RADIUS Attributes for Address plus Port (A+P) based Softwire Mechanisms

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Abstract

IPv4-over-IPv6 transition mechanisms provide IPv4 connectivity services over IPv6 native networks during the IPv4/IPv6 co-existence period. DHCPv6 options have been defined for configuring clients for Lightweight 4over6, Mapping of Address and Port with Encapsulation, and Mapping of Address and Port using Translation unicast softwire mechanisms, and also multicast softwires. However, in many networks, configuration information is stored in an Authentication, Authorization, and Accounting server which utilizes the RADIUS protocol to provide centralized management for users. When a new transition mechanism is developed, new RADIUS attributes need to be defined correspondingly.

This document defines three new RADIUS attributes to carry Address plus Port based software configuration parameters from an Authentication, Authorization, and Accounting server to a Broadband Network Gateway. Both unicast and multicast attributes are covered.

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1. Introduction

Providers have started deploying and transitioning to IPv6. Several IPv4 service continuity mechanisms based on the Address plus Port (A+P) [RFC6346] have been proposed for providing unicast IPv4 over IPv6-only infrastructure, such as Mapping of Address and Port with Encapsulation (MAP-E) [RFC7597], Mapping of Address and Port using Translation (MAP-T) [RFC7599], and Lightweight 4over6 [RFC7596]. Also, [RFC8114] specifies a generic solution for the delivery of IPv4 multicast services to IPv4 clients over an IPv6 multicast network. For each of these mechanisms, DHCPv6 options have been specified for client configuration.

In many networks, user configuration information is stored in an Authentication, Authorization, and Accounting (AAA) server. AAA
servers generally communicate using the Remote Authentication Dial In User Service (RADIUS) [RFC2865] protocol. In a fixed broadband network, a Broadband Network Gateway (BNG) acts as the access gateway for users. That is, the BNG acts as both an AAA client to the AAA server, and a DHCPv6 server for DHCPv6 messages sent by clients. Throughout this document, the term BNG describes a device implementing both the AAA client and DHCPv6 server functions.

Since IPv4-in-IPv6 softwire configuration information is stored in an AAA server, and user configuration information is mainly transmitted through DHCPv6 protocol between the BNGs and Customer Premises Equipment (CEs, a.k.a., CPE), new RADIUS attributes are needed to propagate the information from the AAA servers to BNGs.

The RADIUS attributes defined in this document provide configuration to populate the corresponding DHCPv6 options for unicast and multicast softwire configuration, specifically:

- "Mapping of Address and Port with Encapsulation (MAP-E)" [RFC7597] (DHCPv6 options defined in [RFC7598]).
- "Mapping of Address and Port using Translation (MAP-T)" [RFC7599] (DHCPv6 options defined in [RFC7598]).
- "Lightweight 4over6: An Extension to the Dual-Stack Lite Architecture" [RFC7596] (DHCPv6 options defined in [RFC7598]).
- "Unified IPv4-in-IPv6 Softwire Customer Premises Equipment (CPE): A DHCPv6-Based Prioritization Mechanism" [RFC8026].
- "Delivery of IPv4 Multicast Services to IPv4 Clients over an IPv6 Multicast Network" [RFC8114] (DHCPv6 options defined in [RFC8115]).

The contents of the attributes/sub-TLVs defined in this document have a 1:1 mapping into the fields of the various DHCPv6 options in [RFC7598], [RFC8026], and [RFC8115]. Table 1 shows how the DHCPv6 options map to the corresponding RADIUS attribute, or Sub-TLV. For detailed mappings between each DHCPv6 option field and the corresponding RADIUS Attribute, TLV, or Sub-TLV field, see Appendix A.
A RADIUS attribute for Dual-Stack Lite [RFC6333] is defined in [RFC6519].

2. Terminology

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 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

The reader should be familiar with the concepts and terms defined in [RFC7596], [RFC7597], [RFC7599], and [RFC8026].

The terms "multicast Basic Bridging BroadBand" element (mB4) and "multicast Address Family Transition Router" element (mAFTR) are defined in [RFC8114].

S46 is used throughout to denote any of the IPv4-in-IPv6 softwire mechanisms listed above. Additionally, the following abbreviations are used within the document:

- BMR: Basic Mapping Rule
- BNG: Broadband Network Gateway
- BR: Border Relay
- CE: Customer Edge
- DMR: Default Mapping Rule
- EA: Embedded Address
3. Extensions of RADIUS Attributes and TLVs

This section defines the following attributes:

1. **Softwire46-Configuration Attribute ([Section 3.1](#))**: This attribute carries the configuration information for MAP-E, MAP-T, and Lightweight 4over6. The configuration information for each S46 mechanism is carried in the corresponding Softwire46 TLVs. Different Sub-TLVs are required for each type of Softwire46 TLVs.

2. **Softwire46-Priority Attribute ([Section 3.2](#))**: Depending on the deployment scenario, a client may support several different S46 mechanisms and so request configuration for more than one S46 mechanism at a time. The Softwire46-Priority Attribute contains information allowing the client to prioritize which mechanism to use, corresponding to OPTION_S46_PRIORITY defined in [RFC8026].

3. **Softwire46-Multicast Attribute ([Section 3.3](#))**: This attribute conveys the IPv6 prefixes to be used in [RFC8114] to synthesize IPv4-embedded IPv6 addresses. The BNG uses the IPv6 prefixes returned in the RADIUS Softwire46-Multicast Attribute to populate the DHCPv6 PREFIX64 Option [RFC8115].

All of these attributes are allocated from the RADIUS "Extended Type" code space per [RFC6929].

All of these attribute designs follow [RFC6158] and [RFC6929].

### 3.1. Softwire46-Configuration Attribute

This attribute is of type "TLV", as defined in the RADIUS Protocol Extensions [RFC6929]. It contains some sub-attributes, with the following requirements:
The Softwire46-Configuration Attribute MUST contain one or more of the following: S46-MAP-E TLV, S46-MAP-T TLV, and/or S46-Lightweight-4over6 TLV.

The Softwire46-Configuration Attribute conveys the configuration information for MAP-E, MAP-T, or Lightweight 4over6. The BNG SHALL use the configuration information returned in the RADIUS attribute to populate the DHCPv6 Softwire46 Container Option defined in Section 5 of [RFC7598].


The Softwire46-Configuration Attribute MAY appear in an Accounting-Request packet.

The Softwire46-Configuration Attribute MUST NOT appear in any other RADIUS packet.

The Softwire46-Configuration Attribute MUST only encapsulate one or more of the Softwire46 TLVs defined in this document.

The Softwire46-Configuration Attribute is structured as follows:
Type
   241 (To be confirmed by IANA).

Length
   Indicates the total length, in bytes, of all fields of
   this attribute, including the Type, Length, Extended-Type,
   and the entire length of the embedded TLVs.

Extended-Type
   TBD1

Value
   Contains one or more of the following TLVs. Each TLV type
   may appear at most once:

S46-MAP-E TLV
   For configuring MAP-E clients. For the construction of
   this TLV, Refer to Section 3.1.1.1.

S46-MAP-T TLV
   For configuring MAP-T clients. For the construction of
   this TLV, Refer to Section 3.1.1.2.

S46-Lightweight-4over6 TLV
   For configuring Lightweight 4over6 clients. For the
   construction of this TLV, Refer to Section 3.1.1.3.

The Softwire46-Configuration Attribute is associated with the
following identifier: 241.Extended-Type(TBD1).

3.1.1. Softwire46 TLVs

The Softwire46 TLVs can only be encapsulated in the
Softwire46-Configuration Attribute. Depending on the deployment
scenario, a client might request for more than one transition
mechanism at a time. There MUST be at least one Softwire46 TLV
encapsulated in one Softwire46-Configuration Attribute. There MUST
be at most one instance of each type of Softwire46 TLV encapsulated
in one Softwire46-Configuration Attribute.

There are three types of Softwire46 TLV, namely:
1. S46-MAP-E TLV (Section 3.1.1.1)

2. S46-MAP-T TLV (Section 3.1.1.2)

3. S46-Lightweight 4over6 TLV (Section 3.1.1.3)

Each type of Softwire46 TLV contains a number of sub-TLVs, defined in Section 3.1.3. The hierarchy of the Softwire46 TLVs is shown in Figure 1. Section 3.1.2 describes which Sub-TLVs are mandatory, optional, or not permitted for each defined Softwire46 TLV.
Figure 1: Softwire46 TLV Hierarchy

3.1.1.1. S46-MAP-E TLV Format

The format of the S46-MAP-E TLV is shown below:
The format of the S46-MAP-T TLV is shown below:
The format of the S46-Lightweight-4over6 TLV is shown below:
TLV-Type

TBD4

TLV-Length
One octet long. Indicates the length of this TLV, including the TLV-Type, TLV-Length, and TLV-Value fields.

TLV-Value
Contains a set of Sub-TLVs as follows:

It MUST contain the S46-BR Sub-TLV, defined in Section 3.1.3.2.

It MUST contain the S46-V4V6Bind Sub-TLV, defined in Section 3.1.3.4.

It MAY contain the S46-PORTPARAMS Sub-TLV, defined in Section 3.1.3.5.

3.1.2. Softwire46 Sub-TLVs

Table 2 shows which encapsulated Sub-TLVs are mandatory, optional, or not permitted for each defined Softwire46 TLV.

<table>
<thead>
<tr>
<th>Sub-TLV</th>
<th>MAP-E</th>
<th>MAP-T</th>
<th>Lightweight 4over6</th>
</tr>
</thead>
<tbody>
<tr>
<td>S46-BR</td>
<td>M</td>
<td>N/P</td>
<td>M</td>
</tr>
<tr>
<td>S46-Rule</td>
<td>M</td>
<td>M</td>
<td>N/P</td>
</tr>
<tr>
<td>S46-DMR</td>
<td>N/P</td>
<td>M</td>
<td>N/P</td>
</tr>
<tr>
<td>S46-V4V6Bind</td>
<td>N/P</td>
<td>N/P</td>
<td>M</td>
</tr>
<tr>
<td>S46-PORTPARAMS</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

M - Mandatory, O - Optional, N/P - Not Permitted

Table 2: Softwire46 Sub-TLVs
3.1.3. Format of the Softwire46 Sub-TLVs

3.1.3.1. S46-Rule Sub-TLV

The S46-Rule Sub-TLV can only be encapsulated in the S46-MAP-E TLV (Section 3.1.1.1) or the S46-MAP-T TLV (Section 3.1.1.2). Depending on the deployment scenario, one Basic Mapping Rule (BMR) and zero or more Forwarding Mapping Rules (RMRs) MUST be included in one S46-MAP-E TLV or S46-MAP-T TLV.

Each type of S46-Rule Sub-TLV also contains a number of Sub-TLVs, including Rule-IPv6-Prefix Sub-TLV, Rule-IPv4-Prefix Sub-TLV, and EA-Length Sub-TLV. The structure of the Sub-TLVs for the S46-Rule Sub-TLV is defined in Section 3.1.4.

Defining multiple TLV-types achieves the same design goals as the "S46 Rule Flags" defined in Section 4.1 of [RFC7598]. Using TLV-type set to 2 is equivalent to setting the F-flag in the OPTION_S46_RULE S46 Rule Flags field.
TLV-Type
   TBD7 Basic Mapping Rule only (not to be used for forwarding)
   TBD8 Forwarding Premitted Mapping Rule (may be used for
   forwarding. Can also be a Basic Mapping Rule)

TLV-Length
   One octet long. Indicates the length of this TLV, including
   the TLV-Type, TLV-Length, and TLV-Value fields.

TLV-Value
   This field contains a set of TLVs as follows:

   Rule-IPv6-Prefix Sub-TLV
   This TLV contains the IPv6 prefix for use in the MAP rule.
   Refer to Section 3.1.4.1.

   Rule-IPv4-Prefix Sub-TLV
   This TLV contains the IPv4 prefix for use in the MAP rule.
   Refer to Section 3.1.4.2.

   EA-Length Sub-TLV
   This TLV contains the Embedded-Address (EA) bit length.
   Refer to Section 3.1.4.1.

3.1.3.2. S46-BR Sub-TLV

   The S46-BR Sub-TLV can only be encapsulated in the S46-MAP-E TLV
   (Section 3.1.1.1) or S46-Lightweight-4over6 TLV (Section 3.1.1.3).

   There MUST be at least one S46-BR Sub-TLV included in each S46-MAP-E
   TLV or S46-Lightweight-4over6 TLV.

   The format of the S46-BR Sub-TLV is shown below:
3.1.3.3. S46-DMR Sub-TLV

The S46-DMR Sub-TLV may only appear in the S46-MAP-T TLV (Section 3.1.1.2). There MUST be exactly one S46-DMR Sub-TLV included in one S46-MAP-T TLV.

The format of the S46-DMR Sub-TLV is shown below:
3.1.3.4. S46-V4V6Bind Sub-TLV

The S46-V4V6Bind Sub-TLV may only be encapsulated in the S46-Lightweight-4over6 TLV (Section 3.1.1.3). There MUST be exactly one S46-V4V6Bind Sub-TLV included in each S46-Lightweight-4over6 TLV.

The format of the S46-V4V6Bind Sub-TLV is shown below:
TLV-Type
TBD11

TLV-Length
8-bits long. Indicates the length of this TLV, including the TLV-Type, TLV-Length, and TLV-Value fields.

TLV-Value
This field contains a set of Sub-TLVs as follows:

IPv4-address Sub-TLV
This TLV contains an IPv4 address, used to specify the full or shared IPv4 address of the CE. Refer to Section 3.1.5.1.

Bind-IPv6-Prefix Sub-TLV
This TLV contains an IPv6 prefix used to indicate which configured prefix the S46 CE should use for constructing the softwire. Refer to Section 3.1.5.2.

3.1.3.5. S46-PORTPARAMS Sub-TLV

The S46-PORTPARAMS Sub-TLV is optional. It is used to specify port set information for IPv4 address sharing between clients. The S46-PORTPARAMS Sub-TLV MAY be included in any of the Softwire46 TLVs.

The format of the S46-PORTPARAMS Sub-TLV is shown below:
TLV-Type
   TBD12

TLV-Length
   8-bits long. Indicates the length of this TLV, including
   the TLV-Type, TLV-Length, and TLV-Value fields.

TLV-Value
   This field contains a set of TLVs as follows:

   PSID-offset Sub-TLV
   This TLV specifies the numeric value for the S46 algorithm’s
   excluded port range/offset bits (a bits). Refer to
   Section 3.1.6.1.

   PSID-len Sub-TLV
   This TLV specifies the number of significant bits in the
   PSID field (also known as ‘k’). Refer to Section 3.1.6.2.

   PSID Sub-TLV
   This TLV specifies PSID value. Refer to Section 3.1.6.3.

3.1.4. Sub-TLVs for S46-Rule Sub-TLV

   There are two types of S46-Rule: the Basic Mapping Rule and the
   Forwarding Mapping Rule, indicated by the value in the TLV-Type field
   of the S46-Rule Sub-TLV (see Section 3.1.3.1).

   Each type of S46-Rule Sub-TLV also contains a number of Sub-TLVs as
   detailed in the following sub-sections.

3.1.4.1. Rule-IPv6-Prefix Sub-TLV

   The Rule-IPv6-Prefix Sub-TLV is REQUIRED for every S46-Rule Sub-TLV.
   There MUST be exactly one Rule-IPv6-Prefix Sub-TLV encapsulated in
   each type of S46-Rule Sub-TLV.

   The Rule-IPv6-Prefix Sub-TLV follows the framed IPv6 prefix designed
   in [RFC3162] and [RFC8044].

   The format of the Rule-IPv6-Prefix Sub-TLV is shown below:
TLV-Type
TBD13

TLV-Length
20

Reserved
This field is reserved. It is always set to zero. This field is one octet in length.

Ruleprefix6-len
The length of IPv6 prefix, specified in the rule-ipv6-prefix field, expressed in bits.

rule-ipv6-prefix
IPv6 Prefix. 128-bits long field that specifying an IPv6 prefix appearing in the MAP rule.

3.1.4.2. Rule-IPv4-Prefix Sub-TLV

This Sub-TLV is used to convey the MAP Rule IPv4 prefix. The format of the Rule-IPv4-Prefix Sub-TLV is shown below:
3.1.4.3.  EA-Length Sub-TLV

This Sub-TLV is used to convey the Embedded-Address (EA) bit length. The format of the EA-Length Sub-TLV is shown below:

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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  TLV-Type  |  TLV-Length  |     EA-len     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

TLV-Type
TBD15

TLV-Length
4

EA-len
16-bits long. Specifies the Embedded-Address (EA) bit length. Allowed values range from 0 to 48.
3.1.5. Sub-TLVs for S46-v4v6Bind Sub-TLV

3.1.5.1. The IPv4-address Sub-TLV

The IPv4-address Sub-TLV MAY be used to specify the full or shared IPv4 address of the CE.

The format of the IPv4-address Sub-TLV is shown below:

```
  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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   TLV-Type    |  TLV-Length   |            ipv4-address       .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
               ipv4-address        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

TLV-Type
TBD16

TLV-Length
6

ipv4-address
32-bits long. Specifies the IPv4 address to appear in the
S46-V4V6Bind Sub-TLV (Section 3.1.3.4).
```

3.1.5.2. The Bind-IPv6-Prefix Sub-TLV

The Bind-IPv6-Prefix Sub-TLV is used by the CE to identify the correct IPv6 prefix to be used as the tunnel source.

The format of the Bind-IPv6-Prefix Sub-TLV is shown below:
TLV-Type
TBD17

TLV-Length
4 + length of bind-ipv6-prefix specified in octets

Reserved
8-bits long. This field is reserved and is always set to zero.

bindprefix6-len
8-bits long. Expresses the bitmask length of the IPv6 prefix specified in the bind-ipv6-prefix field. Allowed values range from 0 to 128.

bind-ipv6-prefix
IPv6 prefix. A variable-length field specifying the IPv6 prefix or address for the S46 CE. This field is right-padded with zeros to the nearest octet boundary when bindprefix6-len is not divisible by 8.

3.1.6. Sub-TLVs for S46-PORTPARAMS Sub-TLV

3.1.6.1. The PSID-offset Sub-TLV

This Sub-TLV is used to convey the Port Set Identifier offset as defined in [RFC7597].

The format of the PSID-offset Sub-TLV is shown below:
3.1.6.2. The PSID-len Sub-TLV

This Sub-TLV is used to convey the PSID length as defined in [RFC7597].

The format of the PSID-len Sub-TLV is shown below:

```
0                   1                   2
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    TLV-Type   |   TLV-Length  |    PSID-len   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV-Type
TBD19

TLV-Length
3

PSID-len

8-bits long field specifying the number of significant bits in the PSID field (also known as 'k'). When set to 0, the PSID field is to be ignored. After the first ‘a’ bits, there are k bits in the port number representing the value of the PSID. Subsequently, the address sharing ratio would be $2^k$. 

Integer. An 8-bits long field that specifies the numeric value for the S46 algorithm’s excluded port range/offset bits (a bits), as per Section 5.1 of RFC7597. Allowed values are between 0 and 15. Default values for this field are specific to the Softwire mechanism being implemented and are defined in the relevant specification document.
3.1.6.3. The PSID Sub-TLV

This Sub-TLV is used to convey the PSID as defined in [RFC7597].

The format of the PSID Sub-TLV is shown below:

```
+-----------------------------+-----------------------------+-----------------------------+
| TLV-Type | TLV-Length | PSID                      |
+-----------------------------+-----------------------------+-----------------------------+
```

- **TLV-Type**: TBD20
- **TLV-Length**: 4
- **PSID (Port-set ID)**: Integer. An explicit 16-bit (unsigned word) PSID value. The PSID value algorithmically identifies a set of ports assigned to a CE. The first k bits on the left of this 2-octet field is the PSID value. The remaining (16-k) bits on the right are padding zeros.

3.2. Softwire46-Priority Attribute

The Softwire46-Priority Attribute defines a 16-bit S46-option-code field to contain the information allowing the client to prioritize which mechanism to use, corresponding to OPTION_S46_PRIORITY defined in [RFC8026]. The following requirements apply:

- The Softwire46-Priority Attribute MAY appear in a CoA-Request packet.
- The Softwire46-Priority Attribute MAY appear in an Accounting-Request packet.
- The Softwire46-Priority Attribute MUST NOT appear in any other RADIUS packet.

The S46-Priority Attribute is structured as follows:
Type
241 (To be confirmed by IANA)

Length
One octet long. Indicates the length of this TLV, including
the TLV-Type, TLV-Length, and TLV-Value fields.

Extended-Type
TBD5

S46-option-code
Integer. A 16-bit IANA-registered option code representing
an S46 mechanism. The option codes and their corresponding
S46 mechanisms are listed in Section 7.3.

S46 mechanisms are prioritized in the appearance order of the
S46-option-code(s) in the Softwire46-Priority Attribute.

A Softwire46-Priority Attribute MUST contain at least one
S46-option-code.

The Softwire46-Priority Attribute is associated with the following
identifier: 241.Extended-Type (TBD5).

3.3. Softwire46-Multicast Attribute

The Softwire46-Multicast Attribute conveys the IPv6 prefixes to be
used to synthesize multicast and unicast IPv4-embedded IPv6 addresses
as per [RFC8114]. This attribute is of type "TLV" and contains
additional TLVs. The following requirements apply:

The BNG SHALL use the IPv6 prefixes returned in the RADIUS
Softwire46-Multicast Attribute to populate the DHCPv6 PREFIX64
Option [RFC8115].

This attribute MAY be used in Access-Request packets as a hint to
the RADIUS server. For example, if the BNG is pre-configured for
Softwire46-Multicast, these prefixes MAY be inserted in the
attribute. The RADIUS server MAY ignore the hint sent by the BNG,
and it MAY assign a different Softwire46-Multicast Attribute.


The Softwire46-Multicast Attribute MAY appear in an Accounting-Request packet.

The Softwire46-Multicast Attribute MUST NOT appear in any other RADIUS packet.

The Softwire46-Multicast Attribute MAY contain the ASM-Prefix64 TLV (see Section 3.3.1).

The Softwire46-Multicast Attribute MAY contain the SSM-Prefix64 TLV (see Section 3.3.2).

The Softwire46-Multicast Attribute MAY contain the U-Prefix64 TLV (see Section 3.3.3).

The Softwire46-Multicast Attribute MUST include the ASM-Prefix64 TLV or the SSM-Prefix64 TLV, and it MAY include both.

The U-Prefix64 TLV MUST be present when the SSM-Prefix64 TLV is present. The U-Prefix64 TLV MAY be present when the ASM-Prefix64 TLV is present.

The Softwire46-Multicast Attribute is structured as follows:
The Softwire46-Multicast Attribute is associated with the following identifier: 241.Extended-Type(TBD6).

3.3.1.  ASM-Prefix64 TLV

The ASM-Prefix64 TLV is structured as follows:
### TLV-Type

- **TBD21**

### Reserved

This field is reserved. It is always set to zero. This field is one octet in length.

### Prefix-Length

The length of the prefix, in bits. It MUST be set to 96 [RFC8115].

### ASM Prefix64

IPv6 prefix. This field specifies the IPv6 multicast prefix to be used to synthesize the IPv4-embedded IPv6 addresses of the multicast groups in the ASM mode. The conveyed multicast IPv6 prefix MUST belong to the ASM range.

**3.3.2. SSM-Prefix64 TLV**

The format of SSM-Prefix64 TLV is shown below:
### TLV-Type

<table>
<thead>
<tr>
<th>TLV-Type</th>
<th>Reserved</th>
<th>Prefix-Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBD22</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Reserved

This field is reserved. It is always set to zero. This field is one octet in length.

### Prefix-Length

The length of the prefix, in bits. It MUST be set to 96 [RFC8115].

### SSM Prefix64

IPv6 prefix. This field specifies the IPv6 multicast prefix to be used to synthesize the IPv4-embedded IPv6 addresses of the multicast groups in the SSM mode. The conveyed multicast IPv6 prefix MUST belong to the SSM range.

#### 3.3.3. U-Prefix64 TLV

The format of the U-Prefix64 TLV is shown below:
TLV-Type
TBD23

Reserved
This field is reserved. It is always set to zero. This field is one octet in length.

Prefix-Length
The length of the prefix, in bits. As specified in [RFC6052], the Unicast-prefix prefix-length MUST be set to 32, 40, 48, 56, 64, or 96.

Unicast Prefix64
IPv6 prefix. This field identifies the IPv6 unicast prefix to be used in SSM mode for constructing the IPv4-embedded IPv6 addresses representing the IPv4 multicast sources in the IPv6 domain. It may also be used to extract the IPv4 address from the received multicast data flows.

4. A Sample Configuration Process with RADIUS

Figure 2 illustrates how the RADIUS and DHCPv6 protocols interwork to provide CE with softwire configuration information.
### Figure 2: Interaction between DHCPv6 and AAA Server with RADIUS authentication

1. The CE creates a DHCPv6 Solicit message. For unicast softwire configuration, the message includes an OPTION_REQUEST_OPTION (6) with the S46 Container option codes as defined in [RFC7598]. OPTION_S46_CONT_MAPE (94) should be included for MAP-E, OPTION_S46_CONT_MAPT (95) for MAP-T, and OPTION_S46_CONT_LW (96) for Lightweight 4over6. For multicast configuration, the option number for OPTION_V6_PREFIX64 (113) is included in the client’s ORO. The message is sent to the BNG.

2. On receipt of the Solicit message, the BNG constructs a RADIUS Access-Request message containing a User-Name Attribute (1) (containing either a CE MAC address, interface-id or both), a User-Password Attribute (2) (with a pre-configured shared password as defined in [RFC2865]). The Softwire46-Configuration Attribute and/or Softwire46-Multicast Attribute are also included (as requested by the client). The resulting message is sent to the AAA server.
3. The AAA server authenticates the request. If this is successful, and suitable configuration is available, an Access-Accept message is sent to the BNG containing the requested Softwire46-Configuration Attribute or Softwire46-Multicast Attribute.

4. The BNG maps the received softwire configuration into the corresponding fields in the DHCPv6 softwire configuration option(s). These are included in the DHCPv6 Advertise message which is sent to the CE.

5. The CE sends a DHCPv6 Request message. In the ORO, the option code(s) of any of the required softwire options that were received in the Advertise message are included.

6. The BNG sends a Reply message to the client containing the softwire container options enumerated in the ORO.

The authorization operation could also be done independently, after the authentication process. In this case, steps 1-5 are completed as above, then the following steps are performed:

6a. When the BNG receives the DHCPv6 Request, it constructs a RADIUS Access-Request message, which contains a Service-Type Attribute (6) with the value "Authorize Only" (17), the corresponding Softwire46-Configuration Attribute, and a State Attribute obtained from the previous authentication process according to [RFC5080]. The resulting message is sent to the AAA server.

7a. The AAA checks the authorization request. If it is approved, an Access-Accept message is returned to the BNG with the corresponding Softwire46-Configuration Attribute.

8a. The BNG sends a Reply message to the client containing the softwire container options enumerated in the ORO.

In addition to the above, the following points need to be considered:

- In both the configuration message flows described above the Message-authenticator (type 80) [RFC2869] SHOULD be used to protect both Access-Request and Access-Accept messages.

- If the BNG does not receive the corresponding Softwire46-Configuration Attribute in the Access-Accept message it MAY fallback to creating the DHCPv6 softwire configuration options using pre-configured S46 configuration, if this is present.
If the BNG receives an Access-Reject from the AAA server, then S46 configuration MUST NOT be supplied to the client.

As specified in [RFC3315], Section 18.1.4, "Creation and Transmission of Rebind Messages", if the DHCPv6 server to which the DHCPv6 Renew message was sent at time T1 has not responded by time T2, the CE (DHCPv6 client) SHOULD enter the Rebind state and attempt to contact any available server. In this situation, a secondary BNG receiving the DHCPv6 message MUST initiate a new Access-Request message towards the AAA server. The secondary BNG includes the Softwire46-Configuration Attribute in this Access-Request message.

For Lightweight 4over6, the subscriber’s binding state needs to be synchronized between the clients and the lwAFTR/BR. This can be achieved in two ways: static pre-configuring of the bindings on both the AAA server and lwAFTR, or on-demand whereby the AAA server updates the lwAFTR with the subscriber’s binding state as it is created or deleted.

5. Table of Attributes

This document specifies three new RADIUS attributes, and their formats are as follows:

- **Softwire46-Configuration Attribute**: 241.TBD1
- **Softwire46-Priority Attribute**: 241.TBD5
- **Softwire46-Multicast Attribute**: 241.TBD6

The following table describes which attributes may be found, in which kinds of packets and in what quantity.

<table>
<thead>
<tr>
<th>Request</th>
<th>Accept</th>
<th>Reject</th>
<th>Challenge</th>
<th>Accounting</th>
<th>#</th>
<th>Attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>0-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0-1</td>
<td>241.TBD1 Softwire46-Configuration</td>
</tr>
<tr>
<td>0-1</td>
<td>0-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0-1</td>
<td>241.TBD5 Softwire46-Priority</td>
</tr>
<tr>
<td>0-1</td>
<td>0-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0-1</td>
<td>241.TBD6 Softwire46-Multicast</td>
</tr>
</tbody>
</table>

The following table defines the meaning of the above table entries.
0     This attribute MUST NOT be present in packet.
0+    Zero or more instances of this attribute MAY be present in packet.
0-1   Zero or one instance of this attribute MAY be present in packet.
1     Exactly one instance of this attribute MUST be present in packet.

6. Security Considerations

Known security vulnerabilities of the RADIUS protocol are discussed in [RFC2607], [RFC2865], and [RFC2869]. Use of IPsec [RFC4301] for providing security when RADIUS is carried in IPv6 is discussed in [RFC3162].

Specific security considerations for interactions between the MAP CE and the BNG are discussed in [RFC7597] and [RFC7599]. Security considerations for Lightweight 4over6 are discussed in [RFC7596]. Security considerations for DHCPv6-Based S46 Prioritization Mechanism are discussed in [RFC8026]. Security considerations for multicast scenarios are discussed in [RFC 8114]. Furthermore, generic DHCPv6 security mechanisms can be applied to DHCPv6 intercommunication between the CE and the BNG.

7. IANA Considerations

IANA is requested to make new code point assignments for RADIUS attributes as described in the following subsections.

7.1. New RADIUS Attributes

This document requests IANA to assign the Attribute Types defined in this document from the RADIUS namespace as described in the "IANA Considerations" section of [RFC3575], in accordance with BCP 26 [RFC5226].

This document requests that IANA register three new RADIUS attributes, from the "Short Extended Space" of [RFC6929]. The attributes are: Softwire46-Configuration Attribute, Softwire46-Priority Attribute, and Softwire46-Multicast Attribute:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Data Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>241.TBD1</td>
<td>Softwire46-Configuration</td>
<td>TLV</td>
<td>Section 4.1</td>
</tr>
<tr>
<td>241.TBD5</td>
<td>Softwire46-Priority</td>
<td>integer</td>
<td>Section 4.2</td>
</tr>
<tr>
<td>241.TBD6</td>
<td>Softwire46-Multicast</td>
<td>TLV</td>
<td>Section 4.3</td>
</tr>
</tbody>
</table>
7.2. New RADIUS TLVs

IANA is requested to create a new registry called "RADIUS Softwire46 Configuration and Multicast TLVs".

All TLVs in this registry have one or more parent RADIUS attributes in nesting (refer to [RFC6929]).

This registry must be initially populated with the following values:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
<th>Data Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Reserved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBD2</td>
<td>S46-MAP-E</td>
<td>TLV</td>
<td>Section 3.1.1.1</td>
</tr>
<tr>
<td>TBD3</td>
<td>S46-MAP-T</td>
<td>TLV</td>
<td>Section 3.1.1.2</td>
</tr>
<tr>
<td>TBD4</td>
<td>S46-Lightweight-4over6</td>
<td>TLV</td>
<td>Section 3.1.1.3</td>
</tr>
<tr>
<td>TBD7</td>
<td>S46-Rule</td>
<td>TLV</td>
<td>Section 3.1.3.1</td>
</tr>
<tr>
<td>TBD8</td>
<td>S46-Rule</td>
<td>TLV</td>
<td>Section 3.1.3.1</td>
</tr>
<tr>
<td>TBD9</td>
<td>S46-BR</td>
<td>ipv6addr</td>
<td>Section 3.1.3.2</td>
</tr>
<tr>
<td>TBD10</td>
<td>S46-DMR</td>
<td>ipv6prefix</td>
<td>Section 3.1.3.3</td>
</tr>
<tr>
<td>TBD11</td>
<td>S46-V4V6Bind</td>
<td>TLV</td>
<td>Section 3.1.3.4</td>
</tr>
<tr>
<td>TBD12</td>
<td>S46-PORTPARAMS</td>
<td>TLV</td>
<td>Section 3.1.3.5</td>
</tr>
<tr>
<td>TBD13</td>
<td>Rule-IPv6-Prefix</td>
<td>ipv6prefix</td>
<td>Section 3.1.4.1</td>
</tr>
<tr>
<td>TBD14</td>
<td>Rule-IPv4-Prefix</td>
<td>ipv4prefix</td>
<td>Section 3.1.4.2</td>
</tr>
<tr>
<td>TBD15</td>
<td>EA-Length</td>
<td>integer</td>
<td>Section 3.1.4.3</td>
</tr>
<tr>
<td>TBD16</td>
<td>IPv4-address</td>
<td>ipv4addr</td>
<td>Section 3.1.5.1</td>
</tr>
<tr>
<td>TBD17</td>
<td>Bind-IPv6-Prefix</td>
<td>ipv6prefix</td>
<td>Section 3.1.5.2</td>
</tr>
<tr>
<td>TBD18</td>
<td>PSID-offset</td>
<td>integer</td>
<td>Section 3.1.6.1</td>
</tr>
<tr>
<td>TBD19</td>
<td>PSID-len</td>
<td>integer</td>
<td>Section 3.1.6.2</td>
</tr>
<tr>
<td>TBD20</td>
<td>PSID</td>
<td>integer</td>
<td>Section 3.1.6.3</td>
</tr>
<tr>
<td>TBD21</td>
<td>ASM-Prefix64</td>
<td>ipv6prefix</td>
<td>Section 3.3.1</td>
</tr>
<tr>
<td>TBD22</td>
<td>SSM-Prefix64</td>
<td>ipv6prefix</td>
<td>Section 3.3.2</td>
</tr>
<tr>
<td>TBD23</td>
<td>U-Prefix64</td>
<td>ipv6prefix</td>
<td>Section 3.3.3</td>
</tr>
<tr>
<td>21-255</td>
<td>Unassigned, TBD2, TBD3, TBD4 will be assigned by IANA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The registration procedure for this registry is Standards Action as defined in [RFC5226]. The registry may be added to using the IETF Review process described in Section 4.1 of [RFC5226].

7.3. S46 Mechanisms and Their Identifying Option Codes

The Softwire46-Priority Attribute defines a 16-bit S46-option-code field, for which IANA is requested to create and maintain a new registry entitled "Option Codes Permitted in the Softwire46-Priority Attribute". The registration procedure for this registry is Standards Action as defined in [RFC5226].
This document requires IANA to register the three option codes of the Softwire46 mechanisms permitted to be included in the Softwire46-Priority Attribute. The value of option code corresponds to the TLV-Type defined in the Section 3.1.1. Additional options may be added to this list in the future using the IETF Review process described in Section 4.1 of [RFC5226].

Table 3. shows the option codes required, and the S46 mechanisms that they represent. The option code for DS-Lite is derived from the IANA allocated RADIUS Attribute Type value for DS-Lite [RFC6519]. The option codes for MAP-E, MAP-T, and Lightweight 4over6 need to be assigned. The option codes for MAP-E, MAP-T, and Lightweight 4over6 should also be used as the TLV-Type values for the MAP-E, MAP-T, and Lightweight 4over6 TLV defined in Section 3.1.1.

<table>
<thead>
<tr>
<th>Option Code</th>
<th>S46 Mechanism</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBD2</td>
<td>MAP-E</td>
<td>RFC7597</td>
</tr>
<tr>
<td>TBD3</td>
<td>MAP-T</td>
<td>RFC7599</td>
</tr>
<tr>
<td>TBD4</td>
<td>Lightweight 4over6</td>
<td>RFC7596</td>
</tr>
<tr>
<td>144</td>
<td>DS-Lite</td>
<td>RFC6519</td>
</tr>
</tbody>
</table>

Table 3: Option Codes to S46 Mechanisms

8. Contributing Authors
9. Acknowledgements

The authors would like to thank the valuable comments made by Peter Lothberg, Wojciech Dec, Ian Farrer, Suresh Krishnan, Qian Wang, Wei Meng and Cui Wang for this document. This document was merged with draft-sun-softwire-lw4over6-radext-01 and draft-wang-radext-
multicast-radius-ext-00, thanks to everyone who contributed to this document.

This document was produced using the xml2rfc tool [RFC7991].

10. References

10.1. Normative References


10.2. Informative References


### Appendix A. DHCPv6 to RADIUS Field Mappings

The following sections detail the mappings between the softwire DHCPv6 option fields and the relevant RADIUS attributes, TLVs and Sub-TLVs as defined in this document.

#### A.1. OPTION_S46_RULE (89) to S46-Rule Sub-TLV Field Mappings

<table>
<thead>
<tr>
<th>OPTION_S46_RULE Field</th>
<th>S46-Rule Sub-TLV Name</th>
<th>TLV Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>flags</td>
<td>N/A</td>
<td>TLV-type (TBD7, TBD8)</td>
</tr>
<tr>
<td>ea-len</td>
<td>EA-Length</td>
<td>EA-len</td>
</tr>
<tr>
<td>prefix4-len</td>
<td>Rule-IPv4-Prefix</td>
<td>ruleprefix4-len</td>
</tr>
<tr>
<td>ipv4-prefix</td>
<td>Rule-IPv4-Prefix</td>
<td>rule-ipv4-prefix</td>
</tr>
<tr>
<td>prefix6-len</td>
<td>Rule-IPv6-Prefix</td>
<td>ruleprefix6-len</td>
</tr>
<tr>
<td>ipv6-prefix</td>
<td>Rule-IPv6-Prefix</td>
<td>rule-ipv6-prefix</td>
</tr>
</tbody>
</table>

#### A.2. OPTION_S46_BR (90) to S46-BR Sub-TLV Sub-TLV Field Mappings

<table>
<thead>
<tr>
<th>OPTION_S46_BR Field</th>
<th>S46-BR Sub-TLV Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>br-ipv6-address</td>
<td>br-ipv6-address</td>
</tr>
</tbody>
</table>

#### A.3. OPTION_S46_DMR (91) to S46-DMR Sub-TLV

<table>
<thead>
<tr>
<th>OPTION_S46_BR Field</th>
<th>S46-DMR Sub-TLV Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>dmr-prefix6-len</td>
<td>dmr-prefix6-len</td>
</tr>
<tr>
<td>dmr-ipv6-prefix</td>
<td>dmr-ipv6-prefix</td>
</tr>
</tbody>
</table>

#### A.4. OPTION_S46_V4V6BIND (92) to S46-V4V6Bind Sub-TLV

<table>
<thead>
<tr>
<th>OPTION_S46_V4V6BIND Field</th>
<th>S46-V4V6Bind Sub-TLV Name</th>
<th>TLV Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>ipv4-address</td>
<td>IPv4-address</td>
<td>ipv4-address</td>
</tr>
<tr>
<td>bindprefix6-len</td>
<td>Bind-IPv6-Prefix</td>
<td>bind6prefix-len</td>
</tr>
<tr>
<td>bind-ipv6-prefix</td>
<td>Bind-IPv6-Prefix</td>
<td>bind-ipv6-prefix</td>
</tr>
</tbody>
</table>
### A.5. OPTION_S46_PORTPARAMS (93) to S46-PORTPARAMS Sub-TLV Field Mappings

<table>
<thead>
<tr>
<th>OPTION_S46_PORTPARAMS Field</th>
<th>S46-PORTPARAMS Sub-TLV Name</th>
<th>TLV Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>offset</td>
<td>PSID-offset</td>
<td>PSID-Offset</td>
</tr>
<tr>
<td>PSID-len</td>
<td>PSID-len</td>
<td>PSID-len</td>
</tr>
<tr>
<td>PSID</td>
<td>PSID</td>
<td>PSID</td>
</tr>
</tbody>
</table>

### A.6. OPTION_S46_PRIORITY (111) to S46-PORTPARAMS Sub-TLV Field Mappings

<table>
<thead>
<tr>
<th>OPTION_S46_PRIORITY Field</th>
<th>Softwire46-Priority Attribute Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>s46-option-code</td>
<td>S46-option-code</td>
</tr>
</tbody>
</table>

### A.7. OPTION_V6_PREFIX64 (113) to Softwire46-Multicast Attribute TLV Field Mappings

<table>
<thead>
<tr>
<th>OPTION_V6_PREFIX64 Field</th>
<th>Softwire46-Multicast Attribute TLV Name</th>
<th>TLV Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>asm-length</td>
<td>ASM-Prefix64</td>
<td>Prefix-Length</td>
</tr>
<tr>
<td>ASM_mPrefix64</td>
<td>ASM-Prefix64</td>
<td>ASM Prefix64</td>
</tr>
<tr>
<td>ssm-length</td>
<td>SSM-Prefix64</td>
<td>Prefix-Length</td>
</tr>
<tr>
<td>SSM_mPrefix64</td>
<td>SSM-Prefix64</td>
<td>SSM Prefix64</td>
</tr>
<tr>
<td>unicast-length</td>
<td>U-Prefix64</td>
<td>Prefix-Length</td>
</tr>
<tr>
<td>uPrefix64</td>
<td>U-Prefix64</td>
<td>Unicast Prefix64</td>
</tr>
</tbody>
</table>

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