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DHCPv6 Options for Mapping of Address and Port
draft-ietf-softwire-map-dhcp-02

Abstract

This document specifies DHCPv6 options for the provisioning of Mapping of Address and Port (MAP) Customer Edge (CE) devices, based on the MAP paramaters defined in [I-D.ietf-softwire-map].

Status of this Memo

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

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This Internet-Draft will expire on August 22, 2013.

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1. Introduction

Mapping of Address and Port (MAP) defined in [I-D.ietf-softwire-map] is a mechanism for providing IPv4 connectivity service to end users over a service provider's IPv6 network, allowing for shared or dedicated IPv4 addressing. It consists of a set of one or more MAP Border Relay (BR) routers, responsible for stateless forwarding, and one or more MAP Customer Edge (CE) routers, that collectively form a MAP Domain when configured with common MAP rule-sets. In a residential broadband deployment the CE is sometimes referred to as a Residential Gateway (RG) or Customer Premises Equipment (CPE).

A typical MAP CE will serve its end-user with one WAN side interface connected to an operator domain providing a MAP service. To function in the MAP domain, the CE requires to be provisioned with the appropriate MAP service paramaters for that domain. Particularly in larger networks it is not feasible to configure such parameters manually, which forms the requirement for a dynamic MAP provisioning mechanism that is defined in this document based on the existing DHCPv6 [RFC3315] protocol. The configuration of the MAP BR is outside of scope of this document.

This document specifies the DHCPv6 options that allow MAP CE provisioning, based on the definitions of parameters provided in [I-D.ietf-softwire-map], and is applicable to both MAP-E and MAP-T transport variants. The definition of DHCPv6 options for MAP CE provisioning does not preclude the definition of other dynamic methods for configuring MAP devices, or supplementing such configuration, nor is the use of DHCPv6 provisioning mandatory for MAP operation.

Since specification of MAP architecture is still expected to evolve, DHCPv6 options may have to evolve too to fit the revised MAP specification.

Defined proposal is not a dynamic port allocation mechanism.

Readers interested in deployment considerations are encouraged to read [I-D.mdt-softwire-map-deployment].

2. Conventions

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].

3. MAP Information

The following presents the information parameters that are used to configure a MAP CE:

- o A Default Mapping Rule (DMR). This rule governs the default forwarding/mapping behaviour of the MAP CE, ie it informs the CE of the BR router's address or prefix that is typically used as a default. The DMR is a mandatory parameter for a MAP CE.
- o A Basic Mapping Rule (BMR). This rule governs the MAP configuration of the CE, including that of completing the CE's MAP IPv6 address, as well as deriving the CEs IPv4 parameters. Key parameters of a BMR include: i) The IPv4 Prefix - Used to derive the CE's IPv4 address; ii) The Embedded Address bit length - Used to derive how many, if any, of the CE's IPv6 address is mapped to the IPv4 address. iii) The IPv6 prefix - used to determine the CE's IPv6 MAP domain prefix that is to form the base for the CE's MAP address. The BMR is an optional rule for a MAP CE.
- o A Forward Mapping Rule (FMR). This rule governs the MAP CE-CE forwarding behaviour for IPv4 destinations covered by the rule. The FMR is effectively a special type of an BMR, given that it shares exactly the same configuration parameters, except that these parameters are only applied for setting up forwarding. Its presence enables a given CE to communicate directly in "mesh mode" with other CEs. The FMR is an optional rule, and the absence of such a rule indicates that the CE is to simply use its default mapping rule for all destinations.
- o Transport mode; encapsulation (MAP-E) or translation (MAP-T) modes to be used for the MAP CE Domain.
- o Additional parameters. The MAP specification allows great flexibility in the level of automation a CE uses to derive its IPv4 address and port-sharing (PSID), ranging from full derivation of these parameters from the CE's IPv6 prefix, to full parametrization of MAP configuration independent of the CE's IPv6 prefix. Optional parameters such as the PSID allow this flexibility.

4. DHCPv6 MAP Options

The DHCPv6 protocol is used for MAP CE provisioning following regular DHCPv6 notions, with the MAP CE assuming a DHCPv6 client role, and the MAP parameters provided by the DHCPv6 server following typical DHCPv6 server side policies. The format and usage of the MAP options is defined in the following sections.

Discussion: As the exact parameters required to configure MAP rules and MAP in general are expected to change, this section is expected

to be updated and follow changes in the [I-D.ietf-softwire-map].

Discussion: It should be noted that initial concept of 4rd/MAP provisioning was presented in DHC working group meeting. It used one complex option to convey all required parameters. Strong suggestion from DHC WG was to use several simpler options. Options (possibly nested) are preferred over conditional option formatting. See DHCP option guidelines document [I-D.ietf-dhc-option-guidelines]).

Server that supports MAP configuration and is configured to provision requesting CE MUST include exactly one OPTION_MAP option in a REPLY message for each MAP domain. It is envisaged that in typical network, there will be only one MAP domain deployed.

4.1. MAP Options Cardinality

Server configured to provision MAP configuration SHOULD return one MAP Container Option for each MAP domain, when requested by clients. As there will typically be only one MAP Domain configured, server will typically return a single instance of MAP Container Option.

Returned MAP Container Option MUST include exactly one MAP DMR Rule option. It also MAY include zero or more MAP Rule Options. It also MAY include MAP Port Parameters option. It MAY include additional options that may be defined in the future.

4.2. MAP Container Option

This MAP Container Option specifies the container used to group all rules and optional port parameters for a specified MAP domain.

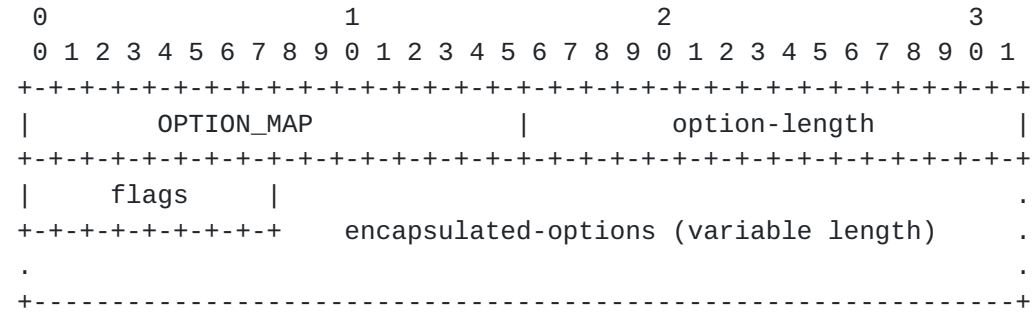

Figure 1: MAP Container Option

- option-code: OPTION_MAP (TBD1)
- option-length: 1 + Length of encapsulated options

- o flags: This 8-bits long conveys the MAP Flags that apply to all encapsulated options. The meaning of specific bits is explained in Figure 2.
- o encapsulated-options: options associatied with this MAP domain.

The encapsulated options field encapsulates those options that are specific to this MAP Option. Currently there are three options that MAY appear here: OPTION_MAP_RULE, OPTION_MAP_DMR and OPTION_MAP_PORTPARAMS. Other options suitable for a MAP domain may be defined in the future. A DHCP message MAY include multiple MAP Container Options (representing multiple MAP domains), but typically it will have only one.

The Format of the MAP flags field is:

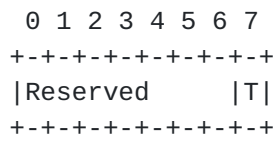

Figure 2: MAP Option Flags

- o Reserved: 7-bits reserved for future use.
- o T: 1 bit field that specifies transport mode to use: translation (0) or encapsulation (1).

Discussion: It was suggested to also provision information whether MAP network is working in hub and spoke or mesh mode. That is not necessary, as mesh mode is assumed when there is at least one FMR present.

4.3. MAP Rule Option

Figure Figure 3 shows the format of the MAP Rule option used for conveying the BMR and FMR.

Server includes zero or more MAP Rule Options in MAP Container Option.

Server MAY send more than one MAP Rule Option, if it is configured to do so. Clients MUST NOT send MAP Rule Option.

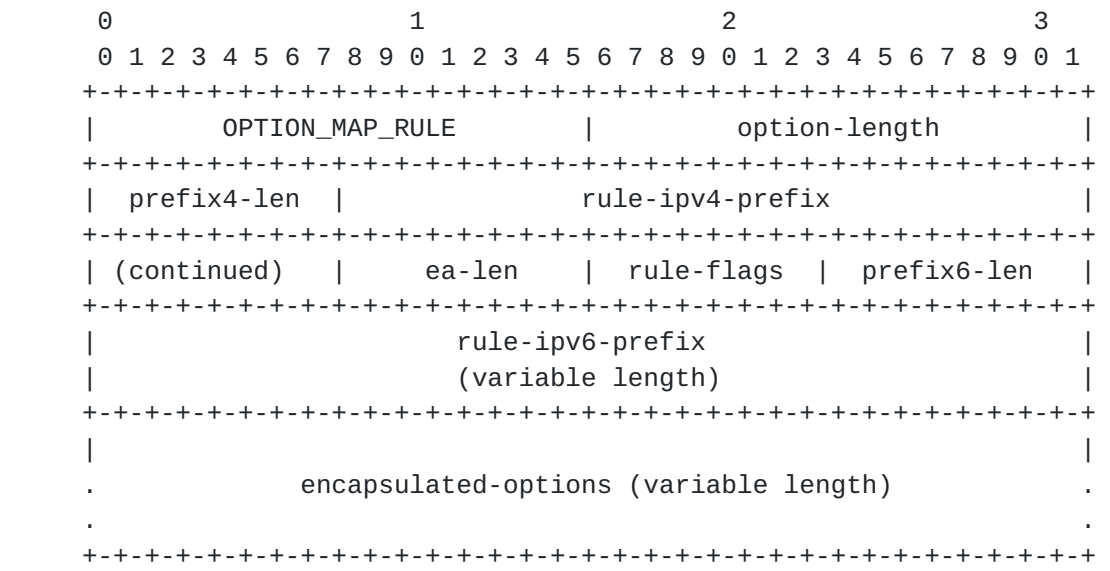

Figure 3: MAP Rule Option

- option-code: OPTION_MAP_RULE (TBD2)
- option-length: length of the option, excluding option-code and option-length fields, including length of all encapsulated options, expressed in bytes.
- prefix4-len: 8 bits long field expressing the bit mask length of the IPv4 prefix specified in the rule-ipv4-prefix field.
- rule-ipv4-prefix: a fixed length 32 bit field that specifies the IPv4 prefix for the MAP rule.
- ea-len: 8 bits long field that specifies the Embedded-Address (EA) bit length. Values allowed range from 0 to 48.
- rule-flags: 8 bits long field carrying flags applicable to the rule. The meaning of specific bits is explained in Figure 4.
- prefix6-len: 8 bits long field expressing the bit mask length of the IPv6 prefix specified in the rule-ipv6-prefix field.
- rule-ipv6-prefix: a variable length field that specifies the IPv6 domain prefix for the MAP rule. The field is padded with follow up zero bits up to the nearest octet boundary when prefix6-len is not divisible by 8.
- encapsulated options: a variable field that may contain zero or more options that specify additional parameters for this MAP BMR/ FMR rule. Currently there are no such options defined, but they may be defined in the future.

The value of the EA-len and prefix4-len SHOULD be equal to or greater than 32.

The Format of the MAP Rule Flags field is:

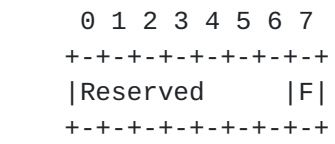

Figure 4: MAP Rule Flags

- Reserved: 7-bits reserved for future use as flags.
- F-Flag: 1 bit field that specifies whether the rule is to be used for forwarding (FMR). 0x0 = This rule is NOT used as a FMR. 0x1 = This rule is also a FMR.
- Note: BMR rules can be also FMR rules by setting the F flag. BMR rules are determined by a match of the Rule-IPv6-prefix against the CPE's prefix(es).

It is expected that in a typical MAP deployment scenarios, there will be a single DMR and a single BMR, which could also be designated as an FMR using the F-Flag.

Discussion: This option format attempts to use option formats recommended by [I-D.ietf-dhc-option-guidelines], namely variable length prefix formats. It should be noted that this format follows prefix length + prefix notation. Reasons for using variable IPv6 prefix field, but fixed IPv4 prefix are given in [I-D.ietf-dhc-option-guidelines], Section 5.9.

4.4. MAP DMR Option

MAP DMR Option is used to convey values for Default Mapping Rule. MAP DMR Option MUST appear in each MAP Container Option exactly once. It MUST NOT appear in the DHCP message directly. Figure Figure 5 shows the format of the MAP Rule option used for conveying a DMR.

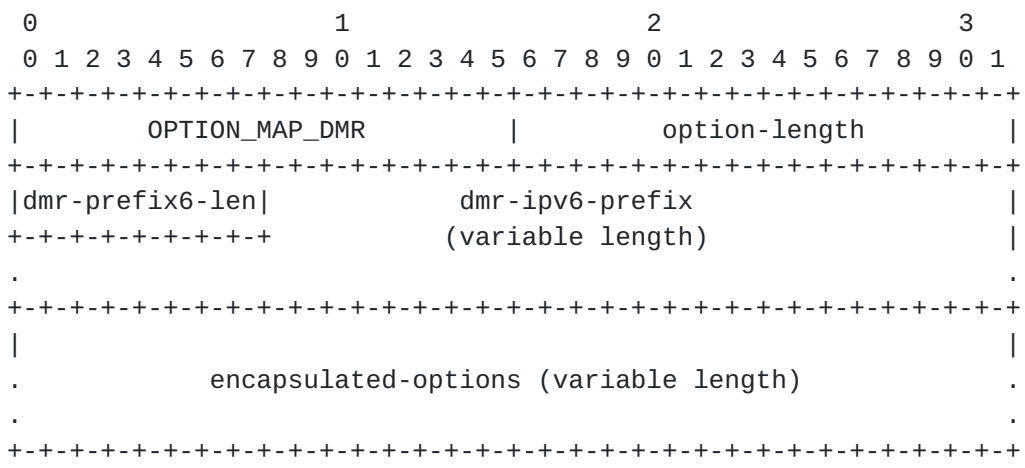

Figure 5: MAP DMR Option

- option-code: OPTION_MAP_DMR (TBD3)
- option-length: 1 + length of dmr-ipv6-prefix + encapsulated options, specified in bytes.
- dmr-prefix6-len: 8 bits long field expressing the bit mask length of the IPv6 prefix specified in the dmr-ipv6-prefix field.
- dmr-ipv6-prefix: a variable length field that specifies the IPv6 prefix or address for the MAP BR. This field is padded with follow up zeros to the nearest octet boundary when dmr-prefix6-len is not divisible by 8.
- encapsulated options: nested options associatied to this MAP DMR option. Currently there are no such options defined, but they may be defined in the future.

4.5. MAP Port Parameters Option

Port Parameters Option specifies optional Rule Port Parameters that MAY be provided as part of the Mapping Rule. It MAY appear as encapsulated option in OPTION_MAP option. It MUST NOT appear directly in a message. It MUST NOT appear in OPTION_MAP_RULE nor OPTION_MAP_DMR options.

See [I-D.ietf-softwire-map], Section 5.1 for detailed description of MAP algorithm that explains meaning of all parameters.

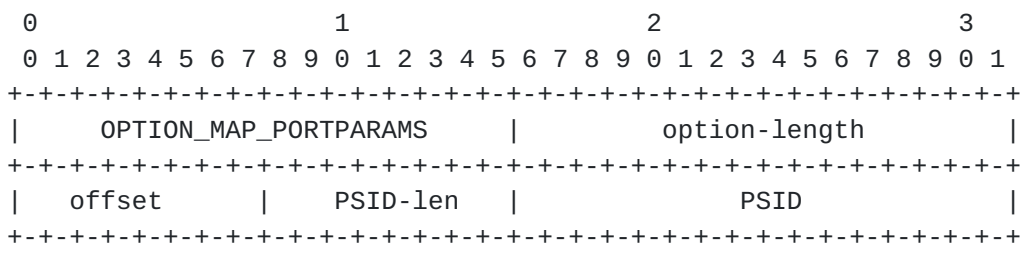

Figure 6: MAP Port Parameters Option

- o option-code: OPTION_MAP_PORTPARAMS (TBD4)
- o option-length: 4
- o offset: (PSID offset) 8 bits long field that specifies the numeric value for the MAP algorithm's excluded port range/offset bits (A-bits), as per section 5.1.1 in [I-D.ietf-softwire-map]. Allowed values are between 0 and 16, with the default value being 4.
- o PSID-len: Bit length value of 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 valid of PSID. Subsequently, the address sharing ratio would be 2^k.
- o PSID: 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-octets field is the PSID value. The remaining (16-k) bits on the right are padding zeros.

When receiveing the Port Parameters option with an explicit PSID, the client MUST use this explicit PSID in configuring its MAP interface.

5. DHCPv6 Server Behavior

RFC 3315 Section 17.2.2 [RFC3315] describes how a DHCPv6 client and server negotiate configuration values using the ORO. As a convenience to the reader, we mention here that a server will by default not reply with a MAP Rule Option if the client has not explicitly enumerated it on its Option Request Option.

A Server following this specification MUST allow the configuration of one or more MAP Rule Options, exactly one DMR Option and optional Port Parameters Option and SHOULD send such options grouped under a single MAP Container Option.

Server MUST include a MAP Container Option (which encapsulates all MAP Rule, MAP DMR, and MAP Port parameters Options) in its responses if client requested it using OPTION_MAP in client's Option Request Option (ORO).

Server MAY include more than one MAP Container Options only in the unlikely case of having more than one MAP Domain configured.

The server SHOULD be capable of following per client assignment rules when assigning MAP options.

6. DHCPv6 Client Behavior

A MAP CE acting as DHCPv6 client will request MAP configuration to be assigned by the DHCPv6 server located in the ISP network. A client supporting MAP functionality SHOULD request OPTION_MAP option in its ORO in SOLICIT, REQUEST, RENEW, REBIND and INFORMATION-REQUEST messages.

When processing received MAP options the following behaviour is expected:

- A client MUST support processing multiple received OPTION_MAP_RULE options in a OPTION_MAP option
- A client receiving an unsupported MAP option, or an unrecognized parameter value SHOULD discard the entire OPTION_MAP.
- Exactly one OPTION_MAP_DMR is allowed per OPTION_MAP option. Client MUST ignore entire OPTION_MAP if there is zero or more than one MAP DMR Option.

The client MUST be capable of applying the received MAP option parameters for the configuration of the local MAP instance.

Note that system implementing MAP CE functionality may have multiple network interfaces, and these interfaces may be configured differently; some may be connected to networks that call for MAP, and some may be connected to networks that are using normal dual stack or other means. The MAP CE system should approach this specification on an interface-by-interface basis. For example, if the CE system is attached to multiple networks that provide the MAP Mapping Rule Option, then the CE system MUST configure a MAP connection (i.e. a translation or encapsulation) for each interface separately as each MAP provides IPv4 connectivity for each distinct interface. Means to bind a MAP configuration to a given interface in a multiple interfaces device are out of scope of this document.

7. Usage of flags and paramaters

The defined MAP options contain a number of flags and parameters that are intended to provide full flexibility in the configuration of a MAP CE. Some usage examples are:

- o A MAP CE receiving an OPTION_MAP option with the T flag set to 1 will assume a MAP-E (encapsulation) mode of operation for the domain and all associated rules. Conversely, when the received option has the T flag set to 0, the CE will assume a MAP-T (stateless NAT46 translation) mode of operation.
- o The presence of a OPTION_MAP_RULE option, along with IPv4 prefix parameters, indicates to the MAP CE that NAPT44 mode of operation is expected, following the address mapping rules defined in [I-D.ietf-softwire-map]. Conversely, the absence of an OPTION_MAP_RULE option indicates that NAT44 mode is not required, and that the MAP CE is to plainly encapsulate (MAP-E mode) or statelessly translate using NAT64 (MAP-T mode) any IPv4 traffic sent following the DMR.
- o The MAP domain ipv6-prefix in the BMR should correspond to a service prefix assigned to the CPE by the operator, with the latter being assigned using regular IPv6 means, e.g. DHCP PD [RFC3633] or SLAAC. This parameter allows the CPE to select the prefix for MAP operation.
- o The EA_LEN parameter, along with the length of the IPv4 prefix in the BMR option, allows the MAP CE to determine whether address sharing is in effect, and what is the address sharing ratio. Eg: A prefix4-len of 16 bits, and EA-len of 18 combines to a 32 bit IPv4 address with a sharing ratio of 4.
- o The use of the F(orward) flag in the BMR allows a CE to apply a received BMR as an FMR, thereby enabling mesh-mode for the domain covered by the BMR rule.
- o In the absence of a BMR, the presence of the mandatory DMR indicates to the CPE the address or prefix of a BR, and makes the MAP CE fully compatible with DS-Lite and stateful or stateless NAT64 core nodes. Eg a MAP CE configured in MAP-E mode, with just a DMR and a BR IPv6 address equivalent to that of the AFTR, effectively acts as a DS-Lite B4 element. For more discussion about MAP deployment considerations, see [I-D.mdt-softwire-map-deployment].

8. Deployment considerations

Usage of PSID Option should be avoided if possible and PSID embedded in the delegated prefix should be used instead. This allows MAP deployment to not introduce any additional state in DHCP server. Port Parameters Option must be assigned on a per CE basis, thus requiring more complicated server configuration.

In a typical environment, there will be only one MAP domain, so server will provide only a single instance of MAP Container Option that acts a container for MAP Rules and other options that are specific to that MAP domain.

In case of multiple provisioning domains, as defined in [I-D.ietf-homenet-arch], one server may be required to provide information about more than one MAP domain. In such case it is envisaged that the server will provide two or more instances of MAP Container Options, each with its own set of encapsulated options that define MAP rules for each specific MAP domain. Details of mulitple provisioning domains are discussed in Section 4.1 of [I-D.mdt-softwire-map-deployment]. Such a deployment is outside of scope for this document.

9. IANA Considerations

IANA is kindly requested to allocate the following DHCPv6 option codes: TBD1 for OPTION_MAP, TBD2 for OPTION_MAP_RULE, TBD3 for OPTION_MAP_DMR, and TBD4 for OPTION_MAP_PORTPARAMS. All values should be added to the DHCPv6 option code space defined in Section 24.3 of [RFC3315].

10. Security Considerations

Implementation of this document does not present any new security issues, but as with all DHCPv6-derived configuration state, it is completely possible that the configuration is being delivered by a third party (Man In The Middle). As such, there is no basis to trust that the access over the MAP can be trusted, and it should not therefore bypass any security mechanisms such as IP firewalls.

Readers concerned with security of MAP provisioning over DHCPv6 are encouraged to read [I-D.ietf-dhc-secure-dhcpv6].

Section XX of [I-D.ietf-softwire-map] discusses security issues of the MAP mechanism.

Section 23 of [RFC3315] discusses DHCPv6-related security issues.

11. Acknowledgements

This document was created as a product of a MAP design team. Following people were members of that team: Congxiao Bao, Mohamed Boucadair, Gang Chen, Maoke Chen, Wojciech Dec, Xiaohong Deng, Jouni Korhonen, Xing Li, Satoru Matsushima, Tomasz Mrugalski, Tetsuya Murakami, Jacni Qin, Necj Scoberne, Qiong Sun, Tina Tsou, Dan Wing, Leaf Yeh and Jan Zorz.

Former MAP design team members are: Remi Despres.

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Appendix A. MAP Options Examples

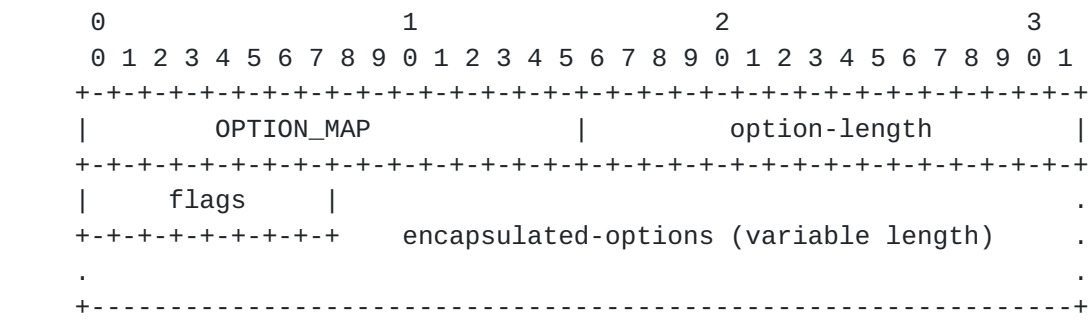
DHCPv6 server provisioning a single MAP Rule to a CE (DHCPv6 client) will convey the following MAP options in its messages:

A.1. BMR Option Example

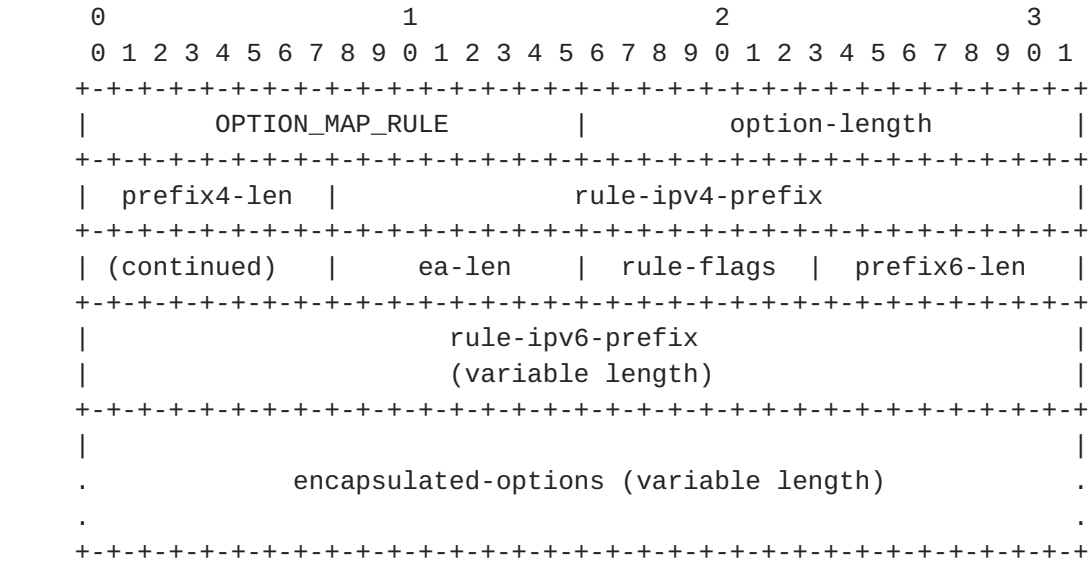
Given the MAP domain information and an IPv6 address of an endpoint:

- IPv6 prefix assigned to the end user: 2001:db8:0012:3400::/56
- Basic Mapping Rule: {2001:db8:0000::/40 (Rule IPv6 prefix), 192.0.2.0/24 (Rule IPv4 prefix), 16 (Rule EA-bits length)}
- PSID offset: 4

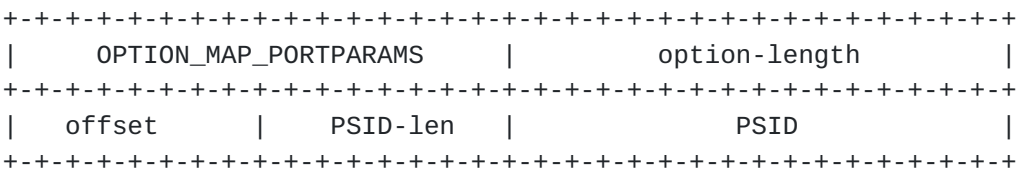
Assume use an independent container and with port sub-option.



OPTION_MAP=TBD1
option-length=26
flags=0x01 # encapsulation



OPTION_MAP_RULE=TBD2
option-length=21
prefix4-len=24
rule-ipv4-prefix=192.0.2.0
ea-len=16
rule-flags=0x01 # BMR and FMR
prefix6-length=40
rule-ipv6-prefix=2001:db8:0000::



OPTION_MAP_PORTPARAMS=TBD4
option-length=4
offset=4
PSID-len=8
PSID=52

Figure 7: BMR Option Example

A.2. FMR Option Example

TODO: Reflect example in section 5.3 of MAP draft

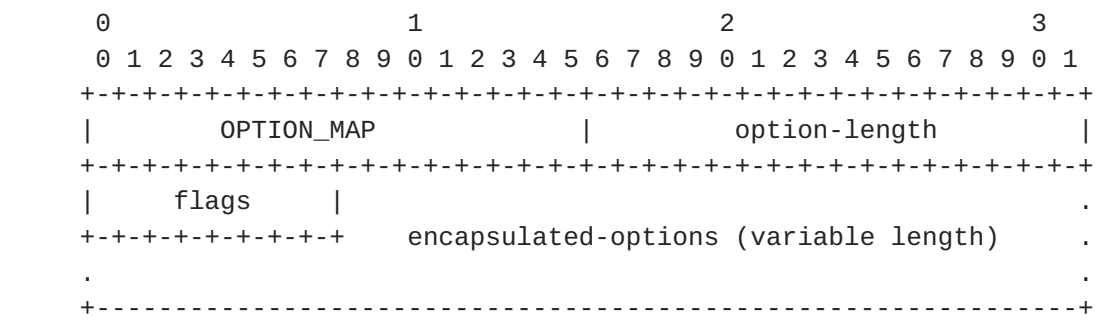
Figure 8: FMR Option Example

A.3. DMR Option Example

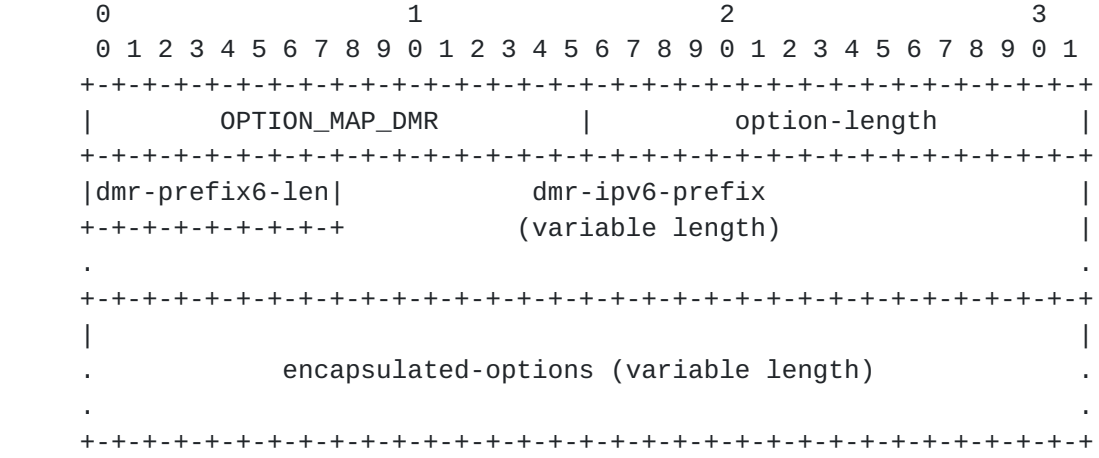
An IPv4 host behind the MAP CE (addressed as per the previous examples) corresponding with IPv4 host 1.2.3.4 will have its packets converted into IPv6 using the DMR configured on the MAP CE as follows:

- Default Mapping Rule: {2001:db8:ffff::1/128 (Rule IPv6 prefix), 0.0.0.0/0 (Rule IPv4 prefix), null (BR IPv4 address)}

Assume use an independent container.




```
OPTION_MAP=TBD1
option-length=22
flags=0x01 # encapsulation
```




```
OPTION_MAP_DMR=TDB3
option-length=17
dmr-prefix6-len=128
dmr-ipv6-prefix=2001:db8:ffff::1
```

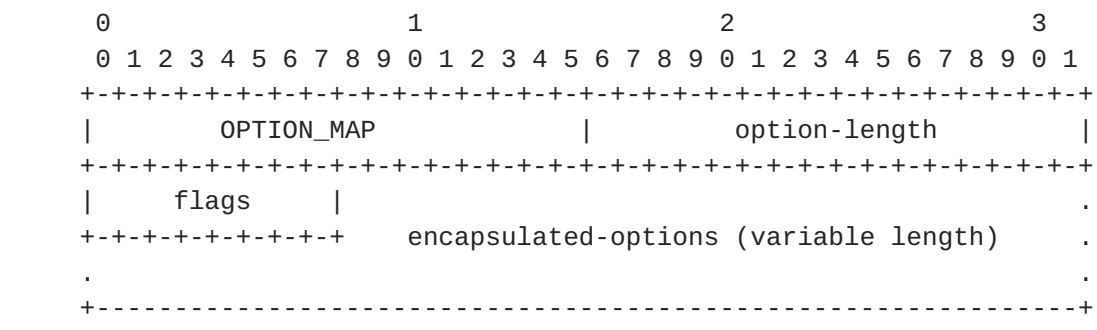
Figure 9: DMR Option Examples

A.4. 1:1 Rule with No Address Sharing Example

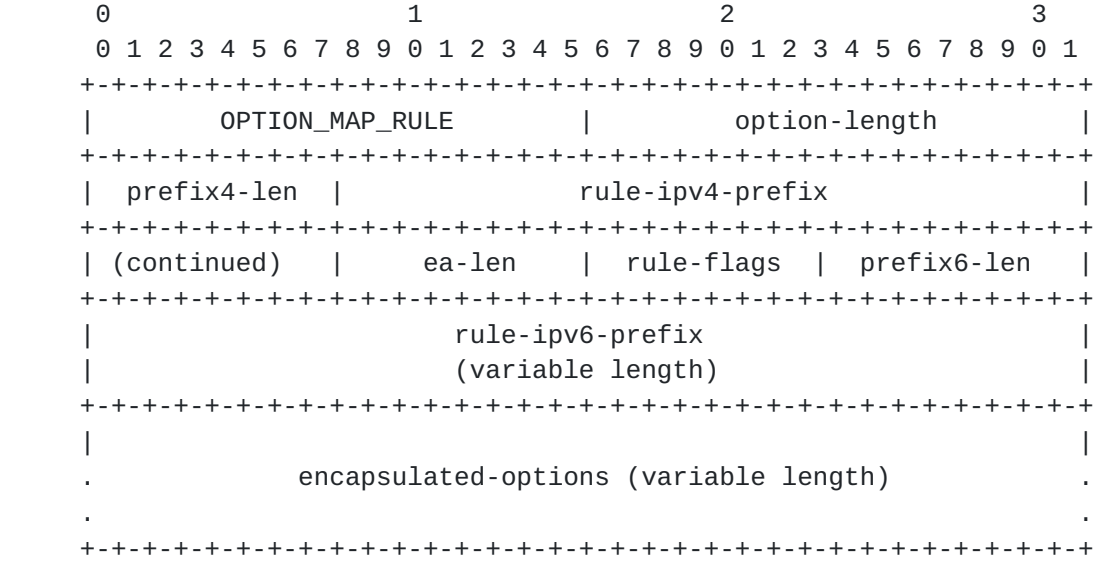
Given the MAP domain information and an IPv6 address of an endpoint:

- IPv6 prefix assigned to the end user: 2001:db8:0012:3400::/56
- Basic Mapping Rule: {2001:db8:0012:3400::/56 (Rule IPv6 prefix), 192.0.2.1/32 (Rule IPv4 prefix), 0 (Rule EA-bits length)}
- PSID offset: n/a

Assume use an independent container.




```
OPTION_MAP=TBD1
option-length=20
flags=0x00 # just for BMR, not for FMR
```




```
OPTION_MAP_RULE=TBD2
option-length=15
prefix4-len=32
rule-ipv4-prefix=192.0.2.1
ea-len=0
rule-flags=0x00 # for BMR only
prefix6-length=56
rule-ipv6-prefix=2001:db8:0012:3400::
```

Figure 10: 1:1 Rule with No Address Sharing Examples

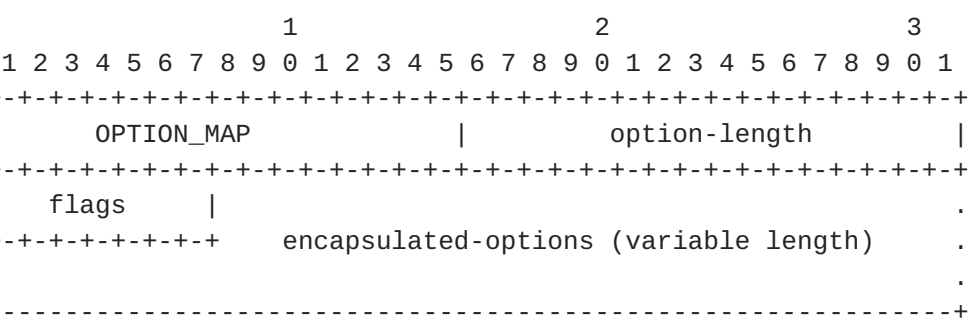
A.5. 1:1 Rule with Address Sharing Example

Given the MAP domain information and an IPv6 address of an endpoint:

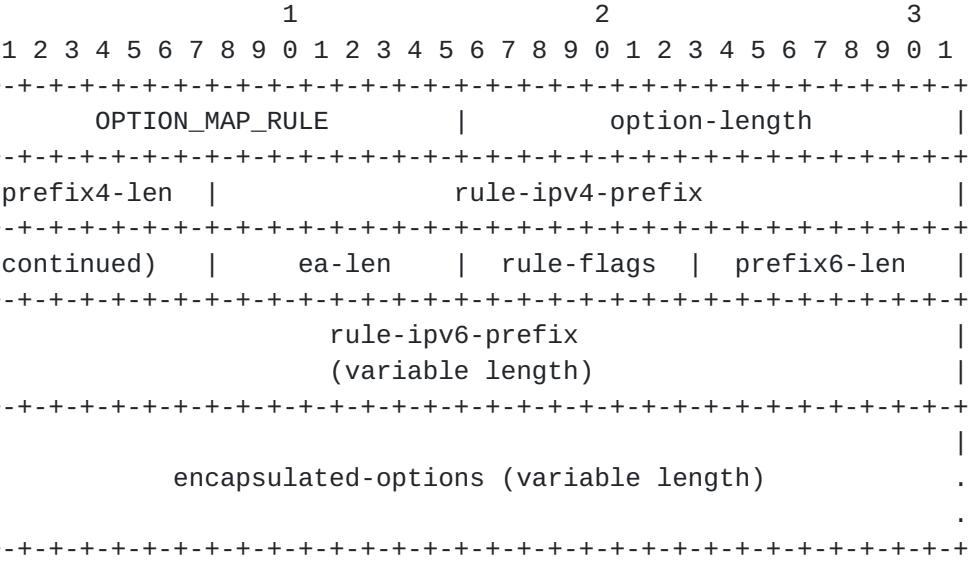
- IPv6 prefix assigned to the end user: 2001:db8:0012:3400::/56
- Basic Mapping Rule: {2001:db8:0012:3400::/56 (Rule IPv6 prefix), 192.0.2.1/32 (Rule IPv4 prefix), 0 (Rule EA-bits length) PSID-len 8, PSID 11 }

o PSID offset: 4

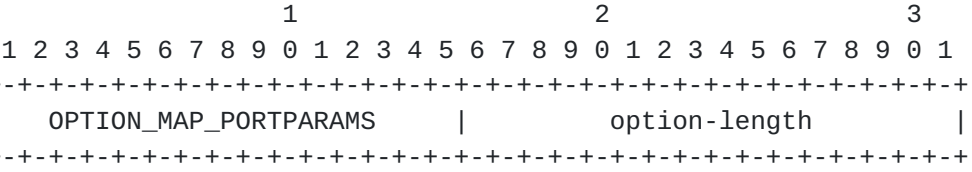
Assume use an independent container and with port sub-option.

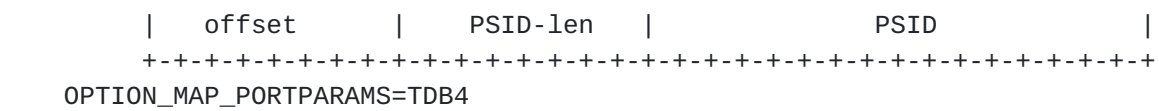


OPTION_MAP=TBD1
option-length=28
flags=0x01



OPTION_MAP_RULE=TBD2
option-length=23
rule-ipv4-prefix=192.0.2.1
rule-flags=0x00 # for BMR only
ea-len=0
prefix4-len=32
prefix6-length=56
rule-ipv6-prefix=2001:db8:0012:3400::






```
   OPTION_MAP_PORTPARAMS=TDB4
   option-length=4
   offset=4
   PSID-len=8
   PSID=11
```

Figure 11: 1:1 Rule with no Address Sharing Examples

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