Francois Le Faucheur
Thomas D. Nadeau
Cisco Systems, Inc.

Angela Chiu
Celion Networks

William Townsend
Tenor Networks

Darek Skalecki
Nortel Networks

Extensions to RSVP-TE and CR-LDP
for support of Diff-Serv-aware MPLS Traffic Engineering

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   RFC 2119, reference [BCP14].

Abstract

   A companion document [DIFF-TE-REQTS] defines the requirements for
   support of Diff-Serv-aware MPLS Traffic Engineering on a per-Class-

Type basis, as discussed in the Traffic Engineering Working Group
Framework document [TEWG-FW].

This document proposes corresponding extensions to RSVP-TE and CR-
LDP for support of Traffic Engineering on a per-Class-Type basis.

Two companion documents [DIFF-TE-OSPF] [DIFF-TE-ISIS] propose
corresponding extensions to OSPF and ISIS for support of Traffic
Engineering on a per-Class-Type basis.

1.   Introduction

As Diff-Serv becomes prominent in providing scalable multi-class of
services in IP networks, performing traffic engineering at a per-
class level instead of an aggregated level is needed in networks
where fine optimisation of resources is sought in order to further
enhance performance and efficiency. By mapping a traffic trunk in a
given class on a separate LSP, it allows the traffic trunk to
utilize resources available on both shortest path(s) and non-
shortest path(s) and follow paths that meet constraints which are
specific to the given class. It also allows each class to select the
proper protection/restoration mechanism(s) that satisfy its
survivability requirements in a cost-effective manner.

Besides the set of parameters defined for the general aggregate TE
[TE-REQ], a new set of per-class parameters needs to be provided at
each LSR interface and propagated via extensions to the IGP
(ISIS/OSPF) [TEWG-FW]. Furthermore, the per-class parameters can be
aggregated into per-Class-Type parameters. The main motivation for
grouping a set of classes into a Class-Type is to improve the
scalability of the IGP link state advertisements by propagating
information on a per-Class-Type basis instead of on a per-class
basis. This approach also has the benefit of allowing better
bandwidth sharing between classes in the same Class-Type.

A Class-Type [TEWG-FW] is defined as a set of classes that satisfy
the following two conditions:

  1) Classes in the same Class-Type possess common aggregate maximum
     and minimum bandwidth requirements to guarantee the required
     performance level.

  2) There is no maximum or minimum bandwidth requirement to be
     enforced at the level of an individual class within the Class-
     Type. One can still implement some "priority" policies for
     classes within the same Class-Type in terms of accessing the
     Class-Type bandwidth (e.g. via the use of preemption

priorities).

An example of Class-Type comprising multiple Diff-Serv classes is a
low-loss Class-Type that includes both AF1-based and AF2-based
Ordering Aggregates.

Note that with per Class-Type TE, Constraint-Based Routing is
performed with bandwidth constraints on a per Class-Type basis but
LSPs may carry a single Diff-Serv class (Ordered Aggregate) with
Diff-Serv scheduling (i.e. PHB) performed separately for each class.

In this document, we will only discuss "per Class-Type TE" because
"per Class TE" can be viewed as a special case of per Class-Type TE
(where each Class-Type is degenerated into a single Diff-Serv
class).

This document focuses on intra-domain operations. Inter-domain
operations is for further study.

A companion document [DIFF-TE-REQTS] defines the requirements for
support of MPLS Traffic Engineering on a per-Class-Type basis. The
following sections propose detailed extensions to RSVP and CR-LDP
that meet those requirements. Two companion documents [DIFF-TE-OSPF]
and [DIFF-TE-ISIS] propose extensions to OSPF and ISIS that also
meet those requirements.

2.   RSVP Extensions

In this section we describe extensions to RSVP for support of
Diff-Serv Traffic Engineering on a per-Class-Type basis which meet
the requirements defined in [DIFF-TE-REQTS]. These extensions are in
addition to the extensions to RSVP defined in [RSVP-TE] for support
of (aggregate) MPLS Traffic Engineering and to the extensions to
RSVP defined in [DIFF-MPLS] for support of Diff-Serv over MPLS.

2.1.   Diff-Serv related RSVP Messages Format

One new RSVP Object is defined in this document: the CLASSTYPE
Object. Detailed description of this Object is provided below. This
new Object is applicable to Path messages. This specification only
defines the use of the CLASSTYPE Object in Path messages used to
establish LSP Tunnels in accordance with [RSVP-TE] and thus
containing a Session Object with a C-Type equal to LSP_TUNNEL_IPv4
and containing a LABEL_REQUEST object.

Restrictions defined in [RSVP-TE] for support of establishment of
LSP Tunnels via RSVP are also applicable to the establishment of LSP
Tunnels supporting Diff-Serv Traffic Engineering. For instance, only

unicast LSPs are supported and Multicast LSPs are for further study.

This new CLASSTYPE object is optional with respect to RSVP so that
general RSVP implementations not concerned with MPLS LSP set up do
not have to support this object.

An LSR supporting Diff-Serv Traffic Engineering on a per-Class-Type
basis in compliance with this specification MUST support the
CLASSTYPE Object. It MUST support Class-Type value 1, and MAY
support other Class-Type values.

2.1.1.   Path Message Format

The format of the Path message is as follows:

```
<Path Message> ::=        <Common Header> [ <INTEGRITY> ]
                          <SESSION> <RSVP_HOP>
                          <TIME_VALUES>
                          [ <EXPLICIT_ROUTE> ]
                          <LABEL_REQUEST>
                          [ <SESSION_ATTRIBUTE> ]
                          [ <DIFFSERV> ]
                          [ <CLASSTYPE> ]
                          [ <POLICY_DATA> ... ]
                          [ <sender descriptor> ]


<sender descriptor> ::=  <SENDER_TEMPLATE> [ <SENDER_TSPEC> ]
                          [ <ADSPEC> ]
                          [ <RECORD_ROUTE> ]
```

2.2.   CLASSTYPE Object

The CLASSTYPE object format is shown below.

2.2.1.   CLASSTYPE object

class = TBD, C_Type = 1 (need to get an official class num from the
IANA with the form 0bbbbbbb)

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Reserved                                           |CT |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```


Reserved : 30 bits
    This field is reserved. It must be set to zero on transmission
    and must be ignored on receipt.

CT : 2 bits
        Indicates the Class-Type. Values currently allowed are 1, 2 and
        3.

2.3.   Handling CLASSTYPE Object

   To establish an LSP tunnel with RSVP, the sender LSR creates a Path
   message with a session type of LSP_Tunnel_IPv4 and with a
   LABEL_REQUEST object as per [RSVP-TE]. The sender LSR may also
   include the DIFFSERV object as per [DIFF-MPLS].

   If the LSP is associated with Class-Type 0, the sender LSR must not
   include the CLASSTYPE object in the Path message.

   If the LSP is associated with Class-Type N (N=1,2,3), the sender LSR
   must include the CLASSTYPE object in the Path message with the
   Class-Type (CT) field set to N.

   If a path message contains multiple CLASSTYPE objects, only the
   first one is meaningful; subsequent CLASSTYPE object(s) must be
   ignored and must not be forwarded.

   Each LSR along the path records the CLASSTYPE object, when present,
   in its path state block.

   If the CLASSTYPE object is not present in the Path message, the LSR
   must associate the Class-Type 0 to the LSP.

   The destination LSR responds to the Path message by sending a Resv
   message without a CLASSTYPE object (whether the Path message
   contained a CLASSTYPE object or not).

   During establishment of an LSP corresponding to the Class-Type N,
   the LSR performs admission control over the bandwidth available for
   that particular Class-Type, which is computed using the smallest of:
     - the Class-Type N bandwidth currently unreserved (i.e. the
       difference between the Maximum Reservable Bandwidth for Class-
       Type N and the bandwidth reserved by existing Class-Type N
       LSPs).
     - the aggregate bandwidth currently unreserved (i.e. the
       difference between the Maximum Reservable Aggregate Bandwidth
       and the bandwidth reserved by existing LSPs of all Class-Types).

   [Editor's Note: the admission control algorithm described in the
   previous paragraph depends on the Bandwidth Reservation Scheme
   discussed in section 2.1 of [DIFF-TE-REQTS]]

In order to accurately apportion the resources associated with a
Class-Type among the classes comprised in this Class-Type, the LSR
may automatically adjust Diff-Serv scheduling parameters associated
with a class within a Class-Type based on the bandwidth currently
reserved by LSPs currently established in that class.

An LSR that recognizes the CLASSTYPE object and that receives a path
message which contains the CLASSTYPE object but which does not
contain a LABEL_REQUEST object or which does not have a session type
of LSP_Tunnel_IPv4, must send a PathErr towards the sender with the

error code `Diff-Serv TE Error' and an error value of `Unexpected
CLASSTYPE object'. Those are defined below in section 4.5.

An LSR receiving a Path message with the CLASSTYPE object, which
recognizes the CLASSTYPE object but does not support the particular
Class-Type, must send a PathErr towards the sender with the error
code `Diff-Serv TE Error' and an error value of `Unsupported Class-
Type'. Those are defined below in section 4.5.

An LSR receiving a Path message with the CLASSTYPE object, which
recognizes the CLASSTYPE object but determines that the Class-Type
value is not valid (i.e. Class-Type value 0), must send a PathErr
towards the sender with the error code `Diff-Serv TE Error' and an
error value of `Invalid Class-Type value'. Those are defined below
in section 4.5.

An LSR MUST handle the situations where the LSP can not be accepted
for other reasons than those already discussed in this section, in
accordance with [RSVP-TE] and [DIFF-MPLS] (e.g. a reservation is
rejected by admission control, a label can not be associated).

2.4.   Non-support of the CLASSTYPE Object

An LSR that does not recognize the CLASSTYPE object Class-Num must
behave in accordance with the procedures specified in [RSVP] for an
unknown Class-Num whose format is 0bbbbbbb (i.e. it must send a
PathErr with the error code `Unknown object class' toward the
sender).

An LSR that recognizes the CLASSTYPE object Class-Num but does not
recognize the CLASSTYPE object C-Type, must behave in accordance
with the procedures specified in [RSVP] for an unknown C-type (i.e.
it must send a PathErr with the error code `Unknown object C-Type'
toward the sender).

In both situations, this causes the path set-up to fail. The sender
should notify management that a LSP cannot be established and
possibly might take action to retry reservation establishment

without the CLASSTYPE object.

2.5.   Error Codes For Diff-Serv TE

In the procedures described above, certain errors must be reported
as a `Diff-Serv TE Error'. The value of the `Diff-Serv TE Error'
error code is (TBD).

The following defines error values for the Diff-Serv TE Error:

   Value   Error

    1   Unexpected CLASSTYPE object
    2   Unsupported Class-Type

    3   Invalid Class-Type value

3.   CR-LDP Extensions

CR-LDP, defined in [CR-LDP], is an extension to LDP, defined in
[LDP], for support of (aggregate) MPLS Traffic Engineering. In this
section we describe extensions to CR-LDP for support of Diff-Serv
Traffic Engineering on a per-Class-Type basis which meet the
requirements defined in [DIFF-TE-REQTS]. These extensions are in
addition to the extensions to LDP defined in [DIFF-MPLS] for support
of Diff-Serv over MPLS. They closely resemble the extensions to RSVP
defined in the previous section.

Note that extensions of this section for support of Diff-Serv
Traffic Engineering are not applicable to LDP due to the fact that
LDP does not support MPLS Traffic Engineering and bandwidth
reservation in particular.

3.1.   Diff-Serv related CR-LDP Messages Encoding

One new CR-LDP TLV is defined in this document: the Class Type TLV.
Detailed description of this TLV is provided below. This new TLV is
applicable to Label Request messages.

Restrictions defined in [CR-LDP] for support of establishment of
LSPs via CR-LDP are also applicable to the establishment of LSPs
supporting Diff-Serv Traffic Engineering: for instance, only unicast
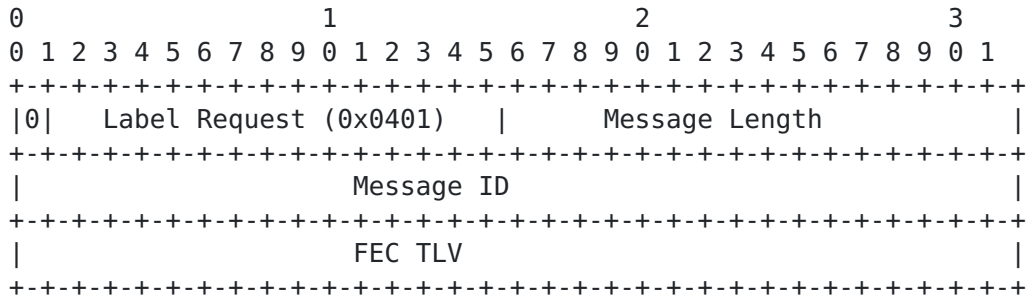LSPs are supported and multicast LSPs are for further study.

This new Class Type TLV is optional with respect to CR-LDP so that
general CR-LDP implementations not concerned with per-Class-Type
Diff-Serv Traffic Engineering are not required to support this TLV.

An LSR supporting Diff-Serv Traffic Engineering on a per-Class-Type

basis in compliance with this specification MUST support the Class Type TLV. It MUST support Class-Type value 1, and MAY support other Class-Type values.
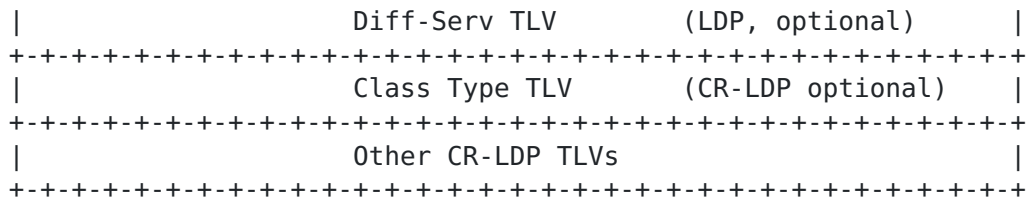
3.1.1. Label Request Message Encoding

The encoding for the CR-LDP Label Request message is extended as follows, to optionally include the Class Type TLV:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0|   Label Request (0x0401)   |         Message Length          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Message ID                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         FEC TLV                                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
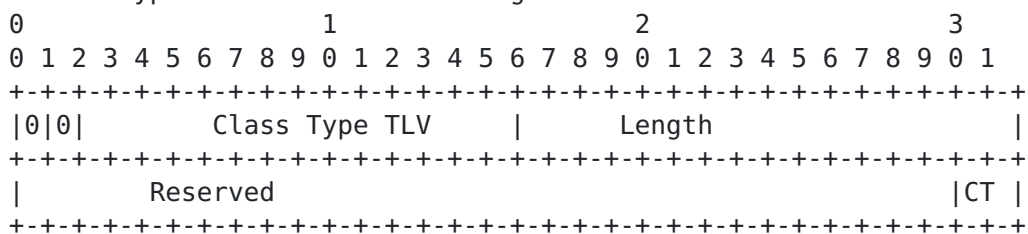
```
|                     Diff-Serv TLV      (LDP, optional)        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Class Type TLV     (CR-LDP optional)      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Other CR-LDP TLVs                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The extension is based on a related LDP extension, defined in [DIFF-MPLS], for support of Diff-Serv TLV but further extended for CR-LDP with CR-LDP TLVs.

3.2. Class Type TLV

The Class Type TLV has the following form:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0|0|      Class Type TLV    |         Length                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Reserved                                       |CT |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Reserved : 30 bits
   This field is reserved. It must be set to zero on transmission and must be ignored on receipt.

CT : 2 bits
   Indicates the Class-Type. Values currently allowed are 1, 2 and 3.

3.3. Handling Class Type TLV

To establish an LSP using CR-LDP, an ingress LSR generates a Label
Request message as per [CR-LDP]. This Label Request may optionally
include the Diff-Serv TLV as defined in [DIFF-MPLS] for LDP but
extended to CR-LDP.

If the LSP is associated with Class-Type 0, the ingress LSR must not
include the Class Type TLV in the Label Request message.

If the LSP is associated with Class-Type N (N=1,2,3), the ingress
LSR must include the Class Type TLV in the Label Request message
with the Class-Type (CT) field set to N.

If a Label Request message contains multiple Class Type TLVs, only
the first one is meaningful; subsequent Class Type TLV(s) must be
ignored and not forwarded.

If the Class Type TLV is not present in the Label Request message,
an LSR must associate the Class-Type 0 to the LSP.

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A downstream LSR sending a Label Mapping message in response to a
Label Request message must not include the Class-Type TLV (whether
the Class-Type TLV was included in the Label Request message or
not).

During establishment of an LSP corresponding to the Class-Type N, an
LSR performs admission control over the bandwidth available for that
particular Class-Type, which is computed using the smallest of:
  - the Class-Type N bandwidth currently unreserved (i.e. the
    difference between the Maximum Reservable Bandwidth for Class-
    Type N and the bandwidth reserved by existing Class-Type N
    LSPs).
  - the aggregate bandwidth currently unreserved (i.e. the
    difference between the Maximum Reservable Aggregate Bandwidth
    and the bandwidth reserved by existing LSPs of all Class-Types).

[Editor's Note: the admission control algorithm described in the
previous paragraph depends on the Bandwidth Reservation Scheme
discussed in section 2.1 of [DIFF-TE-REQTS]]

In order to accurately apportion the resources associated with a
Class-Type among the classes comprised in this Class-Type, an LSR
may automatically adjust Diff-Serv scheduling parameters associated
with a class within a Class-Type based on the bandwidth currently
reserved by LSPs currently established in that class.

An LSR that recognizes the Class Type TLV and receives a Label
Request message which contains the Class Type TLV but which does not

contain any of the CR-LDP TLVs, must reject the label request by
sending upstream a Notification message which includes the Status
TLV with a Status Code of 'Unexpected Class-Type TLV'. This is
defined below in section 5.4. This error can only occur when an LDP
LSP as opposed to CR-LDP LSP is being established. As was already
mentioned, Class Type TLV extension for Diff-Serv Traffic
Engineering is not applicable to LDP.

An LSR receiving a Label Request message with the Class Type TLV,
which recognizes the Class Type TLV but does not support the
particular Class-Type, must reject the label request by sending
upstream a Notification message which includes the Status TLV with a
Status Code of 'Unsupported Class-Type'. This is defined below in
section 5.4.

An LSR receiving a Label Request message with the Class Type TLV,
which recognizes the Class Type TLV but determines that the Class-
Type value is not valid (i.e. Class-Type value 0), must reject the
label request by sending upstream a Notification message which
includes the Status TLV with a Status Code of 'Invalid Class-Type
value'. This is defined below in section 5.4.

An LSR MUST handle the situations where the LSP can not be accepted
for other reasons than those already discussed in this section, in
accordance with [CR-LDP], [LDP] and [DIFF-MPLS] (e.g. reservation
rejected by admission control, a label can not be associated).

3.4. Status Code Values for Diff-Serv TE

In the procedures described above, certain errors must be reported.
The following values are defined for the Status Code field of the
Status TLV:

Status Code	E	Status Data
Unexpected Class Type TLV	0	TBD
Unsupported Class-Type	0	TBD
Invalid Class-Type value	0	TBD

4. Security Considerations

This document raises no new security issues for IS-IS, OSPF, RSVP or
CR-LDP. The security mechanisms already proposed for these
technologies may be used.

5. Acknowledgments

This document has benefited from discussions with Carol Iturralde
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Authors' Address:

Francois Le Faucheur
Cisco Systems, Inc.
Petra B - Les Lucioles - 291, rue Albert Caquot - 06560 Valbonne -
France
Phone: +33 4 92 96 75 64
Email: flefauch@cisco.com

Angela Chiu
Celion Networks
1 Sheila Drive, Suite 2
Tinton Falls, NJ 07724
Phone: +1-732 747 9987
Email: angela.chiu@celion.com

William Townsend
Tenor Networks
100 Nagog Park
Acton, MA 01720
Phone: +1-978-264-4900
Email: btownsend@tenornetworks.com

Thomas D. Nadeau
Cisco Systems, Inc.
250 Apollo Drive
Chelmsford, MA 01824
Phone: +1-978-244-3051
Email: tnadeau@cisco.com

Darek Skalecki
Nortel Networks
3500 Carling Ave,
Nepean K2H 8E9
Phone: +1-613-765-2252
Email: dareks@nortelnetworks.com