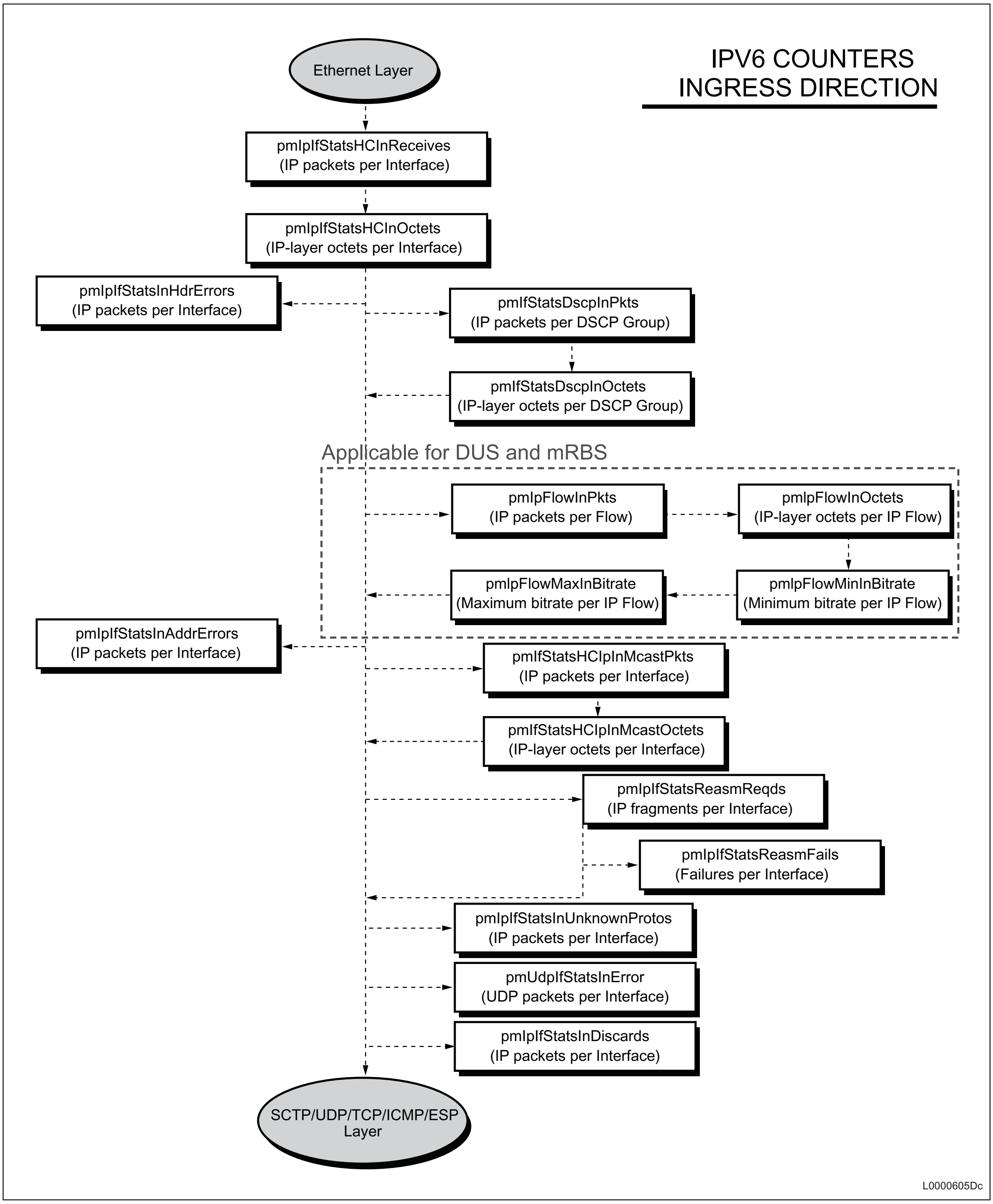

Figure 5 IPv6 Counters Ingress Direction

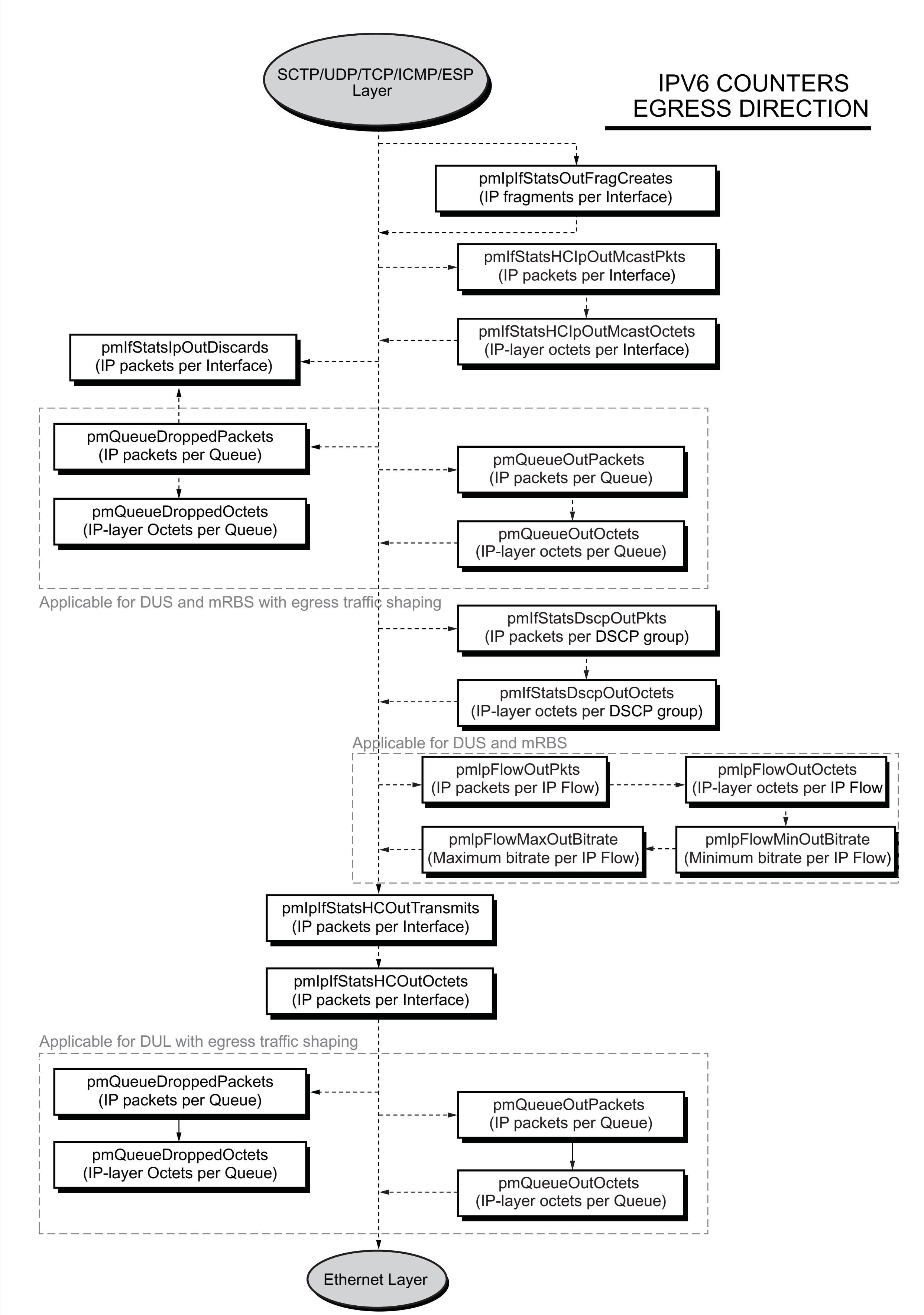

Figure 6 IPv6 Counters Egress Direction

5.1 15-Minute Ingress Packet Discard Ratio

This singleton metric computes the ingress IP-layer packet discard ratio for an IPv6 interface on a GE link over a 15-minute reporting interval. It is the percentage of IP-layer input packets received from any source for which no problem was encountered to prevent delivery to a higher-layer protocol but were discarded by the RBS during a reporting period (including IP packets discarded due to reassembly failure, UDP packets discarded due to UDP buffer overflow, and TWAMP test packets discarded due to high rate). The automatically-defined interface name identifies the IPv6 interface.

The ingress IP-layer packet discard ratio in percentage for a specific IPv6 interface is calculated using Equation 22

$$100 \times \frac{A + B + C}{(D - (E + F + G))}$$

Equation 22 IPv6 Interface 15-Minute Ingress Packet Discard Ratio (%)

Where:

A	*pmIpIfStatsInDiscards*
B	Roundup(*pmIpIfStatsReasmFails*/2.0)
C	*pmUdpIfStatsInError*
D	*pmIpIfStatsHCInReceives*
E	*pmIpIfStatsInAddrErrors*
F	*pmIpIfStatsInHdrErrors*
G	*pmIpIfStatsInUnknownProtos*

The value of the `pmIpIfStatsInDiscards` IPv6 interface counter is included in the equation because it is incremented when the ingress TWAMP test packet rate is too high.

The `pmUdpIfStatsInError` counter is not used for the IPv6 interface dedicated to Operation and Maintenance (O&M) traffic. It is incremented when the ingress UDP queue is full. It is also incremented when UDP packets are received with errors including incorrect UDP checksum.

`Roundup(pmIpIfStatsReasmFails/2.0)` is `pmIpIfStatsReasmFails` rounded up and divided by 2 to 0 decimal places. `pmIpIfStatsReasmFails` counts the number of failures detected by the IPv6 reassembly algorithm.

5.2 15-Minute Egress Packet Discard Ratio

This singleton metric computes the egress IP-layer packet discard ratio for an IPv6 interface on a GE link over a 15-minute reporting interval. It is the percentage of IP-layer output packets for which no problem was encountered to prevent their transmission but were discarded by the RBS during a reporting period. The automatically-defined interface name identifies the IPv6 interface.

This metric does not consider packets discarded because they needed to be fragmented but could not be (for example due to “Don't Fragment” flag set to 1).

The egress IP-layer packet or frame discard ratio in percentage for a specific IPv6 interface is calculated using Equation 23.

$$100 \times \frac{A}{(A + B)}$$

Equation 23 IPv6 Interface 15-Minute Egress Packet Discard Ratio (%)

Where:

A *pmIpIfStatsOutDiscards*

B *pmIpIfStatsHCOutTransmits*

When traffic shaping is configured on the DUS, the above singleton metric is valid. The `pmIfStatsIpOutDiscards` counter is incremented when packets are dropped due to lack of buffer space when the DUS IPv4 interface is associated with the egress traffic shaping feature.

When traffic shaping is configured on the DUL, it is recommended to ignore the above singleton metric and use the traffic scheduler egress packet discard ratio. The traffic scheduler singleton performance metrics are described in Section 6 on page 49. The `pmIpIfStatsIpOutDiscards` counter is not incremented when packets are dropped due to lack of buffer space if the DUS IPv4 interface is associated with the egress traffic shaping feature.

The IPv6 interface is associated with the egress traffic shaping feature when the `trafficScheduleRef` attribute is configured with a reference to a `TrafficScheduler` MO instance.

5.3 15-Minute IP-Layer Ingress Average Usage

This singleton metric computes the average ingress IP-layer usage for an IPv6 interface on a GE link. It is the number of IP-layer bits received in IPv6 unicast, multicast, and broadcast packets from any IPv6 source during a reporting interval divided by the reporting interval. It includes ICMPv6 packets and IPv6 packets received with errors. The automatically-defined interface name identifies the IPv6 interface.

The ingress IP-layer average usage in Mbps for a specific IPv6 interface is calculated using Equation 24.

$$\frac{A \times 8}{1000000 \times ROP}$$

Equation 24 IPv6 Interface 15-Minute IP-Layer Ingress Average Usage (Mbps)

Where

A *pmIpIfStatsHCInOctets*

ROP 900 s

The operator can also calculate the ingress IP-layer average usage over multiple IP interfaces by adding the contribution from each interface.

5.4 15-Minute IP-Layer Egress Average Usage

This singleton metric computes the average egress IP-layer usage for an IPv6 interface on a GE link. It is the number of IP-layer bits supplied to the egress traffic shaping function (when applicable for the DUL) or supplied directly to the Ethernet layer for transmission in IPv6 unicast, multicast and broadcast packets to any IPv6 destination during a reporting interval divided by the reporting interval. It includes ICMPv6 packets. The automatically-defined interface name identifies the IPv6 interface.

The egress IP-layer average usage in Mbps for a specific IPv6 interface is calculated using Equation 25.

$$\frac{A \times 8}{1000000 \times ROP}$$

Equation 25 IPv6 Interface 15-Minute IP-Layer Egress Average Usage (Mbps)

Where

A *pmIpIfStatsHCOutOctets*

ROP 900 s

The operator can also calculate the egress IP-layer average usage over multiple IP interfaces by adding the contribution from each interface.

When traffic shaping is configured on the DUS, the above singleton metric is valid.

When traffic shaping is configured on the DUL, it is recommended to use the traffic scheduler IP-layer egress average usage. The traffic scheduler singleton performance metrics are described in Section 6 on page 49.

The IPv6 interface is associated with the egress traffic shaping feature when the `trafficScheduleRef` attribute is configured with a reference to a `TrafficScheduler` MO instance.

5.5 15-Minute Ethernet-Layer Ingress Average Usage

This singleton metric computes the average ingress Ethernet-layer usage for an IPv6 interface on a GE link. It is the number of Ethernet-layer bits received in IPv6 unicast, multicast, and broadcast packets from any IPv6 source during a reporting interval divided by the reporting interval. It includes ICMPv6 packets and IPv6 packets received with errors. The automatically-defined interface name identifies the IPv6 interface.

The ingress Ethernet-layer average usage in Mbps for a specific IPv6 interface is calculated using Equation 26.

$$\frac{(A \times 8) + (B \times Ethernet\ Overhead)}{1000000 \times ROP}$$

Equation 26 IPv6 Interface 15-Minute Ethernet-Layer Ingress Average Usage (Mbps)

Where

A *pmIpIfStatsHCInOctets*

B *pmIpIfStatsHCInReceives*

Ethernet Overhead

Number of Ethernet bits received on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits) and inter-frame gap (96 bits)

The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

ROP 900 s

The operator can also calculate the ingress Ethernet-layer average usage over multiple IP interfaces by adding the contribution from each interface.

5.6 15-Minute Ethernet-Layer Egress Average Usage

This singleton metric computes the average egress Ethernet-layer usage for an IPv6 interface on a GE link. It is the number of Ethernet-layer bits supplied to the egress traffic shaping function (when applicable for the DUL) or supplied directly to the Ethernet layer for transmission in IPv6 unicast, multicast and broadcast packets to any IPv6 destination during a reporting interval divided by the reporting interval. It includes ICMPv6 packets. The automatically-defined interface name identifies the IPv6 interface.

The egress Ethernet-layer average usage in Mbps for a specific IPv6 interface is calculated using Equation 27.

$$\frac{(A \times 8) + (B \times Ethernet\ Overhead)}{1000000 \times ROP}$$

Equation 27 IPv6 Interface 15-Minute IP-Layer Egress Average Usage (Mbps)

Where

A `pmIpIfStatsHCOutOctets`

B `pmIpIfStatsHCOutTransmits`

Ethernet Overhead

Number of Ethernet bits received on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits), and inter-frame gap (96 bits)

The total Ethernet overhead is 304 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

ROP 900 s

The operator can also calculate the egress Ethernet-layer average usage over multiple IP interfaces by adding the contribution from each interface.

When traffic shaping is configured on the DUS, the above singleton metric is valid.

When traffic shaping is configured on the DUL, it is recommended to use the traffic scheduler Ethernet-layer egress average usage. The traffic scheduler singleton performance metrics are described in Section 6 on page 49.

The IPv6 interface is associated with the egress traffic shaping feature when the `trafficScheduleRef` attribute is configured with a reference to a `TrafficScheduler` MO instance.

5.7 IP-Layer Ingress DSCP Group Usage

This singleton metric provides the ingress IP-layer DSCP aggregation group bandwidth usage for an IPv6 interface on a GE link. It is the number of IP-layer bits received in IP unicast, multicast and broadcast packets from any IP source using one of the DSCP values in a DSCP aggregation group during a configurable measurement period (samplingInterval). It includes IP packets received with errors and IP packets that are discarded due to policy. The automatically-defined interface name identifies the IPv6 interface. The DSCP values identify the DSCP group.

The IP-layer ingress bandwidth instantaneous usage for a specific DSCP aggregation group on a specific IP interface is calculated using Equation 28.

$$\frac{A \times 8}{1000000 \times samplingInterval}$$

Equation 28 IPv6 Interface IP-Layer Ingress DSCP Group Usage (Mbps)

Where

A *pmIfStatsDscpInOctets*

samplingInterval 10, 30, 60 or 300 s

The operator is responsible to configure the appropriate number of DSCP aggregation groups and the DSCP codepoint values for each DSCP aggregation group. By default, the system is not configured with any DSCP aggregation group. The operator can also calculate the IP-layer ingress QOS instantaneous usage over multiple interfaces.

5.8 IP-Layer Egress DSCP Group Usage

This singleton metric provides the egress IP-layer DSCP aggregation group bandwidth usage for an IPv4 interface on a GE link. It is the number of IP-layer bits supplied to the egress traffic shaping function (when applicable for DUL) or supplied directly to the Ethernet layer for transmission in IP unicast, multicast and broadcast packets to any IP destination using one of the DSCP values in a DSCP aggregation group during a configurable measurement period (samplingInterval). The subnet prefix identifies the IP interface instance. The DSCP values identify the DSCP group.

The IP-layer egress bandwidth instantaneous usage for a specific DSCP aggregation group on a specific IP interface is calculated using Equation 29.

$$\frac{A \times 8}{1000000 \times samplingInterval}$$

Equation 29 IPv6 Interface IP-Layer Egress DSCP Group Usage (Mbps)

Where

A *pmIfStatsDscpOutOctets*

samplingInterval 10, 30, 60 or 300 s

The operator is responsible to configure the appropriate number of DSCP aggregation groups and the DSCP codepoint values for each DSCP aggregation group. By default, the system is not configured with any DSCP aggregation group. The operator can also calculate the IP-layer egress QOS instantaneous usage over multiple interfaces.

The `pmIfStatsDscpOutOctets` counter represents the IP octets supplied to the Ethernet layer for transmission when the DUS IPv6 interface is configured with/without traffic shaping or when the DUL IPv6 interface is configured without traffic shaping. The `pmIfStatsDscpOutOctets` counter represents the IP octets supplied to the egress traffic shaping function when the DUL IPv6 interface is configured with traffic shaping.

5.9 Ethernet-Layer Ingress DSCP Group Usage

This singleton metric provides the ingress Ethernet-layer DSCP aggregation group bandwidth usage for an IPv4 interface on a GE link. It is the number of Ethernet-layer bits (including the Ethernet header, VLAN tag, frame check sequence, preamble and inter-frame gap) received in IP unicast, multicast and broadcast packets from any IP source using one of the DSCP values in a DSCP aggregation group during a configurable measurement period (samplingInterval). It includes IP packets received with errors and IP packets that are discarded due to policy. It does not include non-IP traffic like ARP packets. The subnet prefix identifies the IP interface instance. The DSCP values identify the DSCP group.

The Ethernet-layer ingress bandwidth instantaneous usage for a specific DSCP aggregation group on a specific IP interface is calculated using Equation 30

$$\frac{(A \times 8) + (B \times Ethernet\,Overhead)}{1000000 \times samplingInterval}$$

Equation 30 IPv6 Interface Ethernet-Layer Ingress DSCP Group Usage (Mbps)

Where

A $pmIfStatsDscpInOctets$

B $pmIfStatsDscpInPkts$

Ethernet Overhead

The amount of Ethernet bits received on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits) and inter-frame gap (96 bits). The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

samplingInterval 10, 30, 60 or 300 s

The operator is responsible to configure the appropriate number of DSCP aggregation groups and the DSCP codepoint values for each DSCP aggregation group. By default, the system is not configured with any DSCP aggregation group. The operator can also calculate the Ethernet-Layer ingress QOS instantaneous usage over multiple IP interfaces.

5.10 Ethernet-Layer Egress DSCP Group Usage

This singleton metric provides the ingress Ethernet-layer DSCP aggregation group bandwidth usage for an IPv4 interface on a GE link. It is the number of Ethernet-layer bits supplied to the egress traffic shaping function (when applicable for DUL) or supplied directly to the Ethernet layer for transmission in IP unicast, multicast and broadcast packets to any IP destination using one of the DSCP values in a DSCP aggregation group during a configurable measurement period (samplingInterval). The subnet prefix identifies the IP interface instance. The DSCP values identifies the DSCP group.

The Ethernet-layer egress bandwidth instantaneous usage for a specific DSCP aggregation group on a specific IP interface is calculated using Equation 31

$$\frac{(A \times 8) + (B \times Ethernet\ Overhead)}{1000000 \times samplingInterval}$$

Equation 31 IPv6 Interface Ethernet-Layer Egress DSCP Group Usage (Mbps)

Where

A *pmIfStatsDscpOutOctets*

B *pmIfStatsDscpOutPkts*

Ethernet Overhead

The amount of Ethernet bits transmitted on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits) and inter-frame gap (96 bits). The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

samplingInterval 10, 30, 60, 300 s

The operator is responsible to configure the appropriate number of DSCP aggregation groups and the DSCP codepoint values for each DSCP aggregation group. By default, the system is not configured with any DSCP aggregation group. The operator can also calculate the Ethernet-layer egress QOS instantaneous usage over multiple interfaces.

The `pmIfStatsDscpOutOctets` counter represents the IP octets supplied to the Ethernet layer for transmission when the DUS IPv6 interface is configured with/without traffic shaping or when the DUL IPv6 interface is configured without traffic shaping. The `pmIfStatsDscpOutOctets` counter represents the IP octets supplied to the egress traffic shaping function when the DUL IPv6 interface is configured with traffic shaping.

5.11 15-Minute IP-Layer Ingress Multicast Average Usage

This singleton metric computes the average ingress IP-layer multicast usage for an IPv6 interface on a GE link. It is the number of IP-layer bits received in IPv6 multicast packets from multicast groups the RBS has joined or is listening to during a reporting interval divided by the reporting interval. It does not includes IPv6 multicast packets that don't belong to any of the joined multicast groups. It includes ICMPv6, DHCPv6 and MLDv2 multicast packets. The automatically-defined interface name identifies the IPv6 interface.

The ingress IP-layer multicast average usage in Mbps for a specific IPv6 interface is calculated using Equation 32.

$$\frac{A \times 8}{1000000 \times ROP}$$

Equation 32 IPv6 Interface 15-Minute IP-Layer Ingress Multicast Average Usage (Mbps)

Where

A	*pmIfStatsHCIpInMcastOctets*
ROP	900 s

The operator can also calculate the ingress IP-layer multicast average usage over multiple IP interfaces by adding the contribution from each interface.

5.12 15-Minute IP-Layer Egress Multicast Average Usage

This singleton metric computes the average egress IP-layer multicast usage for an IPv6 interface on a GE link. It is the number of IP-layer bits supplied to the Ethernet layer for transmission in IPv6 multicast packets to any multicast address during a reporting interval divided by the reporting interval. It includes ICMPv6, DHCPv6, MLDv2 multicast packets. The automatically-defined interface name identifies the IPv6 interface.

The egress IP-layer multicast average usage in Mbps for a specific IPv6 interface is calculated using Equation 33.

$$\frac{A \times 8}{1000000 \times ROP}$$

Equation 33 IPv6 Interface 15-Minute IP-Layer Egress Multicast Average Usage (Mbps)

Where

A *pmIfStatsHCIpOutMcastOctets*

ROP 900 s

The operator can also calculate the egress IP-layer multicast average usage over multiple IP interfaces by adding the contribution from each interface.

5.13 15-Minute Ethernet-Layer Ingress Multicast Average Usage

This singleton metric computes the average ingress Ethernet-layer multicast usage for an IPv6 interface on a GE link. It is the number of Ethernet-layer bits received in IPv6 multicast packets from multicast groups the RBS has joined or is listening to during a reporting interval divided by the reporting interval. It does not includes IPv6 multicast packets that don't belong to any of the joined multicast groups. It includes ICMPv6, DHCPv6 and MLDv2 multicast packets. The automatically-defined interface name identifies the IPv6 interface.

The ingress Ethernet-layer multicast average usage in Mbps for a specific IPv6 interface is calculated using Equation 34.

$$\frac{(A \times 8) + (B \times Ethernet\ Overhead)}{1000000 \times ROP}$$

Equation 34 IPv6 Interface 15-Minute Ethernet-Layer Ingress Multicast Average Usage (Mbps)

Where

A *pmIfStatsHCIpInMcastOctets*

B *pmIfStatsHCIpInMcastPkts*

Ethernet Overhead

Number of Ethernet bits received on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits) and inter-frame gap (96 bits)

The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

ROP 900 s

The operator can also calculate the ingress Ethernet-layer multicast average usage over multiple IP interfaces by adding the contribution from each interface.

5.14 15-Minute Ethernet-Layer Egress Multicast Average Usage

This singleton metric computes the average egress Ethernet-layer multicast usage for an IPv6 interface on a GE link. It is the number of Ethernet-layer bits supplied to the Ethernet layer for transmission in IPv6 multicast packets to any multicast address during a reporting interval divided by the reporting interval. It includes ICMPv6, DHCPv6, MLDv2 multicast packets. The automatically-defined interface name identifies the IPv6 interface.

The egress IP-layer multicast average usage in Mbps for a specific IPv6 interface is calculated using Equation 35.

$$\frac{(A \times 8) + (B \times Ethernet\ Overhead)}{1000000 \times ROP}$$

Equation 35 IPv6 Interface 15-Minute IP-Layer Egress Multicast Average Usage (Mbps)

Where

A *pmIfStatsHCIpOutMcastOctets*

B *pmIfStatsHCIpOutMcastPkts*

Ethernet Overhead

Number of Ethernet bits received on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits), and inter-frame gap (96 bits)

The total Ethernet overhead is 304 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

ROP 900 s

The operator can also calculate the egress Ethernet-layer multicast average usage over multiple IP interfaces by adding the contribution from each interface.

5.15 IP-Layer Ingress IP Flow Usage

This singleton metric provides the ingress IP-layer bandwidth usage for an IP flow terminating at the IPv6 interface on a GE link. It is the number of IP-layer bits received in IPv6 unicast, multicast and broadcast packets from a specific IPv6 source address, address prefix or subnet (remoteIpAddress) using one of the specified DSCP values (dscpValue) during a configurable measurement period (samplingInterval). It includes IPv6 packets received with errors and IPv6 packets that are discarded due to policy.

The IP-layer ingress bandwidth instantaneous usage for a specific IP flow terminating on a specific IPv6 interface is calculated using Equation 36.

$$\frac{A \times 8}{1000000 \times samplingInterval}$$

Equation 36 IPv6 Interface IP-Layer Ingress IP Flow Usage (Mbps)

Where

A `pmIpFlowInOctets`

samplingInterval 1, 10, 30, 60 or 300 s

The operator is responsible to configure the appropriate number of IP flow monitors as well as the remote IP address prefix and the DSCP codepoint values for each IP flow monitor. By default, the system is not configured with any IP flow monitor. The operator can also calculate the IP-layer ingress instantaneous usage over multiple IP flows. IP flow monitor is only supported on DUS and mRBS.

5.16 IP-Layer Egress IP Flow Usage

This singleton metric provides the egress IP-layer bandwidth usage for an IP flow originating from the IPv6 interface on a GE link. It is the number of IP-layer bits supplied to the egress traffic shaping function (when applicable for DUL) or supplied directly to the Ethernet layer for transmission in IPv6 unicast, multicast and broadcast packets to a specific IPv6 destination address, address prefix or subnet (remoteIpAddress) using one of the specified DSCP values (dscpValue) during a configurable measurement period (samplingInterval).

The IP-layer egress bandwidth instantaneous usage for a specific IP flow originating from a specific IPv6 interface is calculated using Equation 37.

$$\frac{A \times 8}{1000000 \times samplingInterval}$$

Equation 37 IPv6 Interface IP-Layer Egress IP Flow Usage (Mbps)

Where

A `pmIpFlowOutOctets`

samplingInterval 1, 10, 30, 60 or 300 s

The operator is responsible to configure the appropriate number of IP flow monitors as well as the remote IP address prefix and the DSCP codepoint values for each IP flow monitor. By default, the system is not configured with any IP flow monitor. The operator can also calculate the IP-layer egress instantaneous usage over multiple IP flows.

The `pmIpFlowOutOctets` counter represents the IP octets supplied to the Ethernet layer for transmission. It is implemented after traffic shaping if configured. IP flow monitor is only supported on DUS and mRBS.

5.17 Ethernet-Layer Ingress IP Flow Usage

This singleton metric provides the ingress Ethernet-layer bandwidth usage for an IP flow terminating at the IPv6 interface on a GE link. It is the number of Ethernet-layer bits (including the Ethernet header, VLAN tag, frame check sequence, preamble and inter-frame gap) received in IPv6 unicast, multicast and broadcast packets from a specific IPv6 source address, address prefix or subnet (remoteIpAddress) using one of the specified DSCP values (dscpValue) during a configurable measurement period (samplingInterval). It includes IPv6 packets received with errors and IPv6 packets that are discarded due to policy. It does not include non-IP traffic.

The Ethernet-layer ingress bandwidth instantaneous usage for a specific DSCP aggregation group on a specific IPv6 interface is calculated using Equation 38

$$\frac{(A \times 8) + (B \times Ethernet\ Overhead)}{1000000 \times samplingInterval}$$

Equation 38 IPv6 Interface Ethernet-Layer Ingress IP Flow Usage (Mbps)

Where

A *pmIpFlowInOctets*

B *pmIpFlowInPkts*

Ethernet Overhead

The amount of Ethernet bits received on the link per IPv6 packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits) and inter-frame gap (96 bits). The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

samplingInterval 1, 10, 30, 60 or 300 s

The operator is responsible to configure the appropriate number of IP flow monitors as well as the remote IP address prefix and the DSCP codepoint values for each IP flow monitor. By default, the system is not configured with any IP flow monitor. The operator can also calculate the Ethernet-layer ingress instantaneous usage over multiple IP flows. IP flow monitor is only supported on DUS and mRBS.

5.18 Ethernet-Layer Egress IP Flow Usage

This singleton metric provides the ingress Ethernet-layer bandwidth usage for an IP flow originating from the IPv6 interface on a GE link. It is the number of Ethernet-layer bits supplied to the egress traffic shaping function (when applicable for DUL) or supplied directly to the Ethernet layer for transmission in IPv6 unicast, multicast and broadcast packets to a specific IPv6 destination address, address prefix or subnet (remoteIpAddress) using one of the specified DSCP values (dscpValue) during a configurable measurement period (samplingInterval).

The Ethernet-layer egress bandwidth instantaneous usage for a specific IP flow originating from a specific IPv6 interface is calculated using Equation 39

$$\frac{(A \times 8) + (B \times Ethernet\ Overhead)}{1000000 \times samplingInterval}$$

Equation 39 IPv6 Interface Ethernet-Layer Egress IP Flow Usage (Mbps)

Where

A `pmIpFlowOutOctets`

B `pmIpFlowOutPkts`

Ethernet Overhead

The amount of Ethernet bits transmitted on the link per IPv6 packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits) and inter-frame gap (96 bits). The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

samplingInterval 1, 10, 30, 60, 300 s

The operator is responsible to configure the appropriate number of IP flow monitors as well as the remote IP address prefix and the DSCP codepoint values for each IP flow monitor. By default, the system is not configured with any IP flow monitor. The operator can also calculate the Ethernet-layer egress instantaneous usage over multiple IP flows.

The `pmIpFlowOutPkts` counter represents the IP octets supplied to the Ethernet layer for transmission. It is implemented after traffic shaping if configured. IP flow monitor is only supported on DUS and mRBS.

6 Traffic Scheduler Singleton Performance Metrics

Traffic scheduler singleton performance metrics consist of the following:

- 15-minute egress packet discard ratio (%)
- 15-minute IP-layer egress average usage (Mbps)
- 15-minute Ethernet-layer egress average usage (Mbps)

These metric are applicable only when the egress IP traffic shaping feature is configured on the DUL or DUS. They are calculated from measurements made at the IPv4 and/or IPv6 sublayers of the eNB TN interface. The counters used for the traffic scheduler singleton performance metrics are accessible under the TrafficManagementQueue MO class described in *class TrafficManagementQueue*.

6.1 15-Minute Egress Packet Discard Ratio

This singleton metric computes the egress IP-layer packet discard ratio for IPv4 and/or IPv6 interface(s) linked to a traffic scheduler over a 15-minute reporting interval. It is the percentage of IP-layer output packets for which no problem was encountered to prevent their transmission but were discarded by a traffic manager entity during a reporting period.

This metric does not consider packets discarded because they needed to be fragmented but could not be (for example due to “Don't Fragment” flag set to 1).

The egress IP-layer packet discard ratio in percentage for a specific traffic scheduler is calculated using Equation 40.

$$100 \times \frac{\sum A}{(\sum A + \sum B)}$$

Equation 40 Traffic scheduler 15-Minute Egress Packet Discard Ratio (%)

Where:

A	*pmQueueDroppedPackets*
B	*pmQueueOutPackets*

Σ A is the sum of the `pmQueueDroppedPackets` counters from the traffic management queues (1...N) belonging to the traffic scheduler. Σ B is the sum of the `pmQueueOutPackets` counters from the traffic management queues (1..N) belonging to the traffic scheduler.

6.2 15-Minute IP-Layer Egress Average Usage

This singleton metric computes the average egress IP-layer usage for IPv4 and/or IPv6 interface(s) linked to a traffic scheduler. It is the number of IP-layer bits transmitted by the traffic scheduler in IP unicast, multicast, and broadcast packets to any IP destination during a reporting interval divided by the reporting interval. It includes ICMP packets.

The egress IP-layer average usage in Mbps for a for a specific traffic scheduler is calculated using Equation 41.

$$\frac{\sum A \times 8}{1000000 \times ROP}$$

Equation 41 Traffic scheduler 15-Minute IP-Layer Egress Average Usage (Mbps)

Where

A	*`pmQueueOutOctets`*
ROP	900 s

Σ A is the sum of the `pmQueueOutOCtets` counters from the traffic management queues (1..N) belonging to the traffic scheduler. The operator can also calculate the egress IP-layer average usage for each individual traffic management queue.

6.3 15-Minute Ethernet-Layer Egress Average Usage

This singleton metric computes the average egress IP-layer usage for IPv4 and/or IPv6 interface(s) linked to a traffic scheduler. It is the number of Ethernet-layer bits transmitted by the traffic scheduler in IP unicast, multicast, and broadcast packets to any IP destination during a reporting interval divided by the reporting interval. It includes ICMP packets. It does not include non-IP traffic like ARP packets for IPv4 interfaces.

The egress Ethernet-layer average usage in Mbps for a specific traffic scheduler is calculated using Equation 42.

$$\frac{(\sum A \times 8) + (B \times Ethernet\ Overhead)}{1000000 \times ROP}$$

Equation 42 Traffic scheduler 15-Minute Ethernet-Layer Egress Average Usage (Mbps)

Where

A	*`pmQueueOutOctets`*
B	*`pmQueueOutPackets`*

Ethernet Overhead

Number of Ethernet bits received on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits), and inter-frame gap (96 bits)

The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

ROP 900 s

Σ A is the sum of the `pmQueueOutOctets` counters from the traffic management queues (1..N) belonging to the traffic scheduler. Σ B is the sum of the `pmQueueOutPackets` counters from the traffic management queues (1..N) belonging to the traffic scheduler. The operator can also calculate the egress Ethernet-layer average usage for each individual traffic management queue.

7 S1/X2 Control Plane Interface Singleton Performance Metrics

S1/X2 control plane interface singleton performance metrics consist of the following:

- 15-Minute Ingress SCTP Data Chunk Discard Ratio (%)
- 15-Minute Egress SCTP Data Chunk and User Data Discard Ratio (%)
- 15-Minute Ingress SCTP Control Chunk Discard Ratio (%)
- 15-Minute SCTP Data Chunk Retransmission Ratio (%)
- 15-Minute SCTP Availability Ratio (%)
- 15-Minute IP-Layer Ingress Average Usage (Mbps)
- 15-Minute IP-layer Egress Average Usage (Mbps)
- 15-Minute Ethernet-layer Ingress Average Usage (Mbps)
- 15-Minute Ethernet-layer Egress Average Usage (Mbps)

The metrics are calculated from measurements made at the SCTP sublayer of the eNB TN interface. The counters used for the S1/X2 control plane interface singleton performance metrics are accessible under the SctpAssociation MO class described in *class SctpAssociation*.

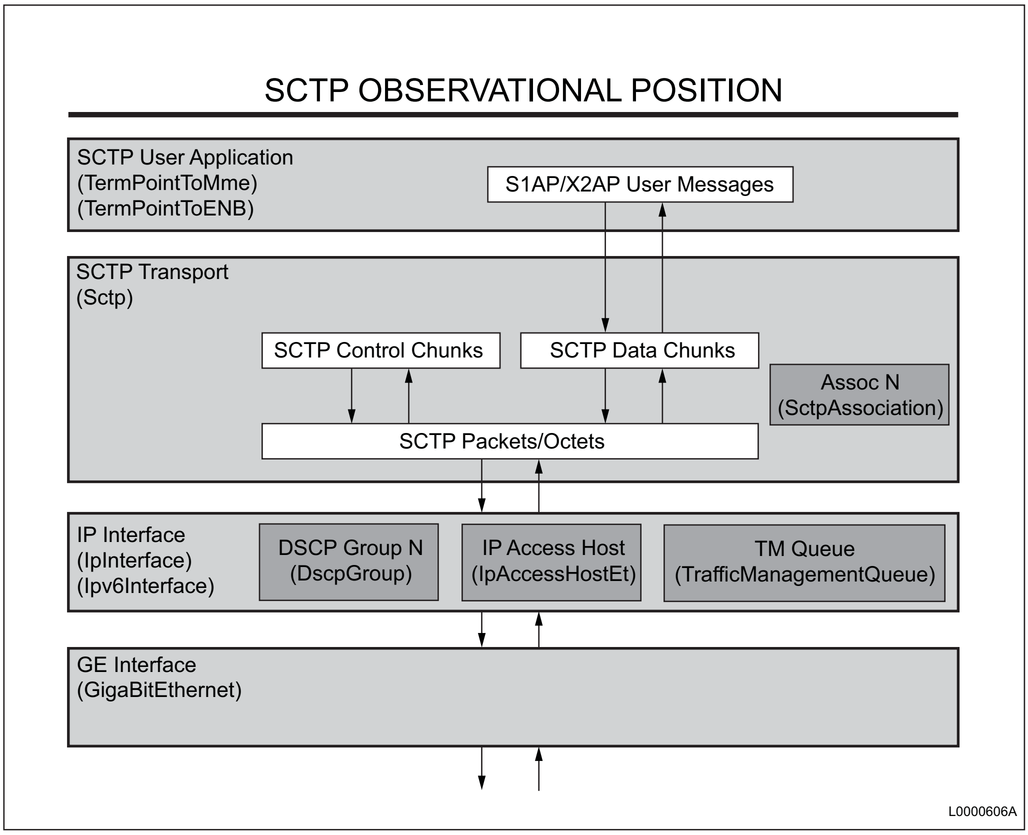

Figure 7 SCTP Observational Position

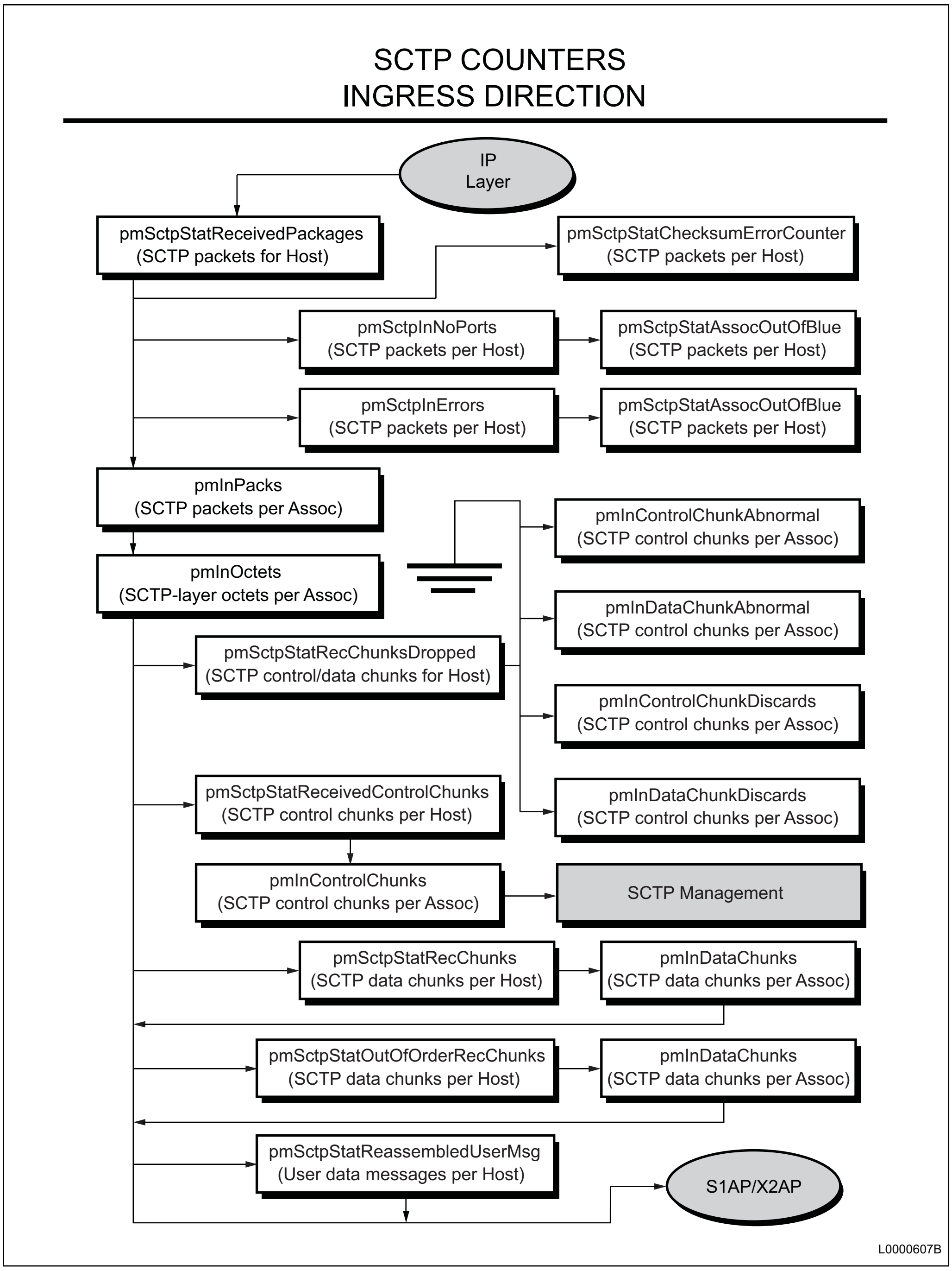

Figure 8   SCTP Counters Ingress Direction

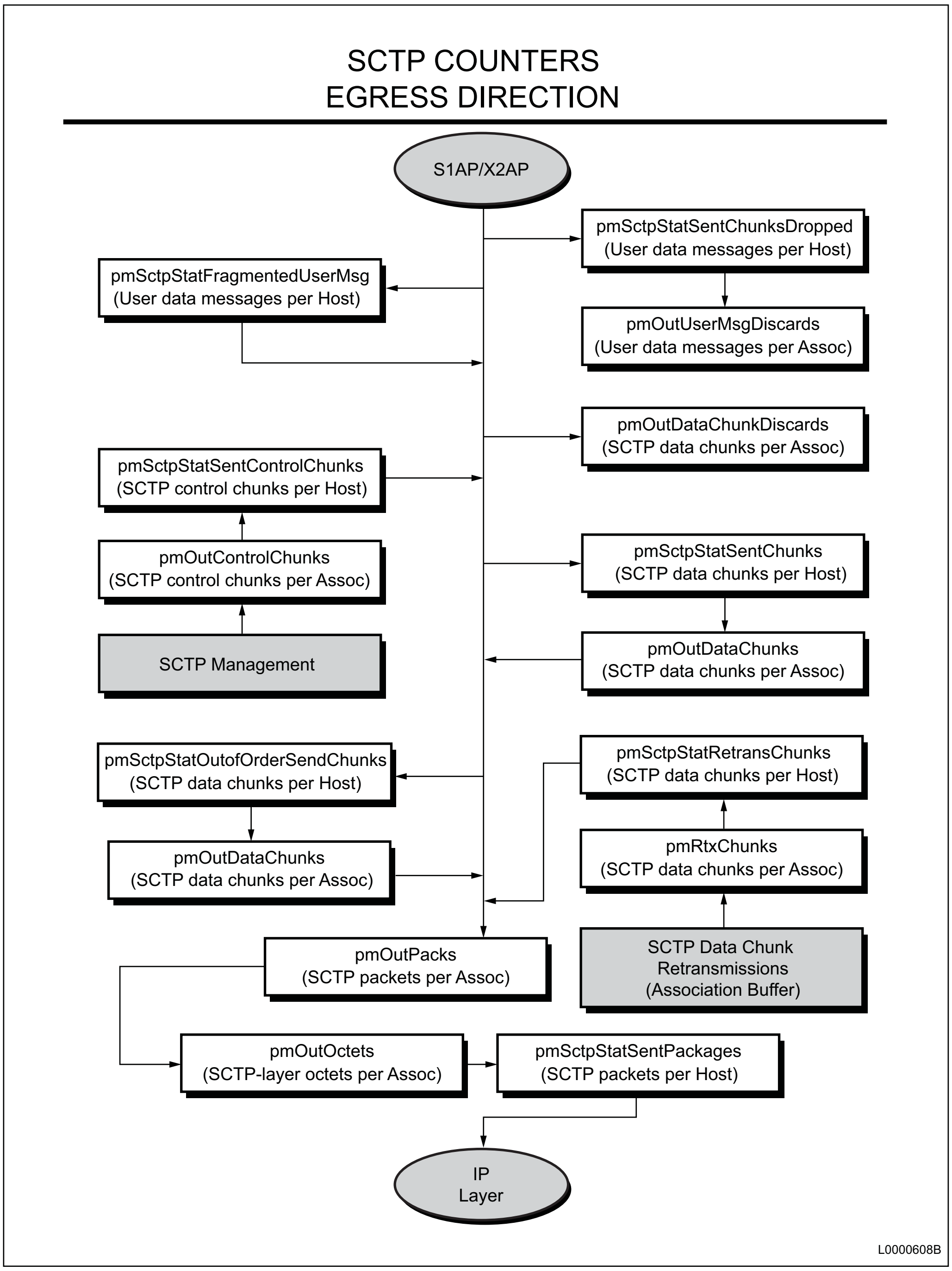

Figure 9 SCTP Counters Egress Direction

7.1 15-Minute Ingress SCTP Data Chunk Discard Ratio

This singleton metric provides the ingress SCTP data chunk discard ratio for a S1-MME or X2-C logical interface instance. It is the percentage of SCTP data chunks received from a remote SCTP peer for which no problems were encountered to prevent their continued processing but were discarded by the eNB SCTP endpoint during a reporting period. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The ingress SCTP data chunk discard ratio in % for a specific S1-MME or X2-C logical interface is calculated using Equation 43 .

$$100 \times \frac{A}{(A+B+C)}$$

Equation 43 S1-MME/X2-C Interface 15-Minute Ingress SCTP Data Chunk Discard Ratio (%)

Where:

A	*pmInDataChunkDiscards*
B	*pmInDataChunks*
C	*pmInDataChunkAbnormal*

7.2 15-Minute Egress SCTP Data Chunk and User Data Discard Ratio

This singleton metric provides the egress SCTP data chunk and user data discard ratio for a S1-MME or X2-C logical interface instance. It is the percentage of user data messages and the SCTP data chunks destined to a remote SCTP peer for which no problems were encountered to prevent their transmission but were discarded by the eNB SCTP endpoint during a reporting period. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The egress SCTP data chunk and user data discard ratio in % for a specific S1-MME or X2-C logical interface is calculated using Equation 44 .

$$100 \times \frac{A+B}{(A+B+C)}$$

Equation 44 S1-MME/X2-C Interface 15-Minute Egress SCTP Data Chunk and User Data Discard Ratio (%)

Where:

A	*pmOutDataChunkDiscards*
B	*pmOutUserMsgDiscards*
C	*pmOutDataChunks*

7.3 15-Minute Ingress SCTP Control Chunk Discard Ratio

This singleton metric provides the ingress SCTP control chunk discard ratio for a S1-MME or X2-C logical interface instance. It is the percentage of SCTP control chunks received from a remote SCTP peer for which no problems were encountered to prevent their continued processing but were discarded by the eNB SCTP endpoint during a reporting period. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The ingress SCTP control chunk discard ratio in % for a specific S1-MME or X2-C logical interface is calculated using Equation 45 .

$$100 \times \frac{A}{(A + B + C)}$$

Equation 45 S1-MME/X2-C Interface 15-Minute Ingress SCTP Control Chunk Discard Ratio (%)

Where:

A	*pmInControlChunkDiscards*
B	*pmInControlChunks*
C	*pmInControlChunkAbnormal*

7.4 15-Minute SCTP Data Chunk Retransmission Ratio

This singleton metric provides the egress SCTP data chunk retransmission ratio for a S1-MME or X2-C logical interface instance over a 15-minute reporting interval. It is the percentage of SCTP data chunks retransmitted to a remote SCTP peer during a reporting period. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The egress SCTP data chunk retransmission ratio in percentage for a specific S1-MME or X2-C logical interface is calculated using Equation 46 .

$$100 \times \frac{A}{A + B}$$

Equation 46 S1-MME/X2-C Interface 15-Minute Egress SCTP Data Chunk Retransmission Ratio (%)

Where:

A	*pmRtxChunks*
B	*pmOutDataChunks*

7.5 15-Minute SCTP Availability Ratio

This singleton metric provides the SCTP availability ratio for a S1-MME or X2-C logical interface instance. It is the percentage of time the SCTP association is available (with ENABLED operational state) during a reporting period. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The SCTP availability ratio in % for a specific S1-MME or X2-C logical interface is calculated using Equation 47 .

$$100 \times \frac{(ROP - A)}{ROP}$$

Equation 47 S1-MME/X2-C Interface 15-Minute SCTP Availability Ratio (%)

Where:

A	*pmTimeUnavail*
ROP	`900 s`

7.6 15-Minute IP-Layer Ingress Average Usage

This singleton metric provides the average ingress IP-layer usage for a S1-MME or X2-C logical interface instance. It is the number of IP-layer bits received in SCTP IP packets from a remote SCTP peer during a reporting period. It does not include SCTP packets received with errors. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The ingress IP-layer average usage in Mbps for a specific S1-MME or X2-C logical interface is calculated using Equation 48 .

$$\frac{(A \times 8) + (B \times IP\ Overhead)}{1000000 \times ROP}$$

Equation 48 S1-MME/X2-C Interface 15-Minute IP-layer Ingress Average Usage (Mbps)

Where:

A	*pmInOctets*
B	*pmInPacks*
ROP	`900 s`

IP Overhead

IP overhead is the amount of IP bits received on the link per SCTP packet including the inner IPv4 header (160 bits) or inner IPv6 header (320 bits) and the IPSec ESP tunnel mode overhead when applicable. The IPSec tunnel mode overhead is variable and is dependant on the configuration of the outer IP protocol, encryption/ciphering algorithm (ESP-Null, ESP-3DES-CBC and ESP-AES-CBC) and integrity algorithm (ESP-HMAC-SHA1 and ESP-HMAC-MD5). The IPSec overhead also depends on the amount of padding in the ESP trailer which is needed to align the size of the plaintext data to the block size of a block cipher required by the encryption algorithm (0-56 bits for ESP-3DES-CBC and 0-120 bits for ESP-AES-CBC).

Table 4 shows the total IP overhead in bits for SCTP data transfer in plaintext or with IPSec encryption and integrity services. It assumes the worst case scenario for padding bytes in the ESP trailer.

Table 4 Total IP Overhead in bits for plain text and IPSec-protected data

Plain Text	**IPSec ESP Tunnel Mode**			
IPv4 Host	Outer tunnel: IPv4 Inner Host: IPv4 Encryption: ESP-3DES-CBC Integrity: ESP-HMAC-SHA-1 or ESP-HMAC-MD5	Outer tunnel: IPv4 Inner Host: IPv4 Encryption: ESP-AES-CBC Integrity: ESP-HMAC-SHA-1 or ESP-HMAC-MD5	Outer tunnel: IPv6 Inner Host: IPv4 Encryption: ESP-3DES-CBC Integrity: ESP-HMAC-SHA-1 or ESP-HMAC-MD5	Outer tunnel: IPv6 Inner Host: IPv4 Encryption: ESP-AES-CBC Integrity: ESP-HMAC-SHA-1 or ESP-HMAC-MD5
160 bits	616 bits	744 bits	776 bits	904 bits

IPv6 Host	Outer tunnel: IPv4 Inner Host: IPv6 Encryption: ESP-3DES-CBC Integrity: ESP-HMAC-SHA-1 or ESP-HMAC-MD5	Outer tunnel: IPv4 Inner Host: IPv6 Encryption: ESP-AES-CBC Integrity: ESP-HMAC-SHA-1 or ESP-HMAC-MD5	Outer tunnel: IPv6 Inner Host: IPv6 Encryption: ESP-3DES-CBC Integrity: ESP-HMAC-SHA-1 or ESP-HMAC-MD5	Outer tunnel: IPv6 Inner Host: IPv6 Encryption: ESP-AES-CBC Integrity: ESP-HMAC-SHA-1 or ESP-HMAC-MD5
320 bits	776 bits	904 bits	936 bits	1064 bits

7.7 15-Minute IP-layer Egress Average Usage

This singleton metric provides the average egress IP-layer usage for a S1-MME or X2-C logical interface instance. It is the number of IP-layer bits in SCTP IP packets supplied to the lower layer for transmission to a remote SCTP peer during a reporting period. It includes SCTP packets that may be discarded by the lower layers, for example, packets discarded by the eNB egress traffic shaping feature (egress traffic shaping). The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME and neighbor eNB) identify the S1-MME X2-C logical interface instance.

The egress IP-layer average usage in Mbps for a specific S1-MME or X2-C logical interface is calculated using Equation 49 .

$$\frac{(A \times 8) + (B \times IP\ Overhead)}{1000000 \times ROP}$$

Equation 49 S1-MME/X2-C Interface 15-Minute IP-layer Egress Average Usage (Mbps)

Where:

A	`pmOutOctets`
B	`pmOutPacks`
ROP	`900 s`

IP Overhead

IP overhead is the amount of IP bits received on the link per SCTP packet including the inner IPv4 header (160 bits) or inner IPv6 header (320 bits) and the IPSec ESP tunnel mode overhead when applicable. The IPSec tunnel mode overhead is variable and is dependant on the configuration of the outer IP protocol, encryption/ciphering algorithm (ESP-Null, ESP-3DES-CBC and ESP-AES-CBC) and integrity algorithm (ESP-HMAC-SHA1 and ESP-HMAC-MD5). The IPSec overhead also depends on the amount of padding in the ESP trailer which is needed to align the size of the plaintext data to the block size of a block cipher required by the encryption algorithm (0-56 bits for ESP-3DES-CBC and 0-120 bits for ESP-AES-CBC).

Table 4 shows the total IP overhead in bits for SCTP data transfer in plaintext or with IPSec encryption and integrity services. It assumes the worst case scenario for padding bytes in the ESP trailer.

7.8 15-Minute Ethernet-layer Ingress Average Usage

This singleton metric provides the average ingress Ethernet-layer usage for a S1-MME or X2-C logical interface instance. It is the number of Ethernet-layer bits received in SCTP IP packets from a remote SCTP peer during a reporting period. It does not includes SCTP packets received with errors. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The ingress Ethernet-layer average usage in Mbps for a specific S1-MME or X2-C logical interface is calculated using Equation 50 .

$$\frac{(A \times 8) + (B \times (IP\,Overhead + Ethernet\,Overhead))}{1000000 \times ROP}$$

Equation 50 S1-MME/X2-C Interface 15-Minute Ethernet-layer Ingress Average Usage (Mbps)

Where:

A `pmInOctets`

B `pmInPacks`

ROP `900 s`

IP Overhead

IP overhead is the amount of IP bits received on the link per SCTP packet including the inner IPv4 header (160 bits) or inner IPv6 header (320 bits) and the IPSec ESP tunnel mode overhead when applicable. The IPSec tunnel mode overhead is variable and is dependant on the configuration of the outer IP protocol, encryption/ciphering algorithm (ESP-Null, ESP-3DES-CBC and ESP-AES-CBC) and integrity algorithm (ESP-HMAC-SHA1 and ESP-HMAC-MD5). The IPSec overhead also depends on the amount of padding in the ESP trailer which is needed to align the size of the plaintext data to the block size of a block cipher required by the encryption algorithm (0-56 bits for ESP-3DES-CBC and 0-120 bits for ESP-AES-CBC).

Table 4 shows the total IP overhead in bits for SCTP data transfer in plaintext or with IPSec encryption and integrity services. It assumes the worst case scenario for padding bytes in the ESP trailer.

Ethernet Overhead

Ethernet overhead is the amount of Ethernet bits received on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits) and inter-frame gap (96 bits). The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

7.9 15-Minute Ethernet-layer Egress Average Usage

This singleton metric provides the average egress Ethernet-layer usage for a S1-MME or X2-C logical interface instance. It is the number of Ethernet-layer bits transmitted in SCTP IP packets to a remote SCTP peer during a reporting period. It includes SCTP packets that may be discarded by the lower layers, for example, packets discarded by the eNB egress traffic shaping feature (egress traffic shaping). The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The egress Ethernet-layer average usage in Mbps for a specific S1-MME or X2-C logical interface is calculated using Equation 51 .

$$\frac{(A \times 8) + (B \times (IP\,Overhead + Ethernet\,Overhead))}{1000000 \times ROP}$$

Equation 51 S1-MME/X2-C Interface 15-Minute Ethernet-layer Egress Average Usage (Mbps)

Where:

A `pmOutOctets`

B	*pmOutPacks*
ROP	`900 s`
IP Overhead	IP overhead is the amount of IP bits received on the link per SCTP packet including the inner IPv4 header (160 bits) or inner IPv6 header (320 bits) and the IPSec ESP tunnel mode overhead when applicable. The IPSec tunnel mode overhead is variable and is dependant on the configuration of the outer IP protocol, encryption/ciphering algorithm (ESP-Null, ESP-3DES-CBC and ESP-AES-CBC) and integrity algorithm (ESP-HMAC-SHA1 and ESP-HMAC-MD5). The IPSec overhead also depends on the amount of padding in the ESP trailer which is needed to align the size of the plaintext data to the block size of a block cipher required by the encryption algorithm (0-56 bits for ESP-3DES-CBC and 0-120 bits for ESP-AES-CBC). Table 4 shows the total IP overhead in bits for SCTP data transfer in plaintext or with IPSec encryption and integrity services. It assumes the worst case scenario for padding bytes in the ESP trailer.
Ethernet Overhead	Ethernet overhead is the amount of Ethernet bits transmitted on the link per IP packet including the Ethernet header (112 bits), VLAN tag (32 bits), frame check sequence (32 bits), preamble (64 bits) and inter-frame gap (96 bits). The total Ethernet overhead is 336 bits/packet with VLAN tagging and 304 bits/packet without VLAN tagging.

8 IPSec Tunnel Singleton Performance Metrics

IPSec tunnel singleton performance metrics consist of the following:

- 15-minute ingress packet discard ratio (%)
- 15-minute egress packet discard ratio (%)
- 15-minute ESP-layer ingress average usage (Mbps)
- 15-minute ESP-layer egress average usage (Mbps)

These metric are applicable only when the IPSec ESP tunnel mode feature is configured on the DUL or DUS. They are calculated from measurements made at the ESP sublayer of the eNB security protocol processor engine. The counters used for the IPSec tunnel singleton performance metrics are accessible under the IpSecTunnel MO class described in *class IpSecTunnel*.

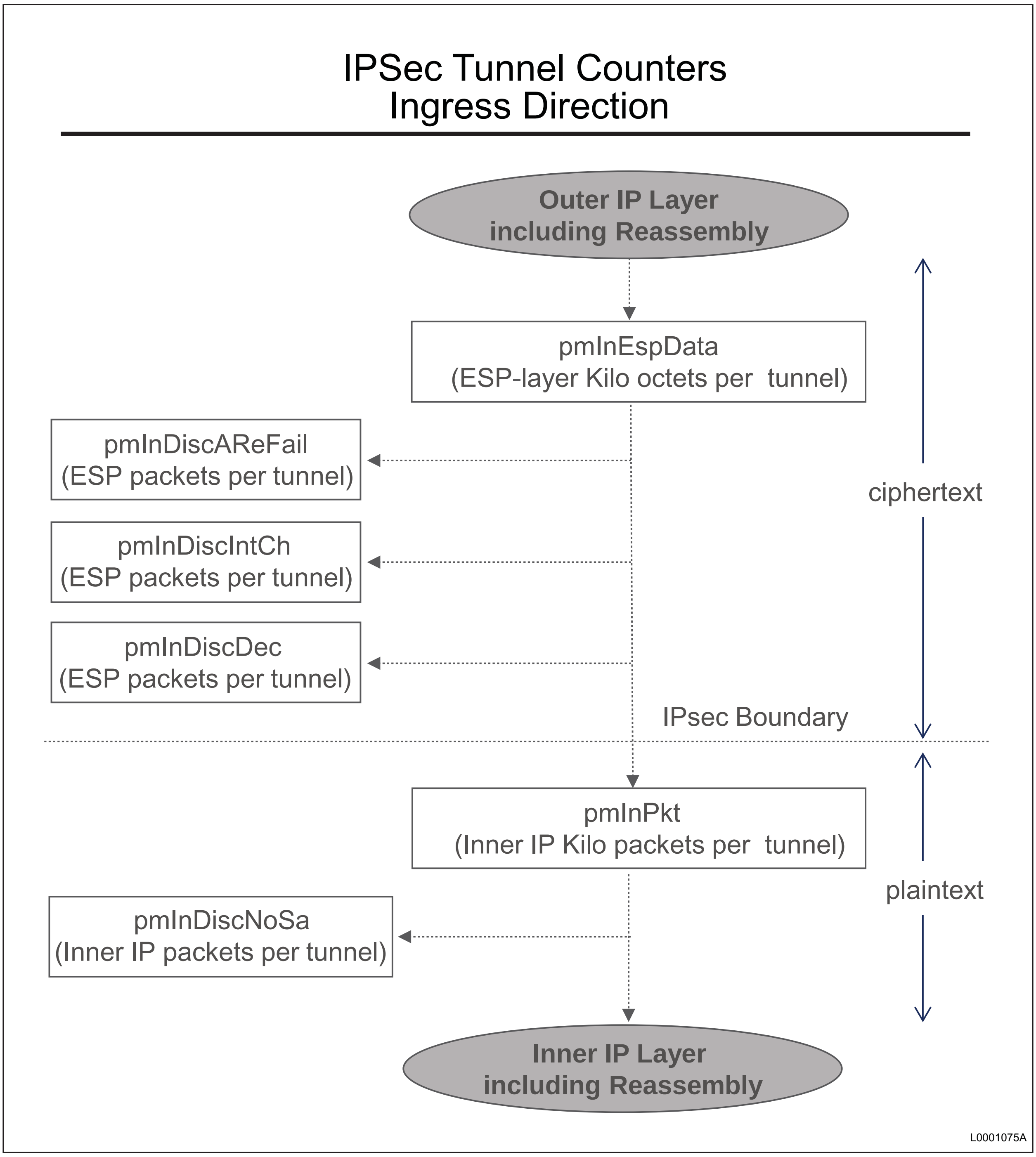

Figure 10 IPSec Tunnel Counters Ingress Direction

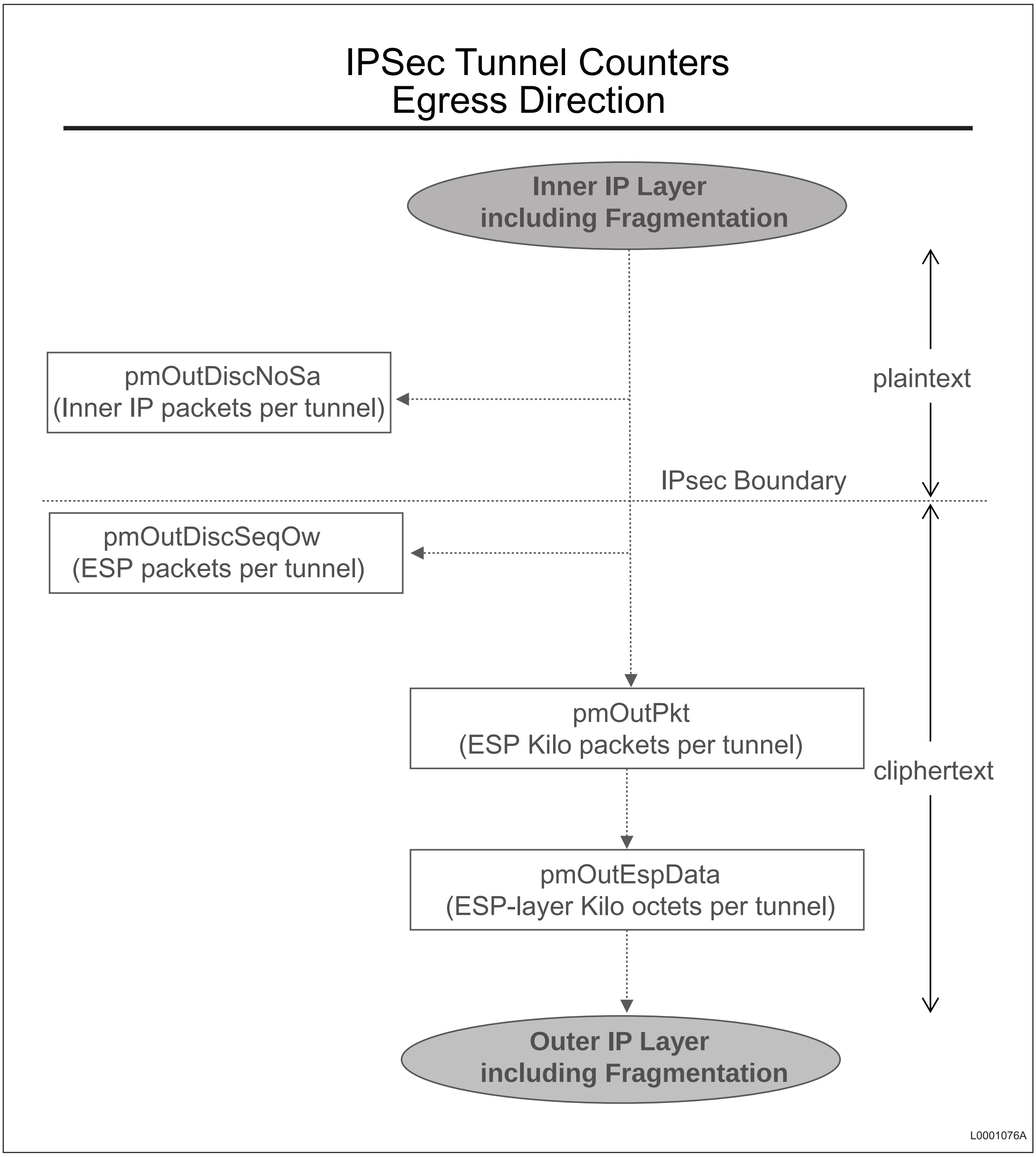

Figure 11 IPSec Tunnel Counters Egress Direction

8.1 15-minute Ingress Packet Discard Ratio

This singleton metric computes the ingress ESP packet discard ratio for an IPSec tunnel over a 15-minute reporting interval. It is the percentage of ESP packets (after outer IP reassembly) received on an IPsec tunnel discarded by the eNB security protocol processor engine during a reporting period.

The ingress ESP packet discard ratio in percentage for a specific tunnel is calculated using Equation 52.

$$100 \times \frac{A+B+C+D}{(A+B+C+(E\times 1000))}$$

Equation 52 IPSec Tunnel 15-Minutes Ingress Packet Discards (%)

Where:

A	*pmInDiscAReFail*
B	*pmInDiscIntCh*
C	*pmInDiscDec*
D	*pmInDiscNoSa*
E	*pmInPkt*

8.2 15-minute Egress Packet Discard Ratio

This singleton metric computes the egress ESP packet discard ratio for an IPSec tunnel over a 15-minute reporting interval. It is the percentage of ESP packets (before outer IP fragmentation) destined to a remote IPsec peer discarded by the eNB security protocol processor engine during a reporting period.

The egress ESP packet discard ratio in percentage for a specific tunnel is calculated using Equation 53.

$$100 \times \frac{A+B}{(A+B+(C\times 1000))}$$

Equation 53 IPSec Tunnel 15-Minutes Egress Packet Discards (%)

Where:

A	*pmOutDiscNoSa*
B	*pmOutDiscSeqOw*
C	*pmOutPkt*

8.3 15-minute ESP-layer Ingress Average Usage

This singleton metric provides the average ingress ESP-layer usage for an IPSec tunnel. It is the number of ESP-layer bits received in ESP packets (after outer IP reassembly) from a remote IPSec peer during a reporting period. It include input ESP packets discarded by the eNB security protocol processor engine.

The ingress ESP-layer packet average usage in Mpbs for a specific tunnel is calculated using Equation 54.

$$\frac{A \times 8}{(1000000 \times ROP)}$$

Equation 54 IPSec Tunnel 15-Minutes Ingress Average Usage (Mbps)

Where:

A *pmInEspData*

ROP `900 s`

8.4 15-minute ESP-layer Egress Average Usage

This singleton metric provides the average egress ESP-layer usage for an IPSec tunnel. It is the number of ESP-layer bits transmitted in ESP packets (before outer IP fragmentation) to a remote IPSec peer during a reporting period. It includes ESP packets that may be discarded by the lower layers, for example, packets discarded by the eNB egress traffic shaping feature (egress traffic shaping).

The egress ESP-layer packet average usage in Mpbs for a specific tunnel is calculated using Equation 55.

$$\frac{A \times 8}{(1000000 \times ROP)}$$

Equation 55 IPSec Tunnel 15-Minutes Egress Average Usage (Mbps)

Where:

A *pmOutEspData*

ROP `900 s`

9 Transport Network Statistical Performance Metrics

The transport network statistical performance metrics are designed to provide a daily performance summary for each LTE RBS. They are calculated for each hour of the day or over a 24-hour period. They may also be reported for each 15-minute reporting interval.

The LTE transport network statistical performance metrics are divided in the following groups:

- GE statistical performance metrics
- IPv4 statistical performance metrics
- IPv6 statistical performance metrics
- Traffic scheduler statistical performance metrics
- S1/X2 control plane statistical performance metrics
- IPSec statistical performance metrics

9.1 GE Statistical Performance Metrics

The GE statistical performance metrics consist of the following:

- GE interface ingress maximum packet error ratio
- GE interface ingress maximum usage
- GE interface ingress average usage
- GE interface egress maximum usage
- GE interface egress average usage

9.1.1 GE Interface Ingress Maximum Packet Error Ratio

This statistical metric provides the maximum (peak) 15-minute ingress Ethernet packet error ratio over a period of 15 minutes, one hour, or 24 hours. The port number identifies the active GE interface.

The maximum ingress Ethernet-layer packet/frame error ratio in % for a specific GE interface is calculated using Equation 56.

$$MAX\left(GeIn15minErrorRatio_1, ..., GeIn15minErrorRatio_N\right)$$

Equation 56 GE Interface Ingress Maximum Packet Error Ratio (%)

Where:

GeIn15minErrorRatio
Singleton metric defined in Section 3.1 on page 7

N Number of measurements in the sample

9.1.2 GE Interface Ingress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute ingress average usage over a period of 15 minutes, one hour, or 24 hours. The port number identifies the active GE interface.

The maximum ingress Ethernet-layer usage in Mbps for a specific GE interface is calculated using Equation 57.

$$MAX\left(GeIn15minAverageUsage_1, ...GeIn15minAverageUsage_N\right)$$

Equation 57 GE Interface Ingress Maximum Usage (Mbps)

Where:

GeIn15minAverageUsage
Singleton metric defined in Section 3.2 on page 7

N Number of measurements in the sample

9.1.3 GE Interface Ingress Average Usage

This statistical metric provides the average (mean) ingress usage over a period of 15 minutes, one hour, or 24 hours. The port number identifies the active GE interface.

The average ingress Ethernet-layer usage in Mbps for a specific GE interface is calculated using Equation 58.

$$\frac{GeIn15minAverageUsage_1 + ... + GeIn15minAverageUsage_N}{N}$$

Equation 58 GE Interface Ingress Average Usage (Mbps)

Where:

GeIn15minAverageUsage
Singleton metric defined in Section 3.2 on page 7

N Number of measurements in the sample

9.1.4 GE Interface Egress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute egress average usage over a period 15 minutes, one hour, or 24 hours. The port number identifies the active GE interface.

The maximum egress Ethernet-layer usage in Mbps for a specific GE interface is calculated using Equation 59.

$$MAX\left(GeOut15minAverageUsage_1, ..., GeOut15minAverageUsage_N\right)$$

Equation 59 GE Interface Egress Maximum Usage (Mbps)

Where:

GeOut15minAverageUsage
Singleton metric defined in Section 3.3 on page 9

N Number of measurements in the sample

9.1.5 GE Interface Egress Average Usage

This statistical metric returns the average (mean) egress usage over a period of 15 minutes, one hour, or 24 hours. The port number identifies the active GE interface.

The average egress Ethernet-layer usage in Mbps for a specific GE interface is calculated using Equation 60.

$$\frac{GeOut15minAverageUsage_1 + ... + GeOut15minAverageUsage_N}{N}$$

Equation 60 GE Interface Egress Average Usage (Mbps)

Where:

GeOut15minAverageUsage
Singleton metric defined in Section 3.3 on page 9

N Number of measurements in the sample

9.2 IPv4 Statistical Performance Metrics

The IPv4 statistical performance metrics consist of the following:

- IPv4 interface ingress maximum packet discard ratio
- IPv4 interface egress maximum packet discard ratio
- IPv4 interface IP-layer ingress maximum usage
- IPv4 interface IP-layer ingress average usage

- IPv4 interface IP-layer egress maximum usage
- IPv4 interface IP-layer egress average usage
- IPv4 interface Ethernet-layer ingress maximum usage
- IPv4 interface Ethernet-layer ingress average usage
- IPv4 interface Ethernet-layer egress maximum usage
- IPv4 interface Ethernet-layer egress average usage
- IPv4 DSCP Group IP-layer ingress maximum usage
- IPv4 DSCP Group IP-layer egress maximum usage
- IPv4 DSCP Group Ethernet-layer ingress maximum usage
- IPv4 DSCP Group Ethernet-layer egress maximum usage
- IPv4 interface IP-layer ingress multicast maximum usage
- IPv4 interface Ethernet-layer ingress multicast maximum usage
- IPv4 Flow IP-layer ingress maximum usage
- IPv4 Flow IP-layer egress maximum usage
- IPv4 Flow Ethernet-layer ingress maximum usage
- IPv4 Flow Ethernet-layer egress maximum usage

9.2.1 IPv4 Interface Ingress Maximum Packet Discard Ratio

This statistical metric provides the maximum 15-minute ingress IP packet discard ratio over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix identifies the IPv4 interface.

The maximum ingress IP-layer packet discard ratio in % for a specific IPv4 interface is calculated using Equation 61.

$$MAX\left(Ipv4In15minDiscardRatio_1, ..., Ipv4In15minDiscardRatio_N\right)$$

Equation 61 IPv4 Interface Ingress Maximum Packet Discard Ratio (%)

Where:

Ipv4In15minDiscardRatio
Singleton metric defined in Section 4.1 on page 14

N Number of measurements in the sample

9.2.2 IPv4 Interface Egress Maximum Packet Discard Ratio

This statistical metric provides the maximum 15-minute egress IP packet discard ratio over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix identifies the IPv4 interface.

The maximum egress IP-layer packet discard ratio in % for a specific IPv4 interface is calculated using Equation 62.

$$MAX\left(Ipv4Out15minDiscardRatio_1, ..., Ipv4Out15minDiscardRatio_N\right)$$

Equation 62 IPv4 Interface Egress Maximum Packet Discard Ratio (%)

Where:

Ipv4Out15minDiscardRatio
Singleton metric defined in Section 4.2 on page 16

N Number of measurements in the sample

9.2.3 IPv4 Interface IP-layer Ingress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute IP-layer ingress average usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix identifies the IPv4 interface.

The maximum ingress IP-layer usage in Mbps for a specific IPv4 interface is calculated using Equation 63.

$$MAX\left(Ipv4IpIn15minAverageUsage_1, ..., Ipv4IpIn15minAverageUsage_N\right)$$

Equation 63 IPv4 Interface IP-Layer Maximum Ingress Usage (Mbps)

Where:

Ipv4IpIn15minAverageUsage
Singleton metric defined in Section 4.3 on page 16

N Number of measurements in the sample

9.2.4 IPv4 Interface IP-layer Ingress Average Usage

This statistical metric provides the average (mean) IP-layer ingress usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix identifies the IPv4 interface.

The average ingress IP-layer usage in Mbps for a specific IPv4 interface is calculated using Equation 64.

$$\frac{Ipv4IpIn15minAverageUsage_1 + ... + Ipv4IpIn15minAverageUsage_N}{N}$$

Equation 64 IPv4 Interface IP-Layer Average Ingress Usage (Mbps)

Where:

Ipv4IpIn15minAverageUsage
Singleton metric defined in Section 4.3 on page 16

N Number of measurements in the sample

9.2.5 IPv4 Interface IP-layer Egress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute IP-layer egress average usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix identifies the IPv4 interface.

The maximum egress IP-layer usage in Mbps for a specific IPv4 interface is calculated using Equation 65.

$$MAX\,(Ipv4IpOut15minAverageUsage_1, ..., Ipv4IpOut15minAverageUsage_N)$$

Equation 65 IPv4 Interface IP-Layer Maximum Egress Usage (Mbps)

Where:

Ipv4IpOut15minAverageUsage
Singleton metric defined in Section 4.4 on page 17

N Number of measurements in the sample

9.2.6 IPv4 Interface IP-layer Egress Average Usage

This statistical metric provides the average (mean) IP-layer egress usage over a period of 15 minutes, one hour or 24 hours. The subnet prefix identifies the IPv4 interface.

The average egress IP-layer usage in Mbps for a specific IPv4 interface is calculated using Equation 66.

$$\frac{Ipv4IpOut15minAverageUsage_1 + ... + Ipv4IpOut15minAverageUsage_N}{N}$$

Equation 66 IPv4 Interface IP-Layer Average Egress Usage (Mbps)

Where:

Ipv4IpOut15minAverageUsage
Singleton metric defined in Section 4.4 on page 17

N Number of measurements in the sample

9.2.7 IPv4 Interface Ethernet-layer Ingress Maximum Usage

This statistical metric provides the average (mean) Ethernet-layer ingress usage over a period of 15 minutes, one hour or 24 hours. The subnet prefix identifies the IPv4 interface.

The average ingress Ethernet-layer usage in Mbps for a specific IPv4 interface is calculated using Equation 67.

$$MAX\left(Ipv4EtherIn15minAverageUsage_1, ..., Ipv4EtherIn15minAverageUsage_N\right)$$

Equation 67 IPv4 Interface Ethernet-Layer Maximum Ingress Usage (Mbps)

Where:

Ipv4EtherIn15minAverageUsage
Singleton metric defined in Section 4.5 on page 18

N Number of measurements in the sample

9.2.8 IPv4 Interface Ethernet-layer Ingress Average Usage

This statistical metric provides the average (mean) Ethernet-layer ingress usage over a period of 15 minutes, one hour or 24 hours. The subnet prefix identifies the IPv4 interface.

The average ingress Ethernet-layer usage in Mbps for a specific IPv4 interface is calculated using Equation 68.

$$\frac{Ipv4EtherIn15minAverageUsage_1 + ... + Ipv4EtherIn15minAverageUsage_N}{N}$$

Equation 68 IPv4 Interface Ethernet-Layer Average Ingress Usage (Mbps)

Where:

Ipv4EtherIn15minAverageUsage
Singleton metric defined in Section 4.5 on page 18

N Number of measurements in the sample

9.2.9 IPv4 Interface Ethernet-layer Egress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute Ethernet-layer egress average usage over a period of 15 minutes, one hour or 24 hours. The subnet prefix identifies the IPv4 interface.

The maximum egress IP-layer usage in Mbps for a specific IPv4 interface is calculated using Equation 69.

$$MAX\left(Ipv4EtherOut15minAverageUsage_{1}, ..., Ipv4EtherOut15minAverageUsage_{N}\right)$$

Equation 69 IPv4 Interface Ethernet-Layer Maximum Egress Usage (Mbps)

Where:

Ipv4EtherOut15minAverageUsage
Singleton metric defined in Section 4.6 on page 19

N Number of measurements in the sample

9.2.10 IPv4 Interface Ethernet-layer Egress Average Usage

This statistical metric provides the average (mean) Ethernet-layer egress usage over a period of 15 minutes, one hour or 24 hours. The subnet prefix identifies the IPv4 interface.

The average egress Ethernet-layer usage in Mbps for a specific IPv4 interface is calculated using Equation 70.

$$\frac{Ipv4EtherOut15minAverageUsage_{1} + ... + Ipv4EtherOut15minAverageUsage_{N}}{N}$$

Equation 70 IPv4 Interface Ethernet-Layer Average Egress Usage (Mbps)

Where:

Ipv4EtherOut15minAverageUsage
Singleton metric defined in Section 4.6 on page 19

N Number of measurements in the sample

9.2.11 IPv4 DSCP Group IP-layer Ingress Maximum Usage

This statistical metric provides the maximum (peak) short sample IP-layer ingress DSCP group usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix identifies the IPv4 interface. The DSCP values identify the DSCP group.

The maximum ingress IP-layer DSCP group usage in Mbps for a specific IPv4 interface is calculated using Equation 71.

$$MAX\left(Ipv4IpInDscpUsage_{1}, ..., Ipv4IpInDscpUsage_{N}\right)$$

Equation 71 IPv4 DSCP Group IP-Layer Maximum Ingress Usage (Mbps)

Where:

Ipv4IpInDscpUsage
Singleton metric defined in Section 4.7 on page 20

N Number of measurements in the sample

9.2.12 IPv4 DSCP Group IP-layer Egress Maximum Usage

This statistical metric provides the maximum (peak) short sample IP-layer egress DSCP group usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix identifies the IPv4 interface. The DSCP values identify the DSCP group.

The maximum egress IP-layer DSCP group usage in Mbps for a specific IPv4 interface is calculated using Equation 72.

$$MAX\left(Ipv4IpOutDscpUsage_1, ..., Ipv4IpOutDscpUsage_N\right)$$

Equation 72 IPv4 DSCP Group IP-Layer Maximum Egress Usage (Mbps)

Where:

Ipv4IpOutDscpUsage
Singleton metric defined in Section 4.8 on page 20

N Number of measurements in the sample

9.2.13 IPv4 DSCP Group Ethernet-layer Ingress Maximum Usage

This statistical metric provides the maximum (peak) short sample Ethernet-layer ingress DSCP group usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix identifies the IPv4 interface. The DSCP values identify the DSCP group.

The maximum ingress Ethernet-layer DSCP group usage in Mbps for a specific IPv4 interface is calculated using Equation 73.

$$MAX\left(Ipv4EtherInDscpUsage_1, ..., Ipv4EtherInDscpUsage_N\right)$$

Equation 73 IPv4 DSCP Group Ethernet-Layer Maximum Ingress Usage (Mbps)

Where:

Ipv4EtherInDscpUsage
Singleton metric defined in Section 4.9 on page 21

N Number of measurements in the sample

9.2.14 IPv4 DSCP Group Ethernet-layer Egress Maximum Usage

This statistical metric provides the maximum (peak) short sample Ethernet-layer egress DSCP group usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix identifies the IPv4 interface. The DSCP values identify the DSCP group.

The maximum egress Ethernet-layer DSCP group usage in Mbps for a specific IPv4 interface is calculated using Equation 74.

$$MAX\,(Ipv4EtherOutDscpUsage_1, ..., Ipv4EtherOutDscpUsage_N)$$

Equation 74 IPv4 DSCP Group IP-Layer Maximum Egress Usage (Mbps)

Where:

Ipv4EtherOutDscpUsage
Singleton metric defined in Section 4.10 on page 22

N Number of measurements in the sample

9.2.15 IPv4 Interface IP-Layer Ingress Multicast Maximum Usage

This statistical metric provides the maximum (peak) 15-minute IP-layer ingress multicast average usage over a sample period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv4 interface.

The maximum ingress IP-layer multicast usage in Mbps for a specific IPv4 interface is calculated using Equation 75.

$$MAX\,(Ipv4IpIn15minMcastAverageUsage_1, ..., Ipv4IpIn15minMcastAverageUsage_N)$$

Equation 75 IPv4 Interface IP-Layer Maximum Ingress Multicast Usage (Mbps)

Where:

Ipv4IpIn15minMcastAverageUsage
Singleton metric defined in Section 4.11 on page 23

N Number of measurements in the sample

9.2.16 IPv4 Interface Ethernet-Layer Ingress Multicast Maximum Usage

This statistical metric provides the maximum (peak) 15-minute Ethernet-layer ingress multicast average usage over a sample period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv4 interface.

The maximum ingress Ethernet-layer multicast usage in Mbps for a specific IPv4 interface is calculated using Equation 76.

$$MAX\,(Ipv4EtherIn15minMcastAverageUsage_1, ..., Ipv4EtherIn15minMcastAverageUsage_N)$$

Equation 76 IPv4 Interface Ethernet-Layer Maximum Ingress Multicast Usage (Mbps)

Where:

Ipv4EtherIn15minMcastAverageUsage
Singleton metric defined in Section 4.13 on page 24

N Number of measurements in the sample

9.2.17 IPv4 Flow IP-layer Ingress Maximum Usage

This statistical metric provides the maximum (peak) short sample IP-layer ingress IPv4 flow usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix of the local IPv4 interface, the DSCP values and the remote IP address prefix identify the IPv4 flow.

The maximum ingress IP-layer usage in Mbps for a specific IPv4 flow is calculated using Equation 77.

$$MAX\left(Ipv4IpInFlowUsage_1, ..., Ipv4IpInFlowUsage_N\right)$$

Equation 77 IPv4 Flow IP-Layer Maximum Ingress Usage (Mbps)

Where:

Ipv4IpInFlowUsage
Singleton metric defined in Section 4.15 on page 26

N Number of measurements in the sample

This statistical metric can also be calculated directly from the `pmIpFlowMaxInBitrate` counter which is the maximum ingress IP-layer flow bitrate provided by the RBS during a 900 seconds reporting period.

9.2.18 IPv4 Flow IP-layer Egress Maximum Usage

This statistical metric provides the maximum (peak) short sample IP-layer egress IPv4 flow usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix of the local IPv4 interface, the DSCP values and the remote IP address prefix identify the IPv4 flow.

The maximum egress IP-layer usage in Mbps for a specific IPv4 flow is calculated using Equation 78.

$$MAX\left(Ipv4IpOutFlowUsage_1, ..., Ipv4IpOutFlowUsage_N\right)$$

Equation 78 IPv4 Flow IP-Layer Maximum Egress Usage (Mbps)

Where:

Ipv4IpOutFlowUsage
Singleton metric defined in Section 4.16 on page 26

N Number of measurements in the sample

This statistical metric can also be calculated directly from the `pmIpFlowMaxOutBitrate` counter which is the maximum egress IP-layer flow bitrate provided by the RBS during a 900 seconds reporting period.

9.2.19 IPv4 Flow Ethernet-layer Ingress Maximum Usage

This statistical metric provides the maximum (peak) short sample Ethernet-layer ingress IPv4 flow usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix of the local IPv4 interface, the DSCP values and the remote IP address prefix identify the IPv4 flow.

The maximum ingress Ethernet-layer usage in Mbps for a specific IPv4 flow is calculated using Equation 79.

$$MAX\left(Ipv4EtherInFlowUsage_1, ..., Ipv4EtherInFlowUsage_N\right)$$

Equation 79 IPv4 Flow Ethernet-Layer Maximum Ingress Usage (Mbps)

Where:

Ipv4EtherInFlowUsage
Singleton metric defined in Section 4.17 on page 27

N Number of measurements in the sample

9.2.20 IPv4 Flow Ethernet-layer Egress Maximum Usage

This statistical metric provides the maximum (peak) short sample Ethernet-layer egress IPv4 flow usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix of the local IPv4 interface, the DSCP values and the remote IP address prefix identify the IPv4 flow.

The maximum egress Ethernet-layer usage in Mbps for a specific IPv4 flow is calculated using Equation 80.

$$MAX\left(Ipv4EtherOutFlowUsage_1, ..., Ipv4EtherOutFlowUsage_N\right)$$

Equation 80 IPv4 Flow IP-Layer Maximum Egress Usage (Mbps)

Where:

Ipv4EtherOutFlowUsage
Singleton metric defined in Section 4.18 on page 28

N Number of measurements in the sample

9.3 IPv6 Statistical Performance Metrics

The IPv6 statistical performance metrics consist of the following:

- IPv6 interface ingress maximum packet discard ratio
- IPv6 interface egress maximum packet discard ratio
- IPv6 interface IP-layer ingress maximum usage

- IPv6 interface IP-layer ingress average usage
- IPv6 interface IP-layer egress maximum usage
- IPv6 interface IP-layer egress average usage
- IPv6 interface Ethernet-layer ingress maximum usage
- IPv6 interface Ethernet-layer ingress average usage
- IPv6 interface Ethernet-layer egress maximum usage
- IPv6 interface Ethernet-layer egress average
- IPv6 DSCP Group IP-layer ingress maximum usage
- IPv6 DSCP Group IP-layer egress maximum usage
- IPv6 DSCP Group Ethernet-layer ingress maximum usage
- IPv6 DSCP Group Ethernet-layer egress maximum usage
- IPv6 interface IP-layer ingress multicast maximum usage
- IPv6 interface Ethernet-layer ingress multicast maximum usage
- IPv6 Flow IP-layer ingress maximum usage
- IPv6 Flow IP-layer egress maximum usage
- IPv6 Flow Ethernet-layer ingress maximum usage
- IPv6 Flow Ethernet-layer egress maximum usage

9.3.1 IPv6 Interface Ingress Maximum Packet Discard Ratio

This statistical metric provides the maximum 15-minute ingress IP packet discard ratio over a period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface.

The maximum ingress IP-layer packet discard ratio in % for a specific IPv6 interface is calculated using Equation 81.

$$MAX\left(Ipv6In15minDiscardRatio_1, ..., Ipv6In15minDiscardRatio_N\right)$$

Equation 81 IPv6 Interface Ingress Maximum Packet Discard Ratio (%)

Where:

Ipv6In15minDiscardRatio
Singleton metric defined in Section 5.1 on page 34

N Number of measurements in the sample

9.3.2 IPv6 Interface Egress Maximum Packet Discard Ratio

This statistical metric provides the maximum 15-minute egress IP packet discard ratio over a period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface.

The maximum egress IP-layer packet discard ratio in % for a specific IPv6 interface is calculated using Equation 82.

$$MAX\left(Ipv6Out15minDiscardRatio_1, ..., Ipv6Out15minDiscardRatio_N\right)$$

Equation 82 IPv6 Interface Egress Maximum Packet Discard Ratio (%)

Where:

Ipv6Out15minDiscardRatio
Singleton metric defined in Section 5.2 on page 35

N Number of measurements in the sample

9.3.3 IPv6 Interface IP-Layer Ingress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute IP-layer ingress average usage over a sample period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface.

The maximum ingress IP-layer usage in Mbps for a specific IPv6 interface is calculated using Equation 83.

$$MAX\left(Ipv6IpIn15minAverageUsage_1, ..., Ipv6IpIn15minAverageUsage_N\right)$$

Equation 83 IPv6 Interface IP-Layer Maximum Ingress Usage (Mbps)

Where:

Ipv6IpIn15minAverageUsage
Singleton metric defined in Section 5.3 on page 36

N Number of measurements in the sample

9.3.4 IPv6 Interface IP-Layer Ingress Average Usage

This statistical metric provides the average (mean) IP-layer ingress usage over a sample period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface.

The average ingress IP-layer usage in Mbps for a specific IPv6 interface is calculated using Equation 84.

$$\frac{Ipv6IpIn15minAverageUsage_1 + ... + Ipv6IpIn15minAverageUsage_N}{N}$$

Equation 84 IPv6 Interface IP-Layer Average Ingress Usage (Mbps)

Where:

Ipv6IpIn15minAverageUsage
Singleton metric defined in Section 5.3 on page 36

N Number of measurements in the sample

9.3.5 IPv6 Interface IP-Layer Egress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute IP-layer egress average usage over a sample period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface.

The maximum egress IP-layer usage in Mbps for a specific IPv6 interface is calculated using Equation 85.

$$MAX\left(Ipv6IpOut15minAverageUsage_1, ..., Ipv6IpOut15minAverageUsage_N\right)$$

Equation 85 IPv6 Interface IP-Layer Maximum Egress Usage (Mbps) Where

Where:

Ipv6IpOut15minAverageUsage
Singleton metric defined in Section 5.4 on page 37

N Number of measurements in the sample

9.3.6 IPv6 Interface IP-Layer Egress Average Usage

This statistical metric provides the average (mean) IP-layer egress usage over a sample period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface.

The average egress IP-layer usage in Mbps for a specific IPv6 interface is calculated using Equation 86.

$$\frac{Ipv6IpOut15minAverageUsage_1 + ... + Ipv6IpOut15minAverageUsage_N}{N}$$

Equation 86 IPv6 Interface IP-Layer Average Egress Usage (Mbps)

Where:

Ipv6IpOut15minAverageUsage
Singleton metric defined in Section 5.4 on page 37

N Number of measurements in the sample

9.3.7 IPv6 Interface Ethernet-Layer Ingress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute Ethernet-layer ingress average usage over a sample period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface.

The maximum ingress Ethernet-layer usage in Mbps for a specific IPv6 interface is calculated using Equation 87.

$$MAX\left(Ipv6EtherIn15minAverageUsage_1, ..., Ipv6EtherIn15minAverageUsage_N\right)$$

Equation 87 IPv6 Interface Ethernet-Layer Maximum Ingress Usage (Mbps)

Where:

Ipv6EtherIn15minAverageUsage
Singleton metric defined in Section 5.5 on page 38

N Number of measurements in the sample

9.3.8 IPv6 Interface Ethernet-Layer Ingress Average Usage

This statistical metric provides the average (mean) Ethernet-layer ingress usage over a sample period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface.

The average ingress Ethernet-layer usage in Mbps for a specific IPv6 interface is calculated using Equation 88.

$$\frac{Ipv6EtherIn15minAverageUsage_1 + ... + Ipv6EtherIn15minAverageUsage_N}{N}$$

Equation 88 IPv6 Interface Ethernet-Layer Average Ingress Usage (Mbps)

Where:

Ipv6EtherIn15minAverageUsage
Singleton metric defined in Section 5.5 on page 38

N Number of measurements in the sample

9.3.9 IPv6 Interface Ethernet-Layer Egress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute Ethernet-layer egress average usage over a sample period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface.

The maximum egress IP-layer usage in Mbps for a specific IPv6 interface is calculated using Equation 89.

$$MAX\left(Ipv6EtherOut15minAverageUsage_1, ..., Ipv6EtherOut15minAverageUsage_N\right)$$

Equation 89 IPv6 Interface Ethernet-Layer Maximum Egress Usage (Mbps)

Where:

Ipv6EtherOut15minAverageUsage
Singleton metric defined in Section 5.6 on page 38

N Number of measurements in the sample

9.3.10 IPv6 Interface Ethernet-Layer Egress Average Usage

This statistical metric provides the average (mean) Ethernet-layer egress usage over a sample period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface.

The average egress Ethernet-layer usage in Mbps for a specific IPv6 interface is calculated using Equation 90.

$$\frac{Ipv6EtherOut15minAverageUsage_1 + ... + Ipv6EtherOut15minAverageUsage_N}{N}$$

Equation 90 IPv6 Interface Ethernet-Layer Average Egress Usage (Mbps)

Where:

Ipv6EtherOut15minAverageUsage
Singleton metric defined in Section 5.6 on page 38

N Number of measurements in the sample

9.3.11 IPv6 DSCP Group IP-layer Ingress Maximum Usage

This statistical metric provides the maximum (peak) short sample IP-layer ingress DSCP group usage over a period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface. The DSCP values identify the DSCP group.

The maximum ingress IP-layer DSCP group usage in Mbps for a specific IPv6 interface is calculated using Equation 91.

$$MAX\left(Ipv6IpInDscpUsage_1, ..., Ipv6IpInDscpUsage_N\right)$$

Equation 91 IPv6 DSCP Group IP-Layer Maximum Ingress Usage (Mbps)

Where:

Ipv6IpInDscpUsage
Singleton metric defined in Section 5.7 on page 39

N Number of measurements in the sample

9.3.12 IPv6 DSCP Group IP-layer Egress Maximum Usage

This statistical metric provides the maximum (peak) short sample IP-layer egress DSCP group usage over a period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface. The DSCP values identify the DSCP group.

The maximum egress IP-layer DSCP group usage in Mbps for a specific IPv6 interface is calculated using Equation 92.

$$MAX\left(Ipv6IpOutDscpUsage_1, ..., Ipv6IpOutDscpUsage_N\right)$$

Equation 92 IPv6 DSCP Group IP-Layer Maximum Egress Usage (Mbps)

Where:

Ipv6IpOutDscpUsage Singleton metric defined in Section 5.8 on page 40

N Number of measurements in the sample

9.3.13 IPv6 DSCP Group Ethernet-layer Ingress Maximum Usage

This statistical metric provides the maximum (peak) short sample Ethernet-layer ingress DSCP group usage over a period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface. The DSCP values identify the DSCP group.

The maximum ingress Ethernet-layer DSCP group usage in Mbps for a specific IPv6 interface is calculated using Equation 93.

$$MAX\left(Ipv6EtherInDscpUsage_1, ..., Ipv6EtherInDscpUsage_N\right)$$

Equation 93 IPv6 DSCP Group Ethernet-Layer Maximum Ingress Usage (Mbps)

Where:

Ipv6EtherInDscpUsage Singleton metric defined in Section 5.9 on page 41

N Number of measurements in the sample

9.3.14 IPv6 DSCP Group Ethernet-layer Egress Maximum Usage

This statistical metric provides the maximum (peak) short sample Ethernet-layer egress DSCP group usage over a period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface. The DSCP values identify the DSCP group.

The maximum egress Ethernet-layer DSCP group usage in Mbps for a specific IPv6 interface is calculated using Equation 94.

$$MAX\left(Ipv6EtherOutDscpUsage_1, ..., Ipv6EtherOutDscpUsage_N\right)$$

Equation 94 IPv6 DSCP Group IP-Layer Maximum Egress Usage (Mbps)

Where:

Ipv6EtherOutDscpUsage
Singleton metric defined in Section 5.10 on page 42

N Number of measurements in the sample

9.3.15 IPv6 Interface IP-Layer Ingress Multicast Maximum Usage

This statistical metric provides the maximum (peak) 15-minute IP-layer ingress multicast average usage over a sample period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface.

The maximum ingress IP-layer multicast usage in Mbps for a specific IPv6 interface is calculated using Equation 95.

$$MAX\left(Ipv6IpIn15minMcastAverageUsage_1, ..., Ipv6IpIn15minMcastAverageUsage_N\right)$$

Equation 95 IPv6 Interface IP-Layer Maximum Ingress Multicast Usage (Mbps)

Where:

Ipv6IpIn15minMcastAverageUsage
Singleton metric defined in Section 5.11 on page 43

N Number of measurements in the sample

9.3.16 IPv6 Interface Ethernet-Layer Ingress Multicast Maximum Usage

This statistical metric provides the maximum (peak) 15-minute Ethernet-layer ingress multicast average usage over a sample period of 15 minutes, 1 hour, or 24 hours. The automatically-defined interface name identifies the IPv6 interface.

The maximum ingress Ethernet-layer multicast usage in Mbps for a specific IPv6 interface is calculated using Equation 96.

$$MAX\left(Ipv6EtherIn15minMcastAverageUsage_1, ..., Ipv6EtherIn15minMcastAverageUsage_N\right)$$

Equation 96 IPv6 Interface Ethernet-Layer Maximum Ingress Multicast Usage (Mbps)

Where:

Ipv6EtherIn15minMcastAverageUsage
Singleton metric defined in Section 5.13 on page 44

N Number of measurements in the sample

9.3.17 IPv6 Flow IP-layer Ingress Maximum Usage

This statistical metric provides the maximum (peak) short sample IP-layer ingress IPv6 flow usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix of the local IPv6 interface, the DSCP values and the remote IP address prefix identify the IPv6 flow.

The maximum ingress IP-layer usage in Mbps for a specific IPv6 flow is calculated using Equation 97.

$$MAX\left(Ipv6pInFlowUsage_1, ..., Ipv6pInFlowUsage_N\right)$$

Equation 97 IPv6 Flow IP-Layer Maximum Ingress Usage (Mbps)

Where:

Ipv6IpInFlowUsage
Singleton metric defined in Section 5.15 on page 45

N Number of measurements in the sample

This statistical metric can also be calculated directly from the *pmIpFlowMaxInBitrate* counter which is the maximum ingress IP-layer flow bitrate provided by the RBS during a 900 seconds reporting period.

9.3.18 IPv6 Flow IP-layer Egress Maximum Usage

This statistical metric provides the maximum (peak) short sample IP-layer egress IPv6 flow usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix of the local IPv6 interface, the DSCP values and the remote IP address prefix identify the IPv6 flow.

The maximum egress IP-layer usage in Mbps for a specific IPv6 flow is calculated using Equation 98.

$$MAX\left(Ipv4pOutFlowUsage_1, ..., Ipv6pOutFlowUsage_N\right)$$

Equation 98 IPv6 Flow IP-Layer Maximum Egress Usage (Mbps)

Where:

Ipv6IpOutFlowUsage
Singleton metric defined in Section 5.16 on page 46

N Number of measurements in the sample

This statistical metric can also be calculated directly from the *pmIpFlowMaxOutBitrate* counter which is the maximum egress IP-layer flow bitrate provided by the RBS during a 900 seconds reporting period.

9.3.19 IPv6 Flow Ethernet-layer Ingress Maximum Usage

This statistical metric provides the maximum (peak) short sample Ethernet-layer ingress IPv6 flow usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix of the local IPv6 interface, the DSCP values and the remote IP address prefix identify the IPv6 flow.

The maximum ingress Ethernet-layer usage in Mbps for a specific IPv6 flow is calculated using Equation 99.

$$MAX\left(Ipv4EtherInFlowUsage_1, ..., Ipv4EtherInFlowUsage_N\right)$$

Equation 99 IPv6 Flow Ethernet-Layer Maximum Ingress Usage (Mbps)

Where:

Ipv6EtherInFlowUsage
Singleton metric defined in Section 5.17 on page 47

N Number of measurements in the sample

9.3.20 IPv6 Flow Ethernet-layer Egress Maximum Usage

This statistical metric provides the maximum (peak) short sample Ethernet-layer egress IPv6 flow usage over a period of 15 minutes, 1 hour, or 24 hours. The subnet prefix of the local IPv6 interface, the DSCP values and the remote IP address prefix identify the IPv6 flow.

The maximum egress Ethernet-layer usage in Mbps for a specific IPv6 flow is calculated using Equation 100.

$$MAX\left(Ipv6EtherOutFlowUsage_1, ..., Ipv6EtherOutFlowUsage_N\right)$$

Equation 100 IPv6 Flow IP-Layer Maximum Egress Usage (Mbps)

Where:

Ipv6EtherOutFlowUsage
Singleton metric defined in Section 5.18 on page 47

N Number of measurements in the sample

9.4 Traffic Scheduler Statistical Performance Metrics

The traffic scheduler statistical performance metrics consist of the following:

- Traffic scheduler egress maximum packet discard ratio
- Traffic scheduler IP-layer egress maximum usage
- Traffic scheduler IP-layer egress average usage

- Traffic scheduler Ethernet-layer egress maximum usage
- IPv4 interface Ethernet-layer egress average usage

9.4.1 Traffic Scheduler Egress Maximum Packet Discard Ratio

This statistical metric provides the maximum 15-minute egress IP packet discard ratio for a traffic scheduler over a period of 15 minutes, 1 hour, or 24 hours.

The maximum egress IP-layer packet discard ratio in % for a specific traffic scheduler is calculated using Equation 101.

$$MAX\left(TSOut15minDiscardRatio_1, ..., TSOut15minDiscardRatio_N\right)$$

Equation 101 Traffic Scheduler Egress Maximum Packet Discard Ratio (%)

Where:

TSOut15minDiscardRatio
Singleton metric defined in Section 6.1 on page 49

N Number of measurements in the sample

9.4.2 Traffic Scheduler IP-layer Egress Maximum Usage

This statistical metric provides the maximum (peak) IP-layer egress usage for a traffic scheduler over a period of 15 minutes, one hour or 24 hours.

The maximum egress IP-layer usage in Mbps for a specific traffic scheduler is calculated using Equation 102.

$$MAX\left(TSIpOut15minAverageUsage_1, ..., TSIpOut15minAverageUsage_N\right)$$

Equation 102 Traffic Scheduler IP-Layer Maximum Egress Usage (Mbps)

Where:

TSIpOut15minAverageUsage
Singleton metric defined in Section 6.2 on page 49

N Number of measurements in the sample

9.4.3 Traffic Scheduler IP-layer Egress Average Usage

This statistical metric provides the average (mean) IP-layer egress usage for a traffic scheduler over a period of 15 minutes, one hour or 24 hours.

The average egress IP-layer usage in Mbps for a specific traffic scheduler is calculated using Equation 103.

$$\frac{TSIpOut15minAverageUsage_1 + ... + TSIpOut15minAverageUsage_N}{N}$$

Equation 103 Traffic Scheduler IP-Layer Average Egress Usage (Mbps)

Where:

TSIpOut15minAverageUsage
Singleton metric defined in Section 6.2 on page 49

N Number of measurements in the sample

9.4.4 Traffic Scheduler Ethernet-layer Egress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute Ethernet-layer egress average usage for a traffic scheduler over a period of 15 minutes, one hour or 24 hours.

The maximum egress Ethernet-layer usage in Mbps for a specific traffic scheduler is calculated using Equation 104.

$$MAX\left(TSEtherOut15minAverageUsage_1, ..., TSEtherOut15minAverageUsage_N\right)$$

Equation 104 Traffic Scheduler Ethernet-Layer Maximum Egress Usage (Mbps)

Where:

TSEtherOut15minAverageUsage
Singleton metric defined in Section 6.3 on page 50

N Number of measurements in the sample

9.4.5 Traffic Scheduler Ethernet-layer Egress Average Usage

This statistical metric provides the average (mean) Ethernet-layer egress usage for a traffic scheduler over a period of 15 minutes, one hour or 24 hours.

The average egress Ethernet-layer usage in Mbps for a specific traffic scheduler is calculated using Equation 105.

$$\frac{TSEtherOut15minAverageUsage_1 + ... + TSEtherOut15minAverageUsage_N}{N}$$

Equation 105 Traffic Scheduler Ethernet-Layer Average Egress Usage (Mbps)

Where:

TSEtherOut15minAverageUsage
Singleton metric defined in Section 6.3 on page 50

N Number of measurements in the sample

9.5 S1/X2 Control Plane Statistical Performance Metrics

The S1/X2 control plane statistical performance metrics consist of the following:

- S1/X2 CP interface ingress maximum SCTP data chunk discard ratio
- S1/X2 CP interface egress maximum SCTP data chunk and user data discard ratio
- S1/X2 CP interface ingress maximum SCTP control chunk discard ratio
- S1/X2 CP interface ingress maximum SCTP data chunk retransmission ratio
- S1/X2 CP interface ingress minimum SCTP availability ratio
- S1/X2 CP interface IP-layer ingress maximum usage
- S1/X2 CP interface IP-layer egress maximum usage
- S1/X2 CP interface Ethernet-layer ingress maximum usage
- S1/X2 CP interface Ethernet-layer egress maximum usage

9.5.1 S1/X2 CP Interface Ingress Maximum SCTP Data Chunk Discard Ratio

This statistical metric provides the maximum 15-minute ingress SCTP data chunk discard ratio over a period of 15 minutes, 1 hour, or 24 hours. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The maximum ingress SCTP data chunk discard ratio in % for a specific S1/X2 control plane interface is calculated using Equation 106.

$$MAX\left(SctpDataIn15minDiscardRatio_1, ..., SctpDataIn15minDiscardRatio_N\right)$$

Equation 106 S1/X2 CP Interface Ingress SCTP Data Chunk Discard Ratio (%)

Where:

SctpDataIn15minDiscardRatio
Singleton metric defined in Section 7.1 on page 56

N Number of measurements in the sample

9.5.2 S1/X2 CP Interface Egress Maximum SCTP Data Chunk and User Data Discard Ratio

This statistical metric provides the maximum 15-minute egress SCTP data chunk and user data discard ratio over a period of 15 minutes, 1 hour, or 24 hours. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The maximum egress SCTP data chunk and user data discard ratio in % for a specific S1/X2 control plane interface is calculated using Equation 107.

$$MAX\left(SctpDataOut15minDiscardRatio_1, ..., SctpDataOut15minDiscardRatio_N\right)$$

Equation 107 S1/X2 CP Interface Egress SCTP Data Chunk and User Data Discard Ratio (%)

Where:

SctpDataOut15minDiscardRatio
Singleton metric defined in Section 7.2 on page 57

N Number of measurements in the sample

9.5.3 S1/X2 CP Interface Ingress Maximum SCTP Control Chunk Discard Ratio

This statistical metric provides the maximum 15-minute ingress SCTP control chunk discard ratio over a period of 15 minutes, 1 hour, or 24 hours. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The maximum ingress SCTP control chunk discard ratio in % for a specific S1/X2 control plane interface is calculated using Equation 108.

$$MAX\left(SctpControlIn15minDiscardRatio_1, ..., SctpControlIn15minDiscardRatio_N\right)$$

Equation 108 S1/X2 CP Interface Ingress SCTP Control Chunk Discard Ratio (%)

Where:

SctpControlIn15minDiscardRatio
Singleton metric defined in Section 7.3 on page 57

N Number of measurements in the sample

9.5.4 S1/X2 CP Interface Maximum SCTP Data Chunk Retransmission Ratio

This statistical metric provides the maximum 15-minute SCTP data chunk retransmission ratio over a period of 15 minutes, 1 hour, or 24 hours. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The maximum SCTP data chunk retransmission ratio in % for a specific S1/X2 control plane interface is calculated using Equation 109.

$$MAX\left(SctpData15minRtxRatio_1, ..., SctpData15minRtxRatio_N\right)$$

Equation 109 S1/X2 CP Interface SCTP Data Chunk Retransmission Ratio (%)

Where:

SctpData15minRtxRatio
Singleton metric defined in Section 7.4 on page 58

N Number of measurements in the sample

9.5.5 S1/X2 CP Interface Minimum SCTP Availability Ratio

This statistical metric provides the minimum 15-minute SCTP association availability ratio over a period of 15 minutes, 1 hour, or 24 hours. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The minimum SCTP availability ratio in % for a specific S1/X2 control plane interface is calculated using Equation 110.

$$MIN\left(Sctp15minAvailabilityRatio_1, ..., Sctp15minAvailabilityRatio_N\right)$$

Equation 110 S1/X2 CP Interface SCTP Availability Ratio (%)

Where:

Sctp15minAvailabilityRatio
Singleton metric defined in Section 7.5 on page 58

N Number of measurements in the sample

9.5.6 S1/X2 CP Interface IP-Layer Ingress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute SCTP association IP-layer ingress average usage over a sample period of 15 minutes, 1 hour, or 24 hours. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The maximum ingress IP-layer usage in Mbps for a specific S1/X2 control plane interface is calculated using Equation 111.

$$MAX\ (SctpIpIn15minAverageUsage_1, ..., SctpIpIn15minAverageUsage_N)$$

Equation 111 S1/X2 CP Interface IP-Layer Maximum Ingress Usage (Mbps)

Where:

SctpIpIn15minAverageUsage
Singleton metric defined in Section 7.6 on page 59

N Number of measurements in the sample

9.5.7 S1/X2 CP Interface IP-Layer Egress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute SCTP association IP-layer egress average usage over a sample period of 15 minutes, 1 hour, or 24 hours. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The maximum egress IP-layer usage in Mbps for a specific S1/X2 control plane interface is calculated using Equation 112.

$$MAX\ (SctpIpOut15minAverageUsage_1, ..., SctpIpOut15minAverageUsage_N)$$

Equation 112 S1/X2 CP Interface IP-Layer Maximum Egress Usage (Mbps)

Where:

SctpIOut15minAverageUsage
Singleton metric defined in Section 7.7 on page 61

N Number of measurements in the sample

9.5.8 S1/X2 CP Interface Ethernet-Layer Ingress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute SCTP association Ethernet-layer ingress average usage over a sample period of 15 minutes, 1 hour, or 24 hours. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The maximum ingress Ethernet-layer usage in Mbps for a specific S1/X2 control plane interface is calculated using Equation 113.

$$MAX\,(SctpEtherIn15minAverageUsage_1,...,SctpEtherIn15minAverageUsage_N)$$

Equation 113 S1/X2 CP Interface Ethernet-Layer Maximum Ingress Usage (Mbps)

Where:

SctpEtherIn15minAverageUsage
Singleton metric defined in Section 7.8 on page 62

N Number of measurements in the sample

9.5.9 S1/X2 CP Interface Ethernet-Layer Egress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute SCTP association Ethernet-layer egress average usage over a sample period of 15 minutes, 1 hour, or 24 hours. The IP address and port number of the local SCTP endpoint with the IP address and port number of the remote SCTP peer (MME or neighbor eNB) identify the S1-MME or X2-C logical interface instance.

The maximum egress Ethernet-layer usage in Mbps for a specific S1/X2 control plane interface is calculated using Equation 114.

$$MAX\,(SctpEtherOut15minAverageUsage_1,...,SctpEtherOut15minAverageUsage_N)$$

Equation 114 S1/X2 CP Interface Ethernet-Layer Maximum Egress Usage (Mbps)

Where:

SctpEtherOut15minAverageUsage
Singleton metric defined in Section 7.9 on page 63

N Number of measurements in the sample

9.6 IPSec Statistical Performance Metrics

The IPSec statistical performance metrics consist of the following:

- IPsec tunnel ingress maximum packet discard ratio
- IPSec tunnel egress maximum packet discard ratio
- IPsec tunnel ESP-layer ingress maximum usage
- IPsec tunnel ESP-layer ingress average usage
- IPsec tunnel ESP-layer egress maximum usage
- IPsec tunnel ESP-layer egress average usage

9.6.1 IPSec Tunnel Ingress Maximum Packet Discard Ratio

This statistical metric provides the maximum 15-minute ingress IPSec tunnel discard ratio over a period of 15 minutes, 1 hour, or 24 hours.

The maximum ingress ESP packet discard ratio in % for a specific IPSec tunnel is calculated using Equation 115.

$$MAX\left(IpSecTunIn15minDiscardRatio_1, ..., IpSecTunIn15minDiscardRatio_N\right)$$

Equation 115 IPSec Tunnel Ingress Maximum Packet Discard Ratio (%)

Where:

IpSecTunIn15minDiscardRatio
Singleton metric defined in Section 8.1 on page 67

N Number of measurements in the sample

9.6.2 IPSec Tunnel Egress Maximum Packet Discard Ratio

This statistical metric provides the maximum 15-minute egress IPSec tunnel discard ratio over a period of 15 minutes, 1 hour, or 24 hours.

The maximum egress ESP packet discard ratio in % for a specific IPSec tunnel is calculated using Equation 116.

$$MAX\left(IpSecTunOut15minDiscardRatio_1, ..., IpSecTunOut15minDiscardRatio_N\right)$$

Equation 116 IPSec Tunnel Egress Maximum Packet Discard Ratio (%)

Where:

IpSecTunOut15minDiscardRatio
Singleton metric defined in Section 8.2 on page 68

N Number of measurements in the sample

9.6.3 IPSec Tunnel ESP-layer Ingress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute ESP-layer IPSec tunnel ingress average usage over a period of 15 minutes, 1 hour, or 24 hours.

The maximum ingress ESP-layer usage in Mbps for a specific IPSec tunnel is calculated using Equation 117.

$$MAX\left(IpSecTunIn15minAverageUsage_1, ..., IpSecIn15minAverageUsage_N\right)$$

Equation 117 IPSec Tunnel ESP-Layer Maximum Ingress Usage (Mbps)

Where:

IpSecTunIn15minAverageUsage
Singleton metric defined in Section 8.3 on page 68

N Number of measurements in the sample

9.6.4 IPsec Tunnel ESP-layer Ingress Average Usage

This statistical metric provides the average (mean) ESP-layer IPSec tunnel ingress usage over a period of 15 minutes, 1 hour, or 24 hours.

The average ingress ESP-layer usage in Mbps for a specific IPSec tunnel is calculated using Equation 118.

$$\frac{IpSecTunIn15minAverageUsage_1 + ... + IpSecTunIn15minAverageUsage_N}{N}$$

Equation 118 IPSec Tunnel ESP-Layer Average Ingress Usage (Mbps)

Where:

IpSecTunIn15minAverageUsage
Singleton metric defined in Section 8.3 on page 68

N Number of measurements in the sample

9.6.5 IPSec Tunnel ESP-layer Egress Maximum Usage

This statistical metric provides the maximum (peak) 15-minute ESP-layer IPSec tunnel egress average usage over a period of 15 minutes, 1 hour, or 24 hours.

The maximum egress ESP-layer usage in Mbps for a specific IPSec tunnel is calculated using Equation 119.

$$MAX\left(IpSecTunOut15minAverageUsage_1, ..., IpSecOut15minAverageUsage_N\right)$$

Equation 119 IPSec Tunnel ESP-Layer Maximum Egress Usage (Mbps)

Where:

IpSecTunOut15minAverageUsage
Singleton metric defined in Section 8.4 on page 69

N Number of measurements in the sample

9.6.6 IPsec Tunnel ESP-layer Egress Average Usage

This statistical metric provides the average (mean) ESP-layer IPSec tunnel egress usage over a period of 15 minutes, 1 hour, or 24 hours.

The average egress ESP-layer usage in Mbps for a specific IPSec tunnel is calculated using Equation 120.

$$\frac{IpSecTunOut15minAverageUsage_1 + ... + IpSecTunOut15minAverageUsage_N}{N}$$

Equation 120 IPSec Tunnel ESP-Layer Average Egress Usage (Mbps)

Where:

IpSecTunOut15minAverageUsage
Singleton metric defined in Section 8.4 on page 69

N Number of measurements in the sample