### Unified IPv4-in-IPv6 Softwire CPE
### draft-ietf-softwire-unified-cpe-04

Abstract

   In IPv6-only provider networks, transporting IPv4 packets
   encapsulated in IPv6 is a common solution to the problem of IPv4
   service continuity.  A number of differing functional approaches have
   been developed for this, each having their own specific
   characteristics.  As these approaches share a similar functional
   architecture and use the same data plane mechanisms, this memo
   describes a specification whereby a single CPE can interwork with all
   of the standardized and proposed approaches to providing encapsulated
   IPv4 in IPv6 services.

Requirements Language

   The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
   "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
   document are to be interpreted as described in RFC 2119 [RFC2119].

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## 1.  Introduction

   IPv4 service continuity is one of the major technical challenges
   which must be considered during IPv6 migration.  Over the past few
   years, a number of different approaches have been developed to assist
   with this problem (e.g., [RFC6333], [RFC7596], or [RFC7597]).  These
   approaches, referred to as 'S46 mechanisms' in this document, exist
   in order to meet the particular deployment, scaling, addressing and
   other requirements of different service provider's networks.

   A common feature shared between all of the differing modes is the
   integration of softwire tunnel end-point functionality into the CPE
   router.  Due to this inherent data plane similarity, a single CPE may

be capable of supporting several different approaches.  Users may
also wish to configure a specific mode of operation.

A service provider's network may also have more than one S46
mechanism enabled in order to support a diverse CPE population with
differing client functionality, such as during a migration between
mechanisms, or where services require specific supporting softwire
architectures.

For softwire based services to be successfully established, it is
essential that the customer end-node, the service provider end-node
and provisioning systems are able to indicate their capabilities and
preferred mode of operation.

A number of DHCPv6 options for the provisioning of softwires have
been standardized:

RFC6334 Defines DHCPv6 option 64 for configuring Basic Bridging
        BroadBand (B4, [RFC6333]) elements with the IPv6 address of
        the Address Family Transition Router (AFTR, [RFC6333]).
RFC7341 Defines DHCPv6 option 88 for configuring the address of a
        DHCPv4 over DHCPv6 server, which can then be used by a
        softwire client for obtaining further configuration.
RFC7598 Defines DHCPv6 options 94, 95 and 96 for provisioning Mapping
        of Address and Port with Encapsulation (MAP-E, [RFC7597]),
        Mapping of Address and Port using Translation (MAP-T,
        [RFC7599]), and Lightweight 4over6 [RFC7596] respectively.

This document describes a DHCPv6 based prioritisation method whereby
a CPE which supports several S46 mechanisms and receives
configuration for more than one can prioritise which mechanism to
use.  The method requires no server side logic to be implemented and
only uses a simple S46 mechanism prioritization to be implemented in
the CPE.

The prioritisation method as described here does not provide
redundancy between S46 mechanisms for the client.  I.e.  If the
highest priority S46 mechanism which has been provisioned to the
client is not available for any reason, the means for identifying
this and falling back to the S46 mechanism with the next highest
priority is not in the scope of this document.

## 1.1.  Rationale

The following rationale has been adopted for this document:

(1)  Simplify solution migration paths: Define unified CPE behavior,
     allowing for smooth migration between the different s46
     mechanisms.
(2)  Deterministic CPE co-existence behavior: Specify the behavior
     when several S46 mechanisms co-exist in the CPE.
(3)  Deterministic service provider co-existence behavior: Specify
     the behavior when several modes co-exist in the service
     providers network.
(4)  Re-usability: Maximize the re-use of existing functional blocks
     including tunnel end-points, port restricted NAPT44, forwarding
     behavior, etc.
(5)  Solution agnostic: Adopt neutral terminology and avoid (as far
     as possible) overloading the document with solution-specific
     terms.
(6)  Flexibility: Allow operators to compile CPE software only for
     the mode(s) necessary for their chosen deployment context(s).
(7)  Simplicity: Provide a model that allows operators to only
     implement the specific mode(s) that they require without the
     additional complexity of unneeded modes.

## 1.2.  S46 Priority Option

The S46 Priority Option is used to convey a priority order of IPv4
service continuity mechanisms.  Figure 1 shows the format of the S46
Priority Option.

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |    OPTION_V6_S46_PRIORITY      |          option-length        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |        s46-option-code         |         s46-option-code       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |              ...               |         s46-option-code       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                   Figure 1: S46 Priority Option

o  option-code: OPTION_V6_S46_PRIORITY (TBD)
o  option-length: variable-length
o  s46-option-code: 16-bits long IANA registered option code of the
   DHCPv6 option which is used to identify the softwire mechanism.
   S46 mechanism are prioritized in the appearance order in the S46
   Priority Option.

Each defined s46_option_code MUST NOT appear more than once within
the list of S46 option codes.  The option MUST contain at least one
s46-option-code.

## 1.3.  Client Behavior

Clients MAY request option OPTION_V6_S46_PRIORITY, as defined in
[RFC3315], Sections 17.1.1, 18.1.1, 18.1.3, 18.1.4, 18.1.5, and 22.7.
As a convenience to the reader, we mention here that the client
includes requested option codes in the Option Request Option.

Upon receipt of a DHCPv6 Advertise message from the server containing
OPTION_V6_S46_PRIORITY the client performs the following steps:

1.  Check the contents of the DHCPv6 message for options containing
    valid S46 mechanism configuration.  A candidate list of possible
    S46 mechanisms is created from these option codes.
2.  Check the contents of OPTION_V6_S46_PRIORITY for the DHCPv6
    option codes contained in the included s46-option-code fields.
    From this, an S46 mechanism priority list is created, ordered
    from highest to lowest following the appearance order.
3.  Sequentially check the priority list against the candidate list
    until a match is found.
4.  When a match is found, the client SHOULD configure the resulting
    S46 mechanism.  Configuration for other S46 mechanisms MUST be
    discarded.

In the event that no match is found between the priority list and the
candidate list, the client MAY proceed with configuring one or more
of the provisioned S46 softwire mechanism(s).  In this case, which
mechanism(s) are chosen by the client is implementation-specific and
not defined here.

In the event that the client receives OPTION_V6_S46_PRIORITY with the
following errors, it MUST be discarded:

o  No s46-option-code field is included.
o  Multiple s46-option-code fields with the same value are included.

If an invalid OPTION_V6_S46_PRIORITY option is received, the client
MAY proceed with configuring the provisioned S46 mechanisms as if
OPTION_V6_S46_PRIORITY had not been received.

In the event that a client receives an OPTION_V6_S46_PRIORITY option
containing a value in s46-option-code representing an S46 mechanism
which the client has not implemented, this is not considered an
error.

## 1.4.  Server Behavior

   Sections 17.2.2 and 18.2 of [RFC3315] govern server operation in
   regards to option assignment.  As a convenience to the reader, we
   mention here that the server will send option foo only if configured
   with specific values for foo and if the client requested it.

   Option OPTION_V6_S46_PRIORITY is a singleton.  Servers MUST NOT send
   more than one instance of the OPTION_V6_S46_PRIORITY option.

## 1.5.  S46 Mechanisms and their Identifying Option Codes

   The following table shows the currently defined option codes and the
   S46 mechanisms which they represent.  This list is complete at the
   time of writing, but should not be considered definitive as new S46
   mechanisms may be defined in the future.

```
        +-------------+--------------------+-----------+
        | Option Code |   S46 Mechanism    | Reference |
        +-------------+--------------------+-----------+
        | 64          |       DS-Lite      | [RFC6334] |
        | 88          | DHCPv4 over DHCPv6 | [RFC7341] |
        | 94          |        MAP-E       | [RFC7598] |
        | 95          |        MAP-T       | [RFC7598] |
        | 96          | Lightweight 4over6 | [RFC7598] |
        +-------------+--------------------+-----------+
```

            Table 1: DHCPv6 Option to S46 Mechanism Mappings

## 2.  Operator Deployment Considerations for Deploying Multiple Sotfwire
     Mechanisms

   The following sub-sections describe some considerations for operators
   who are planning on implementing multiple sofwire mechanisms in their
   network (e.g., during a migration between mechanisms).

## 2.1.  Client Address Planning

   As an operator's available IPv4 resources are likely to be limited,
   it may be desirable to use a common range of IPv4 addresses across
   all of the active Softwire mechanisms.  However, this is likely to
   result in difficulties in routing ingress IPv4 traffic to the correct
   BR/AFTR instance which is actively serving a given CE.  For example,
   a client which is configured to use MAP-E may send it's traffic to
   the MAP-E BR, but on the return path, the ingress IP traffic gets
   routed to a MAP-T BR.  The resulting translated packet that gets
   forwarded to the MAP-E client will be dropped.

Therefore, operators are advised to use separate IPv4 pools for each
of the different mechanisms to simplify planning and IPv4 routing.

For IPv6 planning there is less of a constraint as the BR/AFTR
elements for the different mechanisms can contain configuration for
overlapping client's IPv6 addresses, providing only one mechanism is
actively serving a given client at a time.  However, the IPv6 address
that is used as the tunnel concentrator's endpoint (BR/AFTR address)
needs to be different for each mechanisms to ensure correct
operation.

## 2.2.  Backwards Compatability with Existing Softwire Clients

Deployed clients which can support mutliple softwire mechanisms, but
do not implement the prioritisation mechanism described here may
require additional planning.  In this scenario, the CPE would request
configuration for all of the supported softwire mechanisms in its
DHCPv6 ORO message, but would not request OPTION_V6_S46_PRIORITY.  By
default, the DHCPv6 server will respond with configuration for all of
the requested mechanisms which could result in unpredictable and
unwanted client configuration.

In this scenario, it may be necessary for the operator to implement
logic within the DHCPv6 server to identify such clients and only
provision them with configuration for a single softwire mechanism.
It should be noted that this can lead to complextity and reduced
scalability in the DHCPv6 server implementation due to the addition
DHCPv6 message processing overhead.

## 3.  Security Considerations

Security considerations discussed in [RFC6334] and [RFC7598] apply
for this document.

Misbehaving intermediate nodes may alter the content of the S46
Priority Option.  This may lead to setting a different IPv4 service
continuity mechanism than the one initially preferred by the network
side.

## 4.  IANA Considerations

IANA is kindly requested to allocate the following DHCPv6 option
code:

   TBD for OPTION_V6_S46_PRIORITY

All values should be added to the DHCPv6 option code space defined in
Section 24.3 of [RFC3315].

## [5](#). Acknowledgements

Many thanks to O.  Troan, S.  Barth.  A.  Yourtchenko, B.  Volz, T.
Mrugalski for their input and suggestions.

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