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

time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on December 16, 2019.

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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 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 so that they can be provided to CEs using the existing DHCPv6 options.

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 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. For detailed mappings between each DHCPv6 option field and the corresponding RADIUS Attribute or field, see Appendix A.

DHCPv6 Option	RADIUS Attribute
OPTION_S46_RULE (89)	Softwire46-Rule
OPTION_S46_BR (90)	Softwire46-BR
OPTION_S46_DMR (91)	Softwire46-DMR
OPTION_S46_V4V6BIND (92)	Softwire46-V4V6Bind
OPTION_S46_PORTPARAMS (93)	Softwire46-PORTPARAMS
OPTION_S46_PRIORITY (111)	Softwire46-Priority
OPTION_V6_PREFIX64 (113)	Softwire46-Multicast

Table 1: Mapping between DHCPv6 Options and RADIUS Attributes

A RADIUS attribute for Dual-Stack Lite [RFC6333] is defined in [RFC6519].

This document targets deployments where a trusted relationship is in place between the RADIUS client and server.

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 BCP 14 [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].

Softwire46 (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:

- BNG: Broadband Network Gateway
- BR: Border Relay
- CE: Customer Edge
- DMR: Default Mapping Rule
- lwAFTR: Lightweight AFTR

- PSID: Port Set Identifier
- TLV: Type, Length, Value
- MAP-E: Mapping of Address and Port with Encapsulation
- MAP-T: Mapping of Address and Port using Translation

3. New RADIUS Attributes

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 Softwire46 mechanism is carried in the corresponding Softwire46 attributes. Different attributes are required for each Softwire46 mechanism.

2. Softwire46-Priority Attribute (Section 3.2):

   Depending on the deployment scenario, a client may support several different Softwire46 mechanisms. Therefore, a client may request configuration for more than one Softwire46 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].

This document adheres to [RFC8044] for defining the new RADIUS attributes.

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 attributes: Softwire46-MAP-E, Softwire46-MAP-T, and/or Softwire46-Lightweight-4over6.

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(s) defined in Section 5 of [RFC7598].

The Softwire46-Configuration Attribute MAY appear in an Access-Accept packet. It MAY also appear in an Access-Request packet to indicate a preferred Softwire46 configuration. However, the server is not required to honor such a preference.

The Softwire46-Configuration Attribute MAY appear in a CoA-Request packet.

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 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 attributes.

Extended-Type
TBD1

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

Softwire46-MAP-E
For configuring MAP-E clients. For the construction of this attribute, refer to Section 3.1.1.1.

Softwire46-MAP-T
For configuring MAP-T clients. For the construction of this attribute, refer to Section 3.1.1.2.

Softwire46-Lightweight-4over6
For configuring Lightweight 4over6 clients. For the construction of this attribute, 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 Attributes

The Softwire46 attributes 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 attribute encapsulated in one Softwire46-Configuration Attribute. There MUST be at most one instance of each type of Softwire46 attribute encapsulated in one Softwire46-Configuration Attribute.

There are three types of Softwire46 attributes, namely:

1. Softwire46-MAP-E (Section 3.1.1.1)

2. Softwire46-MAP-T (Section 3.1.1.2)

3. Softwire46-Lightweight 4over6 (Section 3.1.1.3)

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

Figure 1: Softwire46 Attributes Hierarchy

3.1.1.1. Softwire46-MAP-E Attribute

Softwire46-MAP-E attribute is designed for carrying the configuration information for MAP-E. The structure of Softwire46-MAP-E is shown below:

TLV-Type
1

TLV-Length
Indicates the length of this attribute, including the TLV-Type, TLV-Length, and TLV-Value fields.

TLV-Value
Contains a set of sub-attributes, with the following requirements:

It MUST contain Softwire46-Rule, defined in Section 3.1.3.1.

It MUST contain Softwire46-BR, defined in Section 3.1.3.2.

It MAY contain Softwire46-PORTPARAMS, defined in Section 3.1.3.5.

3.1.1.2. Softwire46-MAP-T Attribute

Softwire46-MAP-T attribute is designed for carrying the configuration information for MAP-T. The structure of Softwire46-MAP-T is shown below:

TLV-Type
2

TLV-Length
Indicates the length of this attribute, including the TLV-Type, TLV-Length, and TLV-Value fields.

TLV-Value
Contains a set of sub-attributes, with the following requirements:

It MUST contain Softwire46-Rule, defined in Section 3.1.3.1.

It MUST contain Softwire46-DMR, defined in Section 3.1.3.3.

It MAY contain Softwire46-PORTPARAMS, defined in Section 3.1.3.5.

3.1.1.3. Softwire46-Lightweight-4over6 Attribute

Softwire46-Lightweight-4over6 attribute is designed for carrying the configuration information for Lightweight 4over6. The structure of Softwire46-Lightweight-4over6 is shown below:

TLV-Type
3

TLV-Length
Indicates the length of this attribute, including the TLV-Type, TLV-Length, and TLV-Value fields.

TLV-Value
Contains a set of sub-attributes as follows:

It MUST contain Softwire46-BR, defined in Section 3.1.3.2.

It MUST contain Softwire46-V4V6Bind, defined in Section 3.1.3.4.

It MAY contain Softwire46-PORTPARAMS, defined in Section 3.1.3.5.

3.1.2. Softwire46 Sub-Attributes

Table 2 shows which encapsulated sub-attributes are mandatory, optional, or not permitted for each defined Softwire46 attribute.

Sub-Attributes	MAP-E	MAP-T	Lightweight 4over6
Softwire46-BR	1+	0	1+
Softwire46-Rule	1	1	0
Softwire46-DMR	0	1	0
Softwire46-V4V6Bind	0	0	1
Softwire46-PORTPARAMS	0-1	0-1	0-1

Table 2: Softwire46 Sub-Attributes

The following table defines the meaning of Table 2 entries.

0	Not Permitted
0-1	Optional, zero or one instance of the attribute may be present.
1	Mandatory, only one instance of the attribute must be present.
1+	Mandatory, one or more instances of the attribute may be present.

3.1.3. Specification of the Softwire46 Sub-Attributes

3.1.3.1. Softwire46-Rule Attribute

Softwire46-Rule can only be encapsulated in Softwire46-MAP-E (Section 3.1.1.1) or Softwire46-MAP-T (Section 3.1.1.2). Depending on the deployment scenario, one Basic Mapping Rule (BMR) and zero or more Forwarding Mapping Rules (FMRs) MUST be included in one Softwire46-MAP-E or Softwire46-MAP-T.

Each type of Softwire46-Rule also contains a number of sub-attributes, including Rule-IPv6-Prefix, Rule-IPv4-Prefix, and EA-Length. The structure of the sub-attributes for Softwire46-Rule is defined in Section 3.1.4.

Defining multiple TLV-types achieves the same design goals as the "Softwire46 Rule Flags" defined in Section 4.1 of [RFC7598]. Using TLV-type set to 5 is equivalent to setting the F-flag in the OPTION_S46_RULE S46 Rule Flags field.

TLV-Type
4 Basic Mapping Rule only (not to be used for forwarding)
5 Forwarding Permitted Mapping Rule

TLV-Length
Indicates the length of this attribute, including the TLV-Type, TLV-Length, and TLV-Value fields.

Data Type
The attribute Softwire46-Rule is of type tlv (Section 3.13 of [RFC8044]).

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

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

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

EA-Length
This attribute contains the Embedded-Address (EA) bit length. Refer to Section 3.1.4.3.

3.1.3.2. Softwire46-BR Attribute

Softwire46-BR can only be encapsulated in Softwire46-MAP-E (Section 3.1.1.1) or Softwire46-Lightweight-4over6 (Section 3.1.1.3).

There MUST be at least one Softwire46-BR included in each Softwire46-MAP-E or Softwire46-Lightweight-4over6.

The structure of Softwire46-BR is shown below:

TLV-Type
6

TLV-Length
18 octets

Data Type
The attribute Softwire46-BR is of type ip6addr (Section 3.9 of [RFC8044]).

TLV-Value
br-ipv6-address. A fixed-length field of 16 octets that specifies the IPv6 address for the Softwire46 Border Relay (BR).

3.1.3.3. Softwire46-DMR Attribute

Softwire46-DMR may only appear in Softwire46-MAP-T (Section 3.1.1.2). There MUST be exactly one Softwire46-DMR included in one Softwire46-MAP-T.

The structure of Softwire46-DMR is shown below:

TLV-Type
7

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

Data Type
The attribute Softwire46-DMR is of type ipv6pref (Section 3.10 of [RFC8044]).

TLV-Value
A variable-length (dmr-prefix6-len) field specifying the IPv6 prefix (dmr-ipv6-prefix) for the BR. This field is right-padded with zeros to the nearest octet boundary when dmr-prefix6-len is not divisible by 8. Prefixes with length from 0 to 96 are allowed.

3.1.3.4. Softwire46-V4V6Bind Attribute

Softwire46-V4V6Bind may only be encapsulated in Softwire46-Lightweight-4over6 (Section 3.1.1.3). There MUST be exactly one Softwire46-V4V6Bind included in each Softwire46-Lightweight-4over6.

The structure of Softwire46-V4V6Bind is shown below:

TLV-Type
8

TLV-Length
Indicates the length of this attribute, including the TLV-Type, TLV-Length, and TLV-Value fields.

Data Type
The attribute Softwire46-V4V6Bind is of type tlv (Section 3.13 of [RFC8044]).

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

IPv4-Address
This attribute 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
This attribute contains an IPv6 prefix used to indicate which configured prefix the Softwire46 CE should use for constructing the softwire. Refer to Section 3.1.5.2.

3.1.3.5. Softwire46-PORTPARAMS Attribute

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

The structure of Softwire46-PORTPARAMS is shown below:

TLV-Type
9

TLV-Length
Indicates the length of this attribute, including the TLV-Type, TLV-Length, and TLV-Value fields.

Data Type
The attribute Softwire46-PORTPARAMS is of type tlv (Section 3.13 of [RFC8044]).

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

PSID-Offset
This attribute specifies the numeric value for the Softwire46 algorithm's excluded port range/offset bits (a bits). Refer to Section 3.1.6.1.

PSID-Len
This attribute specifies the number of significant bits in the PSID field (also known as 'k'). Refer to Section 3.1.6.2.

PSID
This attribute specifies PSID value. Refer to Section 3.1.6.3.

3.1.4. Sub-Attributes for Sofwtire46-Rule

There are two types of Softwire46-Rule: the Basic Mapping Rule and the Forwarding Mapping Rule, indicated by the value in the TLV-Type field of Softwire46-Rule (Section 3.1.3.1).

Each type of Softwire46-Rule also contains a number of Sub-attributes as detailed in the following sub-sections.

3.1.4.1. Rule-IPv6-Prefix Attribute

Rule-IPv6-Prefix is REQUIRED for every Softwire46-Rule. There MUST be exactly one Rule-IPv6-Prefix encapsulated in each type of Softwire46-Rule.

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

The structure of Rule-IPv6-Prefix is shown below:

TLV-Type
10

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

Data Type
The attribute Rule-IPv6-Prefix is of type ipv6pref (Section 3.10 of [RFC8044]).

TLV-Value
A variable-length field that specifies an IPv6 prefix (rule-ipv6-prefix) appearing in the MAP rule.

3.1.4.2. Rule-IPv4-Prefix Attribute

This attribute is used to convey the MAP Rule IPv4 prefix. The structure of Rule-IPv4-Prefix is shown below:

TLV-Type
11

TLV-Length
4 + length of rule-ipv4-prefix specified in octets.

Data Type
The attribute Rule-IPv4-Prefix is of type ipv4pref (Section 3.11 of [RFC8044]).

TLV-Value
A variable-length field that specifies an IPv4 prefix (rule-ipv4-prefix) appearing in the MAP rule.

3.1.4.3. EA-Length Attribute

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

TLV-Type
12

TLV-Length
6 octets

Data Type
The attribute EA-Length is of type integer (Section 3.1 of [RFC8044]).

TLV-Value
EA-len; 32-bits long. Specifies the Embedded-Address (EA) bit length. Allowed values range from 0 to 48.

3.1.5. Attributes for Softwire46-v4v6Bind

3.1.5.1. IPv4-Address Attribute

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

The structure of IPv4-Address is shown below:

TLV-Type
13

TLV-Length
6 octets

Data Type
The attribute IPv4-Address is of type ipv4addr (Section 3.8 of [RFC8044]).

TLV-Value
32-bits long. Specifies the IPv4 address (ipv4-address) to appear in Softwire46-V4V6Bind (Section 3.1.3.4).

3.1.5.2. Bind-IPv6-Prefix Attribute

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

The structure of Bind-IPv6-Prefix is shown below:

TLV-Type
14

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

Data Type
The attribute Bind-IPv6-Prefix is of type ipv6pref (Section 3.10 of [RFC8044]).

TLV-Value
A variable-length field specifying the IPv6 prefix or address for the Softwire46 CE (bind-ipv6-prefix). This field is right-padded with zeros to the nearest octet boundary when the prefix length is not divisible by 8.

3.1.6. Attributes for Softwire46-PORTPARAMS

3.1.6.1. PSID-Offset Attribute

This attribute is used to convey the Port Set Identifier offset as defined in [RFC7597]. This attribute is encoded in 32 bits as per the recommendation in Appendix A.2.1 of [RFC6158].

The structure of PSID-Offset is shown below:

TLV-Type
15

TLV-Length
6 octets

Data Type
The attribute PSID-Offset is of type integer (Section 3.1 of [RFC8044]).

TLV-Value
Contains the PSID-Offset (8-bits) right justified, and the unused bits in this field MUST be set to zero. This field specifies the numeric value for the Softwire46 algorithm's excluded port range/offset bits (a bits), as per Section 5.1 of [RFC7597].
Default values for this field are specific to the Softwire mechanism being implemented and are defined in the relevant specification document.

3.1.6.2. PSID-Len Attribute

This attribute is used to convey the PSID length as defined in [RFC7597]. This attribute is encoded in 32 bits as per the recommendation in Appendix A.2.1 of [RFC6158].

The structure of PSID-Len is shown below:

TLV-Type
16

TLV-Length
6 octets

Data Type
The attribute PSID-Len is of type integer (Section 3.1 of [RFC8044]).

TLV-Value
Contains the PSID-len (8-bits) right justified, and the unused bits in this field MUST be set to zero. This field specifies 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.

3.1.6.3. PSID Attribute

This attribute is used to convey the PSID as defined in [RFC7597]. This attribute is encoded in 32 bits as per the recommendation in Appendix A.2.1 of [RFC6158].

The structure of PSID is shown below:

TLV-Type
17

TLV-Length
6 octets

Data Type
The attribute PSID is of type integer (Section 3.1 of [RFC8044]).

TLV-Value
Contains the PSID (16-bits) right justified, and the unused bits in this field MUST be set to zero.
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 includes an ordered list of Softwire46 mechanisms 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 an Access-Accept packet. It MAY also appear in an Access-Request packet.

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 Softwrie46-Priority Attribute is structured as follows:

Type
241 (To be confirmed by IANA)

Length
Indicates the length of this attribute,
including the Type, Length, Extended-Type and Value fields.

Extended-Type
TBD5

TLV-Value
The attribute includes one or more Softwire46-Option-Code TLVs:
A Softwire46-Priority Attribute MUST contain at least one Softwire46-Option-Code TLV (Section 3.2.1).

Softwire46 mechanisms are prioritized in the appearance order of the in the Softwire46-Priority Attribute. That is, the first-appearing mechanism is most preferred.

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

3.2.1. Softwire46-Option-Code

This attribute is used to convey an option code assigned to a Softwire46 mechanism [RFC8026]. This attribute is encoded in 32 bits as per the recommendation in Appendix A.2.1 of [RFC6158].

The structure of Softwire46-Option-Code is shown below:

TLV-Type
18

TLV-Length
6 octets

Data Type
The attribute Softwire46-Option-Code is of type integer (Section 3.1 of [RFC8044]).

TLV-Value
A 32-bit IANA-registered option code representing a Softwire46 mechanism (Softwire46-option-code). The codes and their corresponding Softwire46 mechanisms are listed in Section 7.3.

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 Access-Request, Access-Accept, CoA-Request, and Accounting-Request packet.

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

- The Softwire46-Multicast Attribute MAY contain ASM-Prefix64 (Section 3.3.1), SSM-Prefix64 (Section 3.3.2), and U-Prefix64 (Section 3.3.3).

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

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

The Softwire46-Multicast Attribute is structured as follows:

Type
241 (To be confirmed by IANA)

Length
This field 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 attributes.

Extended-Type
TBD6

Value
This field contains a set of attributes as follows:

ASM-Prefix64
This attribute contains the Any-Source Multicast (ASM) IPv6 prefix. Refer to Section 3.3.1.

SSM-Prefix64
This attribute contains the Source-Source Multicast (SSM) IPv6 prefix. Refer to Section 3.3.2.

U-Prefix64
This attribute contains the IPv4 prefix used for address translation. Refer to Section 3.3.3.

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

3.3.1. ASM-Prefix64 Attribute

The ASM-Prefix64 attribute is structured as follows:

TLV-Type
19

TLV-Length
16 octets. The length of asm-prefix64 must be /96 [RFC8115].

Data Type
The attribute ASM-Prefix64 is of type ipv6prefix (Section 3.10 of [RFC8044]).

TLV-Value
This field specifies the IPv6 multicast prefix (asm-prefix64) 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 Attribute

The SSM-Prefix64 attribute is structured as follows:

Type
20

TLV-Length
16 octets. The length of ssm-prefix64 must be /96 [RFC8115].

Data Type
The attribute SSM-Prefix64 is of type ipv6prefix (Section 3.10 of [RFC8044]).

TLV-Type
This field specifies the IPv6 multicast prefix (ssm-prefix64) 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 Attribute

The structure of U-Prefix64 is shown below:

TLV-Type
21

TLV-Length
4 + length of unicast-prefix. As specified in [RFC6052], the unicast-prefix prefix-length MUST be set to 32, 40, 48, 56, 64, or 96.

Data Type
The attribute U-Prefix64 is of type ipv6prefix (Section 3.10 of [RFC8044]).

TLV-Value
This field identifies the IPv6 unicast prefix (u-prefix64) 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.

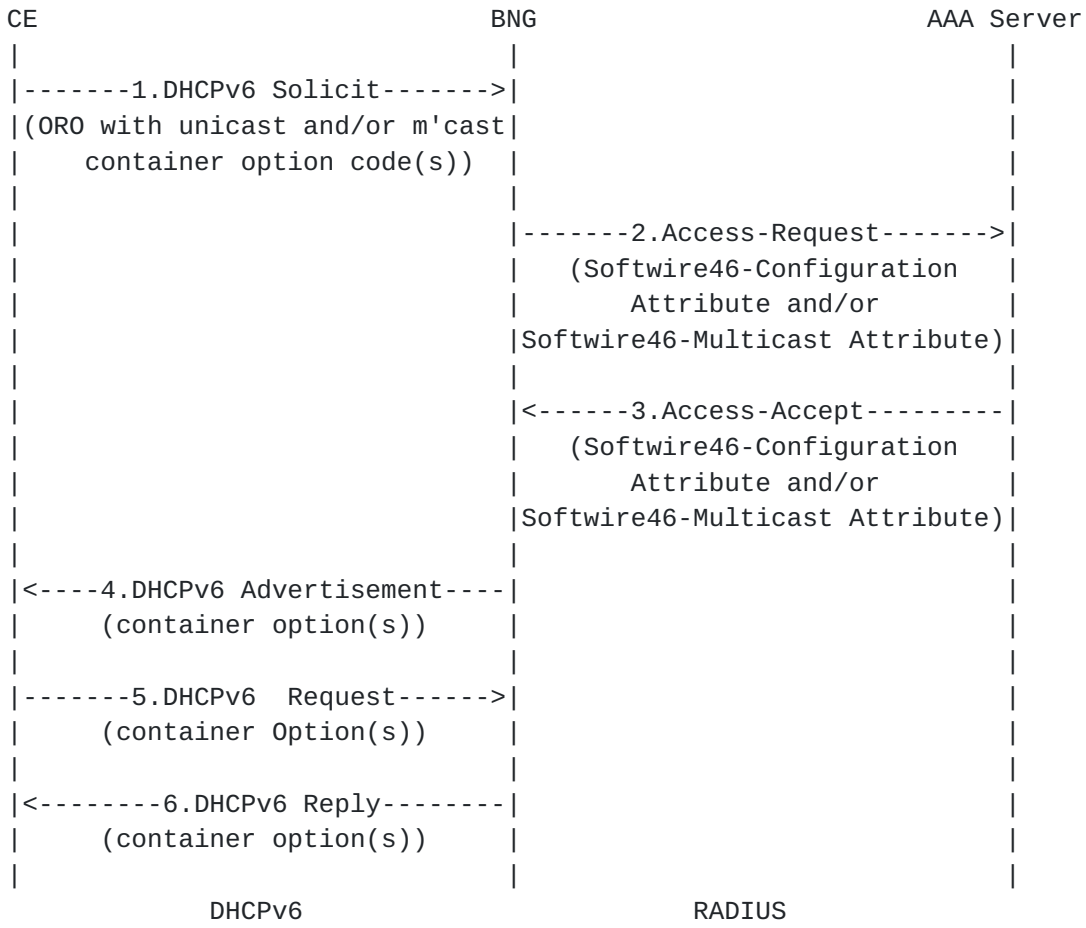

Figure 2: Interaction between DHCPv6 and AAA Server with RADIUS authentication

1. The CE creates a DHCPv6 Solicit message. For unicast softwire configuration, the message includes an OPTION_REQUEST_OPTION (6) with the Softwire46 Container option code(s) 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 between the CE and AAA server 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. It is the responsibility of the AAA server to ensure the consistency of the provided configuration.

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 DHCPv6 Reply message to the client containing the softwire container option(s) enumerated in the ORO.

The authorization operation could 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 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 fall back to creating the DHCPv6 softwire configuration options using pre-configured Softwire46 configuration, if this is present.

- If the BNG receives an Access-Reject from the AAA server, then Softwire46 configuration must not be supplied to the client.

- As specified in [RFC8415], Section 18.2.5, "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 CE's binding state needs to be synchronized between the clients and the Lightweight AFTR (lwAFTR)/BR. This can be achieved in two ways: static pre-configuration of the bindings on both the AAA server and lwAFTR, or on-demand whereby the AAA server updates the lwAFTR with the CE's binding state as it is created or deleted.

In some deployments, the DHCP server may use the Accounting-Request to report to a AAA server the softwire configuration returned to a requesting host. It is the responsibility of the DHCP server to ensure the consistency of the configuration provided to requesting hosts. Reported data to a AAA server may be required for various operational purposes (e.g., regulatory).

A configuration change (e.g., BR address) may result in an exchange of CoA-Requests between the BNG and the AAA server as shown in Figure 3. Concretely, when the BNG receives a CoA-Request message containing Softwire46 attributes, it sends a DHCPv6 Reconfigure message to the appropriate CE to inform that CE that an updated configuration is available. Upon receipt of such message, the CE sends a DHCPv6 Renew or Information-Request in order to receive the updated Softwire46 configuration. In deployments where the BNG embeds a DHCPv6 relay, CoA-Requests can be used following the procedure specified in [RFC6977].

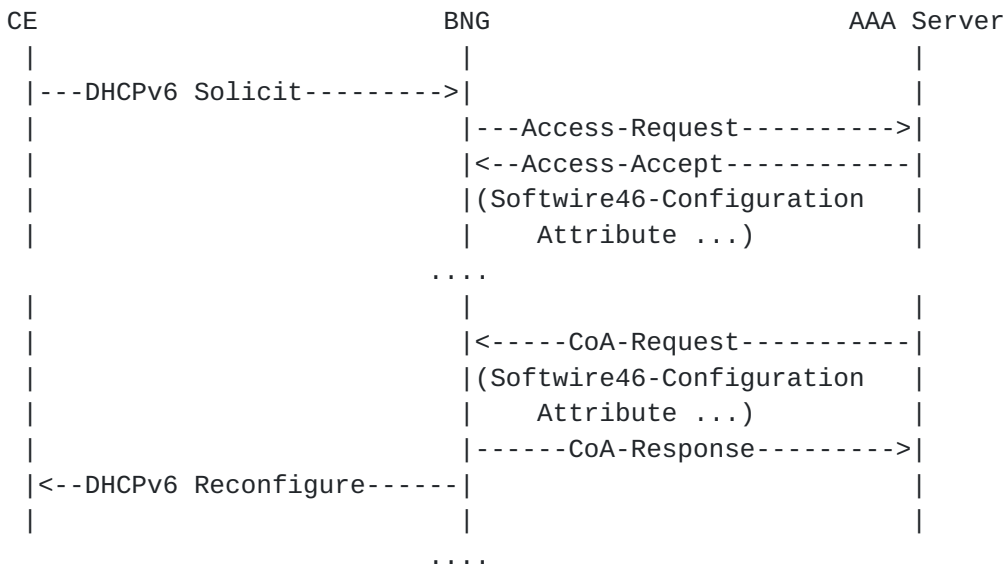

Figure 3: Change of Configuration Example

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

Table 3 describes which attributes may be found, in which kinds of packets and in what quantity.

Request	Accept	Reject	Challenge	Acct Req	CoA-Req	#	Attribute
0-1	0-1	0	0	0-1	0-1	241.TBD1	Softwire46-Configuration
0-1	0-1	0	0	0-1	0-1	241.TBD5	Softwire46-Priority
0-1	0-1	0	0	0-1	0-1	241.TBD6	Softwire46-Multicast

Table 3: Table of Attributes

6. Security Considerations

Section 9 of [RFC7596] discusses security issues related to Lightweight 4over6, Section 10 of [RFC7597] discusses security issues related to MAP-E, Section 13 of [RFC7599] discusses security issues related to MAP-T, and Section 9 of [RFC8114] discusses security issues related to the delivery of IPv4 multicast services to IPv4 clients over an IPv6 multicast network.

This document does not introduce any security issues inherently different from those already identified in Section 8 of [RFC2865] and Section 6 of [RFC5176] for CoA messages. Known security vulnerabilities of the RADIUS protocol discussed in Section 7 of [RFC2607] and Section 7 of [RFC2869] apply to this specification. These well-established properties of the RADIUS protocol place some limitations on how it can safely be used, since there is some inherent requirement to trust the counterparty to not misbehave.

Accordingly, this document targets deployments where a trusted relationship is in place between the RADIUS client and server with communication optionally secured by IPsec or Transport Layer Security (TLS) [RFC6614]. The use of IPsec [RFC4301] for providing security when RADIUS is carried in IPv6 is discussed in [RFC3162].

Security considerations for interactions between a Softwire46 CE and the BNG are discussed in Section 9 of [RFC7598] (DHCPv6 options for configuration of softwire46 address and port-mapped clients), Section 3 of [RFC8026] (DHCPv6-based Softwire46 prioritization mechanism), and Section 5 of [RFC8115] (DHCPv6 options for configuration of IPv4-embedded IPv6 prefixes).

7. IANA Considerations

IANA is requested to make new code point assignments for RADIUS attributes as described in the following subsections. The assignments should use the RADIUS registry available at https://www.iana.org/assignments/radius-types/.

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 [RFC8126].

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:

Type	Description	Data Type	Reference
241.TBD1	Softwire46-Configuration	tlv	Section 3.1
241.TBD5	Softwire46-Priority	tlv	Section 3.2
241.TBD6	Softwire46-Multicast	tlv	Section 3.3

7.2. RADIUS Softwire46 Configuration and Multicast Attributes

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

All attributes 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:

Value	Description	Data Type	Reference
0	Reserved		
1	Softwire46-MAP-E	tlv	Section 3.1.1.1
2	Softwire46-MAP-T	tlv	Section 3.1.1.2
3	Softwire46-Lightweight-4over6	tlv	Section 3.1.1.3
4	Softwire46-Rule (BMR)	tlv	Section 3.1.3.1
5	Softwire46-Rule (FMR)	tlv	Section 3.1.3.1
6	Softwire46-BR	ipv6addr	Section 3.1.3.2
7	Softwire46-DMR	ipv6prefix	Section 3.1.3.3
8	Softwire46-V4V6Bind	tlv	Section 3.1.3.4
9	Softwire46-PORTPARAMS	tlv	Section 3.1.3.5
10	Rule-IPv6-Prefix	ipv6prefix	Section 3.1.4.1
11	Rule-IPv4-Prefix	ipv4prefix	Section 3.1.4.2
12	EA-Length	integer	Section 3.1.4.3
13	IPv4-Address	ipv4addr	Section 3.1.5.1
14	Bind-IPv6-Prefix	ipv6prefix	Section 3.1.5.2
15	PSID-Offset	integer	Section 3.1.6.1
16	PSID-Len	integer	Section 3.1.6.2
17	PSID	integer	Section 3.1.6.3
18	Softwire46-Option-Code	integer	Section 3.2.1
19	ASM-Prefix64	ipv6prefix	Section 3.3.1
20	SSM-Prefix64	ipv6prefix	Section 3.3.2
21	U-Prefix64	ipv6prefix	Section 3.3.3
22-255	Unassigned		

The registration procedure for this registry is Standards Action as defined in [RFC8126].

7.3. Softwire46 Mechanisms and Their Identifying Option Codes

The Softwire46-Priority Attribute conveys an ordered list of option codes assigned to Softwire46 mechanisms, for which IANA is requested to create and maintain a new registry entitled "Option Codes Permitted in the Softwire46-Priority Attribute".

Table 4 shows the initial version of allowed option codes, and the Softwire46 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 are the TLV-Type values for the MAP-E, MAP-T, and Lightweight 4over6 attributes defined in Section 3.1.1.

Option Code	Softwire46 Mechanism	Reference
1	MAP-E	RFC7597
2	MAP-T	RFC7599
3	Lightweight 4over6	RFC7596
144	DS-Lite	RFC6519

Table 4: Option Codes to S46 Mechanisms

Additional option codes may be added to this list in the future using the IETF Review process described in Section 4.8 of [RFC8126].

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Appendix A. DHCPv6 to RADIUS Field Mappings

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

A.1. OPTION_S46_RULE (89) to Softwire46-Rule Sub-TLV Field Mappings

OPTION_S46_RULE Field	Softwire46-Rule Name	TLV Subfield
flags	N/A	TLV-type (TBD7, TBD8)
ea-len	EA-Length	EA-len
prefix4-len	Rule-IPv4-Prefix	Prefix-Length
ipv4-prefix	Rule-IPv4-Prefix	rule-ipv4-prefix
prefix6-len	Rule-IPv6-Prefix	Prefix-Length
ipv6-prefix	Rule-IPv6-Prefix	rule-ipv6-prefix

A.2. OPTION_S46_BR (90) to Softwire46-BR Field Mappings

OPTION_S46_BR Field	Softwire46-BR Subfield
br-ipv6-address	br-ipv6-address

A.3. OPTION_S46_DMR (91) to Softwire46-DMR

OPTION_S46_BR Field	Softwire46-DMR Subfield
dmr-prefix6-len	dmr-prefix6-len
dmr-ipv6-prefix	dmr-ipv6-prefix

A.4. OPTION_S46_V4V6BIND (92) to Softwire46-V4V6Bind

OPTION_S46_V4V6BIND Field	Softwire46-V4V6Bind Name	TLV Subfield
ipv4-address	IPv4-Address	ipv4-address
bindprefix6-len	Bind-IPv6-Prefix	Prefix-Length
bind-ipv6-prefix	Bind-IPv6-Prefix	bind-ipv6-prefix

A.5. OPTION_S46_PORTPARAMS (93) to Softwire46-PORTPARAMS Field Mappings

OPTION_S46_PORTPARAMS Field	Softwire46-PORTPARAMS Name	TLV Subfield
offset	PSID-Offset	PSID-Offset
PSID-len	PSID-Len	PSID-len
PSID	PSID	PSID

A.6. OPTION_S46_PRIORITY (111) to Softwire46-PORTPARAMS Field Mappings

OPTION_S46_PRIORITY Field	Softwire46-Priority Attribute Subfield
s46-option-code	Softwire46-option-code

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

OPTION_V6_PREFIX64 Field	Softwire46-Multicast Attribute TLV Name	TLV Subfield
asm-length	ASM-Prefix64	Prefix-Length
ASM_mPrefix64	ASM-Prefix64	asm-prefix64
ssm-length	SSM-Prefix64	Prefix-Length
SSM_mPrefix64	SSM-Prefix64	ssm-prefix64
unicast-length	U-Prefix64	Prefix-Length
uPrefix64	U-Prefix64	u-prefix64

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