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# A YANG Data Model for Augmenting VPN Service and Network Models with Attachment Circuits
## draft-ietf-opsawg-ac-lxsm-lxnm-glue-14

## Abstract

This document defines a YANG data model, referred to as the "AC Glue" model, to augment the Layer 2/3 Service Model (LxSM) and Layer 2/3 Network Model (LxNM) with references to attachment circuits (ACs). The AC Glue model enables a provider to associate Layer 2/3 VPN services (LxVPNs) with the underlying AC infrastructure, thereby facilitating consistent provisioning and management of new or existing ACs in conjunction with LxVPN services. Specifically, by introducing an integrated approach to AC and LxVPN management, this model supports Attachment Circuit-as-a-Service (ACaaS) and provides a standardized mechanism for aligning AC/VPN requests with the network configurations required to deliver them.

## Discussion Venues

This note is to be removed before publishing as an RFC.

Discussion of this document takes place on the Operations and Management Area Working Group Working Group mailing list (opsawg@ietf.org), which is archived at https://mailarchive.ietf.org/arch/browse/opsawg/.

Source for this draft and an issue tracker can be found at https://github.com/boucadair/attachment-circuit-model.

## Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

## Copyright Notice



## Table of Contents

## 1. Introduction

To facilitate data transfer within the provider network, it is assumed that the appropriate setup is provisioned over the links that connect customer termination points and a provider network (usually via a Provider Edge (PE)), allowing successfully data exchanged over these links. The required setup is referred to in this document as an attachment circuit (AC), while the underlying link is referred to as "bearer".

The document specifies a YANG module ("ietf-ac-glue", Section 6) that updates existing service and network Virtual Private Network (VPN) modules with the required information to bind specific services to ACs that are created using the AC service model [I-D.ietf-opsawg-teas-attachment-circuit]. Specifically, the following modules are augmented:

* The Layer 2 Service Model (L2SM) [RFC8466]

* The Layer 3 Service Model (L3SM) [RFC8299]

* The Layer 2 Network Model (L2NM) [RFC9291]

* The Layer 3 Network Model (L3NM) [RFC9182]

Likewise, the document augments the L2NM and L3NM with references to the ACs that are managed using the AC network model [I-D.ietf-opsawg-ntw-attachment-circuit].

This approach allows operators to separate AC provisioning from actual VPN service provisioning. Refer to Section 4.2 for more discussion.

The YANG data model in this document conforms to the Network Management Datastore Architecture (NMDA) defined in [RFC8342].

Examples to illustrate the use of the "ietf-ac-glue" model are provided in Appendix A.

### 1.1. Editorial Note (To be removed by RFC Editor)

Note to the RFC Editor: This section is to be removed prior to publication.

This document contains placeholder values that need to be replaced with finalized values at the time of publication. This note summarizes all of the substitutions that are needed.

Please apply the following replacements:

* XXXX --> the assigned RFC number for this I-D

* SSSS --> the assigned RFC number for [I-D.ietf-opsawg-teas-attachment-circuit]

* NNNN --> the assigned RFC number for [I-D.ietf-opsawg-ntw-attachment-circuit]

* 2025-01-07 --> the actual date of the publication of this document

## 2. Conventions and Definitions

The meanings of the symbols in the YANG tree diagrams are defined in [RFC8340].

This document uses terms defined in [I-D.ietf-opsawg-teas-attachment-circuit].

LxSM refers to both the L2SM and the L3SM.

LxNM refers to both the L2NM and the L3NM.

The following terms are used in the modules prefixes:

ac: Attachment circuit

ntw: Network

ref: Reference

svc: Service

The names of data nodes are prefixed using the prefix associated with the corresponding imported YANG module as shown in Table 1:

| Prefix | Module | Reference |
|---|---|---|
| ac-svc | ietf-ac-svc | Section 5.2 of RFC SSSS |
| ac-ntw | ietf-ac-ntw | RFC NNNN |
| l2nm | ietf-l3vpn-ntw | [RFC9291] |
| l2vpn-svc | ietf-l2vpn-svc | [RFC8466] |
| l3nm | ietf-l3vpn-ntw | [RFC9182] |
| l3vpn-svc | ietf-l3vpn-svc | [RFC8299] |

Table 1: Modules and Their Associated Prefixes

## 3. Relationship to Other AC Data Models

Figure 1 depicts the relationship between the various AC data models:

* "ietf-ac-common" ([I-D.ietf-opsawg-teas-common-ac])

* "ietf-bearer-svc" (Section 5.1 of [I-D.ietf-opsawg-teas-attachment-circuit])

* "ietf-ac-svc" (Section 5.2 of [I-D.ietf-opsawg-teas-attachment-circuit])

* "ietf-ac-ntw" ([I-D.ietf-opsawg-ntw-attachment-circuit])

* "ietf-ac-glue" (Section 6)

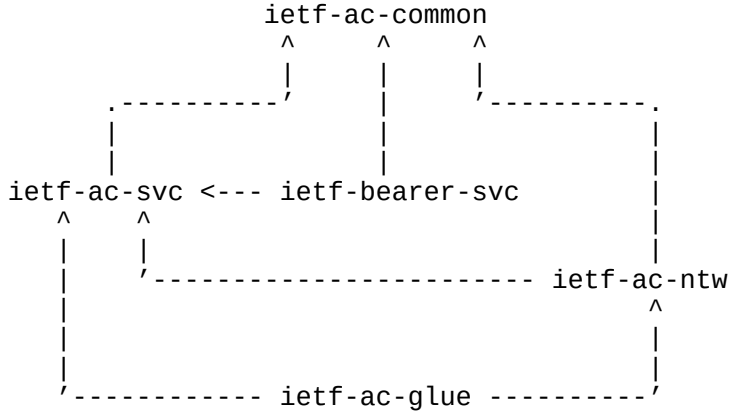


Figure 1: AC Data Models

The "ietf-ac-common" module is imported by the "ietf-bearer-svc", "ietf-ac-svc", and "ietf-ac-ntw" modules. Bearers managed using the "ietf-bearer-svc" module may be referenced by service ACs managed using the "ietf-ac-svc" module. Similarly, a bearer managed using the "ietf-bearer-svc" module may list the set of ACs that use that bearer. To facilitate correlation between an AC service request and the actual AC provisioned in the network, "ietf-ac-ntw" leverages the AC references exposed by the "ietf-ac-svc" module. Furthermore, to bind Layer 2 VPN or Layer 3 VPN services with ACs, the "ietf-ac-glue" module augments the LxSM and LxNM with AC service references exposed by the "ietf-ac-svc" module and AC network references exposed by the "ietf-ac-ntw" module.

## 4. Sample Uses of the Data Models

### 4.1. ACs Terminated by One or Multiple Customer Edges (CEs)

Figure 2 depicts two target topology flavors that involve ACs. These topologies have the following characteristics:

* A Customer Edge (CE) can be either a physical device or a logical entity. Such logical entity is typically a software component (e.g., a virtual service function that is hosted within the provider’s network or a third-party infrastructure). A CE is seen by the network as a peer Service Attachment Point (SAP) [RFC9408].

* CEs may be either dedicated to one single connectivity service or host multiple connectivity services (e.g., CEs with roles of service functions [RFC7665]).

* A network provider may bind a single AC to one or multiple peer SAPs (e.g., CE1 and CE2 are tagged as peer SAPs for the same AC). For example, and as discussed in [RFC4364], multiple CEs can be attached to a PE over the same attachment circuit. This scenario is typically implemented when the Layer 2 infrastructure between the CE and the network is a multipoint service.

* A single CE may terminate multiple ACs, which can be associated with the same bearer or distinct bearers (e.g., CE4).

* Customers may request protection schemes in which the ACs associated with their endpoints are terminated by the same PE (e.g., CE3), distinct PEs (e.g., CE4), etc. The network provider uses this request to decide where to terminate the AC in the service provider network and also whether to enable specific capabilities (e.g., Virtual Router Redundancy Protocol (VRRP)).

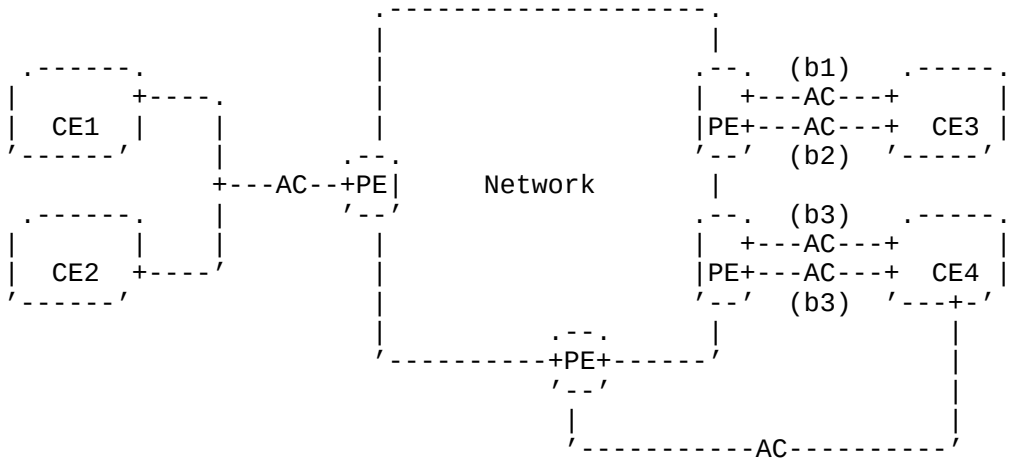


Figure 2: Examples of ACs

These ACs can be referenced when creating VPN services. Refer to the examples provided in Appendix A to illustrate how VPN services can be bound to ACs.

### 4.2. Separate AC Provisioning From Actual VPN Service Provisioning

The procedure to provision a service in a service provider network may depend on the practices adopted by a service provider. This includes the flow put in place for the provisioning of advanced network services and how they are bound to an attachment circuit. For example, a single attachment circuit may be used to host multiple connectivity services (e.g., Layer 2 VPN ("ietf-l2vpn-svc"), Layer 3 VPN ("ietf-l3vpn-svc"), Network Slice Service ("ietf-network-slice-service")). In order to avoid service interference and redundant information in various locations, a service provider may expose an interface to manage ACs network-wide using [I-D.ietf-opsawg-teas-attachment-circuit]. Customers can request an attachment circuit ("ietf-ac-svc") to be put in place, and then refer to that AC when requesting VPN services that are bound to the AC ("ietf-ac-glue").

Also, internal references ("ietf-ac-ntw") used within a service provider network to implement ACs can be used by network controllers to glue the L2NM ("ietf-l2vpn-ntw") or the L3NM ("ietf-l3vpn-ntw") services with relevant ACs.

Figure 3 shows the positioning of the AC models in the overall service delivery process.

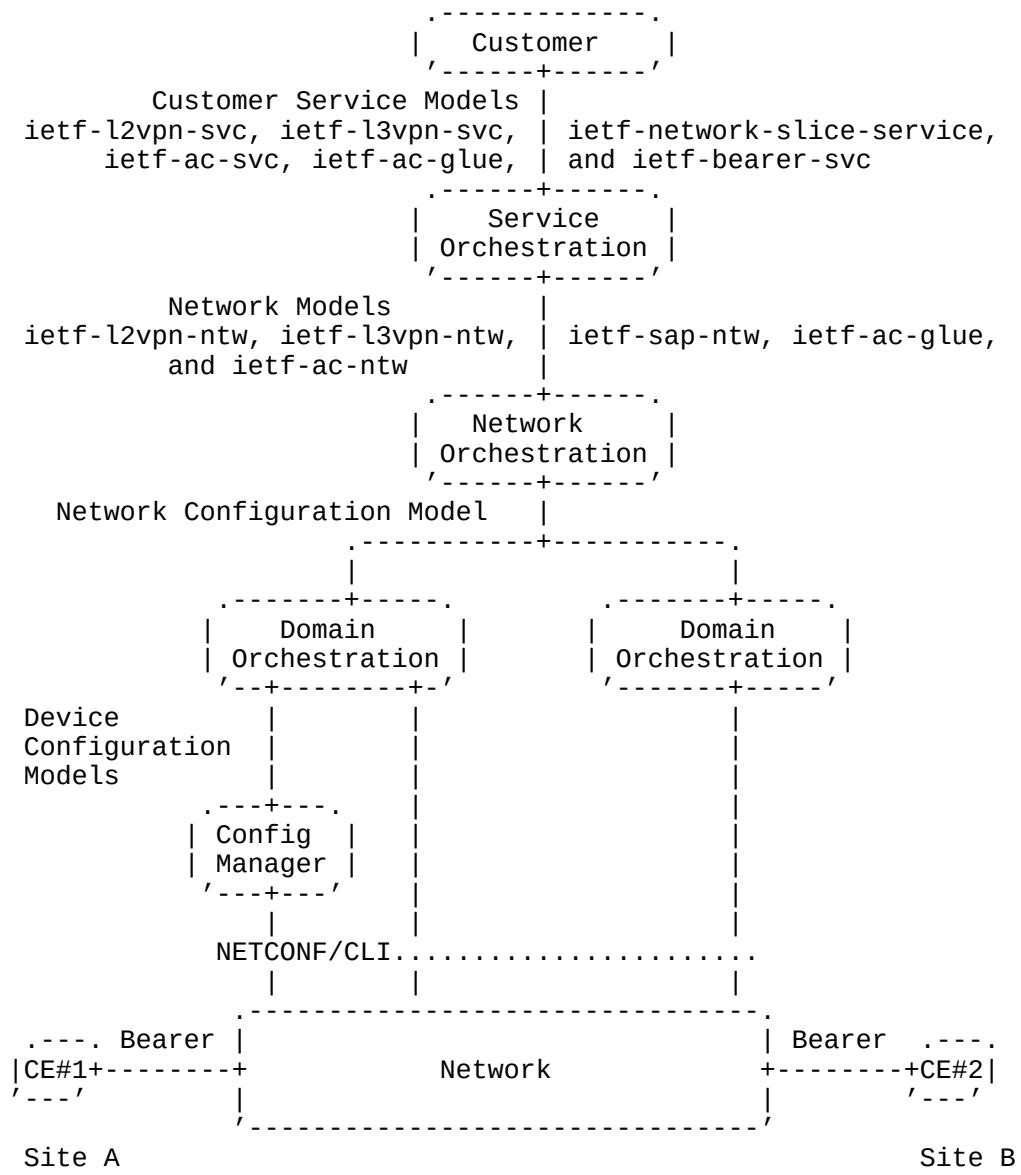


Figure 3: An Example of AC Models Usage

## 5. Module Tree Structure

[RFC8299] specifies that a 'site-network-access' attachment is achieved through a 'bearer' with an 'ip-connection' on top. From that standpoint, a 'site-network-access' is mapped to an attachment circuit with both Layers 2 and 3 properties per [I-D.ietf-opsawg-teas-attachment-circuit]. [RFC8466] specifies that a 'site-network-access' represents a logical Layer 2 connection to a site. A 'site-network-access' can thus be mapped to an attachment circuit with Layer 2 properties [I-D.ietf-opsawg-teas-attachment-circuit]. Similarly, 'vpn-network-access' defined in both [RFC9182] and [RFC9291] is mapped to an attachment circuit per [I-D.ietf-opsawg-teas-attachment-circuit] or [I-D.ietf-opsawg-ntw-attachment-circuit].

As such, ACs created using the "ietf-ac-svc" module [I-D.ietf-opsawg-teas-attachment-circuit] can be referenced in other VPN-related modules (e.g., LxSM and LxNM). Also, ACs managed using the "ietf-ac-ntw" module [I-D.ietf-opsawg-ntw-attachment-circuit] can be referenced in VPN-related network modules (mainly, the LxNM). The required augmentations to that aim are shown in Figure 4.

```
  module: ietf-ac-glue

    augment /l2vpn-svc:l2vpn-svc/l2vpn-svc:sites/l2vpn-svc:site
              /l2vpn-svc:site-network-accesses:
      +--rw ac-svc-ref*   ac-svc:attachment-circuit-reference
    augment /l2vpn-svc:l2vpn-svc/l2vpn-svc:sites/l2vpn-svc:site
              /l2vpn-svc:site-network-accesses
              /l2vpn-svc:site-network-access:
      +--rw ac-svc-ref?   ac-svc:attachment-circuit-reference {ac-glue}?
    augment /l3vpn-svc:l3vpn-svc/l3vpn-svc:sites/l3vpn-svc:site
              /l3vpn-svc:site-network-accesses:
      +--rw ac-svc-ref*   ac-svc:attachment-circuit-reference
    augment /l3vpn-svc:l3vpn-svc/l3vpn-svc:sites/l3vpn-svc:site
              /l3vpn-svc:site-network-accesses
              /l3vpn-svc:site-network-access:
      +--rw ac-svc-ref?   ac-svc:attachment-circuit-reference {ac-glue}?
    augment /l2nm:l2vpn-ntw/l2nm:vpn-services/l2nm:vpn-service
              /l2nm:vpn-nodes/l2nm:vpn-node/l2nm:vpn-network-accesses:
      +--rw ac-svc-ref*   ac-svc:attachment-circuit-reference
      +--rw ac-ntw-ref* [ac-ref]
         +--rw ac-ref         leafref
         +--rw node-ref?      leafref
         +--rw network-ref?   -> /nw:networks/network/network-id
    augment /l2nm:l2vpn-ntw/l2nm:vpn-services/l2nm:vpn-service
              /l2nm:vpn-nodes/l2nm:vpn-node/l2nm:vpn-network-accesses
              /l2nm:vpn-network-access:
      +--rw ac-svc-ref?   ac-svc:attachment-circuit-reference {ac-glue}?
      +--rw ac-ntw-ref {ac-glue}?
         +--rw ac-ref?        leafref
         +--rw node-ref?      leafref
         +--rw network-ref?   -> /nw:networks/network/network-id
    augment /l3nm:l3vpn-ntw/l3nm:vpn-services/l3nm:vpn-service
              /l3nm:vpn-nodes/l3nm:vpn-node/l3nm:vpn-network-accesses:
      +--rw ac-svc-ref*   ac-svc:attachment-circuit-reference
      +--rw ac-ntw-ref* [ac-ref]
         +--rw ac-ref         leafref
         +--rw node-ref?      leafref
         +--rw network-ref?   -> /nw:networks/network/network-id
    augment /l3nm:l3vpn-ntw/l3nm:vpn-services/l3nm:vpn-service
              /l3nm:vpn-nodes/l3nm:vpn-node/l3nm:vpn-network-accesses
              /l3nm:vpn-network-access:
      +--rw ac-svc-ref?   ac-svc:attachment-circuit-reference {ac-glue}?
      +--rw ac-ntw-ref {ac-glue}?
         +--rw ac-ref?        leafref
         +--rw node-ref?      leafref
         +--rw network-ref?   -> /nw:networks/network/network-id
```

Figure 4: AC Glue Tree Structure

When an AC is referenced within a specific network access, then that AC information takes precedence over any overlapping information that is also enclosed for this network access.

> This approach is consistent with the design in [I-D.ietf-teas-ietf-network-slice-nbi-yang] where an AC service reference, called 'ac-svc-name', is used to indicate the names of AC services. As per [I-D.ietf-teas-ietf-network-slice-nbi-yang], when both 'ac-svc-name' and the attributes of 'attachment-circuits' are defined, the 'ac-svc-name' takes precedence.

The "ietf-ac-glue" module includes provisions to reference ACs within or outside a VPN network access to accommodate deployment contexts where an AC reference may be created before or after a VPN instance is created. Appendix A.1 illustrates how an AC reference can be included as part of a specific VPN network access, while Appendix A.2 shows how AC references can be indicated outside individual VPN network access entries.

## 6. The AC Glue ("ietf-ac-glue") YANG Module

This modules augments the L2SM [RFC8466], the L3SM [RFC8299], the L2NM [RFC9291], and the L3NM [RFC9182].

This module uses references defined in [I-D.ietf-opsawg-teas-attachment-circuit] and [I-D.ietf-opsawg-ntw-attachment-circuit].

<CODE BEGINS> file "ietf-ac-glue@2025-01-07.yang"

```
module ietf-ac-glue {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-ac-glue";
  prefix ac-glue;

  import ietf-l3vpn-svc {
    prefix l3vpn-svc;
    reference
      "RFC 8299: YANG Data Model for L3VPN Service Delivery";
  }
  import ietf-l2vpn-svc {
    prefix l2vpn-svc;
    reference
      "RFC 8466: A YANG Data Model for Layer 2 Virtual Private
                 Network (L2VPN) Service Delivery";
  }
  import ietf-l3vpn-ntw {
    prefix l3nm;
    reference
```

```
        "RFC 9182: A YANG Network Data Model for Layer 3 VPNs";
    }
    import ietf-l2vpn-ntw {
      prefix l2nm;
      reference
        "RFC 9291: A YANG Network Data Model for Layer 2 VPNs";
    }
    import ietf-ac-svc {
      prefix ac-svc;
      reference
        "RFC SSSS: YANG Data Models for Bearers and 'Attachment
                   Circuits'-as-a-Service (ACaaS)";
    }
    import ietf-ac-ntw {
      prefix ac-ntw;
      reference
        "RFC NNNN: A Network YANG Data Model for Attachment Circuits";
    }

    organization
      "IETF OPSAWG (Operations and Management Area Working Group)";
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      "WG Web:   <https://datatracker.ietf.org/wg/opsawg/>
       WG List:  <mailto:opsawg@ietf.org>

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       Author:   Oscar Gonzalez de Dios
                 <mailto:oscar.gonzalezdedios@telefonica.com>";
    description
      "This YANG module defines a YANG model for augmenting the LxSM
       and the LxNM with attachment circuit references.

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       authors of the code.  All rights reserved.

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       This version of this YANG module is part of RFC XXXX; see the
```

```
        RFC itself for full legal notices.";

    revision 2025-01-07 {
      description
        "Initial revision.";
      reference
        "RFC XXXX: A YANG Data Model for Augmenting VPN Service
                   and Network Models with Attachment Circuits";
    }

    feature ac-glue {
      description
        "The VPN implementation supports binding a specific VPN
         network access or site access to an attachment circuit.";
    }

    grouping single-ac-svc-ref {
      description
        "A grouping with single reference to a service AC.";
      leaf ac-svc-ref {
        type ac-svc:attachment-circuit-reference;
        description
          "A reference to the AC as exposed at the service that was
           provisioned using the ACaaS module.";
      }
    }

    grouping single-ac-svc-ntw-ref {
      description
        "A grouping with single AC references.";
      leaf ac-svc-ref {
        type ac-svc:attachment-circuit-reference;
        description
          "A reference to the AC as exposed at the service that was
           provisioned using the ACaaS module.";
      }
      container ac-ntw-ref {
        description
          "A reference to the AC that was provisioned using the AC
           network module.";
        uses ac-ntw:attachment-circuit-reference;
      }
    }

    grouping ac-svc-ref {
      description
        "A set of service-specific AC-related data.";
      leaf-list ac-svc-ref {
```

```
        type ac-svc:attachment-circuit-reference;
        description
          "A reference to the AC as exposed at the service that was
           provisioned using the ACaaS module.";
      }
    }

    grouping ac-svc-ntw-ref {
      description
        "A set of AC-related data.";
      leaf-list ac-svc-ref {
        type ac-svc:attachment-circuit-reference;
        description
          "A reference to the AC as exposed at the service that was
           provisioned using the ACaaS module.";
      }
      list ac-ntw-ref {
        key "ac-ref";
        description
          "A reference to the AC that was provisioned using the AC
           network module.";
        uses ac-ntw:attachment-circuit-reference;
      }
    }

    augment "/l2vpn-svc:l2vpn-svc"
          + "/l2vpn-svc:sites/l2vpn-svc:site"
          + "/l2vpn-svc:site-network-accesses" {
      description
        "Augments VPN site network accesses with AC provisioning
         details. Concretely, it binds a site to a set of
         attachment circuits with Layer 2 properties that were
         created using the ACaaS module.";
      uses ac-svc-ref;
    }

    augment "/l2vpn-svc:l2vpn-svc"
          + "/l2vpn-svc:sites/l2vpn-svc:site"
          + "/l2vpn-svc:site-network-accesses"
          + "/l2vpn-svc:site-network-access" {
      if-feature "ac-glue";
      description
        "Augments VPN site network access with AC provisioning
         details. Concretely, it glues a 'site-network-access'
         to an attachment circuit with Layer 2 properties that was
         created using the ACaaS module.

         The ACaaS information takes precedence over any overlapping
```

```
        information that is also provided for a site network access.";
      uses single-ac-svc-ref;
    }

    augment "/l3vpn-svc:l3vpn-svc"
          + "/l3vpn-svc:sites/l3vpn-svc:site"
          + "/l3vpn-svc:site-network-accesses" {
      description
        "Augments VPN site network accesses with AC provisioning
         details. Concretely, it binds a site to a set of attachment
         circuits with both Layers 2 and 3 properties that were
         created using the ACaaS module.";
      uses ac-svc-ref;
    }

    augment "/l3vpn-svc:l3vpn-svc"
          + "/l3vpn-svc:sites/l3vpn-svc:site"
          + "/l3vpn-svc:site-network-accesses"
          + "/l3vpn-svc:site-network-access" {
      if-feature "ac-glue";
      description
        "Augments VPN site network access with AC provisioning
         details. Concretely, it glues a 'site-network-access' to an
         attachment circuit with both Layer 2 and Layer 3 properties
         that was created using the ACaaS module.

         The ACaaS information takes precedence over any overlapping
         information that is also provided for a site network access.";
      uses single-ac-svc-ref;
    }

    augment "/l2nm:l2vpn-ntw/l2nm:vpn-services/l2nm:vpn-service"
          + "/l2nm:vpn-nodes/l2nm:vpn-node"
          + "/l2nm:vpn-network-accesses" {
      description
        "Augments VPN network accesses with both service and network
         AC provisioning details. Concretely, it binds a site to (1)
         a set of attachment circuits with Layer 2 properties that were
         created using the ACaaS module and (2) a set of attachment
         circuits with Layer 2 properties that were provisioned using
         the AC network model.";
      uses ac-svc-ntw-ref;
    }

    augment "/l2nm:l2vpn-ntw/l2nm:vpn-services/l2nm:vpn-service"
          + "/l2nm:vpn-nodes/l2nm:vpn-node"
          + "/l2nm:vpn-network-accesses"
          + "/l2nm:vpn-network-access" {
```

```
      if-feature "ac-glue";
      description
        "Augments VPN network access with service and network
         references to an AC. Concretely, it glues a VPN network
         access to (1) an attachment circuit with Layer 2 properties
         that was created using the ACaaS module and (2) an attachment
         circuit with Layer 2 properties that was created using the AC
         network module.

         The AC service and network information takes precedence over
         any overlapping information that is also provided for a VPN
         network access.";
      uses single-ac-svc-ntw-ref;
    }

    augment "/l3nm:l3vpn-ntw/l3nm:vpn-services/l3nm:vpn-service"
          + "/l3nm:vpn-nodes/l3nm:vpn-node"
          + "/l3nm:vpn-network-accesses" {
      description
        "Augments VPN network accesses with both service and network
         AC provisioning details. Concretely, it binds a site to (1)
         a set of attachment circuits with both Layer 2 and Layer 3
         properties that were created using the ACaaS module and (2)
         a set of attachment circuits with both Layer 2 and Layer 3
         properties that were provisioned using the AC network model.";
      uses ac-svc-ntw-ref;
    }

    augment "/l3nm:l3vpn-ntw/l3nm:vpn-services/l3nm:vpn-service"
          + "/l3nm:vpn-nodes/l3nm:vpn-node"
          + "/l3nm:vpn-network-accesses"
          + "/l3nm:vpn-network-access" {
      if-feature "ac-glue";
      description
        "Augments VPN network access with service and network
         references to an AC. Concretely, it glues a VPN network
         access to (1) an attachment circuit with both Layer 2 and
         Layer 3 properties that was created using the ACaaS module
         and (2) an attachment circuit with both Layer 2 and Layer 3
         properties that was created using the AC network module.

         The AC service and network information takes precedence over
         any overlapping information that is also provided for a VPN
         network access.";
      uses single-ac-svc-ntw-ref;
    }
  }
  <CODE ENDS>
```

## 7. Security Considerations

This section is modeled after the template described in Section 3.7 of [I-D.ietf-netmod-rfc8407bis].

The "ietf-ac-common" YANG module defines a data model that is designed to be accessed via YANG-based management protocols, such as NETCONF [RFC6241] and RESTCONF [RFC8040]. These protocols have to use a secure transport layer (e.g., SSH [RFC4252], TLS [RFC8446], and QUIC [RFC9000]) and have to use mutual authentication.

The Network Configuration Access Control Model (NACM) [RFC8341] 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.

There are a number of data nodes defined in this YANG module that are writable/creatable/deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) and delete operations to these data nodes without proper protection or authentication can have a negative effect on network operations. Specifically, the following subtrees and data nodes have particular sensitivities/vulnerabilities:

’ac-svc-ref’ and ’ac-ntw-ref’: An attacker who is able to access network nodes can undertake various attacks, such as deleting a running VPN service, interrupting all the traffic of a client. Specifically, an attacker may modify (including delete) the ACs that are bound to a running service, leading to malfunctioning of the service and therefore to Service Level Agreement (SLA) violations. : Such activity can be detected by adequately monitoring and tracking network configuration changes.

Some of the readable data nodes in this YANG module may be considered sensitive or vulnerable in some network environments. It is thus important to control read access (e.g., via get, get-config, or notification) to these data nodes. Specifically, the following subtrees and data nodes have particular sensitivities/ vulnerabilities:

’ac-svc-ref’ and ’ac-ntw-ref’: These references do not expose per se privacy-related information, however ’ac-svc-ref’ may be used to track the set of VPN instances in which a given customer is involved.

Note that, unlike ’ac-svc-ref’, ’ac-ntw-ref’ is unique within the scope of a node and may multiplex many peer CEs.

## 8. IANA Considerations

IANA is requested to register the following URI in the "ns" subregistry within the "IETF XML Registry" [RFC3688]:

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

IANA is requested to register the following YANG module in the "YANG Module Names" registry [RFC6020] within the "YANG Parameters" registry group:

Name: ietf-ac-glue
Namespace: urn:ietf:params:xml:ns:yang:ietf-ac-glue
Prefix: ac-glue
Maintained by IANA? N
Reference: RFC XXXX

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## Appendix A. Examples

### A.1. A Service AC Reference within The VPN Network Access

Let us consider the example depicted in Figure 5 which is inspired from Section 2.1 of [RFC4664]. Each PE is servicing two CEs. Let us also assume that the service references to identify attachment circuits with these CEs are shown in the figure.

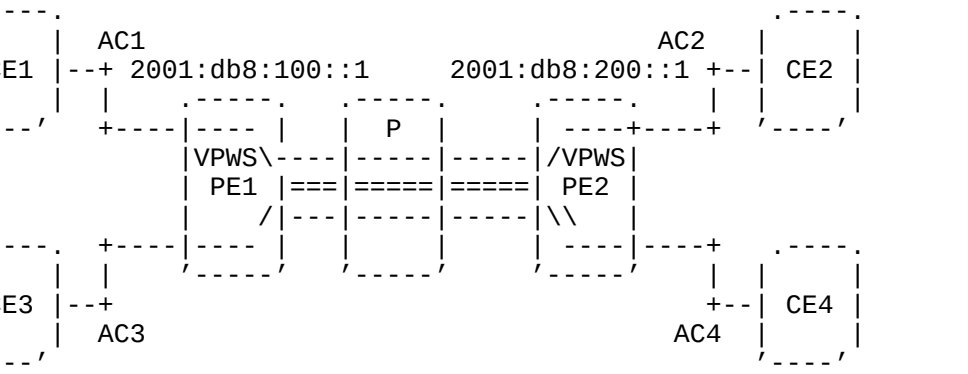


Figure 5: VPWS Topology Example

As shown in Figure 6, the service AC references can be explicitly indicated in the L2NM query for the realization of the Virtual Private Wire Service (VPWS) (Section 3.1.1 of [RFC4664]).

=============== NOTE: '\' line wrapping per RFC 8792 ================

```
{
   "ietf-l2vpn-ntw:l2vpn-ntw":{
      "vpn-services":{
         "vpn-service":[
            {
               "vpn-id":"vpws12345",
               "vpn-description":"Sample VPWS with AC service \
                                                      references",
               "customer-name":"customer-12345",
               "vpn-type":"ietf-vpn-common:vpws",
               "bgp-ad-enabled":true,
               "signaling-type":"ietf-vpn-common:ldp-signaling",
```

```
"global-parameters-profiles":{
   "global-parameters-profile":[
      {
         "profile-id":"simple-profile",
         "local-autonomous-system":65550,
         "rd-auto":{
            "auto":[
               null
            ]
         },
         "vpn-target":[
            {
               "id":1,
               "route-targets":[
                  {
                     "route-target":"0:65535:1"
                  }
               ],
               "route-target-type":"both"
            }
         ]
      }
   ]
},
"vpn-nodes":{
   "vpn-node":[
      {
         "vpn-node-id":"pe1",
         "ne-id":"2001:db8:100::1",
         "active-global-parameters-profiles":{
            "global-parameters-profile":[
               {
                  "profile-id":"simple-profile"
               }
            ]
         },
         "bgp-auto-discovery":{
            "vpn-id":"587"
         },
         "signaling-option":{
            "advertise-mtu":true,
            "ldp-or-l2tp":{
               "saii":1,
               "remote-targets":[
                  {
                     "taii":2
                  }
               ],
```

```
                "t-ldp-pw-type":"ethernet"
              }
            },
            "vpn-network-accesses":{
              "vpn-network-access":[
                {
                  "id":"1/1/1.1",
                  "interface-id":"1/1/1",
                  "description":"Interface to CE1",
                  "active-vpn-node-profile":"simple-\
                                            profile",
                  "status":{
                    "admin-status":{
                      "status":"ietf-vpn-common:\
                                            admin-up"
                    },
                    "ietf-ac-glue:ac-svc-ref":"AC1"
                  }
                },
                {
                  "id":"1/1/3.1",
                  "interface-id":"1/1/3",
                  "description":"Interface to CE3",
                  "active-vpn-node-profile":"simple-\
                                            profile",
                  "status":{
                    "admin-status":{
                      "status":"ietf-vpn-common:\
                                            admin-up"
                    },
                    "ietf-ac-glue:ac-svc-ref":"AC3"
                  }
                }
              ]
            }
          },
          {
            "vpn-node-id":"pe2",
            "ne-id":"2001:db8:200::1",
            "active-global-parameters-profiles":{
              "global-parameters-profile":[
                {
                  "profile-id":"simple-profile"
                }
              ]
            },
            "bgp-auto-discovery":{
              "vpn-id":"587"
```

```
                        },
                        "signaling-option":{
                           "advertise-mtu":true,
                           "ldp-or-l2tp":{
                              "saii":2,
                              "remote-targets":[
                                 {
                                    "taii":1
                                 }
                              ],
                              "t-ldp-pw-type":"ethernet"
                           }
                        },
                        "vpn-network-accesses":{
                           "vpn-network-access":[
                              {
                                 "id":"2/1/2.1",
                                 "interface-id":"2/1/2",
                                 "description":"Interface to CE2",
                                 "active-vpn-node-profile":"simple-\
                                                           profile",
                                 "status":{
                                    "admin-status":{
                                       "status":"ietf-vpn-common:\
                                                           admin-up"
                                    },
                                    "ietf-ac-glue:ac-svc-ref":"AC2"
                                 }
                              },
                              {
                                 "id":"2/1/4.1",
                                 "interface-id":"2/1/4",
                                 "description":"Interface to CE4",
                                 "active-vpn-node-profile":"simple-\
                                                           profile",
                                 "status":{
                                    "admin-status":{
                                       "status":"ietf-vpn-common:\
                                                           admin-up"
                                    },
                                    "ietf-ac-glue:ac-svc-ref":"AC4"
                                 }
                              }
                           ]
                        }
                     }
                  ]
               }
```

```
              }
            ]
          }
        }
      }
```

Figure 6: Example of VPWS Creation with AC Service References

## A.2. Network and Service AC References

Let us consider the example depicted in Figure 7 with two customer termination points (CE1 and CE2). Let us also assume that the bearers to attach these CEs to the service provider network are already in place. References to identify these bearers are shown in the figure.

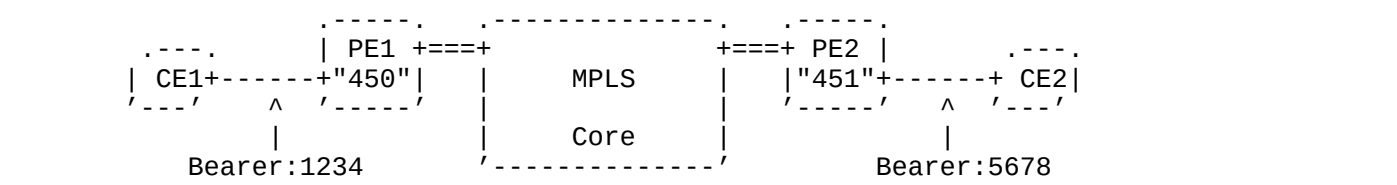


Figure 7: Topology Example

The AC service model [I-D.ietf-opsawg-teas-attachment-circuit] can be used by the provider to manage and expose the ACs over existing bearers as shown in Figure 8.

```
{
  "ietf-ac-svc:attachment-circuits": {
    "ac-group-profile": [
      {
        "name": "an-ac-profile",
        "l2-connection": {
          "encapsulation": {
            "type": "ietf-vpn-common:dot1q",
            "dot1q": {
              "tag-type": "ietf-vpn-common:c-vlan",
              "cvlan-id": 550
            }
          }
        },
        "service": {
          "mtu": 1550,
          "svc-pe-to-ce-bandwidth": {
            "bandwidth": [
              {
```

```
                  "bw-type": "ietf-vpn-common:bw-per-port",
                  "cir": "20480000"
                }
              ]
            },
            "svc-ce-to-pe-bandwidth": {
              "bandwidth": [
                {
                  "bw-type": "ietf-vpn-common:bw-per-port",
                  "cir": "20480000"
                }
              ]
            },
            "qos": {
              "qos-profiles": {
                "qos-profile": [
                  {
                    "profile": "QoS_Profile_A",
                    "direction": "ietf-vpn-common:both"
                  }
                ]
              }
            }
          }
        }
      ],
      "ac": [
        {
          "name": "ac-1",
          "description": "First attachment",
          "ac-group-profile": [
            "an-ac-profile"
          ],
          "l2-connection": {
            "bearer-reference": "1234"
          }
        },
        {
          "name": "ac-2",
          "description": "Second attachment",
          "ac-group-profile": [
            "an-ac-profile"
          ],
          "l2-connection": {
            "bearer-reference": "5678"
          }
        }
      ]
```

```
  }
}
```

Figure 8: ACs Created Using ACaaS

Let us now consider that the customer wants to request a VPLS instance between the sites as shown in Figure 9.

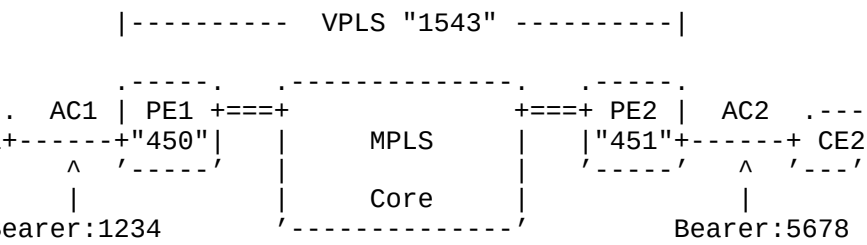


Figure 9: Example of VPLS

To that aim, existing ACs are referenced during the creation of the VPLS instance using the L2NM [RFC9291] and the "ietf-ac-glue" as shown in Figure 10.

```
{
  "ietf-l2vpn-ntw:l2vpn-ntw": {
    "vpn-services": {
      "vpn-service": [
        {
          "vpn-id": "1543",
          "vpn-name": "CORPO-EXAMPLE",
          "customer-name": "EXAMPLE",
          "vpn-type": "ietf-vpn-common:vpls",
          "vpn-service-topology": "ietf-vpn-common:hub-spoke",
          "bgp-ad-enabled": false,
          "signaling-type": "ietf-vpn-common:ldp-signaling",
          "global-parameters-profiles": {
            "global-parameters-profile": [
              {
                "profile-id": "simple-profile",
                "ce-vlan-preservation": true,
                "ce-vlan-cos-preservation": true
              }
            ]
          },
          "vpn-nodes": {
            "vpn-node": [
              {
                "vpn-node-id": "450",
```

```
      "ne-id": "2001:db8:5::1",
      "role": "ietf-vpn-common:hub-role",
      "status": {
        "admin-status": {
          "status": "ietf-vpn-common:admin-up"
        }
      },
      "active-global-parameters-profiles": {
        "global-parameters-profile": [
          {
            "profile-id": "simple-profile"
          }
        ]
      },
      "signaling-option": {
        "ldp-or-l2tp": {
          "t-ldp-pw-type": "vpls-type",
          "pw-peer-list": [
            {
              "peer-addr": "2001:db8:50::1",
              "vc-id": "1543"
            }
          ]
        }
      },
      "vpn-network-accesses": {
        "ietf-ac-glue:ac-svc-ref": ["ac-1"]
      }
    },
    {
      "vpn-node-id": "451",
      "ne-id": "2001:db8:50::1",
      "role": "ietf-vpn-common:spoke-role",
      "status": {
        "admin-status": {
          "status": "ietf-vpn-common:admin-up"
        }
      },
      "active-global-parameters-profiles": {
        "global-parameters-profile": [
          {
            "profile-id": "simple-profile"
          }
        ]
      },
      "signaling-option": {
        "ldp-or-l2tp": {
          "t-ldp-pw-type": "vpls-type",
```

```
                      "pw-peer-list": [
                        {
                          "peer-addr": "2001:db8:5::1",
                          "vc-id": "1543"
                        }
                      ]
                    }
                  },
                  "vpn-network-accesses": {
                    "ietf-ac-glue:ac-svc-ref": ["ac-2"]
                  }
                }
              ]
            }
          }
        ]
      }
    }
  }
```

Figure 10: Example of a VPLS Request Using L2NM and AC Glue (Message Body)

Note that before implementing the VPLS instance creation request, the provider service orchestrator may first check if the VPLS service can be provided to the customer using the target delivery locations. The orchestrator uses the SAP model [RFC9408] as exemplified in Figure 11. This example assumes that the query concerns only PE1. A similar query can be issued for PE2.

```
{
   "ietf-sap-ntw:service":[
      {
         "service-type":"ietf-vpn-common:vpls",
         "sap":[
            {
               "sap-id":"sap#1",
               "peer-sap-id":[
                  "ce-1"
               ],
               "description":"A parent SAP",
               "attachment-interface":"GE0/6/1",
               "interface-type":"ietf-sap-ntw:phy",
               "role":"ietf-sap-ntw:uni",
               "allows-child-saps":true,
               "sap-status":{
                  "status":"ietf-vpn-common:op-up"
               }
            }
         ]
      }
   ]
}
```


Figure 11: Example of SAP Response (Message Body)

The response in Figure 11 indicates that the VPLS service can be delivered to CE1. [I-D.ietf-opsawg-ntw-attachment-circuit] can be also used to access AC-related details that are bound to the target SAP (Figure 12).

```
{
   "ietf-sap-ntw:service":[
      {
         "service-type":"ietf-vpn-common:vpls",
         "sap":[
            {
               "sap-id":"sap#1",
               "peer-sap-id":[
                  "ce-1"
               ],
               "description":"A parent SAP",
               "attachment-interface":"GE0/6/1",
               "interface-type":"ietf-sap-ntw:phy",
               "role":"ietf-sap-ntw:uni",
               "allows-child-saps":true,
               "sap-status":{
                  "status":"ietf-vpn-common:op-up"
               }
            },
            {
               "sap-id":"sap#11",
               "description":"A child SAP",
               "parent-termination-point":"GE0/6/4",
               "attachment-interface":"GE0/6/4.2",
               "interface-type":"ietf-sap-ntw:logical",
               "encapsulation-type":"ietf-vpn-common:vlan-type",
               "sap-status":{
                  "status":"ietf-vpn-common:op-up"
               },
               "ietf-ac-ntw:ac":[
                  {
                     "ac-ref":"ac-1",
                     "node-ref":"example:pe2",
                     "network-ref":"example:an-id"
                  }
               ]
            }
         ]
      }
   ]
}
```


Figure 12: Example of AC Network Response with SAP (Message Body)

The provisioned AC at PE1 can be retrieved using the AC network model [I-D.ietf-opsawg-ntw-attachment-circuit] as depicted in Figure 13.

```
{
   "ietf-ac-ntw:ac":[
      {
         "name":"ac-11",
         "svc-ref":"ac-1",
         "peer-sap-id":[
            "ce-1"
         ],
         "status":{
            "admin-status":{
               "status":"ietf-vpn-common:admin-up"
            },
            "oper-status":{
               "status":"ietf-vpn-common:op-up"
            }
         },
         "l2-connection":{
            "encapsulation":{
               "encap-type":"ietf-vpn-common:dot1q",
               "dot1q":{
                  "tag-type":"ietf-vpn-common:c-vlan",
                  "cvlan-id":550
               }
            },
            "bearer-reference":"1234"
         },
         "service":{
            "mtu":1550,
            "svc-pe-to-ce-bandwidth":{
               "bandwidth":[
                  {
                     "bw-type": "ietf-vpn-common:bw-per-port",
                     "cir":"20480000"
                  }
               ]
            },
            "svc-ce-to-pe-bandwidth":{
               "bandwidth":[
                  {
                     "bw-type": "ietf-vpn-common:bw-per-port",
                     "cir":"20480000"
                  }
               ]
            },
            "qos":{
               "qos-profiles":{
                  "qos-profile":[
                     {
```

```
                            "qos-profile-ref":"QoS_Profile_A",
                            "network-ref":"example:an-id",
                            "direction":"ietf-vpn-common:both"
                          }
                        ]
                      }
                    }
                  }
                }
              ]
            }
          }
```

Figure 13: Example of AC Network Response (Message Body)

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