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**IGP-TE Extensions for DetNet Information Distribution
draft-geng-detnet-info-distribution-04**

Abstract

This document extends the IGP-TE, including OSPF-TE and ISIS-TE, to support DetNet by specifying new information that can be placed in Link State Protocol Data Units (LSP). This information describes additional details regarding the state of the network that are useful for DetNet computations.

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 [RFC 2119](#) [[RFC2119](#)].

Status of This Memo

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1. Introduction

There are many use cases from diverse industries which have the need in common for deterministic service, for example: audio video production, industrial process control and mobile access networks. The requirements can be summarized as:

Deterministic minimum and maximum end-to-end latency from source to destination

Extremely low packet loss rate

Deterministic Networking (DetNet) can satisfy the requirements by the following techniques:

- o Congestion Protection by reserving data plane resources for DetNet flows in intermediate nodes along the path
- o Explicit Route that do not rapidly change with the network topology
- o Seamless Redundant which can distribute DetNet flow packets over multi paths to ensure delivery of each packet spite of the loss of a path

To make the above techniques work, it's necessary to know the capabilities (e.g., DetNet capable or not, which congestion protection algorithms are supported, etc.), resources (e.g, dedicated bandwidth for DetNet, buffers, etc.), performance (e.g., device/queue/link delay etc.) and other relevant information of each DetNet capable node. Then, a DetNet path computation element (e.g., PCE or ingress of a DetNet flow) can use these information to compute a path that satisfies the requirement of a specific DetNet flow. Specifically, according to the requirements stated in DetNet architecture, the information should include:

- o Bandwidth related attributes (e.g., bandwidth reserved for DetNet);
- o Buffer/queue management related attributes (e.g., queue management algorithm, etc.);
- o PREOF (Packet Replication, Ordering and Elimination Function) capabilities and parameters (e.g., maximum out-of-order packets, etc.);

- o Delay related attributes (e.g., node processing delay, queuing delay, link delay, etc.);

This document defines extensions to OSPF and ISIS to distribute the above DetNet information at node and/or link granularity.

Some of information (e.g., Link delay/loss) can be distributed and collected through Traffic Engineering (TE) metric extensions [[RFC7471](#)] and [[RFC7810](#)], which are not covered by this document.

2. Terminology

All the DetNet related terminologies used in this document conform to the DetNet architecture [[I-D.ietf-detnet-architecture](#)].

3. DetNet Extensions to OSPF TE

This document defines an extension to OSPF used to advertise DetNet information.

3.1. DetNet Node Attributes Advertisement

New OSPF DetNet sub-TLVs for Node Attribute TLV[RFC5786] are defined to distribute the DetNet information of a node. These sub-TLVs include:

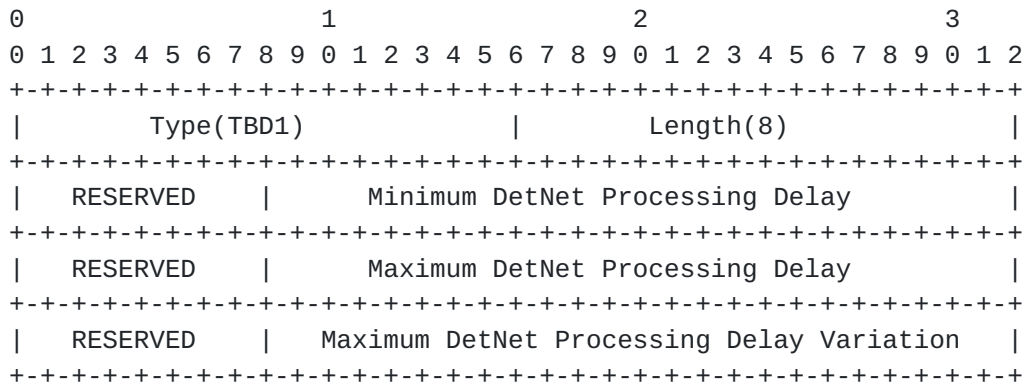
Type	Length	Value
TBD1	8	DetNet Processing Delay
TBD4	4	PREOF Capability

3.1.1. Packet Processing Delay Sub-TLV

In the scope of DetNet, packet processing delay, which begins after the packet goes into the input port and ends before the packet arrives the output buffer, can be expected in a known range, and the value of the delay bound is specified in this sub-TLV, including:

- o Maximum DetNet packet processing delay
- o Minimum DetNet packet processing delay
- o Maximum DetNet packet processing delay variation

The format of this sub-TLV is shown in the following diagram:



The Type field is 2 octets in length, and the value is TBD1.

The Length field is 2 octets in length and its value is 8.

The RESERVED field is reserved for future use. It MUST be set to 0 when sent and MUST be ignored when received.

The Minimum DetNet Processing Delay field is 3 octets, and presents the minimum delay for a DetNet flow in the device, excluding the queuing delay in output port. The units are microsecond.

The Maximum DetNet Processing Delay field is 3 octets, and presents the maximum delay for a DetNet flow in the device, excluding the queuing delay in output port. The units are microsecond.

The Maximum DetNet Processing Delay Variation field is 3 octets in length, and presents the maximum delay variation for a DetNet flow in the device, excluding the queuing delay in output port. The units are microsecond.

3.1.2. PREOF Capability Sub-TLV

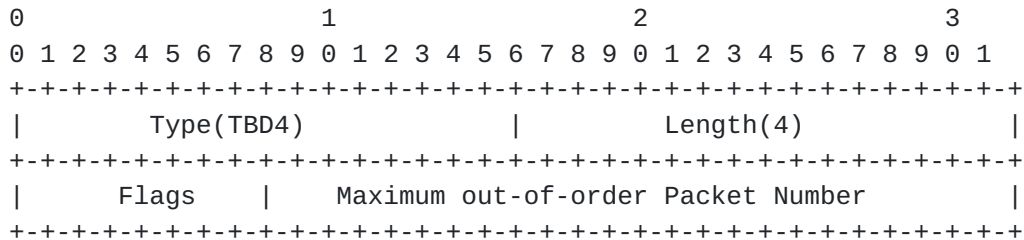
PREOF (Packet Replication/Elimination/Ordering Function) is for DetNet service protection, which includes:

- o In-order delivery function: defined in Section 3.2.2.1 of [\[I-D.ietf-detnet-architecture\]](#)
- o Packet replication function: defined in Section 3.2.2.2 of [\[I-D.ietf-detnet-architecture\]](#)
- o Packet elimination function: defined in Section 3.2.2.3 of [\[I-D.ietf-detnet-architecture\]](#)

This sub-TLV specifies a set of PREOF capabilities and relevant parameters at node granularity. PREOF can also be advertised as Link

attribute ([section 3.2.3](#)), when not all of the ports in the node support PREOF.

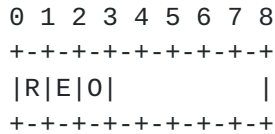
The format of this sub-TLV is shown in the following diagram:



The Type field is 2 octets in length, and the value is TBD4.

The Length field is 2 octets in length and its value is 4.

The Flags field is 1 octet in length, and it is designed as follows:



where:

- o R-flag: replication-capability flag, which indicates whether a node has the packet replication capability.
- o E-flag: elimination-capability flag, which indicates whether a node has the packet elimination capability
- o O-flag: in-order-capability, which indicates whether a LTP has the in-order delivery capability

Maximum out-of-order Packet Number field is 3 octet in length, and presents the maximum number of out-of-order packets that this link can support, it depends on the reserved buffer size for packet reordering. This value is valid only when the O-flag is set.

Editor' note: Maximum Replicated Copies number may be added in the future version.

3.2. DetNet Link Attributes Advertisement

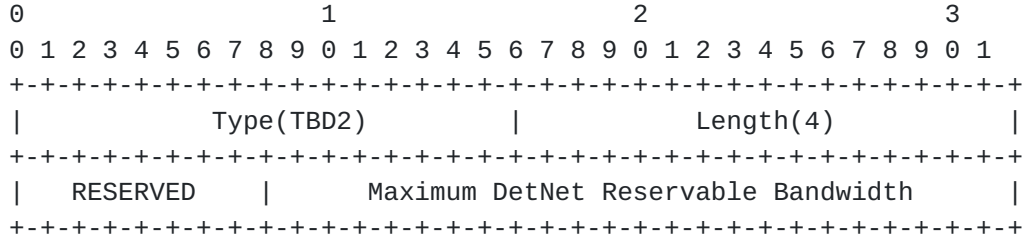
New OSPF DetNet sub-TLVs for Link TLV are defined to distribute DetNet information of a link. These sub-TLVs include:

Type	Length	Value
TBD2	4	Max DetNet Reservable Bandwidth
TBD3	4	DetNet Available Bandwidth
TBD4	4	PREOF Capability
TBD5	4	Queuing Algorithm Capabilities
TBD6	10	Queue Parameters

3.2.1. Max DetNet Reservable Bandwidth Sub-TLV

This sub-TLV specifies the maximum amount of bandwidth that is reserved for DetNet on this link. Note that this value SHOULD be smaller than the value of Maximum Reservable Bandwidth sub-TLV [RFC3630]. The value normally depends on the queuing management algorithm and is user-configurable. In some particular queuing management algorithm (e.g. Credit Based shaper in AVB), this value will affect the calculation of maximum queuing delay of the DetNet flow. The units are bytes per second.

The format of this sub-TLV is shown in the following diagram:



The Type field is 2 octets in length, and the value is TBD2.

The Length field is 2 octets in length and its value is 4.

The RESERVED field is reserved for future use. It MUST be set to 0 when sent and MUST be ignored when received.

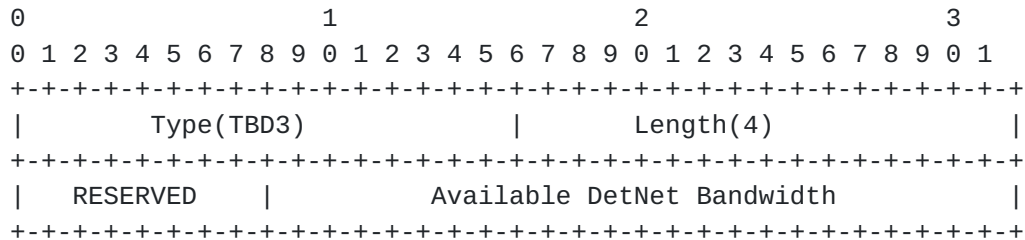
This Maximum DetNet Reservable Bandwidth field is 3 octets in length, and presents the maximum bandwidth that may be reserved for DetNet. The units are bytes per second.

3.2.2. DetNet Available Bandwidth Sub-TLV

This sub-TLV specifies the available bandwidth that can be reserved for DetNet flow on this link for now. Considering that there is no generally accepted DetNet traffic classification, this value contains all the available DetNet Bandwidth from different DetNet traffic

classes (if there is any), which differs from the Unreserved Bandwidth defined in [RFC3630].

The format of this sub-TLV is shown in the following diagram:



The Type field is 2 octets in length, and the value is TBD3.

The Length field is 2 octets in length and its value is 4.

The RESERVED field is reserved for future use. It MUST be set to 0 when sent and MUST be ignored when received.

This Available DetNet Bandwidth field is 3 octets in length, and presents the available bandwidth for DetNet in this link. The units are bytes per second.

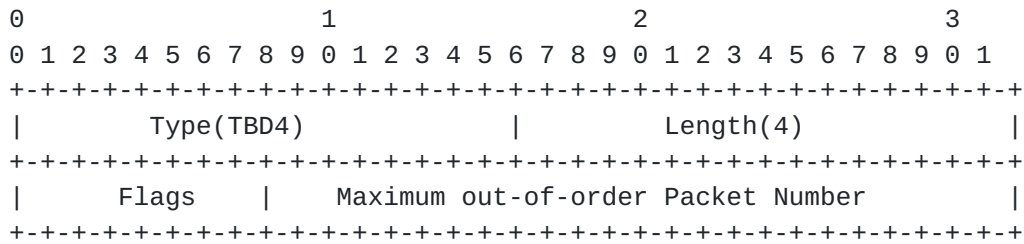
3.2.3. PREOF Capability Sub-TLV

PREOF (Packet Replication/Elimination/Ordering Function) is for DetNet service protection, which includes :

- o In-order delivery function: defined in Section 3.2.2.1 of [I-D.ietf-detnet-architecture]
- o Packet replication function: defined in Section 3.2.2.2 of [I-D.ietf-detnet-architecture]
- o Packet elimination function: defined in Section 3.2.2.3 of [I-D.ietf-detnet-architecture]

This sub-TLV specifies a set of PREOF capabilities and relevant parameters at link granularity. PREOF can also be advertised as node attribute (section 3.1.2), when all of the ports in the node support PREOF.

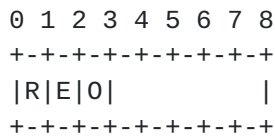
The format of this sub-TLV is shown in the following diagram:



The Type field is 2 octets in length, and the value is TBD4.

The Length field is 2 octets in length and its value is 4.

The Flags field is 1 octet in length, and it is designed as follows:



where:

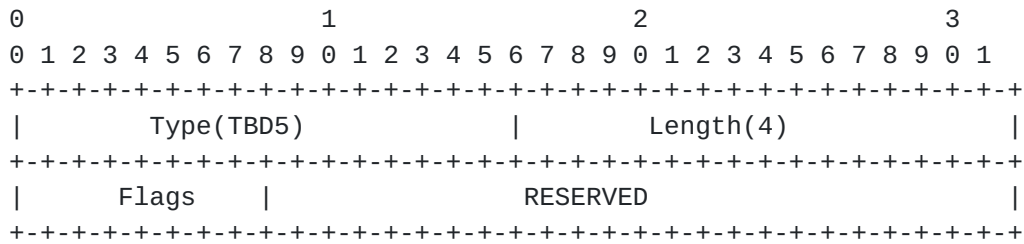
- o R-flag: replication-capability flag, which indicates whether a link has the packet replication capability.
- o E-flag: elimination-capability flag, which indicates whether a link has the packet elimination capability
- o O-flag: in-order-capability, which indicates whether a LTP has the in-order delivery capability

Maximum out-of-order Packet Number field is 3 octet in length, and presents the maximum number of out-of-order packets that this link can support, it depends on the reserved buffer size for packet reordering. This value is valid only when the O-flag is set.

3.2.4. Queuing Algorithm Capability Sub-TLV

This sub-TLV specifies queuing management algorithms capabilities to gaurante bounded queuing latency [[I-D.finn-detnet-bounded-latency](#)].

The format of this sub-TLV is shown in the following diagram:

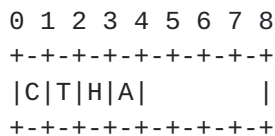


The Type field is 2 octets in length, and the value is TBD5.

The Length field is 2 octets in length and its value is 4.

The RESERVED field is reserved for future use. It MUST be set to 0 when sent and MUST be ignored when received.

The Flags field is 1 octet in length, and it is designed as follows:



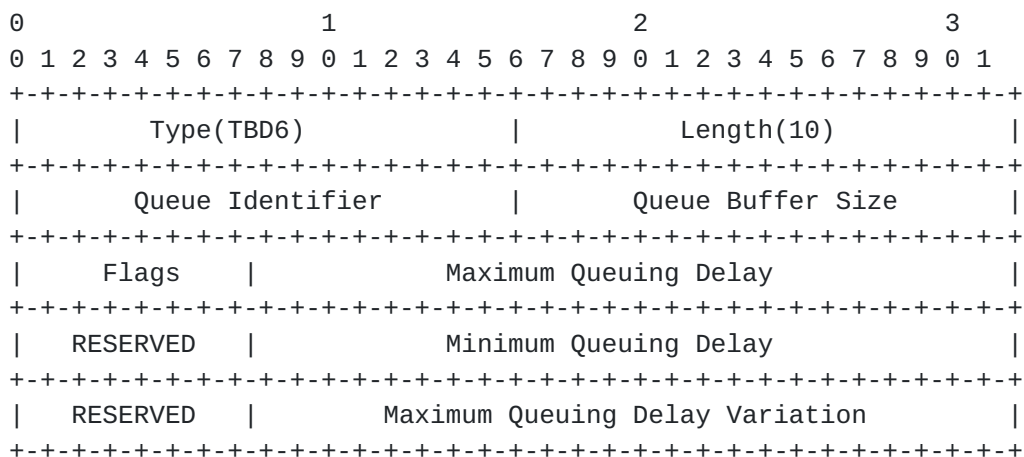
where:

- o C-flag: CBS flag, which indicates whether a link can support Time Aware Shaping [[IEEE802.1Qbv](#)].
- o T-flag: TAS flag, which indicate whether a link can support Credit Based Shaper [[IEEE802.1Q-2014](#)]
- o H-flag: CQF flag, which indicate whether a link can support Cyclic Queuing and Forwarding [[IEEE802.1Qch](#)]
- o A-flag: ATS flag, which indicate whether a link can support Asynchronous Traffic Shaping [[IEEE802.1Qcr](#)]

3.2.5. DetNet Queue Sub-TLV

In the context of DetNet, the delay of queuing is bounded, and the bound depends on what queuing management method is used and how many buffers are allocated. This sub-TLV specifies the DetNet queue parameters.

The format of this sub-TLV is shown in the following diagram:



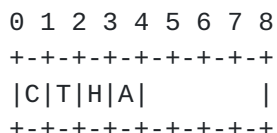
The Type field is 2 octets in length, and the value is TBD6.

The Length field is 2 octets in length and its value is 10.

The Queue Identifier field is 3 octets in length, and specifies the identifier of a queue. It could be an internal identifier that is only used within a node. Or it could be used by a centralized controller to specify in which specific queue a flow/packet is required to enter.

The Queue Buffer Size field is 3 octets in length, and specifies the size of a queue with unit of bytes.

The Flags field is 1 octet in length, and it is designed as follows:



where:

- o C-flag: CBS flag, which indicates whether a link can support Time Aware Shaping [[IEEE802.1Qbv](#)].
- o T-flag: TAS flag, which indicate whether a link can support Credit Based Shaper [[IEEE802.1Q-2014](#)]
- o H-flag: CQF flag, which indicate whether a link can support Cyclic Queuing and Forwarding [[IEEE802.1Qch](#)]
- o A-flag: ATS flag, which indicate whether a link can support Asynchronous Traffic Shaping [[IEEE802.1Qcr](#)]

The RESERVED field is reserved for future use. It MUST be set to 0 when sent and MUST be ignored when received.

Minimum Queuing Delay is 3 octets in length, and carries minimum queuing delay value (in microseconds) encoded as an integer value. Implementations may also add this to the value of Min Delay Unidirectional Link Delay Sub-TLV [[RFC7471](#)] in order to advertise the minimum delay of this link. Min Queuing Delay can be the same with the Max Queuing Delay.

Maximum Queuing Delay is 3 octets in length, and carries the maximum queuing delay value (in microseconds) encoded as an integer value. Implementations may also add this to the value of Max Delay Unidirectional Link Delay Sub-TLV [[RFC7471](#)] to order to advertise the maximum delay of this link.

Maximum Queuing Delay variation is 3 octets in length, and carries the maximum queuing delay variation value (in microseconds) encoded as an integer value.

The RESERVED field is reserved for future use. It MUST be set to 0 when sent and MUST be ignored when received.

4. DetNet Extensions to ISIS TE

This document defines an extension to IS-IS used to advertise DetNet information.

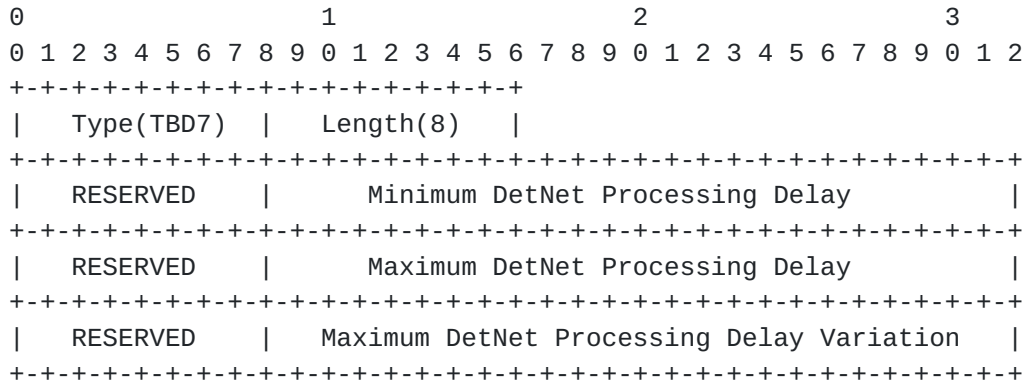
4.1. DetNet Node Attributes Advertisement

The DetNet node sub-TLVs are defined within the body of the IS-IS Router Capability TLV [[RFC7981](#)] to carry DetNet information.

4.1.1. DetNet Processing Delay Sub-TLV

This sub-TLV specifies the DetNet packet processing parameters. The reader can know more about this sub-TLV referring to [section 3.1](#).

The format of this sub-TLV is shown in the following diagram:



The Type field is 1 octets in length, and the value is TBD7.

The Length field is 1 octets in length and its value is 8.

The RESERVED field is reserved for future use. It MUST be set to 0 when sent and MUST be ignored when received.

The Minimum DetNet Processing Delay is 3 octets in length and presents the minimum delay for a DetNet flow in the device, excluding the queuing delay in output port. The units are microsecond.

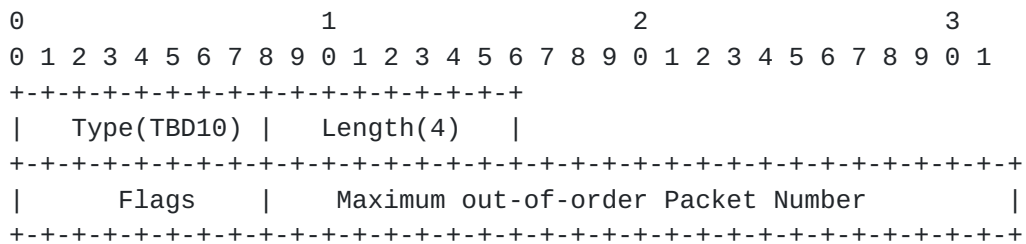
The Maximum DetNet Processing Delay is 3 octets in length and presents the maximum delay for a DetNet flow in the device, excluding the queuing delay in output port. The units are microsecond.

The Maximum DetNet Processing Delay Variation is 3 octets in length and presents the maximum delay variation for a DetNet flow in the device, excluding the queuing delay in output port. The units are microsecond.

4.1.2. PREOF Capability Sub-TLV

This sub-TLV specifies a set of PREOF capabilities and relevant parameters in sub-TLV. The reader can know more about this sub-TLV referring to [section 3.4](#).

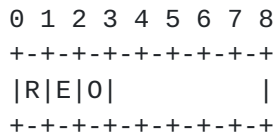
The format of this sub-TLV is shown in the following diagram:



The Type field is 1 octets in length, and the value is TBD10.

The Length field is 1 octets in length and its value is 4.

The Flags field is 1 octet in length, and it is designed as follows:



where:

- o R-flag: replication-capability flag, which indicates whether a node has the packet replication capability.
- o E-flag: elimination-capability flag, which indicates whether a node has the packet elimination capability
- o O-flag: in-order-capability, which indicates whether a LTP has the in-order delivery capability

Maximum out-of-order Packet Number field is 3 octets in length and presents the maximum number of out-of-order packets that this link can support, it depends on the reserved buffer size for packet reordering. This value is valid only when the O-flag is set.

Editor' note: Maximum Replicated Copies number may be added in the future version.

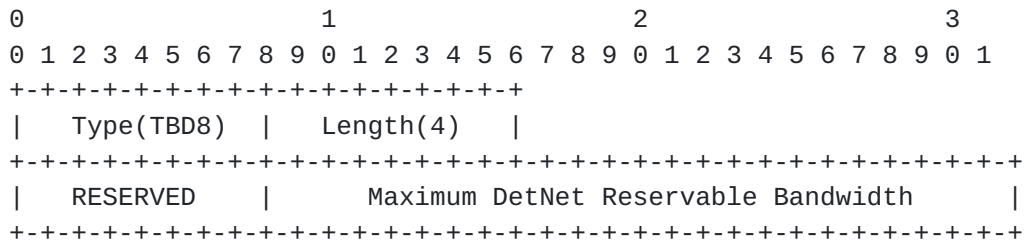
4.2. DetNet Link Attributes Advertisement

This document defines new IS-IS TE sub-TLVs that can be announced in the TLVs 22, 23, 141, 222, and 223 in order to distribute DetNet information. The sub-TLV extensions below build on the ones provided in [\[RFC5305\]](#), [\[RFC5316\]](#)and [\[RFC7310\]](#)

4.2.1. Max DetNet Reservable Bandwidth Sub-TLV

This sub-TLV specifies the maximum amount of bandwidth that is reserved for DetNet on this link. Note that this value SHOULD be smaller than the value of Maximum Reservable Link Bandwidth [\[RFC5305\]](#). The reader can know more about this sub-TLV referring to [section 3.2](#).

The format of this sub-TLV is shown in the following diagram:



The Type field is 1 octets in length, and the value is TBD8.

The Length field is 1 octets in length and its value is 4.

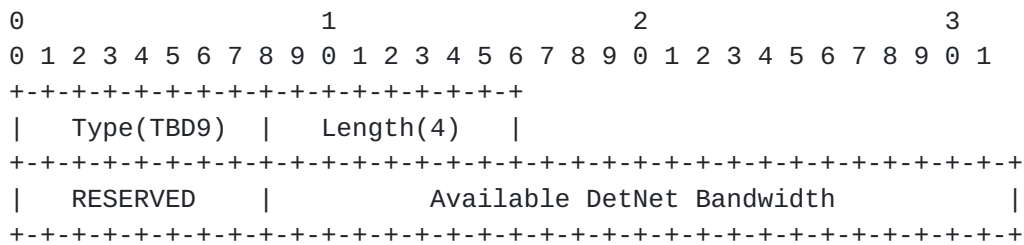
The RESERVED field is reserved for future use. It MUST be set to 0 when sent and MUST be ignored when received.

This Maximum DetNet Reservable Bandwidth field is 3 octets in length and presents the maximum bandwidth that may be reserved for DetNet. The units are bytes per second.

4.2.2. DetNet Available Bandwidth Sub-TLV

This sub-TLV specifies the available bandwidth that can be reserved for DetNet flow on this link for now. It is different from the Unreserved Bandwidth sub-TLV defined in [RFC5305] referring to [section 3.3](#).

The format of this sub-TLV is shown in the following diagram:



The Type field is 1 octets in length, and the value is TBD9.

The Length field is 1 octets in length and its value is 4.

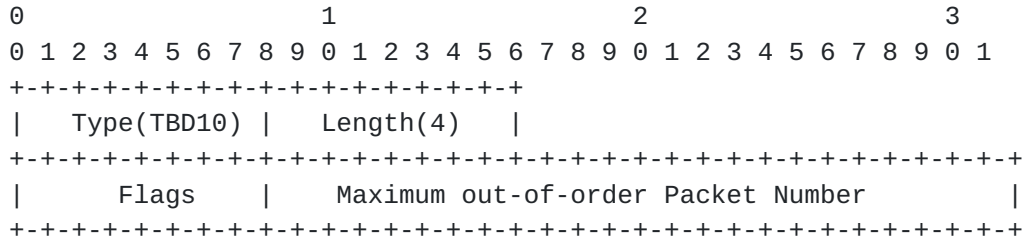
The RESERVED field is reserved for future use. It MUST be set to 0 when sent and MUST be ignored when received.

This Available DetNet Bandwidth field is 3 octets in length and presents the available bandwidth for DetNet in this link. The units are bytes per second.

4.2.3. PREOF Capability Sub-TLV

This sub-TLV specifies a set of PREOF capabilities and relevant parameters in sub-TLV. The reader can know more about this sub-TLV referring to [section 3.4](#).

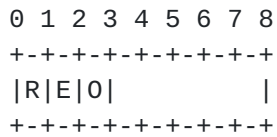
The format of this sub-TLV is shown in the following diagram:



The Type field is 1 octets in length, and the value is TBD10.

The Length field is 1 octets in length and its value is 4.

The Flags field is 1 octet in length, and it is designed as follows:



where:

- o R-flag: replication-capability flag, which indicates whether a link has the packet replication capability.
- o E-flag: elimination-capability flag, which indicates whether a link has the packet elimination capability
- o O-flag: in-order-capability, which indicates whether a LTP has the in-order delivery capability

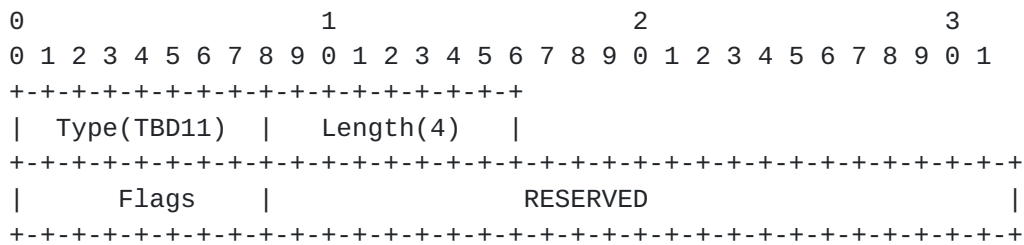
Maximum out-of-order Packet Number field is 3 octets in length and presents the maximum number of out-of-order packets that this link can support, it depends on the reserved buffer size for packet reordering. This value is valid only when the O-flag is set.

Editor' note: Maximum Replicated Copies number may be added in the future version.

4.2.4. Queuing Algorithm Capability Sub-TLV

This sub-TLV specifies queuing management algorithms capabilities to gaurante bounded queuing latency [[I-D.finn-detnet-bounded-latency](#)].

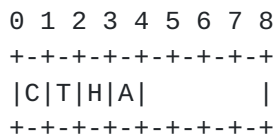
The format of this sub-TLV is shown in the following diagram:



The Type field is 1 octets in length, and the value is TBD11.

The Length field is 1 octets in length and its value is 4.

The Flags field is 1 octet in length, and it is designed as follows:



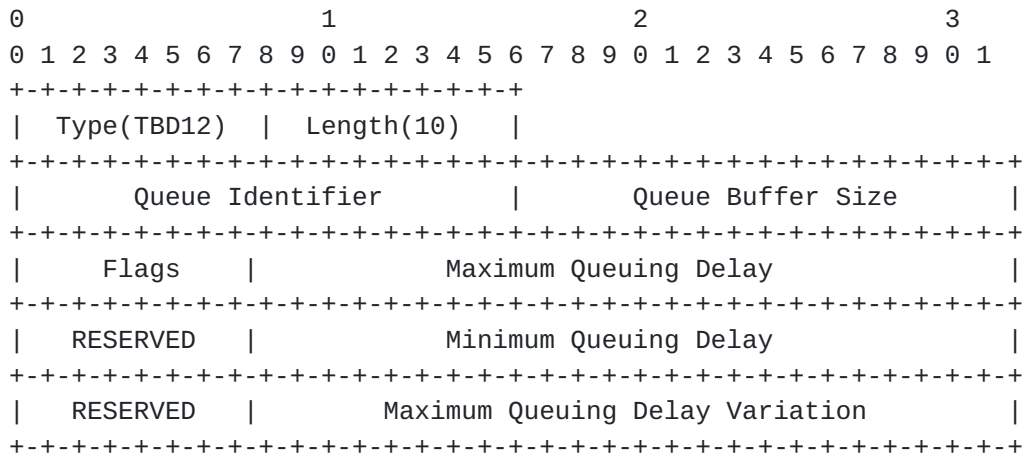
where:

- o C-flag: CBS flag, which indicates whether a link can support Time Aware Shaping [[IEEE802.1Qbv](#)].
- o T-flag: TAS flag, which indicuate whether a link can support Credit Based Shaper [[IEEE802.1Q-2014](#)]
- o H-flag: CQF flag, which indicuate whether a link can support Cyclic Queuing and Forwarding [[IEEE802.1Qch](#)]
- o A-flag: ATS flag, which indicuate whether a link can support Asynchronous Traffic Shaping [[IEEE802.1Qcr](#)]

4.2.5. DetNet Queue Sub-TLV

In the context of DetNet, the delay of queuing is bounded, and the bound depends on what queuing management method is used and how many buffers are allocated. This sub-TLV specifies the DetNet queue parameters.

The format of this sub-TLV is shown in the following diagram:



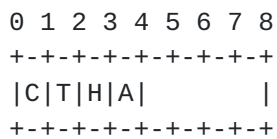
The Type field is 1 octets in length, and the value is TBD12.

The Length field is 1 octets in length and its value is 10.

The Queue Identifier field specifies the identifier of a queue. It could be an internal identifier that is only used within a node. Or it could be used by a centralized controller to specify in which specific queue a flow/packet is required to enter.

The Queue Buffer Size field specifies the size of a queue with unit of bytes.

The Flags field is 1 octet in length, and it is designed as follows:



where:

- o C-flag: CBS flag, which indicates whether a link can support Time Aware Shaping [[IEEE802.1Qbv](#)].
- o T-flag: TAS flag, which indicate whether a link can support Credit Based Shaper [[IEEE802.1Q-2014](#)]
- o H-flag: CQF flag, which indicate whether a link can support Cyclic Queuing and Forwarding [[IEEE802.1Qch](#)]
- o A-flag: ATS flag, which indicate whether a link can support Asynchronous Traffic Shaping [[IEEE802.1Qcr](#)]

The RESERVED field is reserved for future use. It MUST be set to 0 when sent and MUST be ignored when received.

Minimum Queuing Delay is 3 octets in length and presents minimum queuing delay value (in microseconds) encoded as an integer value. Implementations may also add this to the value of Min Delay Unidirectional Link Delay Sub-TLV [RFC7471] in order to advertise the minimum delay of this link. Min Queuing Delay can be the same with the Max Queuing Delay.

Maximum Queuing Delay is 3 octets in length and presents the maximum queuing delay value (in microseconds) encoded as an integer value. Implementations may also add this to the value of Max Delay Unidirectional Link Delay Sub-TLV [RFC7471] to order to advertise the maximum delay of this link.

Maximum Queuing Delay variation is 3 octets in length and presents the maximum queuing delay variation value (in microseconds) encoded as an integer value.

5. IANA Considerations

5.1. Sub-TLVs for OSPF Node Attribute TLV

IANA is requested to register the OSPF sub-TLVs defined in this document in the sub-TLVs for Node Attribute TLV registry.

Type	Description
----	-----
TBD1	Packet Processing Delay
TBD2	PREOF Capability

5.2. Sub-TLVs for OSPF Link TLV

IANA is requested to register the OSPF sub-TLVs defined in this document in the sub-TLVs for Link TLV registry.

Type	Description
----	-----
TBD3	Maximum DetNet Reservable Bandwidth
TBD4	DetNet Available Bandwidth
TBD5	PREOF Capability
TBD6	Queuing Algorithm Capabilities
TBD7	Queue Parameters

5.3. Sub-TLVs for ISIS Router Capability TLV

IANA is requested to register the ISIS sub-TLVs defined in this document in the sub-TLVs for Router Capability TLV registry.

Type	Description
----	-----
TBD8	Packet Processing Delay
TBD9	PREOF Capability

5.4. Sub-TLVs for IS-IS TLVs 22, 23, 141, 222, and 223

IANA is requested to register the ISIS sub-TLVs defined in this document in the Sub-TLVs for TLVs 22, 23, 141, 222, and 223 registry.

Type	Description
----	-----
TBD10	Maximum DetNet Reservable Bandwidth
TBD11	DetNet Available Bandwidth
TBD12	PREOF Capability
TBD13	Queuing Algorithm Capabilities
TBD14	Queue Parameters

6. Security Considerations

This document does not introduce security issues beyond those discussed in [[RFC7471](#)] and [[RFC7810](#)].

7. Acknowledgements

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