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An IP Traffic Engineering Policy Information Base  
<[draft-jacquenet-ip-te-pib-02.txt](#)>

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## Abstract

This draft specifies a set of Policy Rule Classes (PRC) for the enforcement of an IP traffic engineering policy by COPS-PR ([2])-capable routers. Instances of such classes reside in a virtual information store, which is called the IP Traffic Engineering Policy Information Base (IP TE PIB). The corresponding IP TE policy provisioning data are intended for use by the COPS-PR IP TE Client-Type([3]), and they complement the PRC classes that have been defined in the Framework PIB ([4]).

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## [1.](#) Introduction

The deployment of value-added IP services over the Internet has become one of the most competing challenges for service providers, as well as a complex technical issue.

Within the context of network resource provisioning and allocation, the COPS protocol and its usage for the support of Policy Provisioning is one of the ongoing specification efforts of the Resource Allocation Protocol (rap) Working Group of the IETF that should help service providers in dynamically enforcing IP Traffic Engineering (IP TE) policies.

An IP traffic engineering policy consists in appropriately provisioning, and allocating/de-allocating, the switching and the transmission resources of an IP network (i.e. the routers and the links that connect these routers, respectively), according to Quality of Service (QoS) requirements (e.g. rate, one-way delay, inter-packet delay variation, etc.) that have been expressed by the customers who can access such resources within the context of a given service subscription procedure ([5]).

Thus, the enforcement of an IP traffic engineering policy yields the introduction of a high level of automation for the dynamic provisioning of the configuration data that will be taken into account by the routers to select the appropriate IP routes.

Within the context of this document, the actual enforcement of an IP traffic engineering policy is primarily based upon the activation of both intra- and inter-domain dynamic routing protocols (e.g. [6], [7]) that will be activated in the network to select, install, maintain and possibly withdraw routes that will comply with the above-mentioned QoS requirements and/or specific routing constraints, depending on the type of traffic that will be conveyed along these traffic engineered routes.

It is therefore necessary to provide the route selection processes with the information that will reflect these QoS requirements, given the dynamic routing protocols support traffic engineering capabilities for the computation of such routes.

Some of these capabilities are currently being specified in [8] and [9] for the OSPF (Open Shortest Path First, [6]) and the IS-IS (Intermediate System to Intermediate System routing protocol, [10]) interior routing protocols respectively, while there is a comparable

effort for the BGP4 (Border Gateway Protocol, version 4) protocol, as described in [11], for example.

To provide the route selection processes with the aforementioned information, one possibility is to use the COPS-PR protocol, together with a collection of policy provisioning data that will be stored in a virtual information store, called a Policy Information Base.

This draft describes a collection of Policy Rule Classes that will be stored and dynamically maintained in the IP TE PIB. The "rule" and "role" concepts, which have been defined in [12], are adopted by this document to distribute the IP traffic engineering policy provisioning data over the COPS-PR protocol.

This document is organized as follows:

- [Section 4](#) introduces some considerations about the scalability of such a dynamic provisioning scheme,
- [Section 5](#) provides an overview of the organization of the IP TE PIB,
- [Section 6](#) provides a description of the PRC classes of the IP TE PIB, according to the semantics of the Structure of Policy Provisioning Information (SPPI, [13]).

## [2.](#) Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC 2119](#) [14].

## [3.](#) Changes since the previous version

- The PIB has been slightly reorganized to introduce an additional table for IS-IS-related policy provisioning data according to [9],
- The introduction has been slightly reworded,
- The references section has been updated.

#### 4. Scalability considerations

The usage of the COPS-PR protocol for the dynamic enforcement of an IP traffic engineering policy raises some scalability issues, as far as the volume of configuration information that will be exchanged not only between the routers themselves (because of the OSPF machinery for example), but also between the PEP (Policy Enforcement Point) components embedded in the routers and the PDP (Policy Decision Point) they communicate with is concerned.

While the concern strictly related to the design of a routing policy is outside the scope of this document, the dynamic provisioning of metric values as well as the reports related to the actual enforcement of decisions taken by the PDP, deserve some elaboration.

##### 4.1. A tentative metric taxonomy

The metrics that will be taken into account by the Shortest Path First (SPF) algorithms for IP TE route calculation can be classified into two basic categories:

1. Metrics assigned on a long-term basis, which basically consist of the "usual" cost metrics, like those defined in [5]. These metrics are those that are assigned on a (logical) interface basis, and they aim at reflecting the link quality the corresponding interface is attached to,
2. Metrics assigned on a (very) short term basis, which MAY consist of the following information:
  - The available bandwidth, (e.g. based upon the information provided by SNMP (Simple Network Management Protocol, [15]) counters like ifInOctets and ifOutOctets),
  - The amount of bandwidth that can be reserved,

- The amount of reserved bandwidth.

While "long term" metric values should not change frequently by definition, the "short term" metric values MAY vary like the ongoing usage of the resources of the network.

Therefore, the dynamic computation of "short term" metric values SHOULD remain in the magnitude of the corresponding SPF computation, since newly assigned values yield the spontaneous generation of LSU (Link State Update, [5]) messages. Thus, the traffic generated by the IP traffic engineering provisioning data SHOULD be minimized according to pre-computation engineering recommendations like those described in [16].

#### [4.2.](#) Reporting the enforcement of an IP traffic engineering policy

Likewise, the actual enforcement of policy decisions implies the activation of a reporting mechanism, as described in the COPS-PR specification.

From this perspective, this draft assumes that the corresponding reports sent by the PEP components of the routers towards the PDP SHOULD include the traffic engineered routes that have been computed by the routers, at least for network planning purposes: the service subscription requests will be negotiated according to the knowledge of the network resources that are actually available, and this information includes the routes that could very well service the aforementioned requirements, without any extra computation.

Therefore, the traffic generated by the notification reports of the installed routes SHOULD remain in the magnitude of the route announcement procedures of the IP routing protocols machineries (like OSPF), and it is assumed that the volume of the corresponding COPS-PR traffic is also highly dependent on the pre-computation engineering recommendations that have been mentioned in the above [section 3.1](#).

In other words, this draft assumes that it is mainly the responsibility of a network operator to enforce an IP traffic engineering policy that should raise scalability issues (raised by design), NOT the choice of activating the COPS-PR protocol as a means to convey the corresponding IP TE provisioning data.

Nevertheless, it is obviously one of the most important concerns of

the ongoing specification and development effort that is partly reflected by this draft. In particular, it is the intention of the authors of this draft to later submit a publication that will aim at depicting the simulation results obtained through the validation of this COPS-PR architecture for the dynamic enforcement of an IP traffic engineering policy within the context of an operational service provider's environment.

## 5. PIB Overview

The dynamic enforcement of an IP traffic engineering policy relies on the activation of intra- and inter-domain routing protocols that will have the ability to take into account traffic engineering-related information for the computation and the selection of routes, which will comply as much as possible with the QoS requirements that have been contractually defined between customers and service providers.

This traffic engineering-related information is basically composed of metric values that will aim at reflecting an IP TE policy, as well as the result of the enforcement of such a policy, so that customers and providers can check anytime that the IP service is provisioned with the appropriate (and contractual) levels of quality (which can be expressed in terms of service availability, for example).

Therefore, the IP TE PIB mainly aims at:

- Storing and maintaining the configuration information that will be used by the routers to compute and select the routes that will comply with a collection of QoS requirements, such as the one-way maximum transit delay, or the maximum inter-packet delay variation,
- Storing and maintaining the information related to the traffic engineered routes that have been installed in the routers' Forwarding Information Bases, so that the service providers have the permanent knowledge of the network's resources availability.

From this perspective, the IP TE PIB is currently organized into the following provisioning classes:

1. The Forwarding Classes (ipTeFwClasses): the information contained in these classes is meant to provide a detailed description of the traffic-engineered routes. Only one table is

defined at the current stage of this draft: the IP TE Route table which describes the information related to TE routes that have been installed by the routers in their FIBs,

2. The Metrics Classes (ipTeMetricsClasses): the information stored in the tables of this class is meant to provide a description of the metric values that will be taken into account by intra- and inter-domain routing protocols for the computation and the selection of traffic-engineered routes. So far, two groups have been identified: the first group is based upon the traffic engineering extensions of intra-domain routing protocols, the second group is related to QoS-related information that can be conveyed in BGP-4 messages,
3. The Statistics Classes (ipTeStatsClasses): the information contained in these classes is meant to provide statistic on the enforcement of the TE policies.

#### 6. The IP Traffic Engineering Policy Information Base

```
IP-TE-PIB PIB-DEFINITIONS ::= BEGIN
```

```
IMPORTS
```

```
    Unsigned32, Integer32, MODULE-IDENTITY,  
    MODULE-COMPLIANCE, OBJECT-TYPE, OBJECT-GROUP  
        FROM COPS-PR-SPPI  
    InstanceId, ReferenceId, Prid, TagId  
        FROM COPS-PR-SPPI-TC  
    InetAddress, InetAddressType  
        FROM INET-ADDRESS-MIB  
    Count, TEXTUAL-CONVENTION  
        FROM ACCT-FR-PIB-TC  
    TruthValue, TEXTUAL-CONVENTION  
        FROM SNMPv2-TC  
    RoleCombination, PrcIdentifier  
        FROM FRAMEWORK-ROLE-PIB  
    SnmpAdminString  
        FROM SNMP-FRAMEWORK-MIB;
```

```
ipTePib      MODULE-IDENTITY
```

```
    SUBJECT-CATEGORIES { tbd }      -- IP TE client-type to be  
                                     -- assigned by IANA  
    LAST-UPDATED      "200106180900Z"  
    ORGANIZATION      "France Telecom"
```

CONTACT-INFO     "  
                  Christian Jacquenet  
                  France Telecom R & D  
                  42, rue des Coutures  
                  BP 6243  
                  14066 CAEN CEDEX 04  
                  France  
                  Phone: +33 2 31 75 94 28  
                  E-Mail: christian.jacquenet@francetelecom.com"

DESCRIPTION  
      "The PIB module containing a set of policy rule classes  
      that describe IP Traffic Engineering policies to be  
      enforced within and between domains."

REVISION           "200111061600Z"

DESCRIPTION  
      "Initial version."

::= { pib tbd } -- tbd to be assigned by IANA

ipTeFwdClasses     OBJECT IDENTIFIER ::= { ipTePib 1 }  
ipTeMetricsClasses OBJECT IDENTIFIER ::= { ipTePib 2 }  
ipTeStatsClasses   OBJECT IDENTIFIER ::= { ipTePib 3 }

--  
-- Forwarding classes. The information contained in these classes  
-- is meant to provide a detailed description of the traffic  
-- engineered routes. One table has been specified so far, but there  
-- is room for depicting specific kinds of routes, like MPLS LSP  
-- paths, for example.

--  
--

--  
-- The ipTeRouteTable  
--

ipTeRouteTable     OBJECT-TYPE

      SYNTAX           SEQUENCE OF ipTeRouteEntry

      PIB-ACCESS     notify

      STATUS          current

      DESCRIPTION

          "This table describes the traffic engineered routes  
          that are installed in the forwarding tables of the  
          routers."



::= { ipTeFwdClasses 1 }

ipTeRouteEntry            OBJECT-TYPE

SYNTAX                  ipTeRouteEntry

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STATUS                  current

DESCRIPTION

"A particular traffic engineered route to a particular destination."

PIB-INDEX        { ipTeRoutePrid }

UNIQUENESS       { ipTeRouteDest,  
                    ipTeRouteMask,  
                    ipTeRoutePhbId,  
                    ipTeRouteNextHopAddress  
                    ipTeRouteNextHopMask  
                    ipTeRouteIfIndex }

::= { ipTeRouteTable 1 }

ipTeRouteEntry ::= SEQUENCE {  
    ipTeRoutePrid                                InstanceId,  
    ipTeRouteDestAddrType                      InetAddressType,  
    ipTeRouteDest                                InetAddress,  
    ipTeRouteMask                                Unsigned32,  
    ipTeRouteNextHopAddrType                    InetAddressType,  
    ipTeRouteNextHopAddress                    InetAddress,  
    ipTeRouteNextHopMask                        Unsigned32,  
    ipTeRoutePhbId                               Integer32,  
    ipTeRouteOrigin                             Integer32,  
    ipTeRouteIfIndex                            Unsigned32  
}

ipTeRoutePrid                                OBJECT-TYPE

SYNTAX                  InstanceId

STATUS                  current

DESCRIPTION

"An integer index that uniquely identifies this route entry among all the route entries."

::= { ipTeRouteEntry 1 }

ipTeRouteDestAddrType      OBJECT-TYPE

SYNTAX                      InetAddressType

STATUS                      current

DESCRIPTION

"The address type enumeration value ([17]) used to specify the type of a route's destination IP address."

::= { ipTeRouteEntry 2 }

ipTeRouteDest              OBJECT-TYPE

SYNTAX                      InetAddress

STATUS                      current

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DESCRIPTION

"The IP address to match against the packet's destination address."

::= { ipTeRouteEntry 3 }

ipTeRouteMask              OBJECT-TYPE

SYNTAX                      Unsigned32 (0..128)

STATUS                      current

DESCRIPTION

"Indicates the length of a mask for the matching of the destination IP address. Masks are constructed by setting bits in sequence from the most-significant bit downwards for ipTeRouteMask bits length. All other bits in the mask, up to the number needed to fill the length of the address ipTeRouteDest are cleared to zero. A zero bit in the mask then means that the corresponding bit in the address always matches.""

::= { ipTeRouteEntry 4 }

ipTeRouteNextHopAddrType      OBJECT-TYPE

SYNTAX                      InetAddressType

STATUS                      current

DESCRIPTION

"The address type enumeration value used to specify the type of the next hop's IP address."

::= { ipTeRouteEntry 5 }

ipTeRouteNextHopAddress      OBJECT-TYPE

SYNTAX                      InetAddress

STATUS                      current

DESCRIPTION

"On remote routes, the address of the next router en route; Otherwise, 0.0.0.0."

::= { ipTeRouteEntry 6 }

ipTeRouteNextHopMask          OBJECT-TYPE

SYNTAX                      Unsigned32 (0..128)

STATUS                      current

DESCRIPTION

"Indicates the length of a mask for the matching of the next hop's IP address. Masks are constructed by setting bits in sequence from the most-significant bit downwards for ipTeRouteNextHopMask bits length. All other bits in the mask, up to the number needed to fill

the length of the address ipTeRouteNextHop are cleared to zero. A zero bit in the mask then means that the corresponding bit in the address always matches."

::= { ipTeRouteEntry 7 }

ipTeRoutePhbId              OBJECT-TYPE

SYNTAX                      Integer32 (-1 | 0..63)

STATUS                      current

DESCRIPTION

"The binary encoding that uniquely identifies a Per Hop Behaviour (PHB, [18]) or a set of PHBs associated to the DiffServ Code Point (DSCP, [15]) marking of the IP datagrams that will be conveyed along this traffic engineered route. A value of -1 indicates that a specific PHB ID value has not been defined, and thus, all PHB ID values are considered a match."

::= { ipTeRouteEntry 8 }

ipTeRouteOrigin        OBJECT-TYPE

```
SYNTAX INTEGER {
    OSPF (0)
    IS-IS (1)
    BGP (2)
    STATIC (3)
    OTHER (4)
}
```

STATUS                current

DESCRIPTION

"The value indicates the origin of the route. Either the route has been computed by OSPF, by IS-IS, announced by BGP4, is static, or else."

::= { ipTeRouteEntry 9 }

ipTeRouteIfIndex       OBJECT-TYPE

```
SYNTAX                Unsigned32 (0..65535)
```

STATUS                current

DESCRIPTION

"The ifIndex value that identifies the local interface through which the next hop of this route is accessible."

::= { ipTeRouteEntry 10 }

--

--

-- Traffic engineering metrics classes.

--

-- The information stored in the following tables is meant to provide  
-- the description of the metric values that will be taken into  
-- account by intra- and inter-domain routing protocols for the  
-- computation and the selection of traffic-engineered routes. So  
-- far, two tables have been identified: one which is based upon the  
-- traffic engineering extensions of OSPF, the other which is based  
-- upon the contents of a specific BGP4 attribute.

--

--

igpTeGroup    OBJECT IDENTIFIER ::= { ipTeMetricsClasses 1 }

```

bgpTeGroup  OBJECT IDENTIFIER ::= { ipTeMetricsClasses 2 }

--
-- The ospfTeMetricsTable
--

ospfTeMetricsTable  OBJECT-TYPE

    SYNTAX          SEQUENCE OF ospfTeMetricsEntry
    PIB-ACCESS      install-notify
    STATUS          current
    DESCRIPTION
        "This class describes the link and traffic engineering
        metrics that will be used by OSPF for TE route
        calculation purposes."

    ::= { igpTeGroup 1 }

ospfTeMetricsEntry  OBJECT-TYPE

    SYNTAX          ospfTeMetricsEntry
    STATUS          current
    DESCRIPTION
        "The collection of OSPF metrics assigned to the router
        on a per interface and per DSCP basis."

    PIB-INDEX      { ospfTeMetricsPrid }
    UNIQUENESS      { ospfTeMetricsLinkMetricValue,
                      ospfTeMetricsDscpValue,
                      ospfTeMetricSubTlvLinkType,
                      ospfTeMetricSubTlvLinkId,
                      ospfTeMetricSubTlvLocalIfAddress,
                      ospfTeMetricSubTlvRemoteIfAddress,
                      ospfTeMetricSubTlvTeMetric,
                      ospfTeMetricSubTlvMaxBandwidth,
                      ospfTeMetricSubTlvMaxRsvBandwidth,
                      ospfTeMetricSubTlvUnRsvBandwidth,
                      ospfTeMetricIfIndex }

    ::= { ospfTeMetricsTable 1 }

```

```

ospfTeMetricsEntry ::= SEQUENCE {

```

ospfTeMetricsPrid	InstanceId,
ospfTeMetricsIfMetricValue	Unsigned32,
ospfTeMetricsDscpValue	Integer32,
ospfTeMetricsTopTlvAddressType	InetAddressType,
ospfTeMetricsTopTlvRouterAddress	InetAddress,
ospfTeMetricsTopTlvRouterAddrMask	Unsigned32,
ospfTeMetricsSubTlvLinkType	Unsigned32,
ospfTeMetricsSubTlvLinkIdAddressType	InetAddressType,
ospfTeMetricsSubTlvLinkId	InetAddress,
ospfTeMetricsSubTlvLinkIdMask	Unsigned32,
ospfTeMetricsSubTlvLocalIfAddressType	InetAddressType,
ospfTeMetricsSubTlvLocalIfAddress	InetAddress,
ospfTeMetricsSubTlvLocalIfAddrMask	Unsigned32,
ospfTeMetricsSubTlvRemoteIfAddressType	InetAddressType,
ospfTeMetricsSubTlvRemoteIfAddress	InetAddress,
ospfTeMetricsSubTlvRemoteIfAddrMask	Unsigned32,
ospfTeMetricsSubTlvTeMetric	Unsigned32,
ospfTeMetricsSubTlvMaxBandwidth	Unsigned32,
ospfTeMetricsSubTlvMaxRsvBandwidth	Unsigned32,
ospfTeMetricsSubTlvUnrsvBandwidth	Unsigned32,
ospfTeMetricsSubTlvResourceClass	Unsigned32,
ospfTeMetricsIfIndex	Unsigned32

}

ospfTeMetricsPrid                      OBJECT-TYPE

SYNTAX	InstanceId
STATUS	current
DESCRIPTION	

"An integer index that uniquely identifies this instance of the ospfTeMetrics class."

::= { ospfTeMetricsEntry 1 }

ospfTeMetricsIfMetricValue                      OBJECT-TYPE

SYNTAX	Unsigned32 (1..65535)
STATUS	current
DESCRIPTION	

"The link metric assigned on a per-DSCP and per-interface basis, as defined in this instance of the ospfTeMetricsTable."

::= { ospfTeMetricsEntry 2 }

ospfTeMetricsDscpValue                      OBJECT-TYPE

SYNTAX	Integer32 (-1   0..63)
STATUS	current
DESCRIPTION	

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"The DSCP value associated to the link metric value, as defined in the ospfTeMetricsIfMetricValue object. A value of -1 indicates that a specific DSCP value has not been defined and thus all DSCP values are considered a match."

::= { ospfTeMetricsEntry 3 }

ospfTeMetricsTopTlvAddressType OBJECT-TYPE

SYNTAX InetAddressType

STATUS current

DESCRIPTION

"The address type enumeration value used to specify the IP address of the advertising router. This IP address is always reachable, and is typically implemented as a "loopback" address."

::= { ospfTeMetricsEntry 4 }

ospfTeMetricsTopTlvRouterAddress OBJECT-TYPE

SYNTAX InetAddress

STATUS current

DESCRIPTION

"The IP address (typically a "loopback" address) of the advertising router."

::= { ospfTeMetricsEntry 5 }

ospfTeMetricsTopTlvRouterAddrMask OBJECT-TYPE

SYNTAX Unsigned32 (0..128)

STATUS current

DESCRIPTION

"Indicates the length of a mask for the matching of the advertising router's IP address. Masks are constructed by setting bits in sequence from the most-significant bit downwards for ospfTeMetricsTopTlvRouterAddrMask bits length. All other bits in the mask, up to the number needed to fill the length of the address ospfTeMetricsTopTlvRouterAddress are cleared to zero. A zero bit in the mask then means that the corresponding bit in the address always matches."

::= { ospfTeMetricsEntry 6 }

ospfTeMetricsSubTlvLinkType OBJECT-TYPE

SYNTAX INTEGER {  
Point-to-Point (1)  
Multiaccess (2)

STATUS current

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DESCRIPTION

"The type of the link, either point-to-point or multi-access, as defined in [8]."

::= { ospfTeMetricsEntry 7 }

ospfTeMetricsSubTlvLinkIdAddressType OBJECT-TYPE

SYNTAX InetAddressType  
STATUS current

DESCRIPTION

"The address type enumeration value used to identify the other end of the link, described as an IP address."

::= { ospfTeMetricsEntry 8 }

ospfTeMetricsSubTlvLinkId OBJECT-TYPE

SYNTAX InetAddress  
STATUS current

DESCRIPTION

"The identification of the other end of the link, described as an IP address."

::= { ospfTeMetricsEntry 9 }

ospfTeMetricsSubTlvLinkMask OBJECT-TYPE

SYNTAX Unsigned32 (0..128)  
STATUS current

DESCRIPTION

"Indicates the length of a mask for the matching of the other end of the link, described as an IP address. Masks are constructed by setting bits in sequence from the most-



significant bit downwards for ospfTeMetricsSubTlvLinkMask bits length. All other bits in the mask, up to the number needed to fill the length of the address ospfTeMetricsSubTlvLinkId are cleared to zero. A zero bit in the mask then means that the corresponding bit in the address always matches."

::= { ospfTeMetricsEntry 10 }

ospfTeMetricsSubTlvLocalIfAddressType                      OBJECT-TYPE

SYNTAX                      InetAddressType

STATUS                      current

DESCRIPTION

"The address type enumeration value used to specify the IP address of the interface corresponding to this instance of the ospfTeMetricsSubTlvLinkType object."

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::= { ospfTeMetricsEntry 11 }

ospfTeMetricsSubTlvLocalIfAddress                      OBJECT-TYPE

SYNTAX                      InetAddress

STATUS                      current

DESCRIPTION

"Specifies the IP address of the interface of the advertising router which is connected to the link described as an instance of the ospfTeMetricsSubTlvLinkType object."

::= { ospfTeMetricsEntry 12 }

ospfTeMetricsSubTlvLocalIfAddrMask                      OBJECT-TYPE

SYNTAX                      Unsigned32 (0..128)

STATUS                      current

DESCRIPTION

"Indicates the length of a mask for the matching of the IP address of the interface corresponding to this instance of the ospfTeMetricsSubTlvLinkType object. Masks are constructed by setting bits in sequence from the most-significant bit downwards for ospfTeMetricsSubTlvLocalIfAddrMask bits length. All other bits in the mask, up to the number needed to fill the length

of the address ospfTeMetricsSubTlvLocalIfAddress are cleared to zero. A zero bit in the mask then means that the corresponding bit in the address always matches."

```
::= { ospfTeMetricsEntry 13 }
```

ospfTeMetricsSubTlvRemoteIfAddressType      OBJECT-TYPE

SYNTAX            InetAddressType

STATUS            current

DESCRIPTION

"The address type enumeration value used to specify the IP address(es) of the neighbour's interface corresponding to this instance of the ospfTeMetricsSubTlvLinkType object."

```
::= { ospfTeMetricsEntry 14 }
```

ospfTeMetricSubTlvRemoteIfAddress      OBJECT-TYPE

SYNTAX            InetAddress

STATUS            current

DESCRIPTION

"Specifies the IP address of the neighbour's interface that is attached to this instance of the ospfTeMetricsSubTlvLinkType object."

```
::= { ospfTeMetricsEntry 15 }
```

ospfTeMetricSubTlvRemoteIfAddrMask      OBJECT-TYPE

SYNTAX            Unsigned32 (0..128)

STATUS            current

DESCRIPTION

"Indicates the length of a mask for the matching of the IP address of the neighbor's interface corresponding to this instance of the ospfTeMetricsSubTlvLinkType object. Masks are constructed by setting bits in sequence from the most-significant bit downwards for ospfTeMetricSubTlvRemoteIfAddrMaskbits length. All other bits in the mask, up to the number needed to fill the length of the address ospfTeMetricSubTlvRemoteIfAddress are cleared to zero. A zero bit in the mask then means that the

corresponding bit in the address always matches."

::= { ospfTeMetricsEntry 16 }

ospfTeMetricSubTlvTeMetric                      OBJECT-TYPE

SYNTAX                      Unsigned32 (1..65535)

STATUS                      current

DESCRIPTION

"The link metric that has been assigned for traffic engineering purposes. This metric may be different from the ospfTeMetricsLinkMetricValue object of the ospfTeMetrics class."

::= { ospfTeMetricsEntry 17 }

ospfTeMetricSubTlvBandwidthType              OBJECT-TYPE

SYNTAX                      Unsigned32 (0..4294967295)

UNITS                      "bytes per second"

STATUS                      current

DESCRIPTION

"Specifies the maximum bandwidth that can be used on this instance of the ospfTeMetricsSubTlvLinkType object in this direction (from the advertising router), expressed in bytes per second."

::= { ospfpTeMetricsEntry 18 }

ospfTeMetricSubTlvMaxRsvBandwidth          OBJECT-TYPE

SYNTAX                      Unsigned32 (0..4294967295)

UNITS                      "bytes per second"

STATUS                      current

DESCRIPTION

"Specifies the maximum bandwidth that may be reserved on this instance of the ospfTeMetricsSubTlvLinkType object in this direction (from the advertising router), expressed in bytes per second."

::= { ospfTeMetricsEntry 19 }

ospfTeMetricSubTlvUnrsvBandwidth      OBJECT-TYPE

SYNTAX              Unsigned32 (0..4294967295)

UNITS                "bytes per second"

STATUS              current

DESCRIPTION

"Specifies the amount of bandwidth that has not been reserved on this instance of the ospfTeMetricsSubTlvLinkType object in this direction yet (from the advertising router), expressed in bytes per second."

::= { ospfTeMetricsEntry 20 }

ospfTeMetricSubTlvResourceClass      OBJECT-TYPE

SYNTAX              Unsigned32 (0..4294967295)

STATUS              current

DESCRIPTION

"Specifies administrative group membership for the link in terms of a bit mask."

::= { ospfTeMetricsEntry 21 }

ospfTeMetricIfIndex                      OBJECT-TYPE

SYNTAX              Unsigned32 (0..65535)

STATUS              current

DESCRIPTION

"The ifIndex value that identifies the local interface that has been assigned a (set of) metrics."

::= { ospfTeMetricsEntry 22 }

--

-- The isisTeMetricsTable

--

isisTeMetricsTable      OBJECT-TYPE

SYNTAX              SEQUENCE OF isisTeMetricsEntry

PIB-ACCESS          install-notify

STATUS              current

DESCRIPTION

"This class describes the link and traffic engineering metrics that will be used by IS-IS for TE route computation purposes."

::= { igpTeGroup 2 }

isisTeMetricsEntry OBJECT-TYPE

SYNTAX isisTeMetricsEntry

STATUS current

DESCRIPTION

"The collection of IS-IS metrics assigned to the router on a per interface basis."

PIB-INDEX { isisTeMetricsPrid }

UNIQUENESS {  
 isisTeMetricsSubTlvIfAddr,  
 isisTeMetricsSubTlvNbrAddr,  
 isisTeMetricSubTlvTeMetric,  
 isisTeMetricsSubTlvMaxLinkBwth,  
 isisTeMetricsSubTlvMaxRsvLinkBwth,  
 isisTeMetricsPriority,  
 isisTeMetricsSubTlvUnRsvBwth,  
 isisTeMetricsIfIndex }

::= { isisTeMetricsTable 1 }

isisTeMetricsEntry ::= SEQUENCE {

isisTeMetricsPrid	InstanceId,
isisTeMetricsTlvTeRouterID	InetAddress,
isisTeMetricsSubTlvIfAddrType	InetAddressType,
isisTeMetricsSubTlvIfAddr	InetAddress,
isisTeMetricsSubTlvIfAddrMask	Unsigned32,
isisTeMetricsSubTlvNbrAddType	InetAddressType,
isisTeMetricsSubTlvNbrAddr	InetAddress,
isisTeMetricsSubTlvNbrMask	Unsigned32,
isisTeMetricsSubTlvTeMetric	
isisTeMetricsSubTlvMaxLinkBwth	
isisTeMetricsSubTlvMaxRsvLinkBwth	Unsigned32,
isisTeMetricsPriority	Integer32,
isisTeMetricsSubTlvUnRsvBwth	Unsigned32,
isisTeMetricsIfIndex	Unsigned32

}

isisTeMetricsPrid

OBJECT-TYPE

SYNTAX InstanceId

STATUS current

DESCRIPTION

"An integer index that uniquely identifies this instance of the isisTeMetrics class."

::= { isisTeMetricsEntry 1 }

isisTeMetricsTlvTeRouterID OBJECT-TYPE

SYNTAX InetAddress

STATUS current

DESCRIPTION

"Specifies the router ID."

::= { isisTeMetricsEntry 2 }

isisTeMetricsSubTlvIfAddrType OBJECT-TYPE

SYNTAX InetAddressType

STATUS current

DESCRIPTION

"The address type enumeration value used to specify the type of the interface IP address."

::= { isisTeMetricsEntry 3 }

isisTeMetricsSubTlvIfAddr OBJECT-TYPE

SYNTAX InetAddress

STATUS current

DESCRIPTION

"Specifies the IP address of the interface."

::= { isisTeMetricsEntry 4 }

isisTeMetricsSubTlvIfAddrMask OBJECT-TYPE

SYNTAX Unsigned32 (0..128)

STATUS current

DESCRIPTION

"Indicates the length of a mask for the matching of the IP address of the neighbouring router. Masks are constructed by setting bits in sequence from the most significant bit downwards for isisTeMetricsSubTlvIfAddrMask bits length. All

other bits in the mask, up to the number needed to fill the length of the address isisTeMetricsSubTlvIfAddr are cleared to zero. A zero bit in the mask then means that the corresponding bit in the address always matches."

::= { isisTeMetricsEntry 5 }

isisTeMetricsSubTlvNbrAddrType            OBJECT-TYPE

SYNTAX            InetAddressType  
STATUS            current  
DESCRIPTION

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"The address type enumeration value used to specify the type of the neighbouring router's IP address."

::= { isisTeMetricsEntry 6 }

isisTeMetricsSubTlvNbrAddr            OBJECT-TYPE

SYNTAX            InetAddress  
STATUS            current  
DESCRIPTION

"Specifies the IP address of the neighbouring router on the link the corresponding interface (defined by the ifIndex) is attached to."

::= { isisTeMetricsEntry 7 }

isisTeMetricsSubTlvNbrMask            OBJECT-TYPE

SYNTAX            Unsigned32 (0..128)  
STATUS            current  
DESCRIPTION

"Indicates the length of a mask for the matching of the IP address of the neighbouring router. Masks are constructed by setting bits in sequence from the most significant bit downwards for isisTeMetricsSubTlvNbrMask bits length. All other bits in the mask, up to the number needed to fill the length of the address isisTeMetricsSubTlvNbrAddr are cleared to zero. A zero bit in the mask then means that the corresponding bit in the address always matches."

::= { isisTeMetricsEntry 8 }

isisTeMetricsSubTlvTeMetric                      OBJECT-TYPE

SYNTAX                      Unsigned32 (1..65535)

STATUS                      current

DESCRIPTION

"The traffic engineering default metric is used to present a differently weighted topology to TE-based SPF computations."

::= { isisTeMetricsEntry 9 }

isisTeMetricsSubTlvMaxLinkBwth                      OBJECT-TYPE

SYNTAX                      Unsigned32 (0..4294967295)

UNITS                      "bytes per second"

STATUS                      current

DESCRIPTION

"This metric specifies the maximum bandwidth that can be used on this link in this direction."

::= { isisTeMetricsEntry 10 }

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isisTeMetricsSubTlvMaxRsvLinkBwth                      OBJECT-TYPE

SYNTAX                      Unsigned32 (0..4294967295)

UNITS                      "bytes per second"

STATUS                      current

DESCRIPTION

"Specifies the maximum bandwidth that may be reserved on this link in this direction, expressed in bytes per second."

::= { isisTeMetricsEntry 11 }

isisTeMetricsPriority                      OBJECT-TYPE

SYNTAX                      Integer32 (0..7)

STATUS                      current

DESCRIPTION

"Specifies one of the eight priority levels, possible values ranging from 0 and 7."

::= { isisTeMetricsEntry 12 }



isisTeMetricsSubTlvUnRsvBwth                      OBJECT-TYPE

SYNTAX                      Unsigned32 (0..4294967295)

UNITS                      "bytes per second"

STATUS                      current

DESCRIPTION

"Specifies the amount of bandwidth that has not been reserved on this link in this direction and having the priority isisTeMetricsPriority, expressed in bytes per second."

::= { isisTeMetricsEntry 13 }

isisTeMetricsIfIndex                                  OBJECT-TYPE

SYNTAX                      Unsigned32 (0..65535)

STATUS                      current

DESCRIPTION

"The ifIndex value that uniquely identifies the interface that has been assigned a (set of) metrics."

::= { isisTeMetricsEntry 14 }

--

-- The bgpTeTable

--

bgpTeTable                      OBJECT-TYPE

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SYNTAX                      SEQUENCE OF bgpTeEntry

PIB-ACCESS                  install-notify

STATUS                      current

DESCRIPTION

"This class describes the QoS information that MAY be conveyed in BGP4 UPDATE messages for the purpose of enforcing an inter-domain traffic engineering policy."

::= { bgpTeGroup 1 }

bgpTeEntry                      OBJECT-TYPE

SYNTAX                bgpTeEntry  
STATUS                current  
DESCRIPTION  
              "The collection of QoS information to be exchanged by  
BGP peers, as far as the announcement of traffic  
engineered routes between domains is concerned."

PIB-INDEX            { bgpTePrid }  
UNIQUENESS           { bgpTeNlriAddress,  
                      bgpTeNextHopAddress,  
                      bgpTeReservedRate,  
                      bgpTeAvailableRate,  
                      bgpTeLossRate,  
                      bgpTePhbId,  
                      bgpTeMinOneWayDelay,  
                      bgpTeMaxOneWayDelay,  
                      bgpTeAverageOneWayDelay,  
                      bgpTeInterPacketDelay }

::= { bgpTeTable 1 }

bgpTeEntry ::= SEQUENCE {

bgpTePrid	InstanceId,
bgpTeNlriAddressType	InetAddressType,
bgpTeNlriAddress	InetAddress,
bgpTeNlriAddressMask	Unsigned32,
bgpTeNextHopAddressType	InetAddressType,
bgpTeNextHopAddress	InetAddress,
bgpTeNextHopMask	Unsigned32,
bgpTeReservedRate	Unsigned32,
bgpTeAvailableRate	Unsigned32,
bgpTeLossRate	Unsigned32,
bgpTePhbId	Integer32,
bgpTeMinOneWayDelay	Unsigned32,
bgpTeMaxOneWayDelay	Unsigned32,
bgpTeAverageOneWayDelay	Unsigned32,
bgpTeInterPacketDelay	Unsigned32

}

bgpTePrid                                OBJECT-TYPE

SYNTAX                                InstanceId

STATUS	current
DESCRIPTION	"An integer index that uniquely identifies this instance of the bgpTeTable class."
::= { bgpTeEntry 1 }	
bgpTeNlriAddressType	OBJECT-TYPE
SYNTAX	InetAddressType
STATUS	current
DESCRIPTION	"The address type enumeration value used to specify the type of a route's destination IP address."
::= { bgpTeEntry 2 }	
bgpTeNlriAddress	OBJECT-TYPE
SYNTAX	InetAddress
STATUS	current
DESCRIPTION	"The IP address to match against the NLRI field of the QOS_NLRI attribute of the BGP4 UPDATE message."
::= { bgpTeEntry 3 }	
bgpTeNlriAddressMask	OBJECT-TYPE
SYNTAX	Unsigned32 (0..128)
STATUS	current
DESCRIPTION	"Indicates the length of a mask for the matching of the NLRI field of the QOS_NLRI attribute of the BGP4 UPDATE message. Masks are constructed by setting bits in sequence from the most-significant bit downwards for bgpTeNlriMask bits length. All other bits in the mask, up to the number needed to fill the length of the address bgpTeNlri are cleared to zero. A zero bit in the mask then means that the corresponding bit in the address always matches.""
::= { bgpTeEntry 4 }	
bgpTeNextHopAddressType	OBJECT-TYPE
SYNTAX	InetAddressType
STATUS	current
DESCRIPTION	

SYNTAX Unsigned32 (0..4294967295)

UNITS	"kilobits per second"
STATUS	current
DESCRIPTION	"Specifies the available rate that may be reserved on this instance of the bgpTeNlriAddress object in this direction

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(from the advertising BGP peer), expressed in kilobits per second."

::= { bgpTeEntry 9 }

bgpTeLossRate      OBJECT-TYPE

SYNTAX	Unsigned32 (0..4294967295)
STATUS	current
DESCRIPTION	"Specifies the packet loss ratio that has been observed on this route instantiated by the bgpTeNlriAddress object."

::= { bgpTeEntry 10 }

bgpTePhbId      OBJECT-TYPE

SYNTAX	Integer32 (-1   0..63)
STATUS	current
DESCRIPTION	"The binary encoding that uniquely identifies a Per Hop Behaviour (PHB) or a set of PHBs associated to the DiffServ Code Point marking of the IP datagrams that are to be conveyed along this traffic engineered route. A value of -1 indicates that a specific PHB ID value has not been defined, and thus, all PHB ID values are considered a match."

::= { bgpTeEntry 11 }

bgpTeMinOneWayDelay      OBJECT-TYPE

SYNTAX	Unsigned32 (0..4294967295)
UNITS	"milliseconds"
STATUS	current
DESCRIPTION	"Specifies the minimum one-way delay that has been observed on this route instantiated by the bgpTeNlriAddress object,

expressed in milliseconds."

::= { bgpTeEntry 12 }

bgpTeMaxOneWayDelay            OBJECT-TYPE

SYNTAX                        Unsigned32 (0..4294967295)

UNITS                         "milliseconds"

STATUS                        current

DESCRIPTION

"Specifies the maximum one-way delay that has been observed on this route instantiated by the bgpTeNlriAddress object, expressed in milliseconds."

::= { bgpTeEntry 13 }

bgpTeAverageOneWayDelay       OBJECT-TYPE

SYNTAX                        Unsigned32 (0..4294967295)

UNITS                         "milliseconds"

STATUS                        current

DESCRIPTION

"Specifies the average one-way delay that has been observed on this route instantiated by the bgpTeNlriAddress object, expressed in milliseconds."

::= { bgpTeEntry 14 }

bgpTeInterPacketDelay         OBJECT-TYPE

SYNTAX                        Unsigned32 (0..4294967295)

UNITS                         "milliseconds"

STATUS                        current

DESCRIPTION

"Specifies the inter-packet delay variation that has been observed on this route instantiated by the bgpTeNlriAddress object."

::= { bgpTeEntry 15 }

--

-- Traffic engineering statistics classes. The information contained  
-- in the yet-to-be defined tables aim at reporting statistics about

-- COPS control traffic, engineered traffic and potential errors. The  
-- next version of the draft will provide a first table that will be  
-- based upon the use of the "count" clause.  
--  
--

END

## 7. Security Considerations

The traffic engineering policy provisioning data as they are described in this PIB will be used for configuring the appropriate network elements that will be involved in the dynamic enforcement of these traffic engineering policies, by means of a COPS-PR communication that will convey this information.

The function of dynamically provisioning network elements with such configuration information implies that only an authorized COPS-PR communication take place.

From this perspective, this draft does not introduce any additional security issues other than those that have been identified in the COPS-PR specification, and it is therefore recommended that the IPsec

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([\[19\]](#)) protocol suite be used to secure the above-mentioned authorized communication.

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