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Advertising DetNet Resources in BGP Link-State
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Abstract

BGP Link-State (BGP-LS) enables the collection of various topology information from the network. This document specifies the advertisement of DetNet scheduling resources in BGP-LS, providing a foundation for the controller to calculate DetNet based traffic engineering path.

Status of This Memo

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1. Introduction

[RFC8655] describes the architecture of a deterministic networking (DetNet) and defines the QoS goals of deterministic forwarding: 1) Minimum and maximum end-to-end latency from source to destination, timely delivery, and bounded jitter (packet delay variation); 2) A bounded packet loss ratio under various assumptions about the operational states of the nodes and links; 3) An upper bound on out-of-order packet delivery. In order to achieve these goals, DetNet use resource reservation, explicit routing, and service protection, as well as other means. A deterministic forwarding path is typically (but not necessarily) an explicit route so that it does not suffer temporary interruptions caused by the convergence of routing or bridging protocols.

Some enhanced data plane (EDP) queueing mechanisms are under discussion in DetNet WG to meet large scaling requirements in IP/MPLS network. According to [Net-Calculus], queueing mechanisms may be roughly classified into two categories: rate based, and delay based. The latency bound provided by rate based mechanisms is generally overestimated due to inversely proportional to the service rate of the flow or flow aggregate. While the latency bound provided by delay based mechanisms is more tighter due to accurately planning the scheduling slot or deadline. Note that even if two mechanisms belong to the same category, e.g., both based on traffic class queuing, they may provide different worst case latency due to different underlying scheduling principles.

[I-D.peng-lsr-deterministic-traffic-engineering] provides the abstraction and quantification of DetNet scheduling resources for all queueing mechanisms, and defines the IGP advertisement method. DetNet scheduling resources can be used for admission check when set up a new DetNet flow in the network. This document specifies the advertisement of DetNet scheduling resources in BGP-LS, providing a foundation for the controller to calculate DetNet based traffic engineering path.

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. Advertising DetNet Scheduling Capability

The DetNet Scheduling Capability TLV is a BGP-LS Link Attribute TLV associated with the Link NLRI that is used for the advertisement of the DetNet scheduling capability associated with a link. The format of this TLV is as follows:

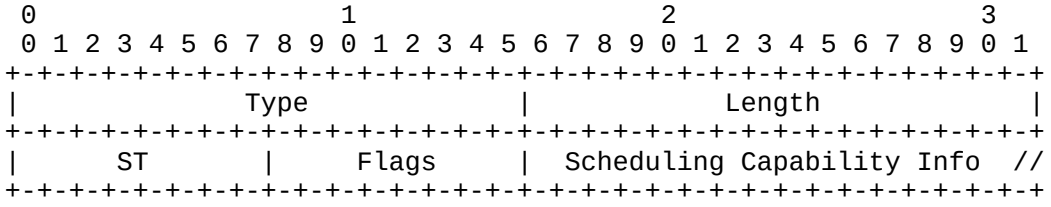

Figure 1: DetNet Scheduling Capbility TLV

where:

* Type: TBD.

* Length: variable, depending on size of the Scheduling Capability Info field.

* ST (Scheduling Type): 1 byte, represents the type of scheduling mechanism supported by the link, as below.

- 0: Reserved for default or unspecified scheduling mechanisms, such as SP (strict priority) that is widely used in the network. It is not recommended to explicitly advertise the detailed capability information of default scheduling mechanisms by the DetNet Scheduling Capability Sub-TLV.

- 1: ATS[IEEE802.1Qcr].

- 2: CBS[IEEE802.1Qav].

- 3: ATS+CBS[ATSplusCBS].

- 4: ECQF[IEEE802.1Qdv]/TCQF[I-D.eckert-detnet-tcqf].

- 5: EDF[I-D.peng-detnet-deadline-based-forwarding].

- 6: TQF[I-D.peng-detnet-packet-timeslot-mechanism].

- 7: C-SCORE[I-D.joung-detnet-stateless-fair-queuing].

- 8: gLBF[I-D.eckert-detnet-glbf].

- 9~255: To be defined in the future.

* Flags: 1 byte, currently two flags are defined as below:

  - I (In-time mode): indicates whether the scheduling mechanism supports in-time scheduling mode. Support if set, otherwise not support. In-time scheduling mode can be understood as sending the packet as soon as possible before its bounded latency per-hop.

  - O (On-time mode): indicates whether the scheduling mechanism supports on-time scheduling mode. Support if set, otherwise not support. On-time scheduling mode can be understood as sending the packet as close as possible to its bounded latency per-hop.

* Scheduling Capability Info: Includes capability level information corresponding to the specific scheduling mechanism type with variable size.

  - If ST is one of ATS, CBS, ATS+CBS, or gLBF, the field size is 1 byte, and it contains the number (i.e., n) of traffic classes supported by the scheduling mechanism. Let the first traffic class be 0, the last traffic class be n-1, with ascending priority order from traffic class 0 to traffic class n-1.

- If ST is ECQF/TCQF, the field size is n*2 bytes, and it contains n cycle durations, each with 2 bytes, in unit of microseconds. For example, the cycle duration may be 10 us, or 20 us, and so on. Different cycle durations represent different CQF instances.

- If ST is EDF, the field size is 6 bytes, and it contains the minimum delay level (2 bytes, in unit of microseconds), maximum delay level (2 bytes, in unit of microseconds), and delay level interval (2 bytes, in unit of microseconds) supported by the EDF scheduling mechanism. The number of supported delay levels can be deduced by n = (maximum delay level - minimum delay level) / delay level interval + 1. For example, the minimum delay level may be 10 us, the maximum delay level may be 100 us, and the delay level interval may be 10 us.

- If ST is TQF, the field size is n*8 bytes, and it contains n TQF instances, each with 8 bytes. These 8 bytes specifically include the Orchestration Period Length (4 bytes, in unit of microseconds), the amount of timeslots N (2 bytes) within the Orchestration Period, and the amount of timeslots M (2 bytes) within the Scheduling Period. The timeslot length can be deduced by Orchestration Period Length / N. For example, the Orchestration Period Length may be 1000 us, containing 100 timeslots, and the Scheduling Period may contain fewer timeslots, such as 10.

- If ST is C-SCORE, the field size is zero, and there is no need to specify capability level information. It can be considered to support a single instance.

The DetNet Scheduling Capbility TLV MAY be advertised more than once in the BGP-LS Attribute, one for each scheduling type. If multiple instances are present for the same scheduling type, then the first one MUST be considered valid, and the rest MUST be ignored.

3. Advertising DetNet Maximum Reservable Bandwidth

The DetNet Maximum Reservable Bandwidth TLV is a BGP-LS Link Attribute TLV associated with the Link NLRI that is used for the advertisement of the maximum reservable bandwidth of specific scheduling mechanism associated with a link. The format of this TLV is as follows:

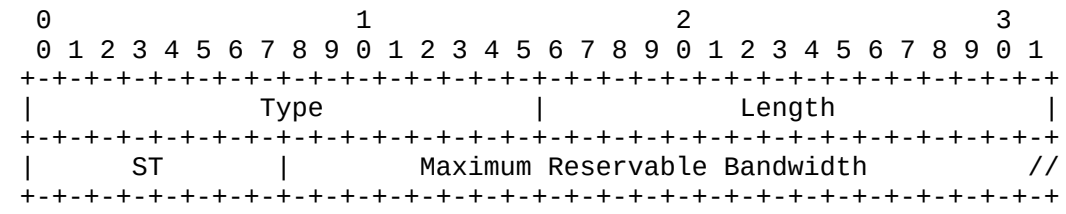

Figure 2: DetNet Maximum Reservable Bandwidth TLV

where:

* Type: TBD.

* Length: variable, depending on size of the Maximum Reservable Bandwidth field.

* ST (Scheduling Type): 1 byte, represents the type of scheduling mechanism supported by the link.

* Maximum Reservable Bandwidth: includes the maximum reservable bandwidth (MRBan) corresponding to the specific scheduling mechanism type with variable size, depending on the ST.

  - If ST is one of ATS, CBS, ATS+CBS, or gLBF, the field size is n*4 bytes, and it contains the MRBan per traffic class (4 bytes, in the unit of bytes per second in IEEE floating point format), from traffic class 0 to traffic class n-1.

  - If ST is CQF/ECQF, the field size is n*6 bytes, and it contains n tuple <cycle duration(2B), MRBan(4B)>, where, cycle duration in the unit of microseconds, and MRBan in the unit of bytes per second in IEEE floating point format.

  - If ST is EDF, the field size is n*6 bytes, and it contains n tuple <delay level(2B), MRBan(4B)>, where, delay level in the unit of microseconds, and MRBan in the unit of bytes per second in IEEE floating point format. Note that all delay levels' maximum reservable bandwidth must meet the schedulability condition.

  - If ST is TQF, the field size is n*8 bytes, and it contains n tuple <OPL(4B), MRBan(4B)>, where, OPL (Orchestration Period Length) in the unit of microseconds, and MRBan in the unit of bytes per second in IEEE floating point format.

- If ST is C-SCORE, the field size is 4 bytes, and it contains the MRBan in the unit of bytes per second in IEEE floating point format.

The DetNet Maximum Reservable Bandwidth TLV MAY be advertised more than once in the BGP-LS Attribute, one for each scheduling type. If multiple instances are present for the same scheduling type, then the first one MUST be considered valid, and the rest MUST be ignored.

4. Advertising DetNet Unreserved Bandwidth

The DetNet Maximum Reservable Bandwidth TLV is a BGP-LS Link Attribute TLV associated with the Link NLRI that is used for the advertisement of the unreserved bandwidth of specific scheduling mechanism associated with a link. The format of this TLV is as follows:

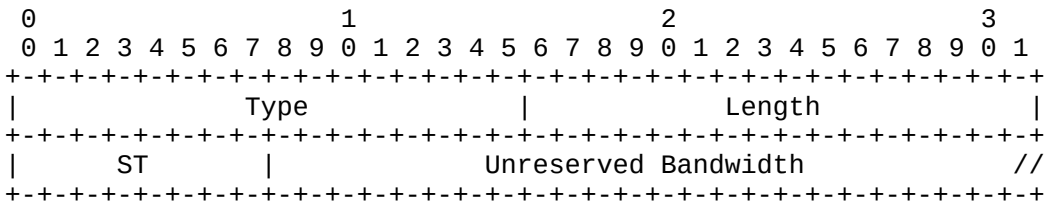

Figure 3: DetNet Unreserved Bandwidth TLV

where:

* Type: TBD.

* Length: variable, depending on size of the Unreserved Bandwidth field.

* ST (Scheduling Type): 1 byte, represents the type of scheduling mechanism supported by the link.

* Unreserved Bandwidth: includes the unreserved bandwidth (UBan) corresponding to the specific scheduling mechanism type with variable size, depending on the ST.

  - If ST is one of ATS, CBS, ATS+CBS, or gLBF, the field size is n*4 bytes, and it contains the UBan per traffic class (4 bytes, in the unit of bytes per second in IEEE floating point format), from traffic class 0 to traffic class n-1.

- If ST is CQF/ECQF, the field size is n*6 bytes, and it contains n tuple <cycle duration(2B), UBan(4B)>, where, cycle duration in the unit of microseconds, and UBan in the unit of bytes per second in IEEE floating point format.

- If ST is EDF, the field size is n*6 bytes, and it contains n tuple <delay level(2B), UBan(4B)>, where, delay level in the unit of microseconds, and UBan in the unit of bytes per second in IEEE floating point format.

- If ST is TQF, the field size is n*8 bytes, and it contains n tuple <OPL(4B), UBan(4B)>, where, OPL (Orchestration Period Length) in the unit of microseconds, and UBan in the unit of bytes per second in IEEE floating point format.

- If ST is C-SCORE, the field size is 4 bytes, and it contains the UBan in the unit of bytes per second in IEEE floating point format.

The DetNet Unreserved Bandwidth TLV MAY be advertised more than once in the BGP-LS Attribute, one for each scheduling type. If multiple instances are present for the same scheduling type, then the first one MUST be considered valid, and the rest MUST be ignored.

5. Advertising DetNet Maximum Reservable Burst

The DetNet Maximum Reservable Burst TLV is a BGP-LS Link Attribute TLV associated with the Link NLRI that is used for the advertisement of the maximum reservable burst of specific scheduling mechanism associated with a link. The format of this TLV is as follows:

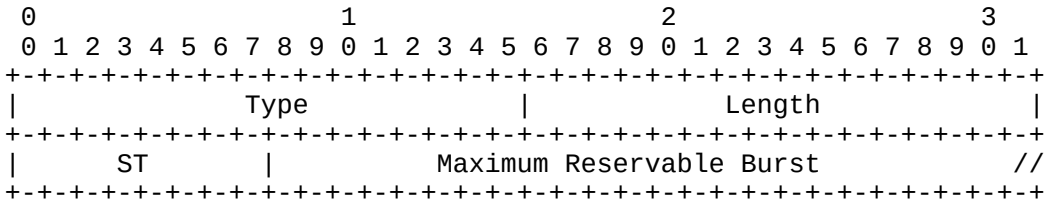

Figure 4: DetNet Maximum Reservable Burst TLV

where:

* Type: TBD.

* Length: variable, depending on size of the Maximum Reservable Burst field.

* ST (Scheduling Type): 1 byte, represents the type of scheduling mechanism supported by the link.

* Maximum Reservable Burst: includes the maximum reservable burst (MRBur) corresponding to the specific scheduling mechanism type with variable size, depending on the ST.

  - If ST is one of ATS, CBS, ATS+CBS, or gLBF, the field size is n*4 bytes, and it contains the MRBur per traffic class (4 bytes, in the unit of bytes), from traffic class 0 to traffic class n-1.

  - If ST is CQF/ECQF, the field size is n*6 bytes, and it contains n tuple <cycle duration(2B), MRBur(4B)>, where, cycle duration in the unit of microseconds, and MRBur in the unit of bytes. Note that MRBur represents the resources of the entire CQF instance, not the resources of a specific cycle (or bin) under that instance (e.g., a CQF instance may configure 3-bin mode, with bin a, b, c).

  - If ST is EDF, the field size is n*6 bytes, and it contains n tuple <delay level(2B), MRBur(4B)>, where, delay level in the unit of microseconds, and MRBur in the unit of bytes. Note that all delay levels' maximum reservable burst must meet the schedulability condition equation.

  - If ST is TQF, the field size is n*8 bytes, and it contains n tuple <OPL(4B), MRBur(4B)>, where, OPL (Orchestration Period Length) in the unit of microseconds, and MRBur in the unit of bytes. Note that MRBur represents resources for individual timeslot within the Orchestration Period, and in general all timeslots have the same MRBur value.

  - If ST is C-SCORE, the field size is 4 bytes, and it contains the MRBur in the unit of bytes.

The DetNet Maximum Reservable Burst TLV MAY be advertised more than once in the BGP-LS Attribute, one for each scheduling type. If multiple instances are present for the same scheduling type, then the first one MUST be considered valid, and the rest MUST be ignored.

6. Advertising DetNet Unreserved Burst

The DetNet Maximum Unreserved Burst TLV is a BGP-LS Link Attribute TLV associated with the Link NLRI that is used for the advertisement of the unreserved burst of specific scheduling mechanism associated with a link. The format of this TLV is as follows:

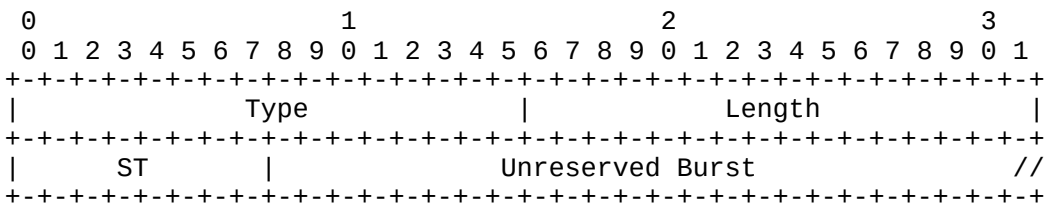

Figure 5: DetNet Unreserved Burst TLV

where:

* Type: TBD.

* Length: variable, depending on size of the Unreserved Burst field.

* ST (Scheduling Type): 1 byte, represents the type of scheduling mechanism supported by the link.

* Unreserved Burst: includes the unreserved burst (UBur) corresponding to the specific scheduling mechanism type with variable size, depending on the ST.

  - If ST is one of ATS, CBS, ATS+CBS, or gLBF, the field size is n*4 bytes, and it contains the UBur per traffic class (4 bytes, in the unit of bytes), from traffic class 0 to traffic class n-1.

  - If ST is CQF/ECQF, the field size is n*6 bytes, and it contains n tuple <cycle duration(2B), UBur(4B)>, where, cycle duration in the unit of microseconds, and UBur in the unit of bytes. Note that UBur represents the resources of the entire CQF instance, not the resources of a specific cycle (or bin) under that instance (e.g., a CQF instance may configure 3-bin mode, with bin a, b, c).

  - If ST is EDF, the field size is n*6 bytes, and it contains n tuple <delay level(2B), UBur(4B)>, where, delay level in the unit of microseconds, and UBur in the unit of bytes.

- If ST is TQF, the field size is 4+k*6 bytes, and it contains OPL(4B) and k (k <= N) tuple <timeslot id(2B), UBur(4B)>, where, OPL (Orchestration Period Length) in the unit of microseconds, and UBur in the unit of bytes. Note that UBur represents resources for individual timeslot within the Orchestration Period.

- If ST is C-SCORE, the field size is 4 bytes, and it contains the UBur in the unit of bytes.

The DetNet Unreserved Burst TLV MAY be advertised more than once in the BGP-LS Attribute, one for each scheduling type. If multiple instances are present for the same scheduling type, then the first one MUST be considered valid, and the rest MUST be ignored, except that TQF may advertise multiple DetNet Unreserved Burst TLV each for a set of timeslots.

7. Advertising DetNet Timeslot Mapping

The DetNet Timeslot Mapping TLV is a BGP-LS Link Attribute TLV associated with the Link NLRI that is used for the advertisement of the timeslot mapping relationship associated with a link. This mapping represents a timeslot id (e.g, x) of the output port of the local node, after link propagation delay, falls into the timeslot id (e.g, y) of the incomming port of the remote node. The format of this TLV is as follows:

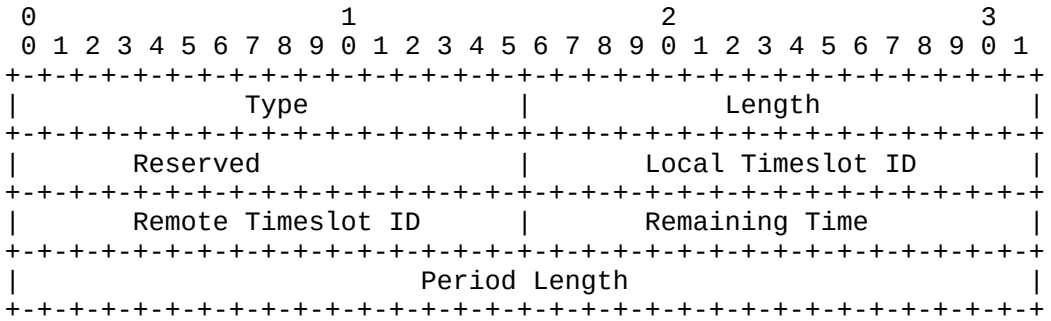

Figure 6: DetNet Timeslot Mapping TLV

where:

* Type: TBD.

* Length: 12.

* Reserved: 2 octet field that MUST be set to 0 by the originator and ignored by the receiver.

* Local Timeslot ID: 2 octet field that represents the type of scheduling mechanism supported by the link.

* Remote Timeslot ID: 2 octet field that represents the timeslot id of the incomming port of the remote node that mapped by Local Timeslot ID.

* Remaining Time: 2 octet field that represents the offset between the end of the Local Timeslot ID and the end of the Remote Timeslot ID.

* Period Length: 4 octet field that represents the dinstinguisher of the instance which contains multiple consecutive cyclic timeslots.

The DetNet Timeslot Mapping TLV SHOULD be advertised once at most for each period length enabled on the link. If multiple instances are present for the same period length, then the first one MUST be considered valid, and the rest MUST be ignored.

8. Advertising DetNet Period Mapping

The DetNet Period Mapping TLV is a BGP-LS Link Attribute TLV associated with the Link NLRI that is used for the advertisement of the period mapping relationship associated with a link. This mapping represents the end of the period of the output port of the local node, after link propagation delay, falls into the period of the incomming port of the remote node. The format of this TLV is as follows:

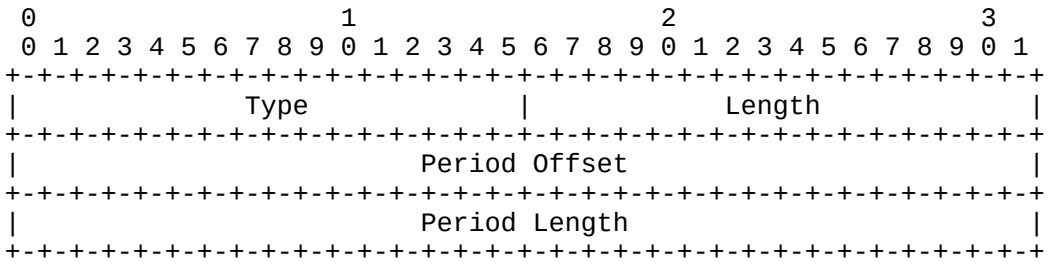

Figure 7: DetNet Period Mapping TLV

where:

* Type: TBD.

* Length: 8.

* Period Offset: 4 octet field that represents the offset between the end of the local period and the end of the remote period.

* Period Length: 4 octet field that represents the dinstinguisher of the instance which contains multiple consecutive cyclic timeslots.

The DetNet Period Mapping TLV SHOULD be advertised once at most for each period length enabled on the link. If multiple instances are present for the same period length, then the first one MUST be considered valid, and the rest MUST be ignored.

9. Advertising DetNet Intra-node Forwarding Delay

The DetNet Intra-node Forwarding Delay TLV is a BGP-LS Node Attribute TLV associated with the Node NLRI that is used for the maximum intra-node forwarding delay associated with a given node. It represents the maximum forwarding delay experienced by a packet from the node's incomming port (or the control plane of this node) to the output port, depending on the node's implementation. The format of this TLV is as follows:

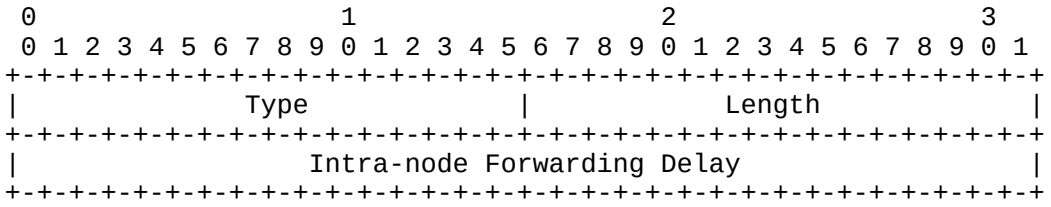

Figure 8: DetNet Intra-node Forwarding Delay TLV

where:

* Type: TBD.

* Length: 4.

* Intra-node Forwarding Delay: 4 octet field that represents the maximum forwarding delay experienced by a packet from the node's incomming port (or the control plane of this node) to the output port.

The DetNet Intra-node Forwarding Delay TLV SHOULD be advertised once at most. If multiple instances are present, then the first one MUST be considered valid, and the rest MUST be ignored.

10. Operations

The controller calculate a DetNet path for the service flow in the network that satisfies RSspec, using a specific scheduling mechanism type based on the resources collected from all links in the network. The unreserved resources of each link in the path should cover the TSpec of the service flow. Choosing continuous links with the same mechanism can achieve better DetNet QoS. Choosing heterogeneous scheduling mechanisms for path calculation usually occurs across domains, where different domains use different scheduling mechanisms.

The controller must furtherly specify the capability level of each link for the service flow. In general, the same capability level (such as the same traffic class) can be used on all links, however, different capability levels is also possible. It is the unreserved resources corresponding to the specific capability level should cover the TSpec of the service flow. Once the path is calculated, the controller reserve the bandwidth and burst resources from the locally maintained database.

11. IANA Considerations

This document try to allocate code points from the "BGP-LS NLRI and Attribute TLVs" sub-registry of the "Border Gateway Protocol - Link-State (BGP-LS) Parameters" registry group as follows:

Code Point	Description	Reference
TBD1	DetNet Maximum Reservable Bandwidth	this document
TBD2	DetNet Unreserved Bandwidth	this document
TBD3	DetNet Maximum Reservable Burst	this document
TBD4	DetNet Unreserved Burst	this document
TBD5	DetNet Timeslot Mapping	this document
TBD6	DetNet Periold Mapping	this document
TBD7	DetNet Intra-node Forwarding Delay	this document

12. Security Considerations

This document does not introduce any new security considerations beyond those covered by [RFC9552].

13. Acknowledgements

TBD

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14.1. Normative References

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