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**YANG Data Modules for Dual-Stack Lite (DS-Lite)
draft-ietf-softwire-dslite-yang-09**

Abstract

This document defines YANG modules for the DS-Lite Address Family Transition Router (AFTR) and Basic Bridging BroadBand (B4) elements.

Editorial Note (To be removed by RFC Editor)

Please update these statements with the RFC number to be assigned to this document:

- o "This version of this YANG module is part of RFC XXXX;"
- o "RFC XXXX: YANG Data Modules for Dual-Stack Lite (DS-Lite)";
- o "reference: RFC XXXX"

Status of This Memo

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1. Introduction

This document defines data models for DS-Lite [[RFC6333](#)], using the YANG data modeling language [[RFC7950](#)]. Both the Address Family Transition Router (AFTR) and Basic Bridging BroadBand (B4) elements are covered by this specification.

As a reminder, Figure 1 illustrates an overview of the DS-Lite architecture that involves AFTR and B4 elements.

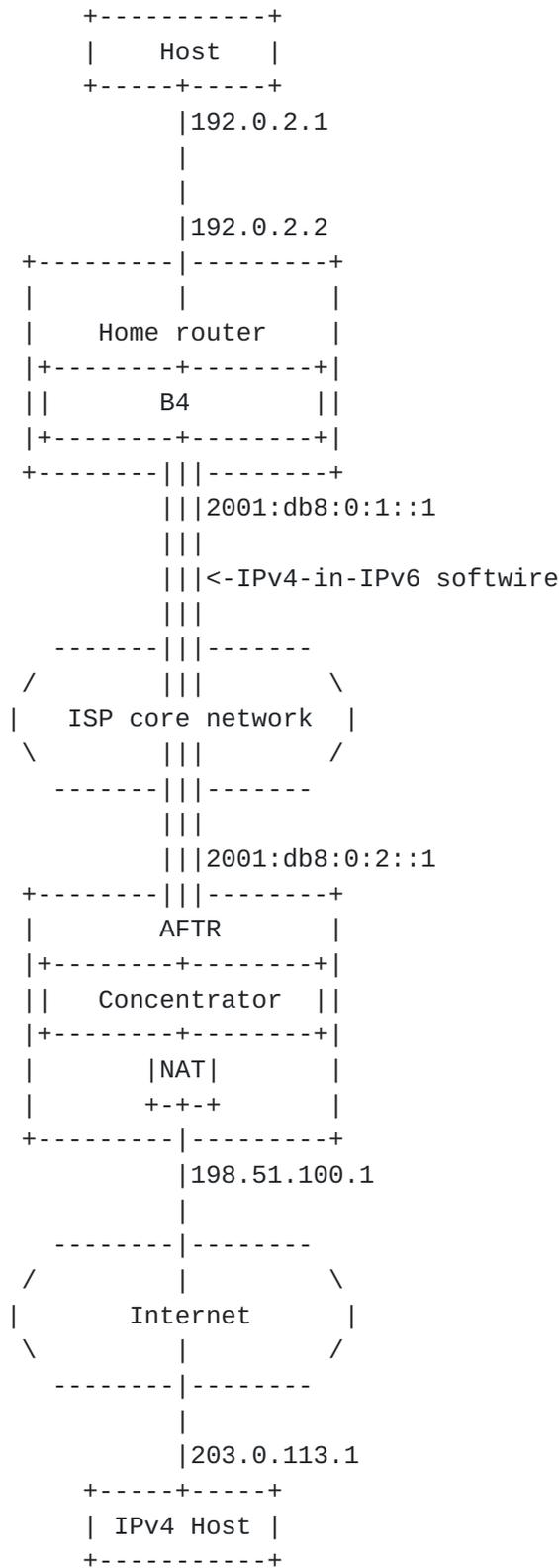


Figure 1: DS-Lite Base Architecture

DS-Lite deployment considerations are discussed in [[RFC6908](#)].

This document follows the guidelines of [[RFC6087](#)], uses the common YANG types defined in [[RFC6991](#)], and adopts the Network Management Datastore Architecture (NMDA).

1.1. Terminology

This document makes use of the terms defined in [Section 3 of \[RFC6333\]](#).

The terminology for describing YANG data modules is defined in [[RFC7950](#)].

The meaning of the symbols in tree diagrams is defined in [[I-D.ietf-netmod-yang-tree-diagrams](#)].

2. DS-Lite YANG Modules: An Overview

As shown in Figure 1:

- o The AFTR element is a combination of an IPv4-in-IPv6 tunnel and a NAT function ([Section 2.2 of \[RFC3022\]](#)).
- o The B4 element is an IPv4-in-IPv6 tunnel.

Therefore, the AFTR YANG module is designed to augment both the Interfaces YANG module [[RFC7223](#)] and the NAT YANG module [[I-D.ietf-opsawg-nat-yang](#)] with DS-Lite specific features. The B4 YANG module augments the interfaces YANG module.

Concretely, the AFTR YANG module (Figure 2) augments the Interfaces YANG module with the following:

- o An IPv6 address used by the AFTR for sending and receiving IPv4-in-IPv6 packets (aftr-ipv6-address).
- o An IPv4 address that is used by the AFTR for troubleshooting purposes (aftr-ipv4-address).
- o The tunnel MTU, used to avoid fragmentation (tunnel-mtu).
- o A policy to instruct the AFTR whether it must preserve DSCP marking when encapsulating/decapsulating packets (v6-v4-dscp-preservation).

In addition, the AFTR YANG module augments the NAT YANG module (policy, in particular) with the following:

- o A policy to limit the number of DS-Lite softwires per subscriber (max-software-per-subscriber).
- o A policy to instruct the AFTR whether a state can be automatically migrated (state-migrate).
- o Further, in order to prevent a denial-of-service by frequently changing the source IPv6 address, 'b4-address-change-limit' is used to rate-limit such changes.
- o An instruction to rewrite the TCP Maximum Segment Size (MSS) option (mss-clamping) to avoid TCP fragmentation.

Given that the NAPT table of the AFTR element is extended to include the source IPv6 address of incoming packets, the AFTR YANG module augments the NAPT44 mapping-entry with the following:

- o b4-ipv6-address which is used to record the source IPv6 address of a packet received from a B4 element. This IPv6 address is required to disambiguate between the overlapping IPv4 address space of subscribers.
- o The value of the Traffic Class field in the IPv6 header as received from a B4 element (v6-dscp): This information is used to preserve DSCP marking when encapsulating/decapsulating at the AFTR.
- o The IPv4 DSCP marking of the IPv4 packet received from a B4 element (internal-v4-dscp): This information can be used by the AFTR for setting the DSCP of packets relayed to a B4 element.
- o The IPv4 DSCP marking as set by the AFTR in its external interface (external-v4-dscp): An AFTR can be instructed to preserve the same marking or to set it to another value when forwarding an IPv4 packet upstream.

Access Control List (ACL) and Quality of Service (QoS) policies discussed in [Section 2.5 of \[RFC6908\]](#) are out of scope. A YANG module for ACLs is documented in [\[I-D.ietf-netmod-acl-model\]](#).

Likewise, PCP-related considerations discussed in [Section 8.5 of \[RFC6333\]](#) are out of scope. A YANG module for PCP is documented in [\[I-D.boucadair-pcp-yang\]](#).


```

module: ietf-dslite-aftr
  augment /if:interfaces/if:interface:
    +--rw aftr-ipv6-address?      inet:ipv6-address
    +--rw aftr-ipv4-address?      inet:ipv4-address
    +--rw tunnel-mtu?             uint16
    +--rw v6-v4-dscp-preservation? boolean
  augment /nat:nat/nat:instances/nat:instance/nat:policy:
    +--rw max-softwires-per-subscriber? uint8
    +--rw state-migrate?           boolean
    +--rw b4-address-change-limit?   uint32
    +--rw mss-clamping
      +--rw enable?               boolean
      +--rw mss-value?            uint16
  augment /nat:nat/nat:instances/nat:instance/nat:mapping-table/nat:mapping-
  entry:
    +--rw b4-ipv6-address
    | +--rw address?              inet:ipv6-address
    | +--rw last-address-change?  yang:date-and-time
    +--rw v6-dscp?                uint8
    +--rw internal-v4-dscp?       uint8
    +--rw external-v4-dscp?       uint8
  augment /nat:nat/nat:instances/nat:instance/nat:statistics/nat:mappings-
  statistics:
    +--ro active-softwires?       yang:gauge32

  notifications:
    +---n b4-address-change-limit-policy-violation
      +--ro id                    -> /nat:nat/instances/instance/id
      +--ro policy-id             -> /nat:nat/instances/instance/policy/id
      +--ro address                inet:ipv6-address

```

Figure 2: YANG Module for DS-Lite AFTR

Examples to illustrate the use of this module are provided in [Appendix B](#).

The B4 YANG module (Figure 3) augments the Interfaces YANG module with the following:

- o An IPv6 address used by a B4 element for sending and receiving IPv4-in-IPv6 packets (b4-ipv6-address).
- o The IPv6 address of the AFTR to use by a B4 element (aftr-ipv6-addr).
- o An IPv4 address that is used by a B4 element for troubleshooting purposes (b4-ipv4-address).
- o The tunnel MTU at the B4 side to avoid fragmentation (tunnel-mtu).

- o An instruction whether DSCP marking is to be preserved when encapsulating an IPv4 packet in an IPv6 packet (v6-v4-dscp-preservation).

```
module: ietf-dslite-b4
  augment /if:interfaces/if:interface:
    +-rw b4-ipv6-address?      inet:ipv6-address
    +-rw aftr-ipv6-addr?      inet:ipv6-address
    +-rw b4-ipv4-address?     inet:ipv4-address
    +-rw tunnel-mtu?          uint16
    +-rw v6-v4-dscp-preservation? boolean
```

Figure 3: YANG Module for DS-Lite B4

An example to illustrate the use of this module is provided in [Appendix A](#).

3. DS-Lite AFTR YANG Module

```
<CODE BEGINS> file "ietf-dslite-aftr@2017-11-14.yang"

module ietf-dslite-aftr {
  yang-version 1.1;

  namespace "urn:ietf:params:xml:ns:yang:ietf-dslite-aftr";
  prefix dslite-aftr;

  import ietf-inet-types { prefix inet; }
  import ietf-interfaces { prefix if; }
  import iana-if-type { prefix ianaift; }
  import ietf-nat {prefix nat;}
  import ietf-yang-types { prefix yang; }

  organization "IETF Softwire Working Group";

  contact

    "WG Web: <https://datatracker.ietf.org/wg/softwire/>
    WG List: <mailto:softwires@ietf.org>

    WG Chair: Ian Farrer
              <mailto:ianfarrer@gmx.com>

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Editor: Christian Jacquenet
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Editor: Senthil Sivakumar
<mailto:ssenthil@cisco.com>;

description

"This module is a YANG module for DS-Lite AFTR implementations.

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This version of this YANG module is part of RFC XXXX; see the RFC itself for full legal notices.";

```
revision 2017-11-14 {  
  description  
    "Initial revision.";  
  reference  
    "RFC XXXX: YANG Data Modules for Dual-Stack Lite (DS-Lite)";  
}
```

```
augment "/if:interfaces/if:interface" {  
  when "if:type = 'ianaift:tunnel'";  
  description  
    "Augments Interface module with AFTR parameters.  
    IANA interface types are maintained at this registry:  
    https://www.iana.org/assignments/ianaifttype-mib/ianaifttype-mib.  
  
    tunnel (131),      -- Encapsulation interface";  
leaf aftr-ipv6-address {  
  type inet:ipv6-address;  
  description  
    "IPv6 address of the DS-Lite AFTR.";  
  reference  
    "RFC 6333: Dual-Stack Lite Broadband Deployments Following IPv4 Exhaustion";  
}
```



```
leaf aftr-ipv4-address {
  type inet:ipv4-address;
  default "192.0.0.1";
  description
    "IPv4 address of the DS-Lite AFTR.

    192.0.0.1 is reserved for the AFTR element.

    This address can be used to report ICMP problems and will
    appear in traceroute outputs.";
  reference
    "RFC 6333: Dual-Stack Lite Broadband Deployments Following
    IPv4 Exhaustion";
}

leaf tunnel-mtu {
  type uint16;
  description
    "Configures a tunnel MTU.
    [RFC6908] specifies that since fragmentation and reassembly
    is not optimal, the operator should do everything possible
    to eliminate the need for it. If the operator uses simple
    IPv4-in-IPv6 software, it is recommended that the MTU size
    of the IPv6 network between the B4 and the AFTR accounts for
    the additional overhead (40 bytes).";
  reference
    "RFC 6908: Deployment Considerations for Dual-Stack Lite";
}

leaf v6-v4-dscp-preservation {
  type boolean;
  description
    "Copies the DSCP value from the IPv6 header and vice versa.

    According to Section 2.10 of \[RFC6908\], operators should
    use this model by provisioning the network such that the AFTR
    copies the DSCP value in the IPv4 header to the Traffic Class
    field in the IPv6 header, after the encapsulation for
    the downstream traffic.";
  reference
    "Section 2.10 of RFC 6908.";
}

augment "/nat:nat/nat:instances/nat:instance/nat:policy" {
  description
    "Augments the NAPTR44 module with AFTR parameters.";
}
```



```
leaf max-sofwires-per-subscriber {
  type uint8;
  default 1;
  description
    "Configures the maximum softwires per subscriber feature.

    A subscriber is uniquely identified by means
    of subscriber-mask.

    This policy aims to prevent a misbehaving subscriber from
    mounting several DS-Lite softwires that would consume
    additional AFTR resources (e.g., get more external ports
    if the quota were enforced on a per-software basis,
    consume extra processing due to a large number of active
    softwires).";

  reference
    "Section 4 of RFC 7785.";
}

leaf state-migrate {
  type boolean;
  default true;
  description
    "State migration is enabled by default.

    In the event a new IPv6 address is assigned to the B4 element,
    the AFTR should migrate existing state to be bound to the new
    IPv6 address. This operation ensures that traffic destined to
    the previous B4's IPv6 address will be redirected to the newer
    B4's IPv6 address. The destination IPv6 address for tunneling
    return traffic from the AFTR should be the last seen as the B4's
    IPv6 source address from the CPE.

    The AFTR uses the subscriber-mask to determine whether two
    IPv6 addresses belong to the same CPE (e.g., if the
    subscriber-mask is set to 56, the AFTR concludes that
    2001:db8:100:100::1 and 2001:db8:100:100::2 belong to the same
    CPE assigned with 2001:db8:100:100::/56).";

  reference
    "RFC 7785: Recommendations for Prefix Binding in the Context
    of Software Dual-Stack Lite";
}

leaf b4-address-change-limit {
  type uint32;
  units "seconds";
```



```
default '1800';
description
  "Minimum number of seconds between successive B4's IPv6 address
  change from the same prefix.

  Changing the source B4's IPv6 address may be used as an attack
  vector. Packets with a new B4's IPv6 address from the same
  prefix should be rate-limited.

  It is recommended to set this rate limit to 30 minutes; other
  values can be set on a per-deployment basis.";

reference
  "RFC 7785: Recommendations for Prefix Binding in the Context
  of Software Dual-Stack Lite";
}
```

```
container mss-clamping {
  description
    "MSS rewriting configuration to avoid IPv6 fragmentation.";

  leaf enable {
    type boolean;
    description
      "Enable/disable MSS rewriting feature.";
  }

  leaf mss-value {
    type uint16;
    units "octets";
    description
      "Sets the MSS value to be used for MSS rewriting.";
  }
}
}
```

```
augment "/nat:nat/nat:instances/nat:instance/"+
  "nat:mapping-table/nat:mapping-entry"{
  description
    "Augments the NAT44 mapping table with DS-Lite specifics.";

  container b4-ipv6-address {
    description
      "Records the IPv6 address used by the B4 element and the last
      time that address changed.";

    leaf address {
      type inet:ipv6-address;
    }
  }
}
```



```
    description
      "Corresponds to the IPv6 address used by the B4 element.";
    reference
      "RFC 6333: Dual-Stack Lite Broadband Deployments Following
        IPv4 Exhaustion";
  }

  leaf last-address-change {
    type yang:date-and-time;
    description
      "Records the last time when the address changed.";
  }
}

leaf v6-dscp {
  when "/if:interfaces/if:interface/" +
    "dslite-aftr:v6-v4-dscp-preservation='true'";
  type uint8;
  description
    "DSCP value used at the software level (i.e., IPv6 header).";
}

leaf internal-v4-dscp {
  when "/if:interfaces/if:interface/" +
    "dslite-aftr:v6-v4-dscp-preservation='true'";
  type uint8;
  description
    "DSCP value of the encapsulated IPv4 packet.";
}

leaf external-v4-dscp {
  when "/if:interfaces/if:interface/" +
    "dslite-aftr:v6-v4-dscp-preservation='true'";
  type uint8;
  description
    "DSCP value of the translated IPv4 packet as marked by
    the AFTR.";
}
}

augment "/nat:nat/nat:instances/nat:instance/nat:statistics/" +
  "nat:mappings-statistics" {
  description
    "Indicates the number of active softwires.";

  leaf active-sofwires{
    type yang:gauge32;
    description
```



```
        "The number of currently active softwires on the AFTR
        instance.";
    }
}

/*
 * Notifications
 */

notification b4-address-change-limit-policy-violation {
    description
        "Generates notifications when a B4 unsuccessfully attempts
        to change IPv6 address in a time shorter than the value of
        b4-address-change-limit.

        Notifications are rate-limited (notify-interval).";

    leaf id {
        type leafref {
            path "/nat:nat/nat:instances/nat:instance/nat:id";
        }
        mandatory true;
        description
            "NAT instance identifier.";
    }

    leaf policy-id {
        type leafref {
            path "/nat:nat/nat:instances/nat:instance/nat:policy/nat:id";
        }
        mandatory true;
        description
            "Policy Identifier.";
    }

    leaf address {
        type inet:ipv6-address;
        mandatory true;
        description
            "B4's IPv6 address.";
    }
}
}
<CODE ENDS>
```


4. DS-Lite B4 YANG Module

```
<CODE BEGINS> file "ietf-dslite-b4@2017-11-13.yang"

module ietf-dslite-b4 {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-dslite-b4";
  prefix dslite-b4;

  import ietf-inet-types { prefix inet; }
  import ietf-interfaces { prefix if; }
  import iana-if-type { prefix ianaift; }

  organization "IETF Softwire Working Group";

  contact

    "WG Web: <https://datatracker.ietf.org/wg/softwire/>
    WG List: <mailto:softwires@ietf.org>

    WG Chair: Ian Farrer
              <mailto:ianfarrer@gmx.com>

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    Editor: Christian Jacquenet
            <mailto:christian.jacquenet@orange.com>

    Editor: Senthil Sivakumar
            <mailto:ssenthil@cisco.com>";

  description
    "This module is a YANG module for DS-Lite B4 implementations.

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    (http://trustee.ietf.org/license-info).
```


This version of this YANG module is part of RFC XXXX; see the RFC itself for full legal notices."

```
revision 2017-11-13 {
  description
    "Initial revision.";
  reference
    "RFC XXXX: YANG Data Modules for Dual-Stack Lite (DS-Lite)";
}
```

```
augment "/if:interfaces/if:interface" {
  when "if:type = 'ianaift:tunnel'";
  description
    "Augments Interface module with B4 parameters.
    IANA interface types are maintained at this registry:
    https://www.iana.org/assignments/ianaifttype-mib/ianaifttype-mib.

    tunnel (131),      -- Encapsulation interface";
```

```
  leaf b4-ipv6-address {
    type inet:ipv6-address;
    description
      "The IPv6 address used by the B4 element.";
    reference
      "RFC 6333: Dual-Stack Lite Broadband Deployments Following
      IPv4 Exhaustion";
  }
}
```

```
  leaf aftr-ipv6-addr {
    type inet:ipv6-address;
    description
      "The AFTR's IPv6 address.";
    reference
      "RFC 6333: Dual-Stack Lite Broadband Deployments Following
      IPv4 Exhaustion";
  }
}
```

```
  leaf b4-ipv4-address {
    type inet:ipv4-address;
    default "192.0.0.2";
    description
      "IPv4 address of the DS-Lite B4.

      192.0.0.0/29 is reserved for the B4 element.

      This address can be used to report ICMP problems and will
      appear in traceroute outputs.";
    reference
```



```
    "RFC 6333: Dual-Stack Lite Broadband Deployments Following
        IPv4 Exhaustion";
}

leaf tunnel-mtu {
    type uint16;
    description
        "Configures a tunnel MTU.

        [RFC6908] specifies that since fragmentation and reassembly is
        not optimal, the operator should do everything possible to
        eliminate the need for it. If the operator uses simple
        IPv4-in-IPv6 software, it is recommended that the MTU size of
        the IPv6 network between the B4 and the AFTR accounts for
        the additional overhead (40 bytes).";
    reference
        "RFC 6908: Deployment Considerations for Dual-Stack Lite";
}

leaf v6-v4-dscp-preservation {
    type boolean;
    description
        "Copies the DSCP value from the IPv6 header and vice versa.

        Operators should use this model by provisioning the network such
        that the AFTR copies the DSCP value in the IPv4 header to
        the Traffic Class field in the IPv6 header, after the
        encapsulation for the downstream traffic.";
    reference
        "Section 2.10 of RFC 6908.";
}
}
}
}
<CODE ENDS>
```

5. Security Considerations

The YANG module defined in this document is designed to be accessed via network management protocols such as NETCONF [[RFC6241](#)] or RESTCONF [[RFC8040](#)]. The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [[RFC6242](#)]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [[RFC5246](#)].

The NETCONF access control model [[RFC6536](#)] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

All data nodes defined in the YANG module which can be created, modified and deleted (i.e., config true, which is the default) are considered sensitive. Write operations (e.g., edit-config) applied to these data nodes without proper protection can negatively affect network operations. An attacker who is able to access to the B4/AFTR can undertake various attacks, such as:

- o Set the value of 'aftr-ipv6-addr' on the B4 to point to an illegitimate AFTR so that it can intercept all the traffic sent by a B4. Illegitimately intercepting users' traffic is a attack with severe implications on privacy.
- o Set the MTU to a low value which may increase the number of fragments ('tunnel-mtu' for both B4 and AFTR).
- o Set 'max-softwire-per-subscriber' to an arbitrary high value, which will be exploited by a misbehaving user to grab more resources (by mounting as many softwires as required to get more external IP addresses/ports) or to perform a Denial-of-Service on the AFTR by mounting a massive number of softwires.
- o Set 'state-migrate' to 'false' on the AFTR. This action may lead to a service degradation for the users.
- o Set 'b4-address-change-limit' to an arbitrary low value can ease DoS attacks based on frequent change of B4 IPv6 address.
- o Set 'v6-v4-dscp-preservation' to 'false' may lead to a service degradation if some policies are applied on the network based on the DSCP value.

Additional security considerations are discussed in [\[I-D.ietf-opsawg-nat-yang\]](#).

Security considerations related to DS-Lite are discussed in [\[RFC6333\]](#).

6. IANA Considerations

This document requests IANA to register the following URIs in the "IETF XML Registry" [\[RFC3688\]](#):

URI: urn:ietf:params:xml:ns:yang:ietf-dslite-aftr
Registrant Contact: The IESG.
XML: N/A; the requested URI is an XML namespace.

URI: urn:ietf:params:xml:ns:yang:ietf-dslite-b4
Registrant Contact: The IESG.
XML: N/A; the requested URI is an XML namespace.

This document requests IANA to register the following YANG modules in the "YANG Module Names" registry [[RFC7950](#)].

name: ietf-dslite-aftr
namespace: urn:ietf:params:xml:ns:yang:ietf-dslite-aftr
prefix: dslite-aftr
reference: RFC XXXX

name: ietf-dslite-b4
namespace: urn:ietf:params:xml:ns:yang:ietf-dslite-b4
prefix: dslite-b4
reference: RFC XXXX

7. Acknowledgements

Thanks to Qin Wu for identifying a compiling error. Mahesh Jethanandani provided an early yangdoctors review; many thanks to him.

Many thanks to Ian Farrer for the review and comments.

8. References

8.1. Normative references

[I-D.ietf-opsawg-nat-yang]
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[Appendix A](#). B4 Example

The following example shows a B4 element (2001:db8:0:1::1) that is configured with an AFTR element (2001:db8:0:2::1). The B4 element is also instructed to preserve the DSCP marking.

```
<interface>
  <name>myB4</name>
  <type>ianaift:tunnel</type>
  <enabled>true</enabled>
  <b4-ipv6-address>2001:db8:0:1::1</b4-ipv6-address>
  <aftr-ipv6-addr>2001:db8:0:2::1</aftr-ipv6-addr>
  <v6-v4-dscp-preservation>true</v6-v4-dscp-preservation>
</interface>
```

[Appendix B](#). AFTR Examples

The following example shows an AFTR that is reachable at 2001:db8:0:2::1. Also, this XML snippet indicates that the AFTR is provided with an IPv4 address (192.0.0.1) to be used for troubleshooting purposes such as reporting problems to B4s.

Note that a subscriber is identified by a subscriber-mask ([\[RFC7785\]](#)) that can be configured by means of [\[I-D.ietf-opsawg-nat-yang\]](#).

```
<interface>
  <name>myAFTR</name>
  <type>ianaift:tunnel</type>
  <enabled>true</enabled>
  <aftr-ipv6-address>2001:db8:0:2::1</aftr-ipv6-address>
  <aftr-ipv4-address>192.0.0.1</aftr-ipv4-address>
</interface>
```

The following shows an XML excerpt depicting a dynamic UDP mapping entry maintained by a DS-Lite AFTR for a packet received from the B4 element introduced in [Appendix A](#). Concretely, this UDP packet received with a source IPv6 address (2001:db8:0:1::1), a source IPv4 address (192.0.2.1), and source port number (1568) is translated into a UDP packet having a source IPv4 address (198.51.100.1) and source port number (15000). The remaining lifetime of this mapping is 300 seconds.


```
<mapping-entry>
  <index>15</index>
  <type>
    dynamic-explicit
  </type>
  <transport-protocol>
    17
  </transport-protocol>
  <b4-ipv6-address>
    <address>
      2001:db8:0:1::1
    </address>
  </b4-ipv6-address>
  <internal-src-address>
    192.0.2.1
  </internal-src-address>
  <internal-src-port>
    <start-port-number>
      1568
    </start-port-number>
  </internal-src-port>
  <external-src-address>
    198.51.100.1
  </external-src-address>
  <external-src-port>
    <start-port-number>
      15000
    </start-port-number>
  </external-src-port>
  <lifetime>
    300
  </lifetime>
</mapping-entry>
```

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