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Export of Segment Routing IPv6 Information in IP Flow Information Export (IPFIX)

Abstract

This document introduces new IP Flow Information Export (IPFIX) information elements to identify the SRv6 Segment Routing Header dimensions, the SRv6 Control Plane Protocol and the SRv6 Endpoint Behavior that traffic is being forwarded with.

Status of This Memo

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This Internet-Draft will expire on 25 January 2023.

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1. Introduction

A new type of Routing Extension Header called Segment Routing Header (SRH) is defined by [RFC8754] which is used for applying Segment Routing (SR) on the IPv6 data plane.

Three routing protocol extensions, OSPFv3 Extensions [I-D.li-lsr-ospfv3-srv6-extensions], IS-IS Extensions [I-D.ietf-lsr-isis-srv6-extensions], BGP Prefix Segment Identifiers (Prefix-SIDs) [I-D.ietf-bess-srv6-services] and one Path Computation Element Communication Protocol (PCEP) Extension [I-D.ietf-pce-segment-routing-ipv6] have been defined to propagate Segment Identifiers (SIDs) for the IPv6 data plane.

SRv6 segment endpoint behaviors have been defined in [RFC8986] and describe how packets should be processed.

This document defines eleven new IPFIX Information Elements (IEs) and three new subregistries within the "IPFIX Information Elements" registry [RFC7012], respectively for the new SRH dimensions, SRv6 endpoint behaviors and routing protocol and PCEP extensions.

2. IPFIX Information Elements

This section defines and describes the new IPFIX IEs.

srhFlagsIPv6
: 8-bit flags defined in the SRH.

srhTagIPv6
: 16-bit tag field defined in the SRH that marks a packet as part of a class or group of packets sharing the same set of properties.

srhSegmentIPv6
: 128-bit IPv6 address that represents an SRv6 segment.

srhActiveSegmentIPv6
: 128-bit IPv6 address that represents the active SRv6 segment.

srhSegmentIPv6BasicList
: Ordered basicList [RFC6313] of zero or more 128-bit IPv6 addresses in the SRH that represents the SRv6 segment list. The Segment List is encoded starting from the last segment of the SR Policy. That is, the first element of the Segment List (Segment List[0]) contains the last segment of the SR Policy, the second

element contains the penultimate segment of the SR Policy, and so on.

srhSegmentIPv6ListSection
Exposes the SRH Segment List as defined in section 2 of [RFC8754] as series of n octets.

srhSegmentIPv6sLeft
8-bit unsigned integer defining the number of route segments remaining to reach the end of the segment list.

srhSectionIPv6
Exposes the SRH and its TLV's as defined in section 2 of [RFC8754] as series of n octets.

srhActiveSegmentIPv6Type
Name of the routing protocol or PCEP extension from where the active SRv6 segment has been learned from.

srhSegmentLocatorLength
The number of significant bits. Together with srhSegmentIPv6 it enables the calculation of the SRv6 Locator.

srhSegmentEndpointBehavior
16-bit unsigned integer that represents a SRv6 Endpoint behavior.

Note that the srhSegmentIPv6, srhSegmentLocatorLength, and srhSegmentEndpointBehavior IPFIX IEs are generic fields, to be used in the context of IPFIX Options Templates or IPFIX Structured Data [RFC6313].

3. Use Cases

By using srhSegmentIPv6BasicList(TBD5) or the srhSegmentIPv6ListSection (TBD6), srhActiveSegmentIPv6 (TBD4), srhSegmentIPv6sLeft (TBD7), srhActiveSegmentIPv6Type(TBD9), the forwardingStatus(89), and some counters information, it is possible to answer the following questions (amongst others):

- how many packets are forwarded or dropped
- if dropped, for which reasons,
- identify the active segment and its control plane protocol,
- the SRv6 segment list,
- the next SRv6 node and its type,
- and how many SRv6 segments are left.

4. IANA Considerations

This document requests IANA to create new IEs (see table 1) and three new subregistries called "IPFIX IPv6 SRH Flags" (table 2), "IPFIX IPv6 SRH Segment type" (table 3) and "IPFIX SRV6 Endpoint Behavior" (table 4) under the "IPFIX Information Elements" registry [RFC7012] available at [IANA-IPFIX] and assign the following initial code points.

Element ID	Name
TBD1	srhFlagsIPv6
TBD2	srhTagIPv6
TBD3	srhSegmentIPv6
TBD4	srhActiveSegmentIPv6
TBD5	srhSegmentIPv6BasicList
TBD6	srhSegmentIPv6ListSection
TBD7	srhSegmentIPv6sLeft
TBD8	srhSectionIPv6
TBD9	srhActiveSegmentIPv6Type
TBD10	srhSegmentLocatorLength
TBD11	srhSegmentEndpointBehavior

Table 1: Creates IEs in the "IPFIX Information Elements" registry

Note to the RFC-Editor:

*Please replace TBD1 - TBD16 with the values allocated by IANA

*Please replace the [RFC-to-be] with the RFC number assigned to this document

4.1. srhFlagsIPv6

Name: srhFlagsIPv6 ElementID: TBD1 Description: This Information Element identifies the 8-bit flags defined in the SRH. Values for this Information Element are listed in the "IPFIX IPv6 SRH Flags" registry, see Abstract Data Type: unsigned8 Data Type Semantics: flags Reference: [RFC-to-be], RFC8754[IANA-IPFIX]. srhFlagsIPv6 values must not be directly added to this "IPFIX IPv6 SRH Flags" registry. They must instead be added to the "Segment Routing Header Flags" registry. Both the "IPFIX IPv6 SRH Flags" and the "Segment Routing Header Flags" registries must be kept in synch. Initial values in the registry are defined by the table below.

Value	Description	Reference
0-1	Unassigned	
2	O-flag	[RFC-ietf-6man-spring-srv6-oam-13]
3-7	Unassigned	

Table 2: "IPFIX IPv6 SRH Flags" registry

4.2. srhTagIPv6

Name: srhTagIPv6 ElementID: TBD2 Description: This Information Element identifies the 16-bit tag field defined in the SRH that marks a packet as part of a class or group of packets sharing the same set of properties. Abstract Data Type: unsigned16 Data Type Semantics: identifier Reference: [RFC-to-be], RFC8754

4.3. srhSegmentIPv6

Name: srhSegmentIPv6 ElementID: TBD3 Description: This Information Element identifies the 128-bit IPv6 address that represents an SRv6 segment. Abstract Data Type: ipv6address Data Type Semantics: default Reference: [RFC-to-be], RFC8754

4.4. srhActiveSegmentIPv6

Name: srhActiveSegmentIPv6 ElementID: TBD4 Description: This Information Element identifies the 128-bit IPv6 address that represents the active SRv6 segment. Abstract Data Type: ipv6address Data Type Semantics: default Reference: [RFC-to-be], RFC8754

4.5. srhSegmentIPv6BasicList

Name: srhSegmentIPv6BasicList ElementID: TBD5 Description: This Information Element identifies the Ordered basicList [RFC6313] of zero or more 128-bit IPv6 addresses in the SRH that represents the SRv6 segment list. The Segment List is encoded starting from the last segment of the SR Policy. That is, the first element of the Segment List (Segment List[0]) contains the last segment of the SR Policy, the second element contains the penultimate segment of the SR Policy, and so on. Abstract Data Type: basicList Data Type Semantics: list Reference: [RFC-to-be], RFC8754

4.6. srhSegmentIPv6ListSection

Name: srhSegmentIPv6ListSection ElementID: TBD6 Description: Exposes the SRH Segment List as defined in section 2 of Abstract Data Type: octetArray Data Type Semantics: default Reference: [RFC-to-be], RFC8754[RFC8754] as series of n octets.

4.7. srhSegmentIPv6sLeft

Name: srhSegmentIPv6sLeft ElementID: TBD7 Description: This Information Element identifies the 8-bit unsigned integer defining the number of route segments remaining to reach the end of the segment list. Abstract Data Type: unsigned8 Data Type Semantics: quantity Reference: [RFC-to-be], RFC8754

4.8. srhSectionIPv6

Name: srhSectionIPv6 ElementID: TBD8 Description: This Information Element exposes the SRH and its TLV's as defined in section 2 of Abstract Data Type: octetArray Data Type Semantics: default Reference: [RFC-to-be], RFC8754[RFC8754] as series of n octets.

4.9. srhActiveSegmentIPv6Type

Name: srhActiveSegmentIPv6Type ElementID: TBD9 Description: This Information Element identifies the name of the routing protocol or PCEP extension from where the active SRv6 segment has been learned from. Values for this Information Element are listed in the "IPFIX IPv6 SRH Segment type" registry, see Abstract Data Type: unsigned8 Data Type Semantics: identifier Reference: [RFC-to-be][IANA-IPFIX]. Initial values in the registry are defined by the table below. New

assignments of values will be administered by IANA and are subject to Expert Review [RFC8126]. Experts need to check definitions of new values for completeness, accuracy, and redundancy.

Value	Description	Reference
TBD12	Unknown	[RFC-to-be]
TBD13	Path Computation Element	[RFC-to-be], draft-ietf-pce-segment-routing-ipv6
TBD14	OSPFv3 Segment Routing	[RFC-to-be], draft-li-ospf-ospfv3-srv6-extensions
TBD15	IS-IS Segment Routing	[RFC-to-be] draft-ietf-lsr-isis-srv6-extensions
TBD16	BGP Segment Routing Prefix-SID	[RFC-to-be], draft-ietf-bess-srv6-services

Table 3: "IPFIX IPv6 SRH Segment type" subregistry

4.10. srhSegmentLocatorLength

Name: srhSegmentLocatorLength ElementID: TBD10 Description: This Information Element identifies the number of significant bits and together with srhSegmentIPv6 enables the calculation of the SRv6 Locator. Abstract Data Type: unsigned8 Data Type Semantics: default Reference: [RFC-to-be], RFC8986 Section 3.1

4.11. srhSegmentEndpointBehavior

Name: srhSegmentEndpointBehavior ElementID: TBD11 Description: This Information Element identifies the 16-bit SRv6 Endpoint behavior. Values for this Information Element are listed in the "IPFIX SRV6 Endpoint Behavior" registry, see Abstract Data Type: unsigned16 Data Type Semantics: identifier Reference: [RFC-to-be], RFC8986 Section 4[IANA-IPFIX]. srhSegmentEndpointBehavior values must not be directly added to this "IPFIX SRV6 Endpoint Behavior" registry. They must instead be added to the "Segment Routing SRv6 Endpoint Behaviors" registry. Both the "IPFIX SRV6 Endpoint Behavior" and the "Segment Routing SRv6 Endpoint Behaviors" registries must be kept in synch.

Value	Hex	Endpoint Behavior	Reference	Change Controller

Table 4: "IPFIX SRV6 Endpoint Behavior" registry

5. Operational Considerations

5.1. SRv6 Segment List

The zero or more 128-bit IPv6 addresses in the SRH [RFC8754] can be exported in two different ways, with two different IPFIX IEs:

- *srhSegmentIPv6BasicList
- *srhSegmentIPv6ListSection

The srhSegmentIPv6BasicList encodes the SID list of IPv6 addresses with a basicList, specified in the IPFIX Structured Data [RFC6313]. This encoding offers the advantage to the data collection that the different IPv6 addresses are already structured as a list, without the need of post processing. However, this method requires some extra processing on the exporter, to realize the BasicList data mapping.

The srhSegmentIPv6ListSection, on the other hand, encodes the list of IPv6 addresses as an octetArray. This doesn't impose any data flow manipulation on the exporter, facilitating the immediate export. However, the data collection must be able to decode the IPv6 addresses according the SR specifications. Compared to the srhSegmentIPv6BasicList, the srhSegmentIPv6ListSection flow records length is slightly reduced.

It is not expected that an exporter would support both srhSegmentIPv6BasicList and srhSegmentIPv6ListSection at the same time.

5.2. Compressed SRv6 Segment List Decomposition

The SRv6 segment list in the IPFIX IEs srhSegmentIPv6BasicList and srhSegmentIPv6ListSection could contain compressed-SID containers as described in [I-D.ietf-spring-srv6-srh-compression]. The SID

endpoint behaviors described in section 4 of [I-D.ietf-spring-srv6-srh-compression] determine wherever the segment list is compressed or not. The SID Locator as described in section 3.1 [RFC8986], determines the common most significant bits.

6. Security Considerations

There exists no significant extra security considerations regarding the allocation of these new IPFIX IEs compared to [RFC7012].

7. Acknowledgements

The authors would like to thank Yao Liu, Paolo Lucente, Eduard Vasilenko, Alex Huang Feng and Bruno Decraene for their review and valuable comments.

8. References

8.1. Normative References

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[RFC8986] Filsfils, C., Ed., Camarillo, P., Ed., Leddy, J., Voyer, D., Matsushima, S., and Z. Li, "Segment Routing over IPv6 (SRv6) Network Programming", RFC 8986, DOI 10.17487/RFC8986, February 2021, <https://www.rfc-editor.org/info/rfc8986>.

Appendix A. IPFIX Encoding Examples

This appendix represents three different encodings for the newly introduced IEs, for the example values in the table 5. The three different encodings uses the following IEs, respectively: srhSegmentIPv6BasicList, srhSegmentIPv6ListSection, and srhSectionIPv6.

SRH Nr	SRH Flags	SRH Tag	Active Segment Type	Segment List
1	0	123	IS-IS [TBD15]	2001:db8::1, 2001:db8::2, 2001:db8::3
2	0	456	IS-IS [TBD15]	2001:db8::4, 2001:db8::5
3	0	789	IS-IS [TBD15]	2001:db8::6

Table 5: three observed SRH headers and their routing protocol

A.1. Template Record and Data Set with Segment Basic List

With this encoding, the examples in Table 5 are represented with the following IEs:

*SR Flags => srhFlagsIPv6

*SR Tag => srhTagIPv6

*Active Segment Type => srhActiveSegmentIPv6Type

*Segment List => srhSegmentIPv6BasicList

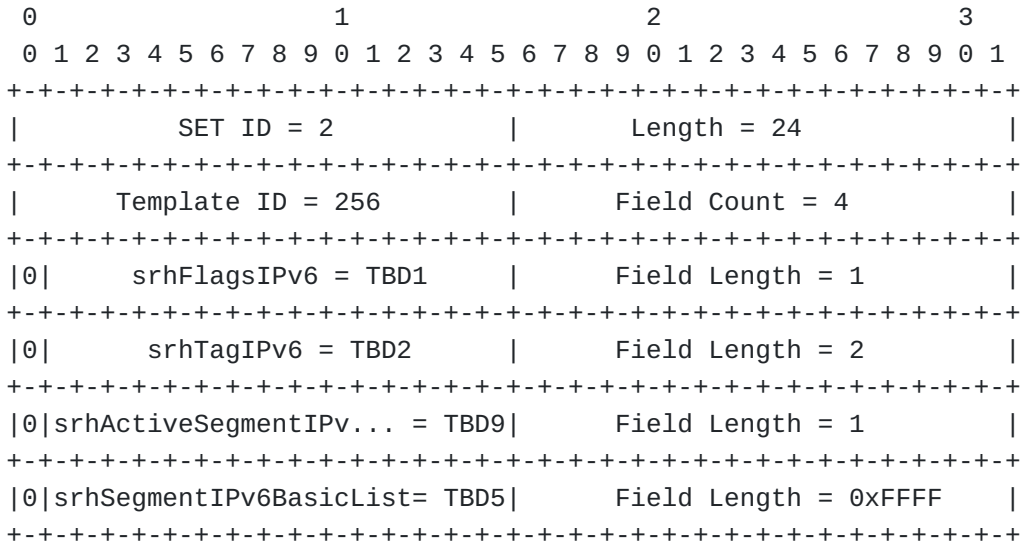
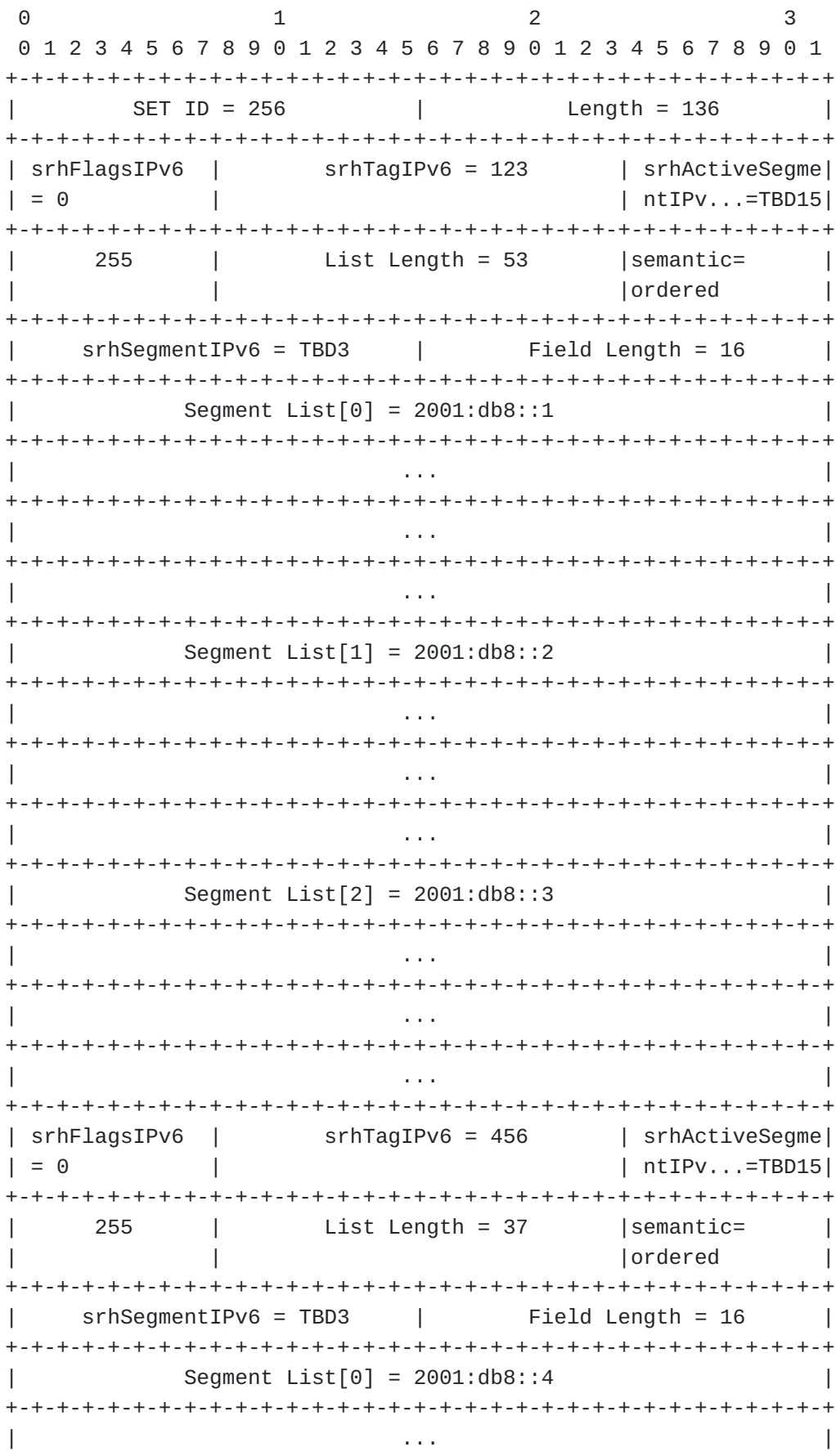


Table 6: Template Record with Basic List Encoding Format

In this example, the Template ID is 256, which will be used in the Data Record. The field length for srhSegmentIPv6BasicList is 0xFFFF,

which means the length of this IE is variable, and the actual length of this IE is indicated by the List Length field in the basicList format as per [RFC6313].

The data set is represented as follows:


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
SET ID = 256
Length = 136
srhFlagsIPv6 = 0
srhTagIPv6 = 123
srhActiveSegmentIPv6...=TBD15
255
List Length = 53
semantic=ordered
srhSegmentIPv6 = TBD3
Field Length = 16
Segment List[0] = 2001:db8::1
...
...
...
Segment List[1] = 2001:db8::2
...
...
...
Segment List[2] = 2001:db8::3
...
...
...
srhFlagsIPv6 = 0
srhTagIPv6 = 456
srhActiveSegmentIPv6...=TBD15
255
List Length = 37
semantic=ordered
srhSegmentIPv6 = TBD3
Field Length = 16
Segment List[0] = 2001:db8::4
...

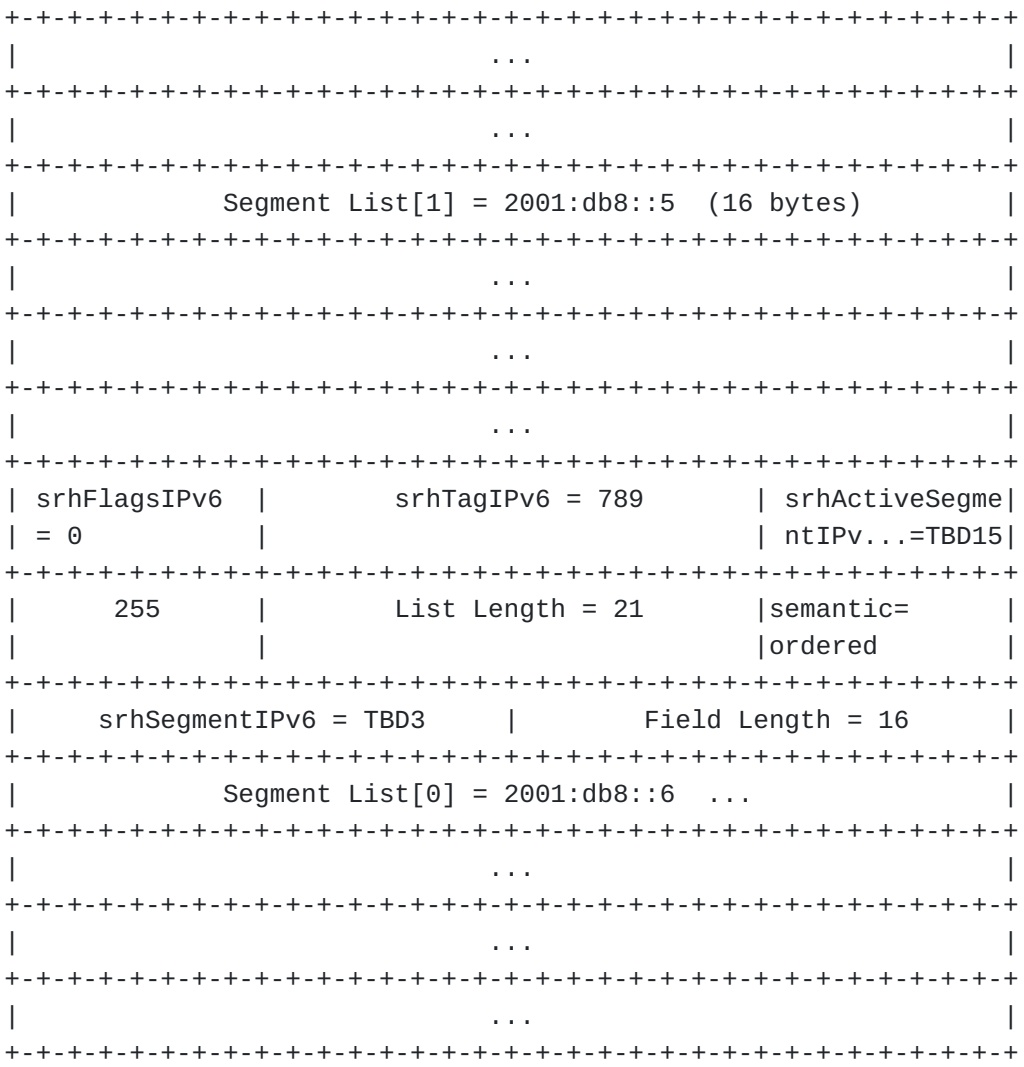


Table 7: Data Set Encoding Format for Basic List

A.2. Template Record and Data Set with Segment List Section

With this encoding, the examples in Table 5 are represented with the following IEs:

*SR Flags => srhFlagsIPv6

*SR Tag => srhTagIPv6

*Active Segment Type => srhActiveSegmentIPv6Type

*Segment List => srhSegmentIPv6List

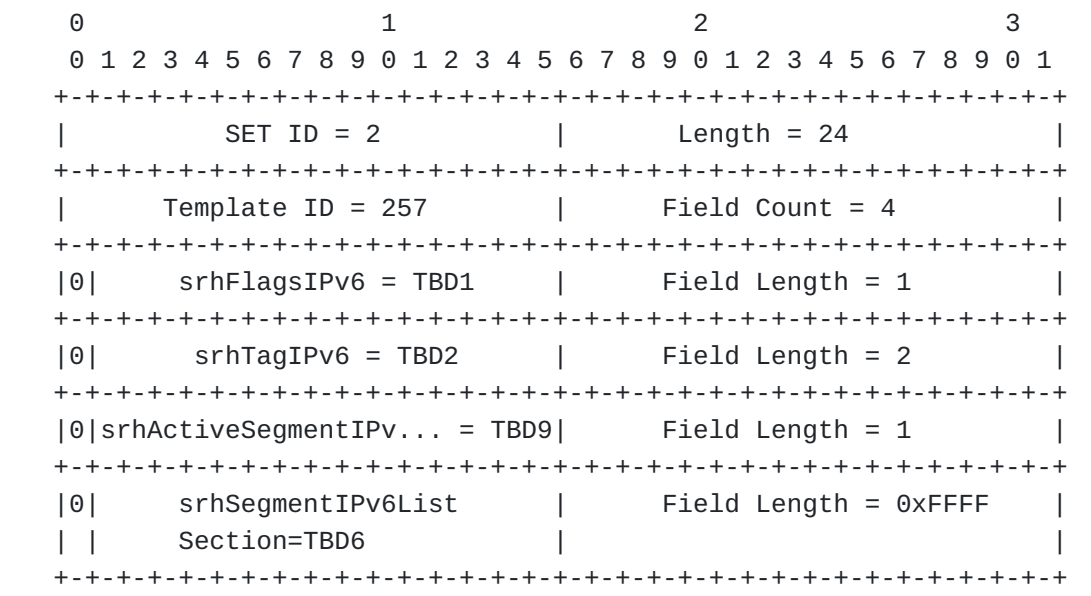


Table 8: Template Record with Segment List Section Encoding Format

In this example, the Template ID is 257, which will be used in the Data Record. The field length for srhSegmentIPv6ListSection is 0xFFFF, which means the length of this IE is variable.

The data set is represented as follows:

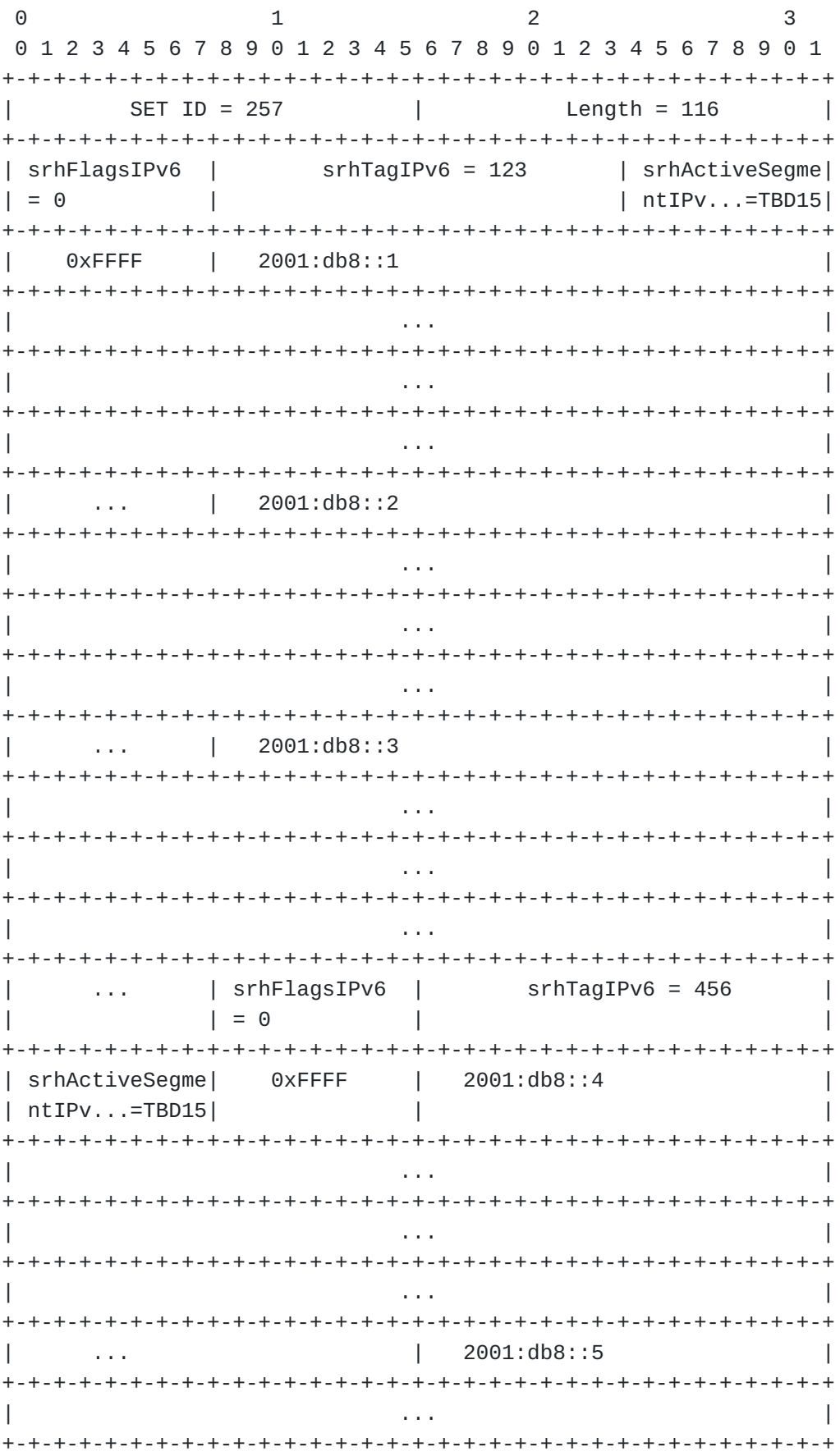

0 1 2 3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
SET ID = 257
Length = 116
srhFlagsIPv6 = 0
srhTagIPv6 = 123
srhActiveSegmentIPv...=TBD15
0xFFFF
2001:db8::1
...
2001:db8::2
2001:db8::3
srhFlagsIPv6 = 0
srhTagIPv6 = 456
srhActiveSegmentIPv...=TBD15
0xFFFF
2001:db8::4
2001:db8::5

Table 9: Data Set Encoding Format for Segment List Section

A.3. Template Record and Data Set with SRH Section

With this encoding, the examples in Table 5 are represented with the following IEs:

*SR Flags + SR Tag + Segment List => srhSectionIPv6

*Active Segment Type => srhActiveSegmentIPv6Type

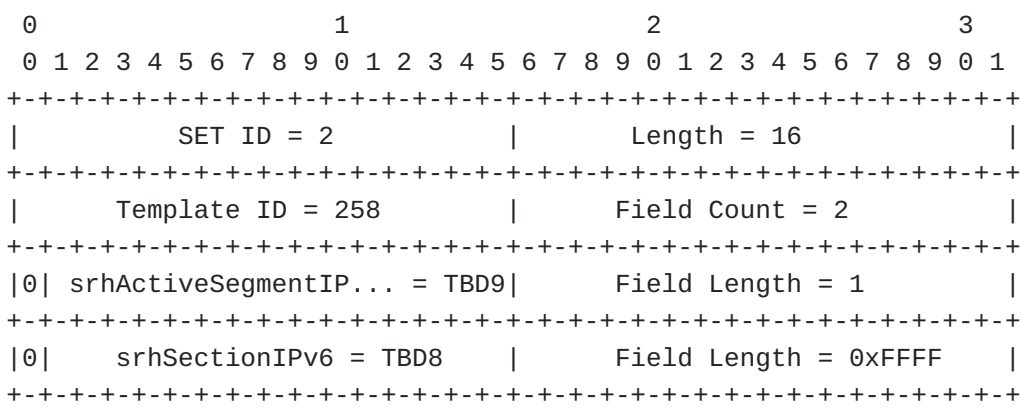
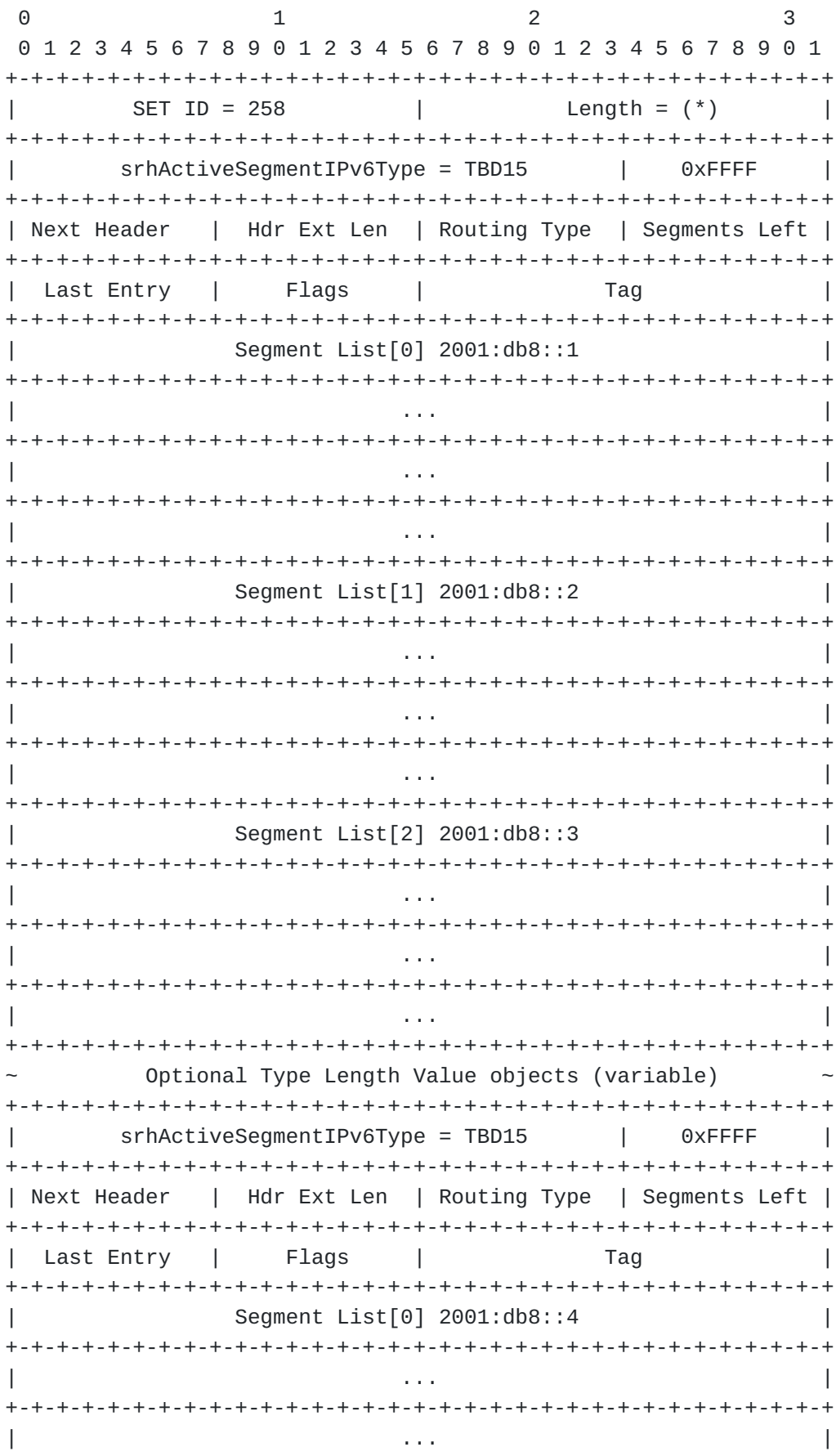


Table 10: Template Record with SRH Section Encoding Format

In this example, the Template ID is 258, which will be used in the Data Record. The field length for srhSectionIPv6 is 0xFFFF, which means the length of this IE is variable.

The data set is represented as follows:


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
SET ID = 258
Length = (*)
srhActiveSegmentIPv6Type = TBD15
0xFFFF
Next Header
Hdr Ext Len
Routing Type
Segments Left
Last Entry
Flags
Tag
Segment List[0] 2001:db8::1
...
...
...
Segment List[1] 2001:db8::2
...
...
...
Segment List[2] 2001:db8::3
...
...
...
Optional Type Length Value objects (variable)
srhActiveSegmentIPv6Type = TBD15
0xFFFF
Next Header
Hdr Ext Len
Routing Type
Segments Left
Last Entry
Flags
Tag
Segment List[0] 2001:db8::4
...
...

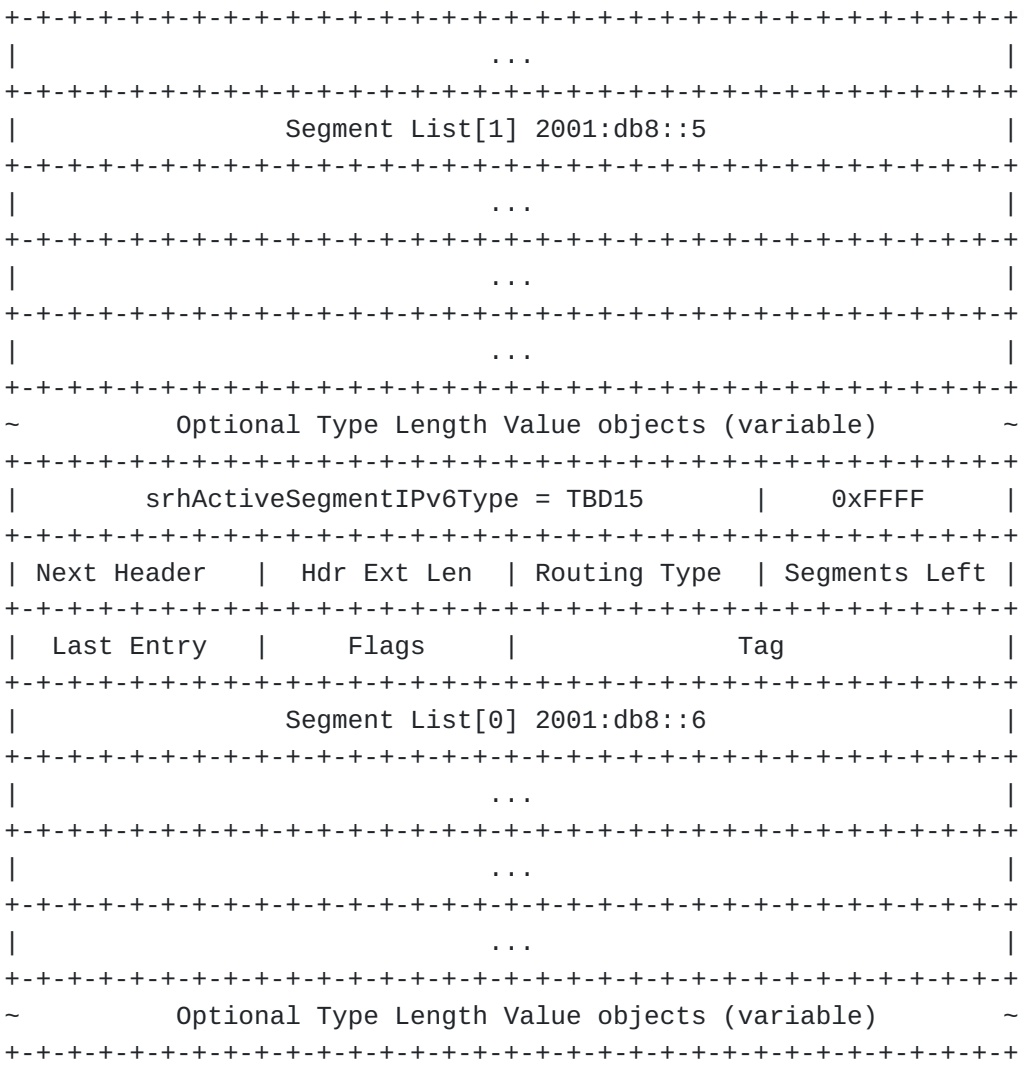


Table 11: Data Set Encoding Format for SRH Section

(*) The Length must be calculated to include the optional Type Length Value objects.

A.4. Options Template Record and Data Set for SRv6 end point behavior and Locator Length

This appendix provides an SRv6 EndPoint Bevahior Options Template example, for the values presented in Table 12. In the Options Template case, the srhEndPointIPv6 Information Element is a Scope field

Entry Nr	SRH End Point IPv6	SRH End Point Behavior	SRH Segment Locator Length
1	2001:db8::1	End [1]	48
2	2001:db8::4	End with NEXT-CSID [43]	48
3	2001:db8::6	End.DX6 [16]	48

Table 12: three observed SRv6 End Point Behaviors

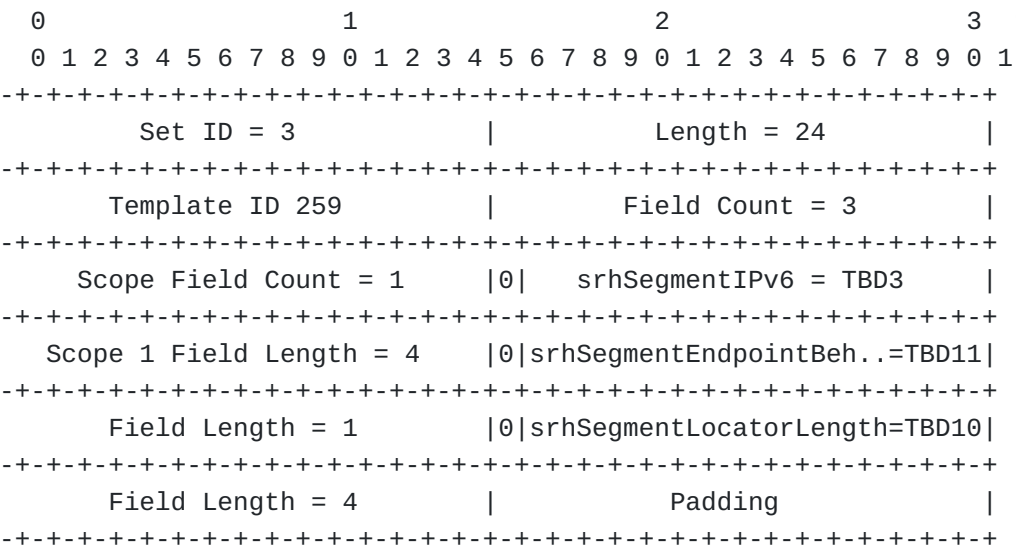


Table 13: Template Record with SRH Section Encoding Format

In this example, the Template ID is 259, which will be used in the Data Record.

The data set is represented as follows:

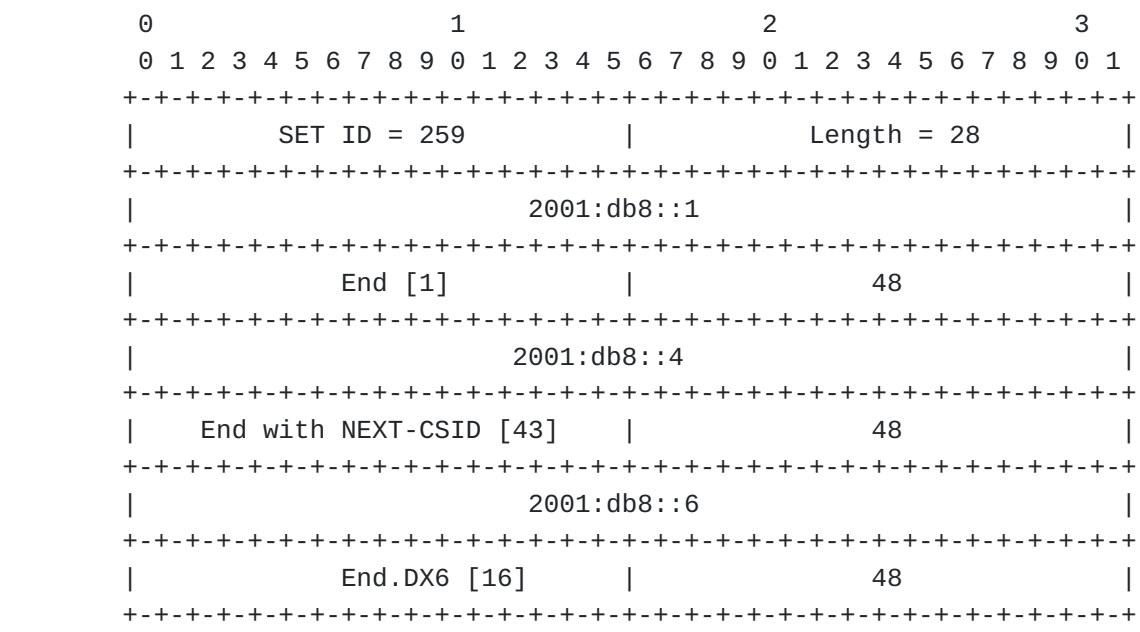


Table 14: Data Set Encoding Format for SRH Section

(*) The Length must be calculated to include the optional Type Length Value objects.

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