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stateful pce bandwidth scheduling
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Abstract

The Path Computation Element Communication Protocol (PCEP) provides mechanisms for Path Computation Elements (PCEs) to perform path computations in response to Path Computation Clients (PCCs) requests. The stateful PCE extensions allow stateful control of Multi-Protocol Label Switching (MPLS) Traffic Engineering Label Switched Paths (TE LSPs) using PCEP.

This document proposes a set of extensions for the stateful PCE, so as to enable bandwidth scheduling for LSP and adjust the bandwidth based on the customers' scheduled bandwidth requirement of a traffic service in a centralized network environment. A bandwidth scheduled LSP can be adjusted to the new bandwidth at its starting time and adjusted back to the original bandwidth at its ending time.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on June 8, 2017.

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1. Introduction

[RFC5440] describes the Path Computation Element Protocol (PCEP) which is used between a Path Computation Element (PCE) and a Path Computation Client (PCC) (or other PCE) to enable computation of Multi-protocol Label Switching (MPLS) for Traffic Engineering Label Switched Path (TE LSP).[I-D.ietf-pce-stateful-pce] specifies a set of extensions to PCEP to enable stateful control of MPLS TE LSPs. [I-D.ietf-pce-pce-initiated-lsp] describes the setup, maintenance and teardown of PCE-initiated LSPs for the stateful PCE model.

In some scenarios, an LSP established with certain bandwidth may require to adjust its bandwidth to a particular value during a period

of time so as to satisfy the network traffic requirement. Traditionally, this can be supported by network management system (NMS) operation through path pre-configuration on the agreed time or accomplished through GMPLS protocol extensions by carrying the related request information across the network. However, as the [I-D.ietf-pce-stateful-pce-app] discussed, this does not provide efficient network usage and will increase the complexity.

[I-D.ietf-pce-stateful-pce-app] describes the requirement of bandwidth scheduling, so as to provide more efficient network resource usage for traffic engineering, and allows network operators to reserve resources in advance according to the agreements with their customers, and allow them to transmit data with specified starting time and duration.

This document proposes bandwidth scheduling and provides scheduled bandwidth adjustment for LSP, so as to adjust the bandwidth to the new value at the starting time and return to the original bandwidth after the duration time. With the scheduled reservation of TE resources, it allows network operators to require scheduled bandwidth adjustment and resource according to the agreements with their customers, and allow them to transmit data with scheduled bandwidth such as specified starting time and ending time.

2. Requirements Language

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 [RFC2119].

2.1. Terminology

The terminology is defined as [RFC5440] and [I-D.ietf-pce-stateful-pce-app] except the following which proposed in this document:

Scheduled Bandwidth (Bandwidth Scheduling): a LSP with the scheduling bandwidth, that carries the demand bandwidth at a starting time and adjust to its original bandwidth at an ending time.

Starting time: This value indicates the time when the scheduled bandwidth is adjusted to the new value.

Ending time: The value indicates the time when the scheduled bandwidth is adjusted to the original value.

3. Bandwidth scheduling Overview

The bandwidth scheduling allows PCEs and PCCs to provide scheduled bandwidth adjustment for customers' traffic services at its particular usage time, so as to improve the network control of traffic flowing.

For a passive stateful PCE, it can support this application with better efficiency and PCCs need to send request to PCEs for bandwidth scheduling including its scheduling parameters.

For an active stateful PCE, the PCE can trigger the scheduled requests in a centralized manner, as specified in [I-D.ietf-pce-pce-initiated-lsp], by notifying the PCCs to modify the paths and adjust the bandwidth. And the scheduled bandwidth information is then configured by NMS or customers.

Then the stateful PCE must reserve the network resource for the traffic and computes a path for the scheduled bandwidth. This requires the PCE to maintain the LSPs, scheduled bandwidth parameters and their associated resource usage, as well as the ability of head-ends to trigger signaling for LSP adjustment at the correct time which uses the make-before-break signaling method so that there is no interruption to the traffic flow.

In both cases, this requires resource reservation and time synchronization between PCEs and PCCs which is to be discussed in the future.

4. New function to support Bandwidth scheduling

Several new functions are required in PCEP to support stateful PCEs. A function can be initiated either from a PCC towards a PCE (C-E) or from a PCE towards a PCC (E-C).

The new functions are:

Capability advertisement (E-C,C-E): both the PCC and the PCE must announce during PCEP session establishment that they support PCEP Stateful PCE bandwidth scheduling extensions defined in this document.

LSP Path Computation Request (C-E): for PCC-Initiated bandwidth scheduling, a PCC can send a request within a path computation request message to PCE with the extensions defined in this document.

LSP State Report (C-E): for PCC-Initiated bandwidth scheduling, LSP creation and bandwidth scheduling request can be separated and the

PCC can send a report message including its bandwidth scheduling information to PCE with the extensions defined in this document.

LSP Update Request (E-C): when the time expires, the PCE SHALL send a update message with the path result to adjust the bandwidth of the LSP.

5. Extensions to the PCEP

5.1. Support of Bandwidth Scheduling Capability

5.1.1. Stateful PCE Capability TLV

The STATEFUL-PCE-CAPABILITY TLV MUST support bandwidth scheduling in Open Object which contained in Open message, as defined in [I-D.ietf-pce-stateful-pce] and updated in [I-D.ietf-pce-pce-initiated-lsp],[I-D.ietf-pce-stateful-sync-optimizations]. In this document, a new flag bit A (SCHED-BW-ADJUST-CAPABLITY) is defined for the STATEFUL- PCE-CAPABILITY TLV to indicate the capability of bandwidth scheduling.

The format of STATEFUL-PCE-CAPABILITY TLV is shown as follow. I, S and U is defined in other documents which mentioned above.

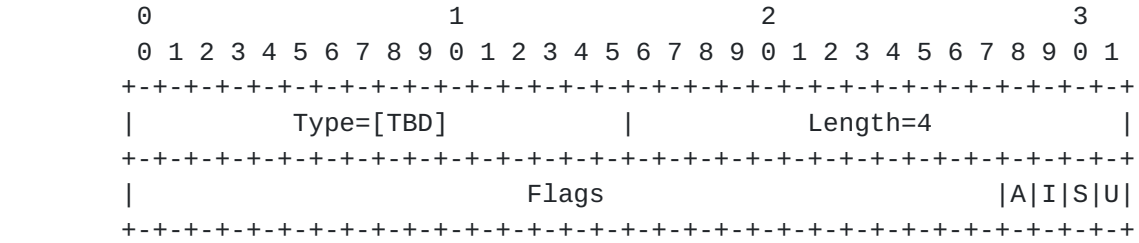

Figure 1 SCHED-BW-ADJUST-CAPABILITY Flags format

A (SCHED-BW-ADJUST-CAPABLITY - 1 bit): If set to 1 by a PCC, the A Flag indicates that the PCC allows bandwidth scheduling; if set to 1 by a PCE, the A Flag indicates that the PCE is capable of bandwidth scheduling. The A bit MUST be set by both PECP peers in order to support bandwidth scheduling for path computation.

5.2. Scheduled Bandwidth adjustment

In order to realize bandwidth scheduling in a centralized network environment, it has to separate the process into two steps. The first step is to send request to PCEs, so as to configure the scheduled parameters and reserve the resource over the network. The second step is to trigger the adjustment to PCCs to re-signal the LSP with the scheduled bandwidth over the network at its starting time and ending time.

To realize PCC-Initiated bandwidth scheduling, the PCC MAY send the bandwidth scheduling request to PCE. Alternatively, the PCE-Initiated bandwidth scheduling request is triggered by NMS or users.

If the bandwidth scheduling request is accepted, the stateful PCE MAY compute a path based on the scheduled bandwidth and adjust the bandwidth of that LSP at its scheduled time by send a PCUpd message with path computation result and SCHED-BW-ADJUST-ATTRIBUTE TLV.

When the ending time expires, the PCE shall send a PCUpd message with the original path and bandwidth of the LSP to adjust back.

The PCC which received the message SHOULD minimize the traffic interruption, and MAY use the make-before-break procedures in order to achieve this bandwidth adjustment.

5.2.1. SCHED-BW-ADJUST-ATTRIBUTE TLV

The LSP object is defined in [I-D.ietf-pce-stateful-pce]. This document adds an optional SCHED-BW-ADJUST-ATTRIBUTE TLV.

The SCHED-BW-ADJUST-ATTRIBUTE TLV in the LSP object indicates that this LSP is requesting scheduled bandwidth parameters. The LSP Object with that TLV carried in the PCReq message, the PCRpt message and the PCUpd message MUST be presented for each LSP which requires scheduled bandwidth.

The SCHED-BW-ADJUST-ATTRIBUTE TLV can be included as an optional TLV within the LSP object for Bandwidth scheduling for the requesting traffic service.

This TLV SHOULD be included only if both PCEP peers have set the A (SCHED-BW-ADJUST-CAPABILITY bit) in STATEFUL-PCE-CAPABILITY TLV carried in open message.

The format of the SCHED-BW-ADJUST-ATTRIBUTE TLV is shown in the following figure:

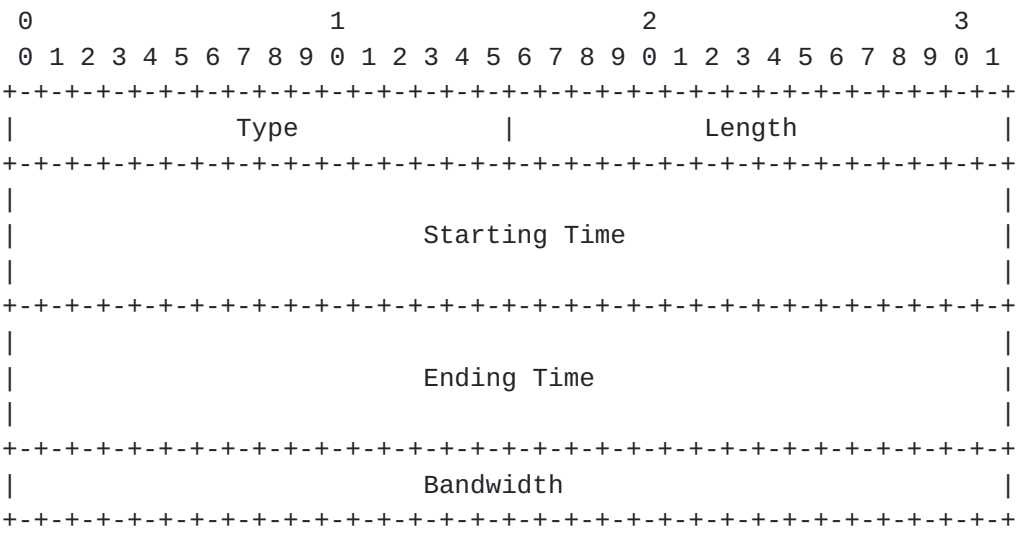

Figure 2 SCHED-BW-ADJUST-ATTRIBUTE TLV format

The time format including starting time and ending time is YYYY-MM-DD-HH-MM and it indicates year, month, date, hour and minute respectively as follows.

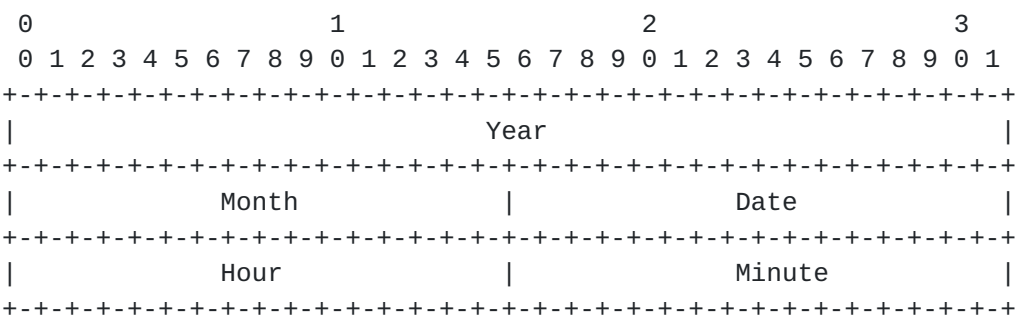

Figure 3 Time TLV format

- The type of the TLV is [TBD]. The fields in the format are:

- Starting Time (32 * 3 bits): This value in minutes, indicates when the bandwidth of LSP is adjusted to the scheduled bandwidth.

- Ending Time (32 * 3 bits): The value in minutes, indicates when the scheduled bandwidth is adjusted to the original value.

- Bandwidth (32 bits): The value indicates the scheduled bandwidth which the LSP is adjusted during the period of time and its detail format see [RFC5440].

Note, that the values of starting time and ending time is from the perspective of the PCEP peer that is sending the message, also note the unit of time is minutes, and thus the time spent on transmission on wire can be easily ignored.

5.2.2. The PCReq Message

For PCC-Initiated bandwidth scheduling, a PCC can choose to send request within a path computation request (PCReq) message or not.

If a PCC send a PCReq message with SCHED-BW-ADJUST-ATTRIBUTE TLV in LSP object, the PCE MUST compute a path for that LSP and check the scheduled request, reserve the resource and store the scheduled information. If that is satisfied, the PCE SHALL sends a PCRep message with the SCHED-LSP-ATTRIBUTE TLV, as well as the LSP Object and path result back to the requesting PCC.

If failures happen or no resource available for the current path, the requesting PCE SHALL return a PCRep message with NO PATH back to the PCC.

If failures happen or no resource reservation for scheduled bandwidth request, the requesting PCE SHALL return a PCErr message with PCEP-ERROR object back to the PCC.

5.2.3. The PCRpt Message

For PCC-Initiated, creation and bandwidth scheduling request can be separated. If a LSP is already set up, the PCC can choose report (PCRpt) message including its bandwidth scheduling information and delegation to a stateful PCE.

Upon receiving the delegation via PCRpt message, the stateful PCE computes the path for the LSP per its starting time and ending time based on bandwidth scheduling parameters.

If failures happen or no resource reservation for scheduled bandwidth request, the requesting PCE SHALL return a PCErr message with PCEP-ERROR object back to the PCC.

5.2.4. The PCUpd Message

When the starting time or ending time expires, if the scheduled bandwidth request from PCCs or NMS can be satisfied and an available path is computed, the stateful PCE SHALL send a PCUpd Message including path computation result and the SCHED-BW-ADJUST-ATTRIBUTE TLV in the LSP Object body to the PCC, so as to adjust the bandwidth of the LSP.

Moreover, the stateful PCE can update the scheduled bandwidth parameters at any time based on bandwidth requirement from customer using the PCUpd message including SCHED-BW-ADJUST-ATTRIBUTE TLV in the LSP Object body.

6. Security Considerations

TBD

7. IANA Considerations

7.1. PCEP TLV Type Indicators

This document defines the following new PCEP TLV; IANA is requested to make the following allocations from this registry.

Value	Meaning	Reference
TBD	SCHED-BW-ADJUST-ATTRIBUTE	[this document]

Table 1

7.2. SCHED-BW-ADJUST-CAPABLITY

This document requests that a registry is created to manage the Flags field in the STATEFUL-PCE-CAPABILITY TLV in the OPEN object. New values are to be assigned by Standards Action [RFC5226].

Bit	Description	Reference
TBD	SCHED-BW-ADJUST-CAPABILITY (A-bit)	[this document]

Table 2

8. Acknowledgements

TBD.

9. References

9.1. Informative References

[I-D.ietf-pce-stateful-pce-app]
Zhang, X. and I. Minei, "Applicability of a Stateful Path Computation Element (PCE)", draft-ietf-pce-stateful-pce-app-08 (work in progress), October 2016.

9.2. Normative References

[I-D.ietf-pce-pce-initiated-lsp]
Crabbe, E., Minei, I., Sivabalan, S., and R. Varga, "PCEP Extensions for PCE-initiated LSP Setup in a Stateful PCE Model", draft-ietf-pce-pce-initiated-lsp-07 (work in progress), July 2016.

[I-D.ietf-pce-stateful-pce]
Crabbe, E., Minei, I., Medved, J., and R. Varga, "PCEP Extensions for Stateful PCE", draft-ietf-pce-stateful-pce-18 (work in progress), December 2016.

[I-D.ietf-pce-stateful-sync-optimizations]
Crabbe, E., Minei, I., Medved, J., Varga, R., Zhang, X., and D. Dhody, "Optimizations of Label Switched Path State Synchronization Procedures for a Stateful PCE", draft-ietf-pce-stateful-sync-optimizations-06 (work in progress), October 2016.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <http://www.rfc-editor.org/info/rfc2119>.

[RFC5440] Vasseur, JP., Ed. and JL. Le Roux, Ed., "Path Computation Element (PCE) Communication Protocol (PCEP)", RFC 5440, DOI 10.17487/RFC5440, March 2009, <http://www.rfc-editor.org/info/rfc5440>.

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