DHCPv6 class based prefix
draft-bhandari-dhc-class-based-prefix-02

Abstract

DHCPv6 defines class based allocation of IA_NA and IA_TA IPv6 addresses. This document extends DHCPv6 prefix delegation with class based prefix allocation. It defines a new usage class option to classify a prefix. It defines the behavior of a DHCPv6 client requesting a prefix to include the class of the prefix to be allocated and the DHCPv6 server behavior to select and offer a prefix from a given class. It discusses how IA_NA can be requested and assigned from a specific usage class.

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Table of Contents

1. Introduction .............................................. 3
   1.1. Motivation ........................................... 3
   1.2. Terminology .......................................... 4
   1.3. Requirements Language ................................. 4
2. Overview .................................................. 4
   2.1. Usage Class Option ................................... 4
   2.2. Consideration for different DHCPv6 entities ............ 6
      2.2.1. Requesting Router Behavior ....................... 6
      2.2.2. Delegating Router Behavior ....................... 7
      2.2.3. DHCPv6 Client Behavior for IA_NA allocation ...... 7
   2.3. Usage ................................................ 8
      2.3.1. OPTION_USAGE_CLASS Values ....................... 8
      2.3.2. Class based prefix and IA_NA allocation .......... 8
      2.3.3. Class based prefix and IA_PD allocation ........... 9
      2.3.4. Class based prefix and SLAAC .................... 9
      2.3.5. Class based prefix and applications .............. 9
3. Example Application ....................................... 9
   3.1. Class based prefix delegation ........................ 12
   3.2. IPv6 address assignment from class based prefix ......... 12
4. Acknowledgements ......................................... 13
5. IANA Considerations ...................................... 13
   5.1. OPTION_USAGE_CLASS values .......................... 13
6. Security Considerations .................................. 14
7. Change History (to be removed prior to publication as an RFC) .... 14
8. References ................................................ 14
   8.1. Normative References ................................ 14
   8.2. Informative References ............................... 15
Authors’ Addresses ........................................... 15
1. Introduction

DHCPv6 based prefix delegation as defined in [RFC3633] is a mechanism for the delegation of IPv6 prefixes using DHCPv6 options. Through these options, a delegating router can delegate prefixes to authorized requesting routers. If the requesting router has to function as a DHCPv6 server there needs to be additional information in the delegated prefix that helps the requesting router to select the address allocation for the DHCPv6 client it serves, from one of the available delegated prefixes.

One way to select an address or longer prefix (from a delegated prefix) to be allocated by a requesting router playing the role of a DHCPv6 server is by introducing additional options in IA_PD to be matched with options for address selection in the DHCPv6 SOLICIT message. [RFC3315] defines the OPTION_USER_CLASS option which is used for selecting address for assignment. This document introduces OPTION_USAGE_CLASS option in IA_PD option for the purpose of selecting a prefix for further delegation either via IA_NA or IA_PD DHCPv6 request. It defines the behavior of the DHCPv6 server, the DHCPv6 prefix requesting router and the DHCPv6 client to use this option.

In IPv6 a network interface can acquire multiple addresses from the same scope. In this case application need to have additional information about the prefix configured on the interface for source address selection. Since the network address can be configured via DHCPv6 as defined in [RFC3315] or via Stateless Address Autoconfiguration (SLAAC) as defined in [RFC4862], additional information of a prefix can be provided via DHCPv6 or via IPv6 Router Advertisement (RA).

1.1. Motivation

In this section motivation for class based prefix delegation that qualifies the delegated prefix with additional class information is described in the context of mobile networks. The class information attached to a delegated prefix helps to distinguish property of a delegated IPv6 prefix and selection of the prefix by different applications using it.

In the mobile network architecture, there is a mobile router which functions as a IP network gateway and provides IP connectivity to mobile nodes. Mobile router can be the requesting router requesting delegated IPv6 prefix using DHCPv6. Mobile router can assume the role of DHCPv6 server for mobile nodes (DHCPv6 clients) attached to it. A mobile node in mobile network architecture can be associated with multiple IPv6 prefixes belonging to different domains for e.g.
home address prefix, care of address prefix as specified in [RFC3775].

The delegated prefixes when seen from the mobile router perspective appear to be like any other prefix, but each prefixes have different properties referred to as "Prefix Color" in the mobile networks. Some delegated prefixes may be topologically local and some may be remote prefixes anchored on a global anchor, but available to the local anchor by means of tunnel setup in the network between the local and global anchor. Some may be local with low latency characteristics suitable for voice call break-out, some may have global mobility support. So, the prefixes have different properties and it is required for the application using the prefix to learn about this property in order to use it intelligently. There is currently no semantics in DHCPv6 prefix delegation that can carry this information to specify properties of a delegated prefix. In this scenario, the mobile router is unable to further delegate a longer prefix intelligently based on properties of the prefix learnt.

1.2. Terminology

This document uses the terminology defined in [RFC2460], [RFC3315] and [RFC3633].

1.3. 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].

2. Overview

This section defines usage class option in IA_PD and IA_NA to aid class based prefix delegation and address assignment. This section defines the behavior of the delegating router, the requesting router and the DHCPv6 client.

2.1. Usage Class Option
The format of the DHCPv6 usage class option is shown below.

```
+---------------+---------------+---------------+---------------+
|         OPTION_USAGE_CLASS   |         option-length(2)       |                |
|---------------+---------------+---------------+---------------|
|             Class            |                                |
+---------------+---------------+---------------+
```

- **option-code:** OPTION_USAGE_CLASS (TBD)
- **option-length:** 2 + Length of Vendor class information if present
- **Class:** 16 bit numeric value maintained as OPTION_USAGE_CLASS enumeration in IANA registered namespace
- **Vendor Class Data:** If the value of Class (3) indicates it is vendor specified additional vendor specified data of variable length will be attached in the form specified below:

```
+---------------+---------------+---------------+---------------+
|         OPTION_USAGE_CLASS   |         option-length(2)       |                |
|---------------+---------------+---------------+---------------|
|             Class            |            Enterprise ID       |                |
|---------------+---------------+---------------+---------------|
|          Enterprise ID(4)    |  Vendor Class length(2)        |                |
+---------------+---------------+---------------+---------------+
```

- **Enterprise ID:** The vendor’s 32-bit Enterprise Number as registered with IANA [IANAEnterprise]
- **Vendor Class Length:** 2, length of vendor class data that follows
- **Vendor Class Data:** Binary data as defined by the vendor. For e.g. 3gpp can specify this data to be Application providers network domain string

The class values are maintained in OPTION_USAGE_CLASS values enumeration explained in Section Section 2.3.1.
2.2. Consideration for different DHCPv6 entities

The model of operation of communicating prefixes to be used by a DHCPv6 server is as follows. A requesting router requests prefix(es) from the delegating router, as described in Section 2.2.1. A delegating router is provided IPv6 prefixes to be delegated to the requesting router. Examples of ways in which the delegating router is provided these prefixes are:

- Configuration
- Prefix delegated via a DHCPv6 request to another DHCPv6 server
- Using a Authentication Authorization Accounting (AAA) protocol like RADIUS [RFC2865]

The delegating router chooses prefix(es) for delegation, and responds with prefix(es) to the requesting router along with additional options in the allocated prefix as described in Section 2.2.2. The requesting router is then responsible for the delegated prefix(es) after the DHCPv6 REQUEST message exchange. For example, the requesting router may create DHCPv6 server configuration pools from the delegated prefix, and function as a DHCPv6 Server. When the requesting router then receives a DHCPv6 IA_NA requests it can select the address to be allocated based on the OPTION_USER_CLASS or OPTION_USAGE_CLASS options received in IA_NA request or any of the other methods as described in Section 2.3.1.

2.2.1. Requesting Router Behavior

DHCPv6 requesting router can request for prefixes in the following ways:

- In the SOLICIT message within the IA_PD Prefix option, it MAY include OPTION_USAGE_CLASS requesting prefix delegation for the specific class indicated in the OPTION_USAGE_CLASS option. It can include multiple IA_PD Prefix options to indicate its preference for more than one usage class.

- In the SOLICIT message include an OPTION_ORO option with the OPTION_USAGE_CLASS option code to request prefixes from all the classes that the DHCPv6 server can provide to this requesting Router.

The requesting router parses the OPTION_USAGE_CLASS option in the OPTION_IAPREFIX option area of the corresponding IA_PD Prefix option in the ADVERTISE message. The Requesting router MUST then include all or subset of the received class based prefix(es) in the
REQUEST message so that it will be responsible for the prefixes selected.

2.2.2. Delegating Router Behavior

If the Delegating router supports class based prefix allocation by supporting the OPTION_USAGE_CLASS option and it is configured to assign prefixes from different classes, it selects prefixes for class based prefix allocation in the following way:

- If requesting router includes OPTION_USAGE_CLASS within the IA_PD Prefix option, it selects prefixes to be offered from that specific class.

- If requesting router includes OPTION_USAGE_CLASS within OPTION_ORO, then based on its configuration and policy it MAY offer prefixes from multiple classes available.

The delegating router responds with an ADVERTISE message after populating the IP_PD option with prefixes from different usage classes. Along with including the IA_PD prefix options in the IA_PD option, it also includes the OPTION_USAGE_CLASS option in the OPTION_IAPREFIX option area of the corresponding IA_PD prefix option.

If neither the OPTION_ORO nor the IA_PD option in the SOLICIT message include the OPTION_USAGE_CLASS option, then the delegating router MAY allocate the prefix as specified in [RFC3633] without including the class option in the IA_PD prefix option in the response.

If OPTION_ORO option in the Solicit message includes the OPTION_USAGE_CLASS option code but the delegating router does not support the solution described in this specification, then the delegating router acts as specified in [RFC3633]. The requesting router MUST in this case also fall back to the behavior specified in [RFC3633].

If both delegating and requesting routers support class-based prefix allocation, but the delegating router cannot offer prefixes for any other reason, it MUST respond to requesting router with appropriate status code as specified in [RFC3633]. For e.g., if no prefixes are available in the specified class then the delegating router MUST include the status code NoPrefixAvail in the response message.

2.2.3. DHCPv6 Client Behavior for IA_NA allocation

DHCPv6 client MAY request for an IA_NA address allocation from a specific usage class in the following way:
In the SOLICIT message within the IA_NA option, it MAY include the
OPTION_USAGE_CLASS requesting address to be allocated from a
specific usage class indicated in that option.

The DHCPv6 server parses OPTION_USAGE_CLASS option received and
includes it in option area of corresponding OPTION_IA_NA in ADVERTISE
message.

2.3. Usage

Class based prefix delegation can be used by the requesting router to
configure itself as a DHCPv6 server to serve its DHCPv6 clients. It
can allocate longer prefixes from a delegated shorter prefix it
received, for serving IA_NA and IA_PD requests.

2.3.1. OPTION_USAGE_CLASS Values

Following values will be allocated from the IANA maintained
OPTION_USAGE_CLASS registry:

- global-anchor(1) - Prefix is globally anchored and hence would
  allow mobility.

- local-breakout(2) - Prefix is managed in a local-breakout domain
  and hence has limited mobility.

- Vendor-specified-class(3) - Prefix class is specified by the
  vendor, Vendor class data in the option that follows will provide
  more information.

New values of OPTION_USAGE_CLASS can be assigned and registered with
IANA as per policy detailed in section Section 5.1.

2.3.2. Class based prefix and IA_NA allocation

The requesting router can use the delegated prefix(es) from different
classes (for example "video", "guest", "voice" etc), for assigning
the IPv6 addresses to the end hosts through DHCPv6 IA_NA based on a
preconfigured mapping with OPTION_USAGE_CLASS option, the following
conditions MAY be observed:

- It MAY have a pre-configured mapping between the usage class and
  OPTION_USER_CLASS option received in IA_NA.

- It MAY match the OPTION_USAGE_CLASS if the IA_NA request received
  contains OPTION_USAGE_CLASS.
2.3.3. Class based prefix and IA_PD allocation

If the requesting router receives prefix(es) for different classes (for example "video", "guest", "voice" etc), it can use these prefix(es) for assigning the longer IPv6 prefixes to requesting routers it serves through DHCPv6 IA_PD by assuming the role of delegating router, its behavior is explained in Section 2.2.2.

2.3.4. Class based prefix and SLAAC

DHCPv6 IA_NA and IPv6 Stateless Address Autoconfiguration (SLAAC as defined in [RFC4862]) are two ways by IPv6 addresses can be dynamically assigned to end hosts. Making SLAAC class aware is outside the scope of this document, it is specified in [I-D.korhonen-dmm-prefix-properties].

2.3.5. Class based prefix and applications

Applications within a host can do source address selection based on the class of the prefix learnt in OPTION_USAGE_CLASS using rules defined in [RFC3484].

3. Example Application

The following sub-sections provide examples of class based prefix delegation and how it is used in a mobile network. Each of the examples will refer to the below network:

The example network consists of:

Mobile Gateway It is network entity anchoring IP traffic in the mobile core network. This entity allocates an IP address which is topologically valid in the mobile network and may act as a mobility anchor if handover between mobile and Wi-Fi is supported.

Mobile Nodes (MN) A host or router that changes its point of attachment from one network or subnetwork to another. A mobile node may change its location without changing its IP address; it may
continue to communicate with other Internet nodes at any location using its (constant) IP address, assuming link-layer connectivity to a point of attachment is available.

Access Point (AP) A wireless access point, identified by a MAC address, providing service to the wired network for wireless nodes.

Access Router (AR) An IP router residing in an access network and connected to one or more Access Point (AP)s. An AR offers IP connectivity to MNs.

WLAN controller (WLC) The entity that provides the centralized forwarding, routing function for the user traffic.
Example mobile network

Figure 1
3.1. Class based prefix delegation

The Access Aggregation Gateway requests for Prefix delegation from Mobile gateway and associates the prefix received with usage class "global-anchor"(1). The Access Aggregation Gateway is preconfigured to provide prefixes from the following classes: "global-anchor" (1), "local-breakout"(2), "guest"(x). It has a preconfigured policy to advertise prefixes to requesting routers and mobile nodes based on the service class supported by the service provider for the requesting device. In the example mobile network, the Access Router (AR) requests class based prefix allocation by sending a DHCPv6 SOLICIT message and include OPTION_USAGE_CLASS in the OPTION_ORO.

The Access Router (AR) receives an advertise with following prefixes in the IA_PD option:

1. P1: IA_PD Prefix option with a prefix 3001::1::/64 containing OPTION_USAGE_CLASS set to "global-anchor"(1)
2. P2: IA_PD Prefix option with a prefix 3001::2::/64 containing OPTION_USAGE_CLASS set to "local-breakout"(2)
3. P3: IA_PD Prefix option with a prefix 3001::3::/64 containing OPTION_USAGE_CLASS set to "guest"(x)

It sends a REQUEST message with all of above prefixes and receives a REPLY message with prefixes allocated for each of the requested class.

3.2. IPv6 address assignment from class based prefix

When the Access Router (AR) receives a DHCPv6 SOLICIT requesting IA_NA from the mobile node that has mobility service enabled, it offers an IPv6 address from the usage class "global-anchor"(1). For MN3 it advertises 3001::1::1 as the IPv6 address in OPTION_IAADDR in response to the IA_NA request.

The Mobile Node (MN4) Figure 1 sends a DHCPv6 SOLICIT message requesting IA_NA address assignment with OPTION_USER_CLASS option containing the value "guest" towards the CPE. The Access Router (AR) assumes the role of the DHCPv6 server and sends an ADVERTISE to the MN with OPTION_IA_NA containing an IPv6 address in OPTION_IAADDR from the "guest" usage class. The IPv6 address in the OPTION_IAADDR is set to 3001::3::1. The "guest" class can also be distinguished based on a preconfigured interface or SSID advertised for MNs connecting to it.

When the Access Aggregation Gateway receives a DHCPv6 SOLICIT
requesting IA_NA from MNs through WLC and it has a preconfigured profile to provide both local-breakout internet access and global-anchor, it offers an IPv6 address from the usage class "local-breakout" (2) and "global-anchor" (1). For MN1 it advertises 3001::2::1 and 3001::1::2 as the IPv6 address in OPTION_IAADDR in response to the IA_NA request. Applications within MN1 can choose to use the appropriate prefix based on the mobility enabled or local-breakout property attached to the prefix based on source address selection policy.

4. Acknowledgements

The authors would like to acknowledge review and guidance received from Frank Brockners, Wojciech Dec, Richard Johnson, Erik Nordmark, Hemant Singh, Mark Townsley, Ole Troan, Bernie Volz

5. IANA Considerations

IANA is requested to assign an option code to OPTION_USAGE_CLASS from the "DHCPv6 and DHCPv6 options" registry (http://www.iana.org/assignments/dhcpv6-parameters/dhcpv6-parameters.xml).

5.1. OPTION_USAGE_CLASS values

IANA is requested to reserve and maintain registry of OPTION_USAGE_CLASS values and manage allocation of values in the following way as per as per policy defined in [RFC5226]:

1. Values 1 to 8191 (0x0001 - 0x1FFF) - IETF assigned class with IETF consensus, RFC Required policy

2. Values 8192 to 16368 (0x2000 - 0x3ff0) - Vendor defined class assigned on a First Come First Served allocation policy

3. Values 16369 to 16383 (0x3ff1 - 0x3fff) - Experimental usage reserved for Private Use

Following values will be allocated from this registry as explained in section Section 2.3.1:

- global-anchor (1) - Prefix is globally anchored and hence would allow mobility.

- local-breakout (2) - Prefix is managed in a local-breakout domain and hence has limited mobility.
6. Security Considerations

Security issues related to DHCPv6 which are described in section 23 of [RFC3315] and [RFC3633] apply for scenarios mentioned in this draft as well.

7. Change History (to be removed prior to publication as an RFC)

Changes from -00 to -01

a. Modified motivation section to focus on mobile networks

b. Modified example with a mobile network and class based prefix delegation in it

Changes from -00 to -02

a. Modified option format to be enumerated values

b. Added IANA section to request managing of registry for the enumerated values

c. Added initial values for the class

d. Added section for applications to select address with a specific property

8. References

8.1. Normative References

[I-D.korhonen-dmm-prefix-properties]
draft-korhonen-dmm-prefix-properties-02 (work in progress), July 2012.

[IANAEnterprise]
IANA, "Private Enterprise Numbers,
http://www.iana.org/assignments/enterprise-numbers".


Vendor-specified-class(3) - Prefix class is vendor specified.
Informative References


8.2. Informative References


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