Network Working Group
Internet Draft
Intended status: Standards Track
Expires: September 03, 2025

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March 03, 2025

PCEP extensions for energy consumption
draft-lin-pce-pcep-energy-efficiency-00

Abstract

[draft-liu-spring-sr-energy-consumption-00] describes the types of energy consumption information, how to collect energy consumption information, and the framework for path selection based on energy consumption information. This document further details the process of using the PCEP protocol for energy consumption based path requests.

The Path Computation Element Communication Protocol (PCEP) provides mechanisms that enable Path Computation Elements (PCEs) to perform path computations in response to requests from Path Computation Clients (PCCs).

This document describes the extension to PCEP for conveying link energy consumption and node energy consumption, allowing path computation based on these energy consumption information.

Status of this Memo

This Internet-Draft will expire on September 03, 2025.

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1. Introduction

[draft-cx-green-green-metrics] describe multiple metrics that can be used to measure the energy consumption.

[draft-liu-spring-sr-energy-efficiency-00] describes how energy-consumption information is utilized in SR networks. It elaborates on the use of energy consumption information for path computation in SR networks.

The metrics for energy consumption include:

Node Maximum Energy Consumption: The power consumption of a node at full load, measured in watts.

Node Real-Time Energy Consumption: The real-time power consumption of a node, measured in watts.

Node Maximum Unit Energy Consumption: The power consumption of a node at full load divided by traffic, measured in watts per gigabyte (W/GB).

Node Real-Time Unit Energy Consumption: The real-time power consumption of a node divided by real-time traffic, measured in watts per gigabyte (W/GB).

Node Average Unit Energy Consumption: The change in power consumption of a node over a measurement period divided by the change in traffic, measured in watts per gigabyte (W/GB).

Interface Maximum Unit Energy Consumption: The power consumption of an interface at full load divided by traffic, measured in watts per gigabyte (W/GB).

Interface Real-Time Unit Energy Consumption: The real-time power consumption of an interface divided by real-time traffic, measured in watts per gigabyte (W/GB).

Interface Average Unit Energy Consumption: The change in power consumption of an interface over a measurement period divided by the change in traffic, measured in watts per gigabyte (W/GB).

A Path Computation Client (PCC) can request a Path Computation Element (PCE) to provide a path that meets end-to-end network performance criteria. This document extends the Path Computation Element Communication Protocol (PCEP) [RFC5440] to handle network performance constraints based on energy consumption.

For PCC, there is no need to differentiate the types of specific energy consumption information, as this is uniformly selected by PCE based on actual energy consumption data.

1.1. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

2. Terminology

See [RFC5540].

3. PCEP Extensions

This section defines PCEP extensions (see [RFC5440]) for energy consumption.

3.1. Extensions to METRIC Object

The METRIC object is defined in Section 7.8 of [RFC5440], comprising metric-value and metric-type (T field), and a flags field, comprising a number of bit flags (B bit and P bit). (Section 3.1.1)This document defines the new type for the METRIC object.

- o T=TBD1: Path Node Maximum Energy Consumption

- o T=TBD2: Path Node Real-Time Energy Consumption

- o T=TBD3: Path Node Maximum Unit Energy Consumption

- o T=TBD4: Path Node Real-Time Unit Energy Consumption
- o T=TBD5: Path Node Average Unit Energy Consumption
- o T=TBD6: Path Interface Maximum Unit Energy Consumption
- o T=TBD7: Path Interface Real-Time Unit Energy Consumption
- o T=TBD8: Path Interface Average Unit Energy Consumption

3.1.1. Path Node Maximum Energy Consumption

The Path Node Maximum Energy Consumption of the METRIC object in PCEP represents the sum of the Node Maximum Energy Consumption of all links along a point-to-point path.

Specifically, extending on the above-mentioned terminology:

o A Link Node Maximum Energy Consumption of link L is denoted G(L).

o A Path Node Maximum Energy Consumption for the P2P path P = Sum {G(Lpi), (i=1...K)}.

A PCC MAY use the Path Node Maximum Energy Consumption in a Path Computation Request (PCReq) message to request a path meeting the end-to-end Node Maximum Energy Consumption requirement. In this case, the B bit MUST be set to suggest a bound (a maximum) for the Path energy consumption that must not be exceeded for the PCC to consider the computed path as acceptable. The Path Node Maximum Energy Consumption must be less than or equal to the value specified in the metric-value field.

A PCC can also use this metric to ask PCE to optimize the path Node Maximum Energy Consumption during path computation. In this case, the B bit MUST be cleared.

A PCE MAY use the Path Node Maximum Energy Consumption in a Path Computation Reply (PCRep) message along with a NO-PATH object in the case where the PCE cannot compute a path meeting this constraint. A

PCE can also use this metric to send the computed Path Node Maximum Energy Consumption to the PCC.

energy consumption value range (0 - 4,294,967,295), in a 32-bit field.

3.1.2. Path Node Real-Time Energy Consumption

The Path Node Real-Time Energy Consumption of the METRIC object in PCEP represents the sum of the Node Real-Time Energy Consumption of all links along a point-to-point path.

Specifically, extending on the above-mentioned terminology:

- o A Link Node Real-Time Energy Consumption of link L is denoted G(L).

- o A Path Node Real-Time Energy Consumption for the P2P path P = Sum {G(Lpi), (i=1...K)}.

A PCC MAY use the Path Node Real-Time Energy Consumption in a Path Computation Request (PCReq) message to request a path meeting the end-to-end Node Real-Time Energy Consumption requirement. In this case, the B bit MUST be set to suggest a bound (a maximum) for the Path Node Real-Time Energy Consumption that must not be exceeded for the PCC to consider the computed path as acceptable. The Node Real-Time Energy Consumption must be less than or equal to the value specified in the metric-value field.

A PCC can also use this metric to ask PCE to optimize the path Node Real-Time Energy Consumption during path computation. In this case, the B bit MUST be cleared.

A PCE MAY use the Path Node Real-Time Energy Consumption in a Path Computation Reply (PCRep) message along with a NO-PATH object in the case where the PCE cannot compute a path meeting this constraint. A PCE can also use this metric to send the computed Path Node Real-Time Energy Consumption to the PCC.

energy consumption value range (0 - 4,294,967,295), in a 32-bit field.

3.1.3. Path Node Maximum Unit Energy Consumption

The Path Node Maximum Unit Energy Consumption of the METRIC object in PCEP represents the sum of the Node Maximum Unit Energy Consumption of all links along a point-to-point path.

Specifically, extending on the above-mentioned terminology:

- o A Link Node Maximum Unit Energy Consumption of link L is denoted G(L).

- o A Path Node Maximum Unit Energy Consumption for the P2P path P = Sum {G(Lpi), (i=1...K)}.

A PCC MAY use the Path Node Maximum Unit Energy Consumption in a Path Computation Request (PCReq) message to request a path meeting the end-to-end Node Maximum Unit Energy Consumption requirement. In this case, the B bit MUST be set to suggest a bound (a maximum) for the Path Node Maximum Unit Energy Consumption that must not be exceeded for the PCC to consider the computed path as acceptable. The Node Maximum Unit Energy Consumption must be less than or equal to the value specified in the metric-value field.

A PCC can also use this metric to ask PCE to optimize the path Node Maximum Unit Energy Consumption during path computation. In this case, the B bit MUST be cleared.

A PCE MAY use the Path Node Maximum Unit Energy Consumption in a Path Computation Reply (PCRep) message along with a NO-PATH object in the case where the PCE cannot compute a path meeting this constraint. A PCE can also use this metric to send the computed Path Node Maximum Unit Energy Consumption to the PCC.

energy consumption value range (0 - 4,294,967,295), in a 32-bit field.

3.1.4. Path Node Real-Time Unit Energy Consumption

The Node Real-Time Unit Energy Consumption of the METRIC object in PCEP represents the sum of the Node Real-Time Unit Energy Consumption of all links along a point-to-point path.

Specifically, extending on the above-mentioned terminology:

- o A Link Node Real-Time Unit Energy Consumption of link L is denoted G(L).

o A Path Node Real-Time Unit Energy Consumption for the P2P path P = Sum {G(Lpi), (i=1...K)}.

A PCC MAY use the Path Node Real-Time Unit Energy Consumption in a Path Computation Request (PCReq) message to request a path meeting the end-to-end Node Real-Time Unit Energy Consumption requirement. In this case, the B bit MUST be set to suggest a bound (a maximum) for the Path Node Real-Time Unit Energy Consumption that must not be exceeded for the PCC to consider the computed path as acceptable. The Node Real-Time Unit Energy Consumption must be less than or equal to the value specified in the metric-value field.

A PCC can also use this metric to ask PCE to optimize the path Node Real-Time Unit Energy Consumption during path computation. In this case, the B bit MUST be cleared.

A PCE MAY use the Path Node Real-Time Unit Energy Consumption in a Path Computation Reply (PCRep) message along with a NO-PATH object in the case where the PCE cannot compute a path meeting this constraint. A PCE can also use this metric to send the computed Path Node Real-Time Unit Energy Consumption to the PCC.

energy consumption value range (0 - 4,294,967,295), in a 32-bit field.

3.1.5. Path Node Average Unit Energy Consumption

The Path Node Average Unit Energy Consumption of the METRIC object in PCEP represents the sum of the Node Average Unit Energy Consumption of all links along a point-to-point path.

Specifically, extending on the above-mentioned terminology:

o A Link Node Average Unit Energy Consumption of link L is denoted G(L).

o A Path Node Average Unit Energy Consumption for the P2P path P = Sum {G(Lpi), (i=1...K)}.

A PCC MAY use the Path Node Average Unit Energy Consumption in a Path Computation Request (PCReq) message to request a path meeting the end-to-end Node Average Unit Energy Consumption requirement. In this case, the B bit MUST be set to suggest a bound (a maximum) for the Path Node Average Unit Energy Consumption that must not be exceeded for the PCC to consider the computed path as acceptable. The Node Average Unit Energy Consumption must be less than or equal to the value specified in the metric-value field.

A PCC can also use this metric to ask PCE to optimize the path Node Node Average Unit Energy Consumption during path computation. In this case, the B bit MUST be cleared.

A PCE MAY use the Path Node Average Unit Energy Consumption in a Path Computation Reply (PCRep) message along with a NO-PATH object in the case where the PCE cannot compute a path meeting this constraint. A PCE can also use this metric to send the computed Path Node Node Average Unit Energy Consumption to the PCC.

energy consumption value range (0 - 4,294,967,295), in a 32-bit field.

3.1.6. Path Interface Maximum Unit Energy Consumption

The Path Interface Maximum Unit Energy Consumption of the METRIC object in PCEP represents the sum of the Interface Maximum Unit Energy Consumption of all links along a point-to-point path.

Specifically, extending on the above-mentioned terminology:

- o A Link Interface Maximum Unit Energy Consumption of link L is denoted G(L).

- o A Path Interface Maximum Unit Energy Consumption for the P2P path P = Sum {G(Lpi), (i=1...K)}.

A PCC MAY use the Path Interface Maximum Unit Energy Consumption in a Path Computation Request (PCReq) message to request a path meeting the end-to-end Interface Maximum Unit Energy Consumption requirement. In this case, the B bit MUST be set to suggest a bound (a maximum) for the Path Interface Maximum Unit Energy Consumption that must not be exceeded for the PCC to consider the computed path as acceptable. The Interface Maximum Unit Energy Consumption must be less than or equal to the value specified in the metric-value field.

A PCC can also use this metric to ask PCE to optimize the path Interface Maximum Unit Energy Consumption during path computation. In this case, the B bit MUST be cleared.

A PCE MAY use the Path Interface Maximum Unit Energy Consumption in a Path Computation Reply (PCRep) message along with a NO-PATH object in the case where the PCE cannot compute a path meeting this constraint. A PCE can also use this metric to send the computed Path Interface Maximum Unit Energy Consumption to the PCC.

energy consumption value range (0 - 4,294,967,295), in a 32-bit field.

3.1.7. Path Interface Real-Time Unit Energy Consumption

The Path Interface Real-Time Unit Energy Consumption of the METRIC object in PCEP represents the sum of the Interface Real-Time Unit Energy Consumption of all links along a point-to-point path.

Specifically, extending on the above-mentioned terminology:

o A Link Interface Real-Time Unit Energy Consumption of link L is denoted G(L).

o A Path Interface Real-Time Unit Energy Consumption for the P2P path P = Sum {G(Lpi), (i=1...K)}.

A PCC MAY use the Path Interface Real-Time Unit Energy Consumption in a Path Computation Request (PCReq) message to request a path meeting the end-to-end Interface Real-Time Unit Energy Consumption requirement. In this case, the B bit MUST be set to suggest a bound (a maximum) for the Path Interface Real-Time Unit Energy Consumption that must not be exceeded for the PCC to consider the computed path as acceptable. The Interface Real-Time Unit Energy Consumption must be less than or equal to the value specified in the metric-value field.

A PCC can also use this metric to ask PCE to optimize the path Interface Real-Time Unit Energy Consumption during path computation. In this case, the B bit MUST be cleared.

A PCE MAY use the Path Interface Real-Time Unit Energy Consumption in a Path Computation Reply (PCRep) message along with a NO-PATH object in the case where the PCE cannot compute a path meeting this constraint. A PCE can also use this metric to send the computed Path Interface Real-Time Unit Energy Consumption to the PCC.

energy consumption value range (0 - 4,294,967,295), in a 32-bit field.

3.1.8. Path Interface Average Unit Energy Consumption

The Path Interface Average Unit Energy Consumption of the METRIC object in PCEP represents the sum of the Interface Average Unit Energy Consumption of all links along a point-to-point path.

Specifically, extending on the above-mentioned terminology:

- o A Link Interface Average Unit Energy Consumption of link L is denoted G(L).

- o A Path Interface Average Unit Energy Consumption for the P2P path P = Sum {G(Lpi), (i=1...K)}.

A PCC MAY use the Path Interface Average Unit Energy Consumption in a Path Computation Request (PCReq) message to request a path meeting the end-to-end Interface Average Unit Energy Consumption requirement. In this case, the B bit MUST be set to suggest a bound (a maximum) for the Path Interface Average Unit Energy Consumption that must not be exceeded for the PCC to consider the computed path as acceptable. The Interface Average Unit Energy Consumption must be less than or equal to the value specified in the metric-value field.

A PCC can also use this metric to ask PCE to optimize the path Interface Average Unit Energy Consumption during path computation. In this case, the B bit MUST be cleared.

A PCE MAY use the Path Interface Average Unit Energy Consumption in a Path Computation Reply (PCRep) message along with a NO-PATH object in the case where the PCE cannot compute a path meeting this constraint. A PCE can also use this metric to send the computed Path Interface Average Unit Energy Consumption to the PCC.

energy consumption value range (0 - 4,294,967,295), in a 32-bit field.

3.1.9. Non-Understanding / Non-Support of energy consumption

If a PCE receives a PCReq message containing a METRIC object with a type defined in this document, and the PCE does not understand or support that metric type, and the P bit is clear in the METRIC object header, then the PCE SHOULD simply ignore the METRIC object as per the processing specified in [RFC5440].

If the PCE understands but does not support the new METRIC type, and the P bit is set in the METRIC object header, then the PCE MUST send a PCErr message containing a PCEP-ERROR Object with Error-Type = 4 (Not supported object) with Error-value = 5 (Unsupported network performance constraint). The path computation request MUST then be canceled.

If the PCE does not understand the new METRIC type, and the P bit is set in the METRIC object header, then the PCE MUST send a PCEP Error (PCErr) message containing a PCEP-ERROR Object with Error-Type = 4 (Not supported object) and Error-value = 4 (Unsupported parameter) [RFC5440][RFC5441].

If the PCE understands the new METRIC type, but the local policy has been configured on the PCE to not allow network energy consumption constraint, and the P bit is set in the METRIC object header, then the PCE MUST send a PCErr message containing a PCEP-ERROR Object with Error-Type = 5 (Policy violation) with Error-value = 8 (Not allowed network performance constraint). The path computation request MUST then be canceled.

3.1.10. Mode of Operation

As explained in [RFC5440], the METRIC object is optional and can be used for several purposes. In a PCReq message, a PCC MAY insert one or more METRIC objects:

o To indicate the metric that MUST be optimized by the path computation algorithm (path Node Maximum Energy Consumption).

o To indicate a bound on the METRIC (path Node Maximum Energy Consumption) that MUST NOT be exceeded for the path to be considered as acceptable by the PCC.

In a PCRep message, the PCE MAY insert the METRIC object with an Explicit Route Object (ERO) so as to provide the METRIC (path Node Maximum Energy Consumption) for the computed path. The PCE MAY also insert the METRIC object with a NO-PATH object to indicate that the metric constraint could not be satisfied.

The path computation algorithmic aspects used by the PCE to optimize a path with respect to a specific metric are outside the scope of this document.

All the rules of processing the METRIC object as explained in [RFC5440] are applicable to the new metric types as well.

3.1.10.1. Examples

If a PCC sends a path computation request to a PCE where the metric to optimize is the path Node Maximum Energy Consumption and the path Node Maximum Energy Consumption must not exceed the value of M, then a METRIC object is inserted in the PCReq message:

- o METRIC object with B=1, T=(TBD1), metric-value=M

As per [RFC5440], if a path satisfying the set of constraints can be found by the PCE and there is no policy that prevents the return of the computed metric, then the PCE inserts one METRIC object with B=0, T=Node Maximum Energy Consumption(TBD1), metric-value= computed path Node Maximum Energy Consumption Metric.

3.1.11. Point-to-Multipoint (P2MP) Path Node Maximum Energy Consumption

The P2MP Path Node Maximum Energy Consumption type of the METRIC object in PCEP encodes the Path Node Maximum Energy Consumption for the destination that observes the worst Node Maximum Energy Consumption among all destinations of the P2MP tree. Specifically, extending on the above-mentioned terminology:

- o A P2MP tree T comprises a set of M destinations {Dest_j,

  (j=1...M)}.

- o The P2P Path Node Maximum Energy Consumption of the path to destination Dest_j is denoted by PDM(Dest_j).

- o The P2MP Path Node Maximum Energy Consumption for the P2MP tree T = Maximum

  {PDM(Dest_j), (j=1...M)}.

The value for the P2MP Path Node Maximum Energy Consumption type (T) = (TBD9).

3.1.12. Point-to-Multipoint (P2MP) Path Node Real-Time Energy Consumption

The P2MP Path Node Real-Time Energy Consumption Consumption type of the METRIC object in PCEP encodes the Path Node Real-Time Energy Consumption for the destination that observes the worst Node Real-Time Energy Consumption among all destinations of the P2MP tree. Specifically, extending on the above-mentioned terminology:

- A P2MP tree T comprises a set of M destinations {Dest_j,

  (j=1...M)}.

- The P2P Path Node Real-Time Energy Consumption of the path to destination Dest_j is denoted by PDM(Dest_j).

- The P2MP Path Node Real-Time Energy Consumption for the P2MP tree T = Maximum

  {PDM(Dest_j), (j=1...M)}.

The value for the P2MP Path Node Real-Time Energy Consumption type (T) = (TBD10).

3.1.13. Point-to-Multipoint (P2MP) Path Node Maximum Unit Energy Consumption

The P2MP Path Node Maximum Unit Energy Consumption type of the METRIC object in PCEP encodes the Path Node Maximum Unit Energy Consumption for the destination that observes the worst Node Maximum Unit Energy Consumption among all destinations of the P2MP tree. Specifically, extending on the above-mentioned terminology:

- A P2MP tree T comprises a set of M destinations {Dest_j,

  (j=1...M)}.

- The P2P Path Node Maximum Unit Energy Consumption of the path to destination Dest_j is denoted by PDM(Dest_j).

- The P2MP Path Node Maximum Unit Energy Consumption for the P2MP tree T = Maximum

  {PDM(Dest_j), (j=1...M)}.

The value for the P2MP Path Node Maximum Unit Energy Consumption type (T) = (TBD11).

3.1.14. Point-to-Multipoint (P2MP) Path Node Real-Time Unit Energy Consumption

The P2MP Path Node Real-Time Unit Energy Consumption type of the METRIC object in PCEP encodes the Path Node Real-Time Unit Energy

Consumption for the destination that observes the worst Node Real-Time Unit Energy Consumption among all destinations of the P2MP tree. Specifically, extending on the above-mentioned terminology:

- A P2MP tree T comprises a set of M destinations {Dest_j,

  (j=1...M)}.

- The P2P Path Node Real-Time Unit Energy Consumption of the path to destination Dest_j is denoted by PDM(Dest_j).

- The P2MP Path Node Real-Time Unit Energy Consumption for the P2MP tree T = Maximum

  {PDM(Dest_j), (j=1...M)}.

The value for the P2MP Path Node Real-Time Unit Energy Consumption type (T) = (TBD12).

3.1.15. Point-to-Multipoint (P2MP) Path Node Average Unit Energy Consumption

The P2MP Path Node Average Unit Energy Consumption type of the METRIC object in PCEP encodes the Path Node Average Unit Energy Consumption for the destination that observes the worst Node Average Unit Energy Consumption among all destinations of the P2MP tree. Specifically, extending on the above-mentioned terminology:

- A P2MP tree T comprises a set of M destinations {Dest_j,

  (j=1...M)}.

- The P2P Path Node Average Unit Energy Consumption of the path to destination Dest_j is denoted by PDM(Dest_j).

- The P2MP Path Node Average Unit Energy Consumption for the P2MP tree T = Maximum

  {PDM(Dest_j), (j=1...M)}.

The value for the P2MP Path Node Average Unit Energy Consumption type (T) = (TBD13).

3.1.16. Point-to-Multipoint (P2MP) Path Interface Maximum Unit Energy Consumption

The P2MP Path Interface Maximum Unit Energy Consumption type of the METRIC object in PCEP encodes the Path Interface Maximum Unit Energy Consumption for the destination that observes the worst Interface Maximum Unit Energy Consumption among all destinations of the P2MP tree. Specifically, extending on the above-mentioned terminology:

o A P2MP tree T comprises a set of M destinations {Dest_j,

(j=1...M)}.

o The P2P Path Interface Maximum Unit Energy Consumption of the path to destination Dest_j is denoted by PDM(Dest_j).

o The P2MP Path Interface Maximum Unit Energy Consumption for the P2MP tree T = Maximum

{PDM(Dest_j), (j=1...M)}.

The value for the P2MP Path Interface Maximum Unit Energy Consumption type (T) = (TBD14).

3.1.17. Point-to-Multipoint (P2MP) Path Interface Real-Time Unit Energy Consumption

The P2MP Path Interface Real-Time Unit Energy Consumption type of the METRIC object in PCEP encodes the Path Interface Real-Time Unit Energy Consumption for the destination that observes the worst Interface Real-Time Unit Energy Consumption among all destinations of the P2MP tree. Specifically, extending on the above-mentioned terminology:

o A P2MP tree T comprises a set of M destinations {Dest_j,

(j=1...M)}.

o The P2P Path Interface Real-Time Unit Energy Consumption of the path to destination Dest_j is denoted by PDM(Dest_j).

o The P2MP Path Interface Real-Time Unit Energy Consumption for the P2MP tree T = Maximum

{PDM(Dest_j), (j=1...M)}.

The value for the P2MP Path Interface Real-Time Unit Energy Consumption type (T) = (TBD15).

3.1.18. Point-to-Multipoint (P2MP) Path Interface Average Unit Energy Consumption

The P2MP Path Interface Average Unit Energy Consumption type of the METRIC object in PCEP encodes the Path Interface Average Unit Energy Consumption for the destination that observes the worst Interface Average Unit Energy Consumption among all destinations of the P2MP tree. Specifically, extending on the above-mentioned terminology:

o A P2MP tree T comprises a set of M destinations {Dest_j,

(j=1...M)}.

o The P2P Path Interface Average Unit Energy Consumption of the path to destination Dest_j is denoted by PDM(Dest_j).

o The P2MP Path Interface Average Unit Energy Consumption for the P2MP tree T = Maximum

{PDM(Dest_j), (j=1...M)}.

The value for the P2MP Path Interface Average Unit Energy Consumption type (T) = (TBD16).

3.1.19. Capability Advertisement

During the PCEP initialization phase, PCEP speakers (PCE or PCC) announce their support for the energy consumption feature. A PCEP speaker includes the ENERGY-CONSUMPTION-CAPABILITY TLV in the OPEN object to indicate its support for PCEP GMetric. The presence of the ENERGY-CONSUMPTION-CAPABILITY TLV in the OPEN object signifies support for the energy consumption feature as described in this document.

```
 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

+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

|               Type=TBD17      |             Length=4          |
```

```
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                              Flag                                |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure: ENERGY-CONSUMPTION-CAPABILITY TLV Format

4. Stateful PCE and PCE Initiated LSPs

[RFC8231] specifies a set of extensions to PCEP to enable stateful control of MPLS-TE and GMPLS LSPs via PCEP and the maintaining of these LSPs at the stateful PCE. It further distinguishes between an active and a passive stateful PCE. A passive stateful PCE uses LSP state information learned from PCCs to optimize path computations but does not actively update LSP state. In contrast, an active stateful PCE utilizes the LSP delegation mechanism to update LSP parameters in those PCCs that delegated control over their LSPs to the PCE.

[PCE-INITIATED] describes the setup, maintenance, and teardown of PCE-initiated LSPs under the stateful PCE model. The document defines the PCInitiate message that is used by a PCE to request a PCC to set up a new LSP.

The new metric type and objective functions defined in this document can also be used with the stateful PCE extensions. The format of PCEP messages described in [RFC8231] and [PCE-INITIATED] uses <intended-attribute-list> and <attribute-list>, respectively, (where the <intended-attribute-list> is the attribute-list defined in Section 6.5 of [RFC5440] and extended in Section 5.2 of this document) for the purpose of including the service-aware parameters.

The stateful PCE implementation MAY use the extension of PCReq and PCRep messages as defined in Sections 5.1 and 5.2 to enable the use of service-aware parameters during passive stateful operations.

5. IANA Considerations

5.1. METRIC Types

IANA maintains the "Path Computation Element Protocol (PCEP) Numbers" registry at <http://www.iana.org/assignments/pcep>. Within this registry, IANA maintains a subregistry for "METRIC Object T Field".

The new metric types are defined in this document for the METRIC object (specified in [RFC5440]).

Value	Description	Reference
TBD1	Path Node Maximum Energy Consumption	This Document
TBD2	Path Node Real-Time Energy Consumption	This Document
TBD3	Path Node Maximum Unit Energy Consumption	This Document
TBD4	Path Node Real-Time Unit Energy Consumption	This Document
TBD5	Path Node Average Unit Energy Consumption	This Document
TBD6	Path Interface Maximum Unit Energy Consumption	This Document
TBD7	Path Interface Real-Time Unit Energy Consumption	This Document
TBD8	Path Interface Average Unit Energy Consumption	This Document
TBD9	P2MP Path Node Maximum Energy Consumption	This Document

TBD10	P2MP Path Node Real-Time Energy Consumption	This Document
TBD11	P2MP Path Node Maximum Unit Energy Consumption	This Document
TBD12	P2MP Path Node Real-Time Unit Energy Consumption	This Document
TBD13	P2MP Path Node Average Unit Energy Consumption	This Document
TBD14	P2MP Path Interface Maximum Unit Energy Consumption	This Document
TBD15	P2MP Path Interface Real-Time Unit Energy Consumption	This Document
TBD16	P2MP Path Interface Average Unit Energy Consumption	This Document

5.2. ENERGY-CONSUMPTION-CAPABILITY

Value	Description
TBD17	ENERGY-CONSUMPTION-CAPABILITY

6. Security Considerations

TBD.

7. References

7.1. Normative References

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7.2. Informational References

TBD

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