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Stateful Path Computation Element (PCE) for Time-based Scheduling

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Status of this Memo

Abstract

This document presents the architecture and procedures for stateful PCE to support time-based scheduling application and also provides PCEP extensions needed.

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 [RFC2119].

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1. Introduction

As described in [stateful-app], stateful PCE are helpful in a variety of applications. One of the applications is time-based scheduling, which books network resources in advance. A simple utilization example of the time-based scheduling application is to support scheduled data transmission between data centers or servers.

To support this without a PCE, network operators need to reserve resources in advance according to customers' requests with specified starting time and duration. This can be supported by NMS operation through path pre-establishment and activation on the agreed starting time. However, this does not provide efficient network usage since the established paths exclude the possibility of being used by other services even when they are not used for undertaking any service due to the lack of a time-based mechanism. It can also be accomplished through GMPLS protocol extensions by carrying the related request information (e.g., starting time and duration) across the network.

Nevertheless, this method inevitably increases the complexity of signaling and routing process.

Since a stateful PCE collects LSP related information for the whole network, it can support this service with resource usage flexibility (i.e., only excluding the time slots reserved for time-based scheduling requests). Moreover, it can avoid the need to add complexity on network elements in this regard.

The fundamental PCEP extensions are covered in [stateful-pcep], [stateful-pcep-mpls] and [stateful-pcep-gmpls]. This document complements these documents by elaborating issues related to the time-based scheduling application as well as providing the extensions needed. Note that the time synchronization required for time-based scheduling does not need a precise one and can be in a coarser scale as long as it does not impact its operation.

2. Architecture

2.1. Terms and Definitions

Following the definitions provided in [PCE-Q&A], a stateful PCE is defined as a PCE with the ability to maintain LSP related information and take advantage of such information to facilitate computing better paths. It is also referred as a passive PCE. On the other hand, an active PCE is defined as a PCE with ability to provide "provisioning suggestions" to the network. The "provisioning suggestions" include both modification of existing LSPs and creation of new LSPs. In this document, a PCE is assumed to have the stateful ability. So, the aforementioned two categories can also be referred as an active PCE with LSP delegation and an active PCE with LSP initiation ability, respectively.

2.2. Network Architecture

The figure below shows the network architecture for deploying time-based scheduling application. The network shown is an example.

The NMS can issues resource scheduling requests to a stateful PCE. Alternatively, it can enquire a stateful PCE whether the network has the ability to undertaken any upcoming service requests. In this document, it is assumed that the PCE system will be a stateful one. It should have access to the database(s) including the following information:

o network TE information: this can be obtained via IGP protocols or configuration;

o In-use LSPs information: this denotes the LSPs that are currently taking network resource. They are helpful for a PCE to better schedule network resource for resource booking requests with constraints related to existing LSPs;

o Scheduled LSP information: this denotes the LSPs that are yet to be activated. A stateful PCE should take this information into consideration when allocating resources upon resource booking requests to avoid double-booking.

The last two types of information are LSPs related and they can be obtained via LSP state update/report messages as defined in [stateful-pcep]. Extensions are needed and are explained later in this document.

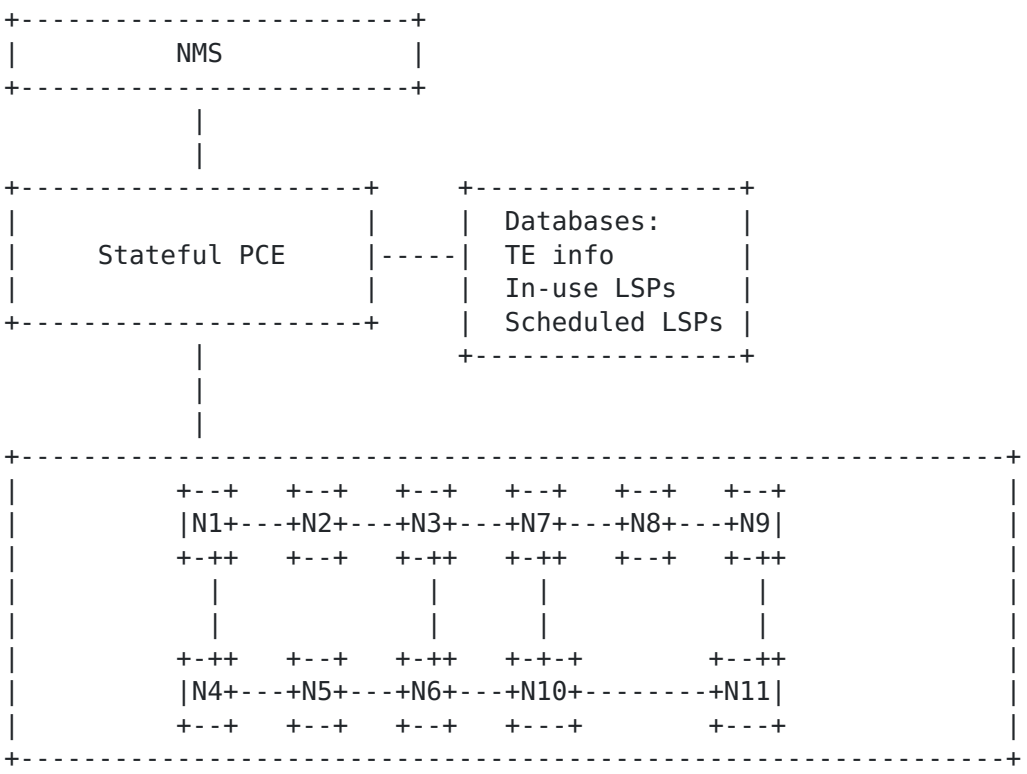


Figure 1: Stateful PCE for Deploying Time-based Scheduling

Depending on the ability of a stateful PCE, there are three available modes for deploying time-based scheduling application.

o Passive stateful PCE and PCC cooperating mode

In this case, PCCs are responsible for the creation, activation and deletion of the scheduled LSPs. With the network level view of resource usage and booking, the stateful PCE can help efficiently allocate network resource upon receiving resource booking requests from PCCs.

This mode requires the least amount of PCE involvement.

o Active stateful PCE with LSP delegation mode

In this mode, PCCs are responsible for the creation of the scheduled LSPs and they will delegate the LSP activation and deletion capability to a stateful PCE prior to the LSP activation time. For example, the delegation can happen at the same time when a PCC sends path computation requests to a PCE. Thus, a stateful PCE is responsible for the activation and/or deletion of LSPs.

o Active stateful PCE with LSP initiation mode

This requires the PCE has the ability to initiating LSPs. In this mode, a PCC does not necessarily be aware of any scheduled LSP ahead of time. The PCE is the entity that accepts such requirements externally, such as Network Management System (NMS). So, an active PCE will initiate the LSP creation/setup as well as its deletion. If returning LSP delegation is allowed, then a PCC also can have the ability to delete a LSP when its duration time ends up.

3. PCEP Extensions

The following lists a number of requirements for implementing time-based scheduling using a stateful PCE.

o A Mechanism to maintain the time synchronization in certain scale, such as in the order of minutes, are expected. In other words, strict time synchronization among requesting PCCs and PCEs is not required. It is assumed that the synchronization scale of the PCE is made known, e.g. through configuration, to all its related PCCs. How to achieve this is out of the scope of this document.

o The ability to exchange time-related information between a stateful PCE and PCCs during path computation request/reply as well as LSP state updates;

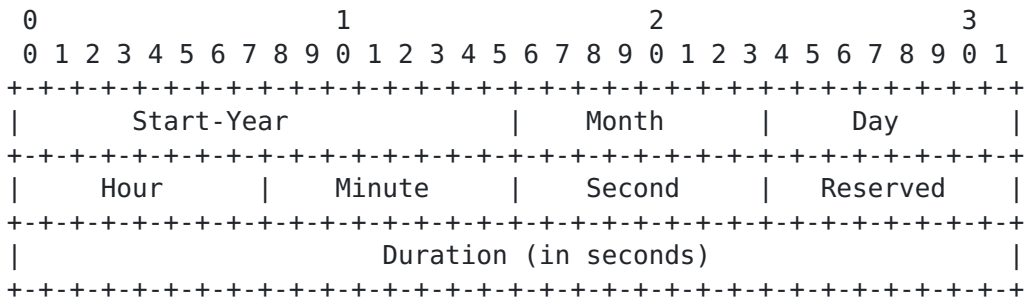
o Maintenance of a database storing the information related to the booking service requests, including the time and resource usage information;

Irrespective of the deployment mode, a database that stores all the reserved information with time reference should be maintained. This can be achieved either by maintaining a separate database or having all the reserved information with time reference incorporated into in-use LSP database (LSP-DB). The details of organizing time-based scheduling related information are subject to network provider's policy and administrative consideration and thus outside of the scope of this document.

3.1. New Object

A SERVICE-TIME object is presented as follows to provide the required information (i.e. service starting time and holding time).

The Object-Class is TBD and the Object-Type is 1.



field	Length	range
Start-Year	16 bit	0..65536
Month	8 bit	1..12
Day	8 bit	1..31
Hour	8 bit	0..23
Minute	8 bit	0..59
Second	8 bit	0..59

3.2. Procedure

There are three fundamental actions required for deploying a time-based scheduling application. They are resource allocation for a scheduled service request, activation of the scheduled service and

deletion of the scheduled service, respectively. For the three modes explained in Section 2, the responsible components may differ. The following elaborates them separately, together with PCEP extensions required.

4.1.1 Passive stateful PCE and PCC cooperating mode

Step 1: Resource Allocation

When a PCC requests to a stateful PCE for booking resource in advance, the SERVICE-TIME object MUST be included in a PCEP request as specified in the following manner:

```
<PCReq Message>::=<Common Header>

                  [<SVEC-list>]

              <request-list>
```

Where:

```
   [<svec-list>]::= <SVEC> [<svec-list>]

  <request-list>::=<request>[<request-list>]

  <request >::=<RP>

            <END-POINTS>

            [<LSPA>]

              [<BANDWIDTH>]

           [<SERVICE-TIME>]

           [<metric-list>]

           [<RRO>[<BANDWIDTH>]]

           [<IRO>]

           [<LOAD-BALANCING>]
```

WHERE:

```
  <metric-list>::=<METRIC>[<metric-list>]
```

Upon receiving a path computation request with the <SERVICE-TIME> object included, the stateful PCE should compute the path, considering the constraints of the TED, LSP-DB as well as other already scheduled service information. Then, it should return the computed route back to the requesting PCC and add such information into the scheduled LSP database. If no path can be found due to insufficient resource, the stateful PCE should return an error message specifying the reason "no resource available for this scheduling request".

If there is any change/update with regard to a particular scheduled LSP, LSP report message should be used to inform the stateful PCE of the change, such as cancelation of the scheduled LSP, assignment of LSP identifiers etc. If attributes such as bandwidth, starting time or duration needs to be updated, a path computation request MAY need to be issued and it is similar to the process of bandwidth modification of an ordinary LSP.

[Editor's note: further extensions are needed, such as adding a "cancellation" status bit etc.]

Step 2: Activation of a scheduled LSP

The PCC will keep track of the time and start the signaling process when it is time to set up the scheduled LSP. The stateful PCE should be informed of the status of the scheduled LSP. For a successful setup of a scheduled LSP, the relevant information should be moved from the scheduled database to the in-use database or the LSP record should be marked in its correct state. If there is a setup error, the PCC should inform the stateful PCE of this failure specifying the reason. The resource may be released instantly to allow acceptance of other requests.

Step 3: Deletion of a scheduled LSP

After a PCC tears a scheduled LSP down, the information related to this LSP should be deleted or marked as in a deleted state. If there is any issue with tearing down a scheduled LSP, the failure reason may be reported to the stateful PCE.

[Editor's note: Error codes to be added.]

4.1.2 Active stateful PCE with LSP delegation mode

In this mode, the resource allocation procedure is similar to that of the first mode. The difference is that the PCC will report this LSP state and set the "delegate" bit in the LSP report message into 1 **[Stateful-pcep]. Thus, the stateful PCE obtains the control of**

this potential LSP. This mode gives the flexibility of a stateful PCE to change the attributes of a potential LSP proactively. The PCC needs to get informed of the change prior to the time when this LSP needs to be activated. This can be done via LSP state update messages sent by a stateful PCE to PCCs.

The activation and deletion of the scheduling LSP is the same as the one described previously.

4.1.3 Active stateful PCE with LSP initiation mode

Step 1: Resource Allocation

The request may not come from a network element in the network, but from other entities instead, such as an NMS.

Step 2 & 3: Activation and Deletion of a scheduled LSP

This mode allows the statful PCE to maintain the information in a centralized way and initiates the activation and deletion of the scheduled LSP. Thus, it does not necessarily need the coarse time synchronization between PCCs and PCE.

This is not the case when a PCC is granted to be in charge of the LSP deletion action. Furthermore, the active PCE may need to inform any changes related to a scheduled LSP. This MAY requires including carrying the time-related information in <attribute-list > of the PCRpt message.

```
<attribute-list> ::= [<LSPA>]

                     [<BANDWIDTH>]

                     [<GENERALIZED-BANDWIDTH>]

                     [<SERVICE-TIME>]

                     [<metric-list>]

      <metric-list>::= <METRIC>[<metric-list>]
```

4. IANA Considerations

IANA is requested to allocate new Types for the TLV/Object defined in this document.

5. Manageability Considerations

The manageability requirements listed in [RFC5440] and [stateful-pcep] apply in this document. Additional considerations are explained below:

5.1. Requirements on Other Protocols

It is expected that the time synchronization should be realized using other protocols, such as Network Time Protocol to ensure the correct operation of the application specified in this document.

[Editor's note: the loss of time synchronization between PCCs and PCEs will impact the performance of the application specified in this document and needs to be investigated further.]

6. Security Considerations

This document defines extensions to PCEP to enable time-based scheduling application to deployed using stateful PCE. The security issues and solutions provided in [RFC5440] and [stateful-pcep] remain applicable to this document. The following issues should also be considered in the context of this document. The following lists other security issues incurred in the context of this document.

A malicious PCC may drain the resource usage of the network by sending large bulks of resource booking requests. This can be avoided by setting a limit to the number of booking requests a PCC can issue or a policy configured on the PCE to reject some or all of the booking requests by monitoring the frequency and amount of resource required.

7. Acknowledgement

We would like to thank Robert Varga and Adrian Farrel for their useful comments and discussions.

8. References

8.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to indicate requirements levels", RFC 2119, March 1997.

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[stateful-pcep-gmpls] Zhang, X., Lee, Y., Casellas, R., Gonzalez de Dios, O., " Path Computation Element (PCE) Protocol Extension for Stateful PCE Usage in GMPLS Networks", draft-zhang-pce-pcep-stateful-pce-gmpls, work in progress

8.2. Informative References

[Stateful-app] Zhang, F., Zhang, X., Lee, Y., Casellas, R., Gonzalez de Dios, O., "Applicability of Stateful Path Computation Element (PCE) ", draft-zhang-pce-stateful-pce-app, work in progress.

[PCE-Q&A] Farrel, A., King, D., "Unanswered Questions in the Path Computation Element Architecture", draft-farrkingel-pce-questions-00, working in progress;

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