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DHCPv6 Options for LWM2M bootstrap information
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Abstract

This document defines Dynamic Host Configuration Protocol and Dynamic Host Configuration Protocol version 6 (DHCPv6) Options for LWM2M client bootstrap information, which are used to carry Uniform Resource Locater of LWM2M bootstrap server and certificate that validates the public key presented by server.

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 March 1, 2018.

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1. Introduction

Light weight machine to machine (LWM2M) protocol is used to manage end device life cycle in machine to machine communication scenarios. LWM2M device bootstrap is an optional life cycle phase for devices to get needed information when starting up for first time. Information gathered during bootstrapping might include management server details and security certificates required to establish connectivity with management server. Information required to connect with bootstrap server might be hard coded during device manufacturing phase.

Hard coding configuration by device manufacturer forces device operator to use same configuration as hard coded. It is possible that reachability information of bootstrap server that is hard coded may be outdated and boot strap server reachability might fail during first use of device. In such cases connectivity with bootstrap server is possible only through device software upgrade.

2. Terminology

This document makes use of the following terms:

LWM2M: Lightweight Machine to Machine is a protocol from Open Mobile alliance for device management in M2M or Internet of Things scenarios

LWM2M bootstrap server: The server that provides LWM2M bootstrap interface which is used to optionally configure a LWM2M Client so that it can successfully register with a LWM2M management Server

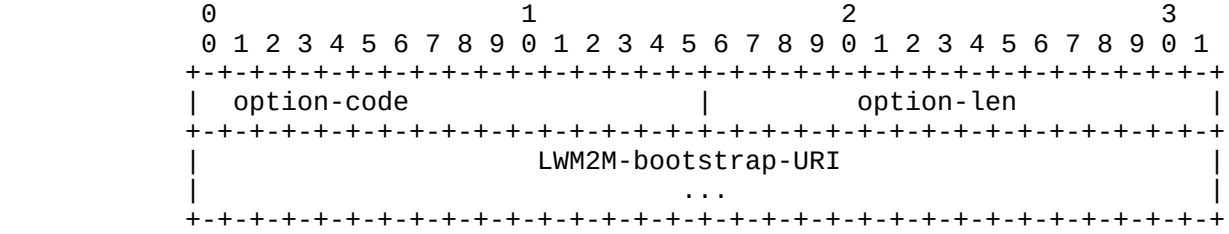
LWM2M management server: The server that provides registration, device management and service enablement interface to manage a LWM2M client.

3. LWM2M bootstrap server information through DHC

LWM2M bootstrap server details like URI and security certificate can be collected during dynamic host configuration phase. DHCPv4 and DHCPv6 options can be extended to collect LWM2M bootstrap server information for IPv4 and IPv6 networks respectively. DHCPv4 or DHCPv6 client requests LWM2M bootstrap server URI and LWM2M server certificate using new options proposed in sections below

3.1. DHCPv6 option for LWM2M bootstrap server URI

DHCPv6 option OPTION_LWM2M_BOOTSTRAP_URI conveys URI through which LWM2M client can reach LWM2M bootstrap server reachable through IPv6 network. The format of LWM2M bootstrap server URI option is as shown below:



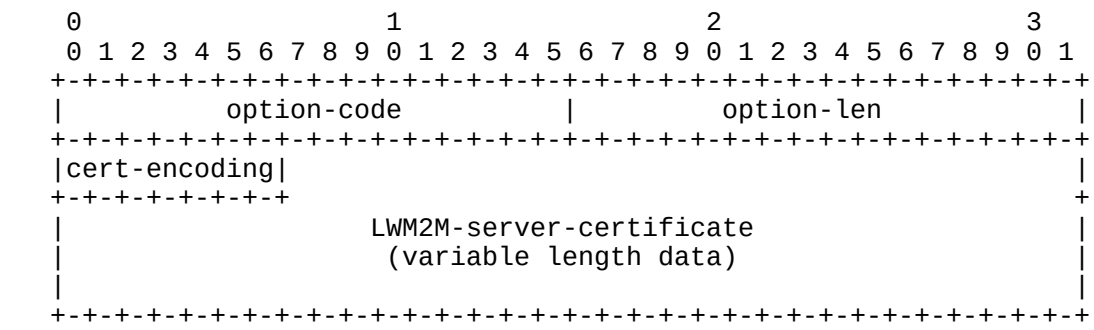
option-code: OPTION_LWM2M_BOOTSTRAP_URI

option-len: Length of the 'LWM2M-bootstrap-URI' field in octets

LWM2M-bootstrap-URI: This string is URI of LWM2M bootstrap server. The string is not null-terminated.

3.2. DHCPv6 option for LWM2M server certificate

DHCPv6 option OPTION_LWM2M_SERVER_CERTIFICATE conveys security certificate which can be used by LWM2M client to establish secure connection with LWM2M server reachable through IPv6 network. The format of LWM2M server certificate option is as shown below:



option-code: OPTION_LWM2M_SERVER_CERTIFICATE

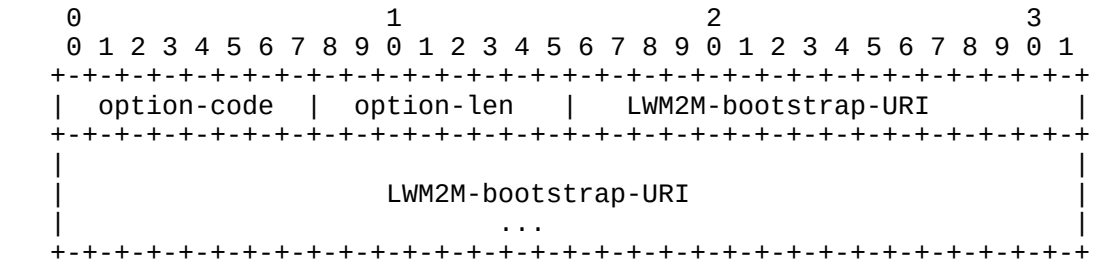
option-len: Length of the 'LWM2M-server-certificate' field in octets + 1

cert-encoding: This field indicates the type of certificate or certificate-related information contained in LWM2M-server-certificate field. See Section 4 for details.

LWM2M-server-certificate: Digital certificate of LWM2M server encoded according to cert-encoding. See Section 4 for details

3.3. DHCPv4 option for LWM2M bootstrap server URI

DHCPv4 option OPTION_LWM2M_BOOTSTRAP_URI conveys URI through which LWM2M client can reach LWM2M bootstrap server reachable through IPv4 network. The format of LWM2M bootstrap server URI option is as shown below:



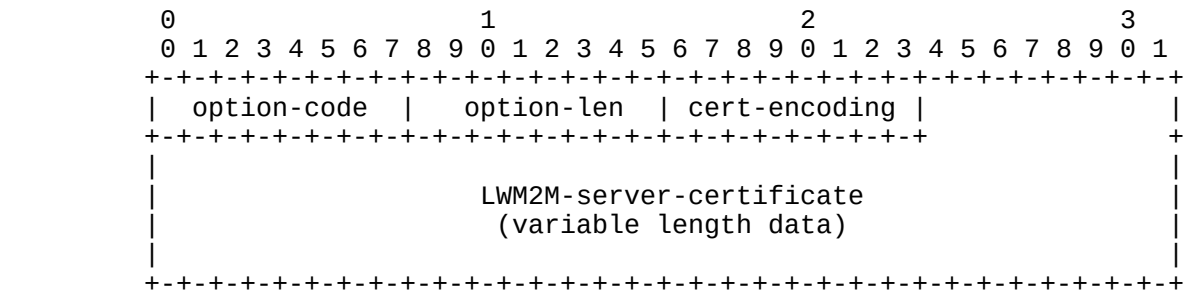
option-code: OPTION_LWM2M_BOOTSTRAP_URI

option-len: Length of the 'LWM2M-bootstrap-URI' field in octets

LWM2M-bootstrap-URI: This string is URI of LWM2M bootstrap server. The string is not null-terminated.

3.4. DHCPv4 option for LWM2M server certificate

DHCPv4 option OPTION_LWM2M_SERVER_CERTIFICATE conveys security certificate which can be used by LWM2M client to establish secure connection with LWM2M server reachable through IPv4 network. The format of LWM2M server certificate option is as shown below:



option-code: OPTION_LWM2M_SERVER_CERTIFICATE

option-len: Length of the 'LWM2M-server-certificate' field in octets + 1

cert-encoding: This field indicates the type of certificate or certificate-related information contained in LWM2M-server-certificate field. See Section 4 for details.

LWM2M-server-certificate: Digital certificate of LWM2M server encoded according to cert-encoding. See Section 4 for details

4. LWM2M-server-certificate encoding

As defined in Section 3.6 of [RFC7296] and [IKEv2IANA] the values in the following table are allocated for Certificate Encoding types. Other values may have been added since then or will be added after the publication of this document. Readers should refer to [IKEv2IANA] for latest values.

Value	Certificate Encoding
0	Reserved
1	PKCS #7 wrapped X.509 certificate
2	PGP Certificate
3	DNS Signed Key
4	X.509 Certificate - Signature
5	Reserved
6	Kerberos Token
7	Certificate Revocation List (CRL)
8	Authority Revocation List (ARL)
9	SPKI Certificate
10	X.509 Certificate - Attribute
11	Raw RSA Key (DEPRECATED)
12	Hash and URL of X.509 certificate
13	Hash and URL of X.509 bundle
14	OCSP Content
15	Raw Public Key
16-200	Unassigned
201-255	Private use

5. Appearance of Option

5.1. Appearance of options in DHCPv6 control messages

The OPTION_LWM2M_BOOTSTRAP_URI and OPTION_LWM2M_SERVER_CERTIFICATE options MUST NOT appear in messages other than the following: SOLICIT (1), ADVERTISE (2), REQUEST (3),REPLY (4) RENEW (5), REBIND (6), INFORMATION-REQUEST (11). If this option appears in messages other than those specified above, the receiver MUST ignore it.

The option number for OPTION_LWM2M_BOOTSTRAP_URI and OPTION_LWM2M_SERVER_CERTIFICATE options MAY appear in the "Option Request" option [RFC3315] in the following messages: SOLICIT (1), REQUEST (3), RENEW (5), REBIND (6), INFORMATION-REQUEST (11) and RECONFIGURE (10). If this option number appears in the "Option Request" option in messages other than those specified above, the receiver SHOULD ignore it.

5.2. Appearance of options in DHCPv4 control messages

The OPTION_LWM2M_BOOTSTRAP_URI and OPTION_LWM2M_SERVER_CERTIFICATE options MUST NOT appear in messages other than the following: DHCPDISCOVER (1), DHCPOFFER (2), DHCPREQUEST (3), DHCPACK (5) and DHCPINFORM (8). If this option appears in messages other than those specified above, the receiver MUST ignore it.

The option number for OPTION_LWM2M_BOOTSTRAP_URI and OPTION_LWM2M_SERVER_CERTIFICATE options MAY appear in the "Parameter Request List" option [RFC2132] in the following messages: DHCPDISCOVER (1), DHCPOFFER (2), DHCPREQUEST (3), DHCPACK (5) and DHCPINFORM (8). If this option number appears in the "Parameter Request List" option in messages other than those specified above, the receiver SHOULD ignore it.

Maximum possible value of DHCPv4 "option-len" is 255. LWM2M-server-certificate MAY be of length more than 255. To accommodate larger certificate, DHCP server SHOULD follow encoding as mentioned in [RFC3396].

6. Configuration Guidelines for the Server

DHCPv4 or DHCPv6 server that supports OPTION_LWM2M_BOOTSTRAP_URI and OPTION_LWM2M_SERVER_CERTIFICATE SHOULD be configured with one and only one LWM2M bootstrap server URI, and one and only one certificate that validates bootstrap server’s public key.

In the absence of URI configuration, DHCP server SHOULD ignore option OPTION_LWM2M_BOOTSTRAP_URI, and SHOULD continue processing of DHCP control message

In the absence of certificate configuration, DHCP server SHOULD ignore option OPTION_LWM2M_SERVER_CERTIFICATE, and SHOULD continue processing of DHCP control message

7. DHCPv4/DHCPv6 Client Behavior

DHCP or DHCPv6 client MAY decide need for inclusion of OPTION_LWM2M_BOOTSTRAP_URI and OPTION_LWM2M_SERVER_CERTIFICATE options in DHCPv4 or DHCPv6 control messages if device is capable of supporting LWM2M client functionality irrespective of state of LWM2M client. It is possible that LWM2M client MAY not be active before DHCPv4 or DHCPv6 message exchanges happens. In such scenario, DHCPv4 or DHCPv6 client MAY collect LWM2M bootstrap server URI and LWM2M server certificate and keep ready for LWM2M client initialization

DHCPv4 or DHCPv6 client MAY prefer collecting LWM2M bootstrap server URI and LWM2M server certificate by including OPTION_LWM2M_BOOTSTRAP_URI and OPTION_LWM2M_SERVER_CERTIFICATE options in DHCPINFORM or INFORMATION-REQUEST message which MAY be send during LWM2M client initialization

LWM2M client devices running with IPv6 stack MAY use stateless auto address configuration to get IPv6 address. Such clients MAY use DHCPv6 INFORMATION-REQUEST to get LWM2M bootstrap URI and LWM2M

server server certificate through options OPTION_LWM2M_BOOTSTRAP_URI and OPTION_LWM2M_SERVER_CERTIFICATE

8. Relay agent Behavior

This draft does not impose any new requirements on DHCPv4 or DHCPv6 relay agent functionality

9. Security Considerations

OPTION_LWM2M_BOOTSTRAP_URI and OPTION_LWM2M_SERVER_CERTIFICAT options could be used by an intruder to advertise the URI of a malicious LWM2M bootstrap server and certificate and can alter the LWM2M management server details provided to LWM2M client. The consequences of such an attack can be critical, because any data that is reported by LWM2M client MAY reach unwanted LWM2M management server. As an example, an attacker could collect data from secure locations by deploying malicious servers.

To prevent these attacks, it is strongly advisable to secure the use of this option by either:

- Using authenticated DHCP as described in [RFC3315], Section 21.
- Using options OPTION_LWM2M_BOOTSTRAP_URI and OPTION_LWM2M_SERVER_CERTIFICATE only with trusted DHCP server

The security considerations documented in [RFC3315] are to be considered.

10. Acknowledgement

Particular thanks to A. Keraenen, J. Jimenez, J. Melen and S. Krishnan for the concept, inputs and review.

11. IANA Considerations

IANA is requested to assign new DHCPv6 option codes in the registry maintained in http://www.iana.org/assignments/dhcpv6-parameters:

Option Name	Value
OPTION_LWM2M_BOOTSTRAP_URI	TBA
OPTION_LWM2M_SERVER_CERTIFICATE	TBA

IANA is requested to assign new DHCPv4 option codes in the registry maintained in http://www.iana.org/assignments/bootp-dhcp-parameters:

Option Name	Value
OPTION_LWM2M_BOOTSTRAP_URI	TBA
OPTION_LWM2M_SERVER_CERTIFICATE	TBA

12. References

12.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC2131] Droms, R., "Dynamic Host Configuration Protocol", RFC 2131, DOI 10.17487/RFC2131, March 1997, <https://www.rfc-editor.org/info/rfc2131>.

[RFC2132] Alexander, S. and R. Droms, "DHCP Options and BOOTP Vendor Extensions", RFC 2132, DOI 10.17487/RFC2132, March 1997, <https://www.rfc-editor.org/info/rfc2132>.

[RFC3315] Droms, R., Ed., Bound, J., Volz, B., Lemon, T., Perkins, C., and M. Carney, "Dynamic Host Configuration Protocol for IPv6 (DHCPv6)", RFC 3315, DOI 10.17487/RFC3315, July 2003, <https://www.rfc-editor.org/info/rfc3315>.

[RFC3396] Lemon, T. and S. Cheshire, "Encoding Long Options in the Dynamic Host Configuration Protocol (DHCPv4)", RFC 3396, DOI 10.17487/RFC3396, November 2002, <https://www.rfc-editor.org/info/rfc3396>.

[RFC4306] Kaufman, C., Ed., "Internet Key Exchange (IKEv2) Protocol", RFC 4306, DOI 10.17487/RFC4306, December 2005, <https://www.rfc-editor.org/info/rfc4306>.

[RFC5280] Cooper, D., Santesson, S., Farrell, S., Boeyen, S., Housley, R., and W. Polk, "Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile", RFC 5280, DOI 10.17487/RFC5280, May 2008, <https://www.rfc-editor.org/info/rfc5280>.

[RFC7227] Hankins, D., Mrugalski, T., Siodelski, M., Jiang, S., and S. Krishnan, "Guidelines for Creating New DHCPv6 Options", BCP 187, RFC 7227, DOI 10.17487/RFC7227, May 2014, <https://www.rfc-editor.org/info/rfc7227>.

[RFC7296] Kaufman, C., Hoffman, P., Nir, Y., Eronen, P., and T. Kivinen, "Internet Key Exchange Protocol Version 2 (IKEv2)", STD 79, RFC 7296, DOI 10.17487/RFC7296, October 2014, <https://www.rfc-editor.org/info/rfc7296>.

12.2. Informative References

[IKEv2IANA] "Internet Key Exchange Version 2 (IKEv2) Parameters", n.d., <https://www.iana.org/assignments/ikev2-parameters/ikev2-parameters.xhtml>.

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YANG Data Model for DHCPv6 Configuration
draft-ietf-dhc-dhcpv6-yang-07

Abstract

This document describes a YANG data model [RFC6020] for the configuration and management of DHCPv6 servers, relays, and clients.

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 [RFC2119].

Status of This Memo

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This Internet-Draft will expire on March 8, 2019.

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1. Introduction

DHCPv6 [RFC3315] is widely used for supplying configuration and other relevant parameters to clients in IPv6 networks. This document defines a DHCPv6 YANG data model, containing sub-modules for the configuration and management of DHCPv6 servers, relays and clients. A single YANG model covering all of these elements provides an operator with a common interface for the management of the entire DHCPv6 deployment in their network.

Since the publication of the original DHCPv6 specification, there have been a large number of addional documents that update the protocol's operation, add new functions and define new options. The YANG model described in this document incorporates all relevent

changes. A full list of the documents which have been considedered in the development of this model is included in Appendix A.

IF - Commment - Does anyone have this list?

It is worth noting that as DHCPv6 is itself a device configuration protocol, it is not the intention of this document to replace the configuration of DHCPv6 options and parameters using the DHCPv6 protocol with the configuration of DHCPv6 options using NETCONF/YANG. The DHCPv6 client model is intended for the configuration of the DHCPv6 client function and also for obtaining read-only state data from the client which has been learnt via the normal DHCPv6 message flow. This gives an operator a better method for managing DHCPv6 clients and simplifies troubleshooting.

1.1. Terminology

The reader should be familiar with the terms defined in DHCPv6 [RFC3315] and other relevant documents.

The DHCPv6 tree diagrams provide a concise representation of a YANG module to help the reader understand the module structure.

A simplified graphical representation of the data model is provided in this d cument. For a description of the symbols in these diagrams, please refer to [I-D.ietf-netmod-yang-tree-diagrams].

2. DHCPv6 Tree Diagram

2.1. DHCPv6 Server Tree Diagrams

```
module: ietf-dhcpv6-server
  +--rw server!
     +--rw server-config
     |  +--rw serv-attributes
     |  |  +--rw duid
     |  |  |  +--rw type-code?                          uint16
     |  |  |  +--rw (duid-type)?
     |  |  |     +--:(duid-llt)
     |  |  |     |  +--rw duid-llt-hardware-type?       uint16
     |  |  |     |  +--rw duid-llt-time?                yang:timeticks
     |  |  |     |  +--rw duid-llt-link-layer-addr?     yang:mac-address
     |  |  |     +--:(duid-en)
     |  |  |     |  +--rw duid-en-enterprise-number?    uint32
     |  |  |     |  +--rw duid-en-identifier?           string
     |  |  |     +--:(duid-ll)
     |  |  |     |  +--rw duid-ll-hardware-type?        uint16
     |  |  |     |  +--rw duid-ll-link-layer-addr?      yang:mac-address
```

```
     |  |  |     +--:(duid-uuid)
     |  |  |     |  +--rw uuid?                        yang:uuid
     |  |  |     +--:(duid-unknown)
     |  |  |        +--rw data?                        binary
     |  |  +--rw name?                string
     |  |  +--rw description?         string
     |  |  +--rw ipv6-address*        inet:ipv6-address
     |  |  +--rw interfaces-config*   if:interface-ref
     |  |  +--rw lease-storage
     |  |  |  +--rw (storage-type)?
     |  |  |     +--:(memfile)
     |  |  |     |  +--rw memfile-name?                 string
     |  |  |     |  +--rw memfile-lfc-interval?         uint64
     |  |  |     +--:(mysql)
     |  |  |     |  +--rw mysql-name?                   string
     |  |  |     |  +--rw mysql-host?                   string
     |  |  |     |  +--rw mysql-password?               string
     |  |  |     |  +--rw mysql-port?                   uint8
     |  |  |     |  +--rw mysql-lfc-interval?           uint64
     |  |  |     |  +--rw mysql-connect-timeout?        uint64
     |  |  |     +--:(postgresql)
     |  |  |     |  +--rw postgresql-name?              string
     |  |  |     |  +--rw postgresql-host?              string
     |  |  |     |  +--rw postgresql-password?          string
     |  |  |     |  +--rw postgresql-port?              uint8
     |  |  |     |  +--rw postgresql-lfc-interval?      uint64
     |  |  |     |  +--rw postgresql-connect-timeout?   uint64
     |  |  |     +--:(cassandra)
     |  |  |        +--rw cassandra-name?              string
     |  |  |        +--rw cassandra-contact-points?    string
     |  |  |        +--rw cassandra-password?          string
     |  |  |        +--rw cassandra-lfc-interval?      uint64
     |  |  |        +--rw cassandra-connect-timeout?   uint64
     |  |  +--rw vendor-info
     |  |     +--rw ent-num    uint32
     |  |     +--rw data*      string
     |  +--rw option-sets
     |  |  +--rw option-set* [option-set-id]
     |  |     +--rw option-set-id                          uint32
     |  |     +--rw server-unicast-option! {server-unicast-op}?
     |  |     |  +--rw server-address?   inet:ipv6-address
     |  |     +--rw sip-server-domain-name-list-option! {sip-server-domain-name-
list-op}?
     |  |     |  +--rw sip-serv-domain-name    string
     |  |     +--rw sip-server-address-list-option! {sip-server-address-list-op}
?
     |  |     |  +--rw sip-server* [sip-serv-id]
     |  |     |     +--rw sip-serv-id      uint8
     |  |     |     +--rw sip-serv-addr    inet:ipv6-address
     |  |     +--rw dns-servers-option! {dns-servers-op}?
```

```
|  |     |  +--rw dns-server* [dns-serv-id]
|  |     |     +--rw dns-serv-id      uint8
|  |     |     +--rw dns-serv-addr    inet:ipv6-address
|  |     +--rw domain-searchlist-option! {domain-searchlist-op}?
|  |     |  +--rw domain-searchlist* [domain-searchlist-id]
|  |     |     +--rw domain-searchlist-id        uint8
|  |     |     +--rw domain-search-list-entry    string
|  |     +--rw nis-config-option! {nis-config-op}?
|  |     |  +--rw nis-server* [nis-serv-id]
|  |     |     +--rw nis-serv-id      uint8
|  |     |     +--rw nis-serv-addr    inet:ipv6-address
|  |     +--rw nis-plus-config-option! {nis-plus-config-op}?
|  |     |  +--rw nis-plus-server* [nis-plus-serv-id]
|  |     |     +--rw nis-plus-serv-id      uint8
|  |     |     +--rw nis-plus-serv-addr    inet:ipv6-address
|  |     +--rw nis-domain-name-option! {nis-domain-name-op}?
|  |     |  +--rw nis-domain-name?   string
|  |     +--rw nis-plus-domain-name-option! {nis-plus-domain-name-op}?
|  |     |  +--rw nis-plus-domain-name?   string
|  |     +--rw sntp-server-option! {sntp-server-op}?
|  |     |  +--rw sntp-server* [sntp-serv-id]
|  |     |     +--rw sntp-serv-id      uint8
|  |     |     +--rw sntp-serv-addr    inet:ipv6-address
|  |     +--rw info-refresh-time-option! {info-refresh-time-op}?
|  |     |  +--rw info-refresh-time    yang:timeticks
|  |     +--rw client-fqdn-option! {client-fqdn-op}?
|  |     |  +--rw server-initiate-update    boolean
|  |     |  +--rw client-initiate-update    boolean
|  |     |  +--rw modify-name-from-cli      boolean
|  |     +--rw posix-timezone-option! {posix-timezone-op}?
|  |     |  +--rw tz-posix    string
|  |     +--rw tzdb-timezone-option! {tzdb-timezone-op}?
|  |     |  +--rw tz-database    string
|  |     +--rw ntp-server-option! {ntp-server-op}?
|  |     |  +--rw ntp-server* [ntp-serv-id]
|  |     |     +--rw ntp-serv-id                           uint8
|  |     |     +--rw (ntp-time-source-suboption)?
|  |     |        +--:(server-address)
|  |     |        |  +--rw ntp-serv-addr-suboption*       inet:ipv6-address
|  |     |        +--:(server-multicast-address)
|  |     |        |  +--rw ntp-serv-mul-addr-suboption*   inet:ipv6-address
|  |     |        +--:(server-fqdn)
|  |     |           +--rw ntp-serv-fqdn-suboption*       string
|  |     +--rw boot-file-url-option! {boot-file-url-op}?
|  |     |  +--rw boot-file* [boot-file-id]
|  |     |     +--rw boot-file-id          uint8
|  |     |     +--rw suitable-arch-type*   uint16
|  |     |     +--rw suitable-net-if*      uint32
```

```
|  |     |     +--rw boot-file-url         string
|  |     +--rw boot-file-param-option! {boot-file-param-op}?
|  |     |  +--rw boot-file-paras* [para-id]
|  |     |     +--rw para-id      uint8
|  |     |     +--rw parameter    string
|  |     +--rw aftr-name-option! {aftr-name-op}?
|  |     |  +--rw tunnel-endpoint-name    string
|  |     +--rw kbr-default-name-option! {kbr-default-name-op}?
|  |     |  +--rw default-realm-name    string
|  |     +--rw kbr-kdc-option! {kbr-kdc-op}?
|  |     |  +--rw kdc-info* [kdc-id]
|  |     |     +--rw kdc-id            uint8
|  |     |     +--rw priority          uint16
|  |     |     +--rw weight            uint16
|  |     |     +--rw transport-type    uint8
|  |     |     +--rw port-number       uint16
|  |     |     +--rw kdc-ipv6-addr     inet:ipv6-address
|  |     |     +--rw realm-name        string
|  |     +--rw sol-max-rt-option! {sol-max-rt-op}?
|  |     |  +--rw sol-max-rt-value    yang:timeticks
|  |     +--rw inf-max-rt-option! {inf-max-rt-op}?
|  |     |  +--rw inf-max-rt-value    yang:timeticks
|  |     +--rw addr-selection-option! {addr-selection-op}?
|  |     |  +--rw a-bit-set       boolean
|  |     |  +--rw p-bit-set       boolean
|  |     |  +--rw policy-table* [policy-id]
|  |     |     +--rw policy-id     uint8
|  |     |     +--rw label         uint8
|  |     |     +--rw precedence    uint8
|  |     |     +--rw prefix-len    uint8
|  |     |     +--rw prefix        inet:ipv6-prefix
|  |     +--rw pcp-server-option! {pcp-server-op}?
|  |     |  +--rw pcp-server* [pcp-serv-id]
|  |     |     +--rw pcp-serv-id      uint8
|  |     |     +--rw pcp-serv-addr    inet:ipv6-address
|  |     +--rw s46-rule-option! {s46-rule-op}?
|  |     |  +--rw s46-rule* [rule-id]
|  |     |     +--rw rule-id           uint8
|  |     |     +--rw rule-type         enumeration
|  |     |     +--rw prefix4-len       uint8
|  |     |     +--rw ipv4-prefix       inet:ipv4-prefix
|  |     |     +--rw prefix6-len       uint8
|  |     |     +--rw ipv6-prefix       inet:ipv6-prefix
|  |     |     +--rw port-parameter
|  |     |        +--rw offset      uint8
|  |     |        +--rw psid-len    uint8
|  |     |        +--rw psid        uint16
|  |     +--rw s46-br-option! {s46-br-op}?
```

```
|  |     |  +--rw br* [br-id]
|  |     |     +--rw br-id           uint8
|  |     |     +--rw br-ipv6-addr    inet:ipv6-address
|  |     +--rw s46-dmr-option! {s46-dmr-op}?
|  |     |  +--rw dmr* [dmr-id]
|  |     |     +--rw dmr-id             uint8
|  |     |     +--rw dmr-prefix-len     uint8
|  |     |     +--rw dmr-ipv6-prefix    inet:ipv6-prefix
|  |     +--rw s46-v4-v6-binding-option! {s46-v4-v6-binding-op}?
|  |     |  +--rw ce* [ce-id]
|  |     |     +--rw ce-id               uint8
|  |     |     +--rw ipv4-addr           inet:ipv4-address
|  |     |     +--rw bind-prefix6-len    uint8
|  |     |     +--rw bind-ipv6-prefix    inet:ipv6-prefix
|  |     |     +--rw port-parameter
|  |     |        +--rw offset      uint8
|  |     |        +--rw psid-len    uint8
|  |     |        +--rw psid        uint16
|  |     +--rw operator-option-ipv6-address! {operator-op-ipv6-address}?
|  |     |  +--rw operator-ipv6-addr* [operator-ipv6-addr-id]
|  |     |     +--rw operator-ipv6-addr-id    uint8
|  |     |     +--rw operator-ipv6-addr       inet:ipv6-address
|  |     +--rw operator-option-single-flag! {operator-op-single-flag}?
|  |     |  +--rw flag* [flag-id]
|  |     |     +--rw flag-id       uint8
|  |     |     +--rw flag-value    boolean
|  |     +--rw operator-option-ipv6-prefix! {operator-op-ipv6-prefix}?
|  |     |  +--rw operator-ipv6-prefix* [operator-ipv6-prefix-id]
|  |     |     +--rw operator-ipv6-prefix-id      uint8
|  |     |     +--rw operator-ipv6-prefix6-len    uint8
|  |     |     +--rw operator-ipv6-prefix         inet:ipv6-prefix
|  |     +--rw operator-option-int32! {operator-op-int32}?
|  |     |  +--rw int32val* [int32val-id]
|  |     |     +--rw int32val-id    uint8
|  |     |     +--rw int32val       uint32
|  |     +--rw operator-option-int16! {operator-op-int16}?
|  |     |  +--rw int16val* [int16val-id]
|  |     |     +--rw int16val-id    uint8
|  |     |     +--rw int16val       uint16
|  |     +--rw operator-option-int8! {operator-op-int8}?
|  |     |  +--rw int8val* [int8val-id]
|  |     |     +--rw int8val-id    uint8
|  |     |     +--rw int8val       uint8
|  |     +--rw operator-option-uri! {operator-op-uri}?
|  |     |  +--rw uri* [uri-id]
|  |     |     +--rw uri-id    uint8
|  |     |     +--rw uri       string
|  |     +--rw operator-option-textstring! {operator-op-textstring}?
```

```
      |  |     |  +--rw textstring* [textstring-id]
      |  |     |     +--rw textstring-id    uint8
      |  |     |     +--rw textstring       string
      |  |     +--rw operator-option-var-data! {operator-op-var-data}?
      |  |     |  +--rw int32val* [var-data-id]
      |  |     |     +--rw var-data-id    uint8
      |  |     |     +--rw var-data       binary
      |  |     +--rw operator-option-dns-wire! {operator-op-dns-wire}?
      |  |        +--rw operator-option-dns-wire* [operator-option-dns-wire-id]
      |  |           +--rw operator-option-dns-wire-id    uint8
      |  |           +--rw operator-option-dns-wire       binary
      |  +--rw network-ranges
      |  |  +--rw option-set-id?   -> /server/server-config/option-sets/option-se
t/option-set-id
      |  |  +--rw network-range* [network-range-id]
      |  |     +--rw network-range-id       uint32
      |  |     +--rw network-description    string
      |  |     +--rw network-prefix         inet:ipv6-prefix
      |  |     +--rw option-set-id?         -> /server/server-config/option-sets/
option-set/option-set-id
      |  |     +--rw address-pools
      |  |     |  +--rw address-pool* [pool-id]
      |  |     |     +--rw pool-id               uint32
      |  |     |     +--rw pool-prefix           inet:ipv6-prefix
      |  |     |     +--rw start-address         inet:ipv6-address-no-zone
      |  |     |     +--rw end-address           inet:ipv6-address-no-zone
      |  |     |     +--rw valid-lifetime        yang:timeticks
      |  |     |     +--rw renew-time            yang:timeticks
      |  |     |     +--rw rebind-time           yang:timeticks
      |  |     |     +--rw preferred-lifetime    yang:timeticks
      |  |     |     +--rw rapid-commit          boolean
      |  |     |     +--rw client-class?         string
      |  |     |     +--rw max-address-count     threshold
      |  |     |     +--rw option-set-id         -> /server/server-config/option-
sets/option-set/option-set-id
      |  |     +--rw pd-pools
      |  |     |  +--rw pd-pool* [pool-id]
      |  |     |     +--rw pool-id                    uint32
      |  |     |     +--rw prefix                     inet:ipv6-prefix
      |  |     |     +--rw prefix-length              uint8
      |  |     |     +--rw valid-lifetime             yang:timeticks
      |  |     |     +--rw renew-time                 yang:timeticks
      |  |     |     +--rw rebind-time                yang:timeticks
      |  |     |     +--rw preferred-lifetime         yang:timeticks
      |  |     |     +--rw rapid-commit               boolean
      |  |     |     +--rw client-class?              string
      |  |     |     +--rw max-pd-space-utilization   threshold
      |  |     |     +--rw option-set-id              -> /server/server-config/o
ption-sets/option-set/option-set-id
      |  |     +--rw host-reservations
      |  |        +--rw host-reservation* [cli-id]
      |  |           +--rw cli-id                                  uint32
```

```
     |  |           +--rw (client-identifier)?
     |  |           |  +--:(duid)
     |  |           |  |  +--rw type-code?                          uint16
     |  |           |  |  +--rw (duid-type)?
     |  |           |  |     +--:(duid-llt)
     |  |           |  |     |  +--rw duid-llt-hardware-type?       uint16
     |  |           |  |     |  +--rw duid-llt-time?                yang:timetick
s
     |  |           |  |     |  +--rw duid-llt-link-layer-addr?     yang:mac-addr
ess
     |  |           |  |     +--:(duid-en)
     |  |           |  |     |  +--rw duid-en-enterprise-number?    uint32
     |  |           |  |     |  +--rw duid-en-identifier?           string
     |  |           |  |     +--:(duid-ll)
     |  |           |  |     |  +--rw duid-ll-hardware-type?        uint16
     |  |           |  |     |  +--rw duid-ll-link-layer-addr?      yang:mac-addr
ess
     |  |           |  |     +--:(duid-uuid)
     |  |           |  |     |  +--rw uuid?                         yang:uuid
     |  |           |  |     +--:(duid-unknown)
     |  |           |  |        +--rw data?                         binary
     |  |           |  +--:(hw-address)
     |  |           |     +--rw hardware-address?                  yang:mac-addr
ess
     |  |           +--rw reserv-addr*                              inet:ipv6-add
ress
     |  |           +--rw prefix-reservation* [reserv-prefix-id]
     |  |           |  +--rw reserv-prefix-id     uint32
     |  |           |  +--rw reserv-prefix        inet:ipv6-prefix
     |  |           |  +--rw reserv-prefix-len    uint8
     |  |           +--rw hostname?                                 string
     |  |           +--rw option-set-id?                            -> /server/se
rver-config/option-sets/option-set/option-set-id
     |  +--rw relay-opaque-paras
     |  |  +--rw relays* [relay-name]
     |  |     +--rw relay-name        string
     |  |     +--rw interface-info* [if-name]
     |  |     |  +--rw if-name         string
     |  |     |  +--rw interface-id    string
     |  |     +--rw subscribers* [subscriber]
     |  |     |  +--rw subscriber       uint32
     |  |     |  +--rw subscriber-id    string
     |  |     +--rw remote-host* [ent-num]
     |  |        +--rw ent-num      uint32
     |  |        +--rw remote-id    string
     |  +--rw rsoo-enabled-options
     |     +--rw rsoo-enabled-option* [option-code]
     |        +--rw option-code    uint16
     |        +--rw description    string
     +--ro server-state
        +--ro network-ranges
        |  +--ro network-range* [network-range-id]
        |     +--ro network-range-id     uint32
        |     +--ro address-pools
```

```
|     |  +--ro address-pool* [pool-id]
|     |  |  +--ro pool-id                   uint32
|     |  |  +--ro total-address-count       uint64
|     |  |  +--ro allocated-address-conut   uint64
|     |  +--ro binding-info* [cli-id]
|     |     +--ro cli-id    uint32
|     |     +--ro duid
|     |     |  +--ro type-code?                          uint16
|     |     |  +--ro (duid-type)?
|     |     |     +--:(duid-llt)
|     |     |     |  +--ro duid-llt-hardware-type?       uint16
|     |     |     |  +--ro duid-llt-time?                yang:timeticks
|     |     |     |  +--ro duid-llt-link-layer-addr?     yang:mac-address
|     |     |     +--:(duid-en)
|     |     |     |  +--ro duid-en-enterprise-number?    uint32
|     |     |     |  +--ro duid-en-identifier?           string
|     |     |     +--:(duid-ll)
|     |     |     |  +--ro duid-ll-hardware-type?        uint16
|     |     |     |  +--ro duid-ll-link-layer-addr?      yang:mac-address
|     |     |     +--:(duid-uuid)
|     |     |     |  +--ro uuid?                         yang:uuid
|     |     |     +--:(duid-unknown)
|     |     |        +--ro data?                         binary
|     |     +--ro cli-ia* [iaid]
|     |        +--ro ia-type     string
|     |        +--ro iaid        uint32
|     |        +--ro cli-addr*   inet:ipv6-address
|     |        +--ro pool-id     uint32
|     +--ro pd-pools
|     |  +--ro prefix-pool* [pool-id]
|     |  |  +--ro pool-id                 uint32
|     |  |  +--ro pd-space-utilization    threshold
|     |  +--ro binding-info* [cli-id]
|     |     +--ro cli-id      uint32
|     |     +--ro duid
|     |     |  +--ro type-code?                          uint16
|     |     |  +--ro (duid-type)?
|     |     |     +--:(duid-llt)
|     |     |     |  +--ro duid-llt-hardware-type?       uint16
|     |     |     |  +--ro duid-llt-time?                yang:timeticks
|     |     |     |  +--ro duid-llt-link-layer-addr?     yang:mac-address
|     |     |     +--:(duid-en)
|     |     |     |  +--ro duid-en-enterprise-number?    uint32
|     |     |     |  +--ro duid-en-identifier?           string
|     |     |     +--:(duid-ll)
|     |     |     |  +--ro duid-ll-hardware-type?        uint16
|     |     |     |  +--ro duid-ll-link-layer-addr?      yang:mac-address
|     |     |     +--:(duid-uuid)
```

```
|     |     |     |  +--ro uuid?                          yang:uuid
|     |     |     +--:(duid-unknown)
|     |     |        +--ro data?                          binary
|     |     +--ro cli-iapd* [iaid]
|     |        +--ro iaid              uint32
|     |        +--ro cli-prefix*       inet:ipv6-prefix
|     |        +--ro cli-prefix-len*   uint8
|     |        +--ro pool-id           uint32
|     +--ro host-reservations
|        +--ro binding-info* [cli-id]
|           +--ro cli-id      uint32
|           +--ro duid
|           |  +--ro type-code?                          uint16
|           |  +--ro (duid-type)?
|           |     +--:(duid-llt)
|           |     |  +--ro duid-llt-hardware-type?       uint16
|           |     |  +--ro duid-llt-time?                yang:timeticks
|           |     |  +--ro duid-llt-link-layer-addr?     yang:mac-address
|           |     +--:(duid-en)
|           |     |  +--ro duid-en-enterprise-number?    uint32
|           |     |  +--ro duid-en-identifier?           string
|           |     +--:(duid-ll)
|           |     |  +--ro duid-ll-hardware-type?        uint16
|           |     |  +--ro duid-ll-link-layer-addr?      yang:mac-address
|           |     +--:(duid-uuid)
|           |     |  +--ro uuid?                         yang:uuid
|           |     +--:(duid-unknown)
|           |        +--ro data?                         binary
|           +--ro cli-ia* [iaid]
|           |  +--ro ia-type     string
|           |  +--ro iaid        uint32
|           |  +--ro cli-addr*   inet:ipv6-address
|           +--ro cli-iapd* [iaid]
|              +--ro iaid              uint32
|              +--ro cli-prefix*       inet:ipv6-prefix
|              +--ro cli-prefix-len*   uint8
|
+--ro packet-stats
   +--ro solicit-count          uint32
   +--ro request-count          uint32
   +--ro renew-count            uint32
   +--ro rebind-count           uint32
   +--ro decline-count          uint32
   +--ro release-count          uint32
   +--ro info-req-count         uint32
   +--ro advertise-count        uint32
   +--ro confirm-count          uint32
   +--ro reply-count            uint32
   +--ro reconfigure-count      uint32
```

```
           +--ro relay-forward-count    uint32
           +--ro relay-reply-count      uint32

  notifications:
    +---n notifications
       +--ro dhcpv6-server-event
          +--ro address-pool-running-out
          |  +--ro total-address-count        uint64
          |  +--ro max-address-count          uint64
          |  +--ro allocated-address-conut    uint64
          |  +--ro duid
          |  |  +--ro type-code?                          uint16
          |  |  +--ro (duid-type)?
          |  |     +--:(duid-llt)
          |  |     |  +--ro duid-llt-hardware-type?      uint16
          |  |     |  +--ro duid-llt-time?               yang:timeticks
          |  |     |  +--ro duid-llt-link-layer-addr?    yang:mac-address
          |  |     +--:(duid-en)
          |  |     |  +--ro duid-en-enterprise-number?   uint32
          |  |     |  +--ro duid-en-identifier?          string
          |  |     +--:(duid-ll)
          |  |     |  +--ro duid-ll-hardware-type?       uint16
          |  |     |  +--ro duid-ll-link-layer-addr?     yang:mac-address
          |  |     +--:(duid-uuid)
          |  |     |  +--ro uuid?                        yang:uuid
          |  |     +--:(duid-unknown)
          |  |        +--ro data?                        binary
          |  +--ro serv-name?                 string
          |  +--ro pool-name                  string
          +--ro pd-pool-running-out
          |  +--ro max-pd-space-utilization    threshold
          |  +--ro pd-space-utilization        threshold
          |  +--ro duid
          |  |  +--ro type-code?                          uint16
          |  |  +--ro (duid-type)?
          |  |     +--:(duid-llt)
          |  |     |  +--ro duid-llt-hardware-type?      uint16
          |  |     |  +--ro duid-llt-time?               yang:timeticks
          |  |     |  +--ro duid-llt-link-layer-addr?    yang:mac-address
          |  |     +--:(duid-en)
          |  |     |  +--ro duid-en-enterprise-number?   uint32
          |  |     |  +--ro duid-en-identifier?          string
          |  |     +--:(duid-ll)
          |  |     |  +--ro duid-ll-hardware-type?       uint16
          |  |     |  +--ro duid-ll-link-layer-addr?     yang:mac-address
          |  |     +--:(duid-uuid)
          |  |     |  +--ro uuid?                        yang:uuid
          |  |     +--:(duid-unknown)
```

```
         |  |       +--ro data?                          binary
         |  +--ro serv-name?                  string
         |  +--ro pool-name                   string
         +--ro invalid-client-detected
            +--ro duid
            |  +--ro type-code?                          uint16
            |  +--ro (duid-type)?
            |     +--:(duid-llt)
            |     |  +--ro duid-llt-hardware-type?       uint16
            |     |  +--ro duid-llt-time?                yang:timeticks
            |     |  +--ro duid-llt-link-layer-addr?     yang:mac-address
            |     +--:(duid-en)
            |     |  +--ro duid-en-enterprise-number?    uint32
            |     |  +--ro duid-en-identifier?           string
            |     +--:(duid-ll)
            |     |  +--ro duid-ll-hardware-type?        uint16
            |     |  +--ro duid-ll-link-layer-addr?      yang:mac-address
            |     +--:(duid-uuid)
            |     |  +--ro uuid?                         yang:uuid
            |     +--:(duid-unknown)
            |        +--ro data?                         binary
            +--ro description?   string
```

Figure 1: DHCPv6 Data Model Structure

Introduction of important nodes:

- server-config: This container contains the configuration data of a server.

- serv-attributes: This container contains basic attributes of a DHCPv6 server such as DUID, server name and so on. Some optional functions that can be provided by the server is also included.

- duid: Each server and client has only one DUID (DHCP Unique Identifier). The DUID here identifies a unique DHCPv6 server for clients. DUID consists of a two-octet type field and an arbitrary length (no more than 128 bytes) content field. Currently there are four defined types of DUIDs in [RFC3315] and [RFC6355] - DUID-LLT, DUID-EN, DUID-LL and DUID-UUID. DUID-Unknown represents those unconventional DUIDs.

- lease-storage: The server can store lease data in different repositories, whether in a CSV file for smaller deployments or in a database for larger deployments.

- operator-option-ipv6-address, operator-option-single-flag, operator-option-ipv6-prefix, operator-option-int32, operator-option-int16, operator-option-int8, operator-option-uri, operator-option-textstring, operator-option-var-data, operator-option-dns-wire: are generic option formats described in [RFC7227].

- interfaces-config: A leaf list to denote which one or more interfaces the server should listen on. The default value is to listen on all the interfaces. This node is also used to set a unicast address for the server to listen with a specific interface. For example, if the server is being configured to listen on a unicast address assigned to a specific interface, the format "eth1/2001:db8::1" can be used.

- option-sets: DHCPv6 employs various options to carry additional information and parameters in DHCP messages. This container defines all the possible options that need to be configured at the server side. The relevant RFCs that define those options include: [RFC3315], [RFC3319], [RFC3646], [RFC3898], [RFC4242], [RFC4704], [RFC4833], [RFC5908], [RFC5970], [RFC4075], [RFC6334], [RFC6784], [RFC7078], [RFC7083], [RFC7291], [RFC7598].

- option-set: A server may allow different option sets to be configured for different conditions (i.e. different networks, clients and etc). This "option-set" list enables various sets of options being defined and configured in a single server. Different sets are distinguished by the key called "option-set-id". All the possible options discussed above are defined in the list and each option is corresponding to a container. Since all the options in the list are optional, each container in this list has a 'presence' statement to indicate whether this option (container) will be included in the current option set or not. In addition, each container also has a 'if-feature' statement to indicate whether the server supports this option (container).

- network-ranges: This model supports a hierarchy to achieve dynamic configuration. That is to say we could configure the server at different levels through this model. The top level is a global level which is defined as the container "network-ranges". The following levels are defined as sub-containers under it. The "network-ranges" contains the parameters (e.g. option-sets) that would be allocated to all the clients served by this server

- network-range: Under the "network-ranges" container, a "network-range" list is defined to configure the server at a network level which is also considered as the second level. Different network are identified by the key "network-range-id". This is because a

server may have different configuration parameters (e.g. option sets) for different networks.

- address-pools: Under the "network-range" list, a container describes the DHCPv6 server's address pools for a specific network is defined. This container supports the server to be configured at a pool level.

- address-pool: A DHCPv6 server can be configured with several address pools for a specific network. This list defines such address pools which are distinguish by the key called "pool-id".

- rapid-commit: Setting the value to '1' represents the adress/ prefix pool support the Solicit-Reply message exchange. '0' means the server will simply ignore the Rapid Commit option in Solicit message.

- client-class: If this is instantiated, the address/pd pool will only serve the clients belonging to this class.

- max-address-count: Maximum count of addresses that can be allocated in this pool. This value may be less than count of total addresses in this pool.

- prefix-pools: If a server supports prefix delegation function, this container under the "network-range" list will be valid to define the delegating router's prefix pools for a specific network. This container also supports the server to be configured at a pool level.

- prefix-pool: Similar to server's address pools, a delegating router can also be configured with multiple prefix pools specified by a list called "prefix-pool".

- max-pd-space-utlization: Maximum utilization of pd space in this pool

- host-reservations: This container allows the server to make reservations at host level.

- host-reservation: This list allows the server to reserve addresses, prefixes, hostname and options for different clients. A server may reserve multiple addresses and prefixes for a single client.

- relay-opaque-paras: This container contains some opaque values in Relay Agent options that need to be configured on the server side

only for value match. Such Relay Agent options include Interface-Id option, Remote-Id option and Subscriber-Id option.

- rsoo-enabled-options: [RFC6422] requires that the server SHOULD have an administrator-configurable list of RSOO-enabled options. This container include a list called "rsoo-enabled-option" to allow new RSOO-enabled options to be defined at the server side.

- server-state: This container includes the state data of a server.

- binding-info: A list records a static binding information for each DHCPv6 client that has already been assigned IPv6 addresses/ prefixes that are dynamically allocated and reserved in advance.

- packet-stats: A container presents the packet statistics related to the DHCPv6 server.

Information about notifications:

- address/pd-pool-running-out: raised when the address/prefix pool is going to run out. A threshold for utilization ratio of the pool (max-address-count/max-pd-space utilization) has been defined in the server feature so that it will notify the administrator when the utilization ratio reaches the threshold, and such threshold is a settable parameter.

- invalid-client-detected: raised when the server has found a client which can be regarded as a potential attacker. Some description could also be included.

2.2. DHCPv6 Relay Tree Diagrams

```
module: ietf-dhcpv6-relay
    +--rw relay!
       +--rw relay-config
       |  +--rw relay-attributes
       |  |  +--rw name?          string
       |  |  +--rw description?   string
       |  |  +--rw dest-addrs*    inet:ipv6-address
       |  |  +--rw subscribers* [subscriber]
       |  |  |  +--rw subscriber       uint8
       |  |  |  +--rw subscriber-id    string
       |  |  +--rw remote-host* [ent-num]
       |  |  |  +--rw ent-num      uint32
       |  |  |  +--rw remote-id    string
       |  |  +--rw vendor-info
       |  |     +--rw ent-num    uint32
       |  |     +--rw data*      string
```

```
|  +--rw rsoo-option-sets
|  |  +--rw option-set* [option-set-id]
|  |     +--rw option-set-id                    uint32
|  |     +--rw erp-local-domain-name-option!
|                        {erp-local-domain-name-op}?
|  |        +--rw erp-for-client* [cli-id]
|  |           +--rw cli-id      uint32
|  |           +--rw duid
|  |           |  +--rw type-code?                   uint16
|  |           |  +--rw (duid-type)?
|  |           |     +--:(duid-llt)
|  |           |     |  +--rw duid-llt-hardware-type?      uint16
|  |           |     |  +--rw duid-llt-time?        yang:timeticks
|  |           |     |  +--rw duid-llt-link-layer-addr?
|                                                  yang:mac-address
|  |           |     +--:(duid-en)
|  |           |     |  +--rw duid-en-enterprise-number?   uint32
|  |           |     |  +--rw duid-en-identifier?          string
|  |           |     +--:(duid-ll)
|  |           |     |  +--rw duid-ll-hardware-type?       uint16
|  |           |     |  +--rw duid-ll-link-layer-addr?
|                                                  yang:mac-address
|  |           |     +--:(duid-uuid)
|  |           |     |  +--rw uuid?                     yang:uuid
|  |           |     +--:(duid-unknown)
|  |           |        +--rw data?                        binary
|  |           +--rw erp-name    string
|  +--rw relay-if* [if-name]
|     +--rw if-name               if:interface-ref
|     +--rw interface-id?         string
|     +--rw ipv6-address?         inet:ipv6-address
|     +--rw rsoo-option-set-id?
 -> /relay/relay-config/rsoo-option-sets/option-set/option-set-id
|     +--rw next-entity* [dest-addr]
|        +--rw dest-addr    inet:ipv6-address
|        +--rw available    boolean
|        +--rw multicast    boolean
|        +--rw server       boolean
+--ro relay-state
   +--ro relay-if* [if-name]
      |  +--ro if-name        string
      |  +--ro pd-route* [pd-route-id]
      |  |  +--ro pd-route-id             uint8
      |  |  +--ro requesting-router-id    uint32
      |  |  +--ro delegating-router-id    uint32
      |  |  +--ro next-router             inet:ipv6-address
      |  |  +--ro last-router             inet:ipv6-address
      |  +--ro next-entity* [dest-addr]
```

```
          |     +--ro dest-addr       inet:ipv6-address
          |     +--ro packet-stats
          |        +--ro solicit-rvd-count       uint32
          |        +--ro request-rvd-count       uint32
          |        +--ro renew-rvd-count         uint32
          |        +--ro rebind-rvd-count        uint32
          |        +--ro decline-rvd-count       uint32
          |        +--ro release-rvd-count       uint32
          |        +--ro info-req-rvd-count      uint32
          |        +--ro relay-for-rvd-count     uint32
          |        +--ro relay-rep-rvd-count     uint32
          |        +--ro packet-to-cli-count     uint32
          |        +--ro adver-sent-count        uint32
          |        +--ro confirm-sent-count      uint32
          |        +--ro reply-sent-count        uint32
          |        +--ro reconfig-sent-count     uint32
          |        +--ro relay-for-sent-count    uint32
          |        +--ro relay-rep-sent-count    uint32
          +--ro relay-stats
             +--ro cli-packet-rvd-count      uint32
             +--ro relay-for-rvd-count       uint32
             +--ro relay-rep-rvd-count       uint32
             +--ro packet-to-cli-count       uint32
             +--ro relay-for-sent-count      uint32
             +--ro relay-rep-sent-count      uint32
             +--ro discarded-packet-count    uint32

  notifications:
    +---n notifications
       +--ro dhcpv6-relay-event
          +--ro topo-changed
             +--ro relay-if-name       string
             +--ro first-hop           boolean
             +--ro last-entity-addr    inet:ipv6-address
```

Introduction of important nodes:

- relay-config: This container contains the configuration data of the relay.

- relay-attributes: A container describes some basic attributes of the relay agent including some relay agent specific options data that need to be configured previously. Such options include Remote-Id option and Subscriber-Id option.

- dest-addrs: Each DHCPv6 relay agent may be configured with a list of destination addresses. This node defines such a list of IPv6

addresses that may include unicast addresses, multicast addresses or other addresses.

- rsoo-options-sets: DHCPv6 relay agent could provide some information that would be useful to DHCPv6 client. Since relay agent cannot provide options directly to the client, [RFC6422] defines RSOO-enabled options to propose options for the server to send to the client. This container models such RSOO-enabled options.

- option-set: This list under the "rsoo-option-sets" container is similar to the that defined in server module. It allows the relay to implement several sets of RSOO-enabled options for different interfaces. The list only include the EAP Re-authentication Protocol (ERP) Local Domain Name DHCPv6 Option defined in [RFC6440], since it is the only one RSOO-enabled options accepted by IANA so far.

- relay-if: A relay agent may have several interfaces, we should provide a way to configure and manage parameters on the interface-level. A list that describes specific interfaces and their corresponding parameters is employed to fulfil the configfuration. Here we use a string called "if-name" as the key of list.

- relay-state: This container contains the configuration data of the relay.

- pd-route: A sub-container of "relay-if" which describes the route for delegated prefixes into the provider edge router.

- next-entity: This node defines a list that is used to describe the next hop entity of this relay agent. Different entities are distinguished by their addresses.

- packet-stats: A container shows packet state information of a specific data communication.

- relay-stats: The "relay-stats" container records and presents the overall packet statistics of the relay agent.

Information about notifications:

- topo-changed: raised when the topology of the relay agent is changed.

2.3. DHCPv6 Client Tree Diagrams

```
module: ietf-dhcpv6-client
    +--rw client!
       +--rw client-config
       |  +--rw duid
       |  |  +--rw type-code?                   uint16
       |  |  +--rw (duid-type)?
       |  |     +--:(duid-llt)
       |  |     |  +--rw duid-llt-hardware-type?      uint16
       |  |     |  +--rw duid-llt-time?               yang:timeticks
       |  |     |  +--rw duid-llt-link-layer-addr?    yang:mac-address
       |  |     +--:(duid-en)
       |  |     |  +--rw duid-en-enterprise-number?   uint32
       |  |     |  +--rw duid-en-identifier?          string
       |  |     +--:(duid-ll)
       |  |     |  +--rw duid-ll-hardware-type?       uint16
       |  |     |  +--rw duid-ll-link-layer-addr?     yang:mac-address
       |  |     +--:(duid-uuid)
       |  |     |  +--rw uuid?                        yang:uuid
       |  |     +--:(duid-unknown)
       |  |        +--rw data?                        binary
       |  +--rw client-if* [if-name]
       |     +--rw if-name                       if:interface-ref
       |     +--rw cli-id                        uint32
       |     +--rw pd-function                   boolean
       |     +--rw rapid-commit                  boolean
       |     +--rw client-configured-options
       |        +--rw new-or-standard-cli-option* [option-code]
       |        |  +--rw option-code           uint16
       |        |  +--rw option-name           string
       |        |  +--rw option-description    string
       |        |  +--rw option-reference?     string
       |        |  +--rw option-value          string
       |        +--rw option-request-option! {option-request-op}?
       |        |  +--rw oro-option* [option-code]
       |        |     +--rw option-code    uint16
       |        |     +--rw description    string
       |        +--rw user-class-option! {user-class-op}?
       |        |  +--rw user-class* [user-class-id]
       |        |     +--rw user-class-id      uint8
       |        |     +--rw user-class-data    string
       |        +--rw vendor-class-option! {vendor-class-op}?
       |        |  +--rw enterprise-number    uint32
       |        |  +--rw vendor-class* [vendor-class-id]
       |        |     +--rw vendor-class-id      uint8
       |        |     +--rw vendor-class-data    string
       |        +--rw client-fqdn-option! {client-fqdn-op}?
```

```
|       |  +--rw fqdn                       string
|       |  +--rw server-initiate-update    boolean
|       |  +--rw client-initiate-update    boolean
|       +--rw client-arch-type-option! {client-arch-type-op}?
|       |  +--rw architecture-types* [type-id]
|       |     +--rw type-id           uint16
|       |     +--rw most-preferred    boolean
|       +--rw client-network-interface-identifier-option!
|                    {client-network-interface-identifier-op}?
|       |  +--rw type     uint8
|       |  +--rw major    uint8
|       |  +--rw minor    uint8
|       +--rw kbr-principal-name-option! {kbr-principal-name-op}?
|       |  +--rw principle-name* [principle-name-id]
|       |     +--rw principle-name-id    uint8
|       |     +--rw name-type            int32
|       |     +--rw name-string          string
|       +--rw kbr-realm-name-option! {kbr-realm-name-op}?
|       |  +--rw realm-name    string
|       +--rw client-link-layer-addr-option!
|                                  {client-link-layer-addr-op}?
|          +--rw link-layer-type    uint16
|          +--rw link-layer-addr    string
+--ro client-state
   +--ro if-other-paras
   |  +--ro server-unicast-option! {server-unicast-op}?
   |  |  +--ro server-address?   inet:ipv6-address
   |  +--ro sip-server-domain-name-list-option!
   |                                {sip-server-domain-name-list-op}?
   |  |  +--ro sip-serv-domain-name    string
   |  +--ro sip-server-address-list-option!
   |                                  {sip-server-address-list-op}?
   |  |  +--ro sip-server* [sip-serv-id]
   |  |     +--ro sip-serv-id      uint8
   |  |     +--ro sip-serv-addr    inet:ipv6-address
   |  +--ro dns-servers-option! {dns-servers-op}?
   |  |  +--ro dns-server* [dns-serv-id]
   |  |     +--ro dns-serv-id      uint8
   |  |     +--ro dns-serv-addr    inet:ipv6-address
   |  +--ro domain-searchlist-option! {domain-searchlist-op}?
   |  |  +--ro domain-searchlist* [domain-searchlist-id]
   |  |     +--ro domain-searchlist-id        uint8
   |  |     +--ro domain-search-list-entry    string
   |  +--ro nis-config-option! {nis-config-op}?
   |  |  +--ro nis-server* [nis-serv-id]
   |  |     +--ro nis-serv-id      uint8
   |  |     +--ro nis-serv-addr    inet:ipv6-address
   |  +--ro nis-plus-config-option! {nis-plus-config-op}?
```

```
|  |  +--ro nis-plus-server* [nis-plus-serv-id]
|  |     +--ro nis-plus-serv-id      uint8
|  |     +--ro nis-plus-serv-addr    inet:ipv6-address
|  +--ro nis-domain-name-option! {nis-domain-name-op}?
|  |  +--ro nis-domain-name?   string
|  +--ro nis-plus-domain-name-option! {nis-plus-domain-name-op}?
|  |  +--ro nis-plus-domain-name?   string
|  +--ro sntp-server-option! {sntp-server-op}?
|  |  +--ro sntp-server* [sntp-serv-id]
|  |     +--ro sntp-serv-id      uint8
|  |     +--ro sntp-serv-addr    inet:ipv6-address
|  +--ro info-refresh-time-option! {info-refresh-time-op}?
|  |  +--ro info-refresh-time    yang:timeticks
|  +--ro client-fqdn-option! {client-fqdn-op}?
|  |  +--ro server-initiate-update    boolean
|  |  +--ro client-initiate-update    boolean
|  |  +--ro modify-name-from-cli      boolean
|  +--ro posix-timezone-option! {posix-timezone-op}?
|  |  +--ro tz-posix    string
|  +--ro tzdb-timezone-option! {tzdb-timezone-op}?
|  |  +--ro tz-database    string
|  +--ro ntp-server-option! {ntp-server-op}?
|  |  +--ro ntp-server* [ntp-serv-id]
|  |     +--ro ntp-serv-id                    uint8
|  |     +--ro (ntp-time-source-suboption)?
|  |        +--:(server-address)
|  |        |  +--ro ntp-serv-addr-suboption*  inet:ipv6-address
|  |        +--:(server-multicast-address)
|  |        |  +--ro ntp-serv-mul-addr-suboption*
                                              inet:ipv6-address
|  |        +--:(server-fqdn)
|  |           +--ro ntp-serv-fqdn-suboption*       string
|  +--ro boot-file-url-option! {boot-file-url-op}?
|  |  +--ro boot-file* [boot-file-id]
|  |     +--ro boot-file-id          uint8
|  |     +--ro suitable-arch-type*   uint16
|  |     +--ro suitable-net-if*      uint32
|  |     +--ro boot-file-url         string
|  +--ro boot-file-param-option! {boot-file-param-op}?
|  |  +--ro boot-file-paras* [para-id]
|  |     +--ro para-id      uint8
|  |     +--ro parameter    string
|  +--ro aftr-name-option! {aftr-name-op}?
|  |  +--ro tunnel-endpoint-name    string
|  +--ro kbr-default-name-option! {kbr-default-name-op}?
|  |  +--ro default-realm-name    string
|  +--ro kbr-kdc-option! {kbr-kdc-op}?
|  |  +--ro kdc-info* [kdc-id]
```

```
|  |     +--ro kdc-id            uint8
|  |     +--ro priority          uint16
|  |     +--ro weight            uint16
|  |     +--ro transport-type    uint8
|  |     +--ro port-number       uint16
|  |     +--ro kdc-ipv6-addr     inet:ipv6-address
|  |     +--ro realm-name        string
|  +--ro sol-max-rt-option! {sol-max-rt-op}?
|  |  +--ro sol-max-rt-value    yang:timeticks
|  +--ro inf-max-rt-option! {inf-max-rt-op}?
|  |  +--ro inf-max-rt-value    yang:timeticks
|  +--ro addr-selection-option! {addr-selection-op}?
|  |  +--ro a-bit-set       boolean
|  |  +--ro p-bit-set       boolean
|  |  +--ro policy-table* [policy-id]
|  |     +--ro policy-id     uint8
|  |     +--ro label         uint8
|  |     +--ro precedence    uint8
|  |     +--ro prefix-len    uint8
|  |     +--ro prefix        inet:ipv6-prefix
|  +--ro pcp-server-option! {pcp-server-op}?
|  |  +--ro pcp-server* [pcp-serv-id]
|  |     +--ro pcp-serv-id      uint8
|  |     +--ro pcp-serv-addr    inet:ipv6-address
|  +--ro s46-rule-option! {s46-rule-op}?
|  |  +--ro s46-rule* [rule-id]
|  |     +--ro rule-id           uint8
|  |     +--ro rule-type         enumeration
|  |     +--ro prefix4-len       uint8
|  |     +--ro ipv4-prefix       inet:ipv4-prefix
|  |     +--ro prefix6-len       uint8
|  |     +--ro ipv6-prefix       inet:ipv6-prefix
|  |     +--ro port-parameter
|  |        +--ro offset      uint8
|  |        +--ro psid-len    uint8
|  |        +--ro psid        uint16
|  +--ro s46-br-option! {s46-br-op}?
|  |  +--ro br* [br-id]
|  |     +--ro br-id           uint8
|  |     +--ro br-ipv6-addr    inet:ipv6-address
|  +--ro s46-dmr-option! {s46-dmr-op}?
|  |  +--ro dmr* [dmr-id]
|  |     +--ro dmr-id             uint8
|  |     +--ro dmr-prefix-len     uint8
|  |     +--ro dmr-ipv6-prefix    inet:ipv6-prefix
|  +--ro s46-v4-v6-binding-option! {s46-v4-v6-binding-op}?
|     +--ro ce* [ce-id]
|        +--ro ce-id              uint8
```

```
          |        +--ro ipv4-addr           inet:ipv4-address
          |        +--ro bind-prefix6-len    uint8
          |        +--ro bind-ipv6-prefix    inet:ipv6-prefix
          |        +--ro port-parameter
          |           +--ro offset      uint8
          |           +--ro psid-len    uint8
          |           +--ro psid        uint16
          +--ro packet-stats
             +--ro solicit-count        uint32
             +--ro request-count        uint32
             +--ro renew-count          uint32
             +--ro rebind-count         uint32
             +--ro decline-count        uint32
             +--ro release-count        uint32
             +--ro info-req-count       uint32
             +--ro advertise-count      uint32
             +--ro confirm-count        uint32
             +--ro reply-count          uint32
             +--ro reconfigure-count    uint32

  notifications:
    +---n notifications
       +--ro dhcpv6-client-event
          +--ro ia-lease-event
          |  +--ro event-type     enumeration
          |  +--ro duid
          |  |  +--ro type-code?                   uint16
          |  |  +--ro (duid-type)?
          |  |     +--:(duid-llt)
          |  |     |  +--ro duid-llt-hardware-type?      uint16
          |  |     |  +--ro duid-llt-time?               yang:timeticks
          |  |     |  +--ro duid-llt-link-layer-addr?    yang:mac-address
          |  |     +--:(duid-en)
          |  |     |  +--ro duid-en-enterprise-number?   uint32
          |  |     |  +--ro duid-en-identifier?          string
          |  |     +--:(duid-ll)
          |  |     |  +--ro duid-ll-hardware-type?       uint16
          |  |     |  +--ro duid-ll-link-layer-addr?     yang:mac-address
          |  |     +--:(duid-uuid)
          |  |     |  +--ro uuid?                        yang:uuid
          |  |     +--:(duid-unknown)
          |  |        +--ro data?                        binary
          |  +--ro iaid           uint32
          |  +--ro serv-name?     string
          |  +--ro description?   string
          +--ro invalid-ia-detected
          |  +--ro duid
          |  |  +--ro type-code?                   uint16
```

```
          |  |  +--ro (duid-type)?
          |  |     +--:(duid-llt)
          |  |     |  +--ro duid-llt-hardware-type?      uint16
          |  |     |  +--ro duid-llt-time?               yang:timeticks
          |  |     |  +--ro duid-llt-link-layer-addr?    yang:mac-address
          |  |     +--:(duid-en)
          |  |     |  +--ro duid-en-enterprise-number?   uint32
          |  |     |  +--ro duid-en-identifier?          string
          |  |     +--:(duid-ll)
          |  |     |  +--ro duid-ll-hardware-type?       uint16
          |  |     |  +--ro duid-ll-link-layer-addr?     yang:mac-address
          |  |     +--:(duid-uuid)
          |  |     |  +--ro uuid?                        yang:uuid
          |  |     +--:(duid-unknown)
          |  |        +--ro data?                        binary
          |  +--ro cli-duid       uint32
          |  +--ro iaid           uint32
          |  +--ro serv-name?     string
          |  +--ro description?   string
          +--ro retransmission-failed
          |  +--ro duid
          |  |  +--ro type-code?                  uint16
          |  |  +--ro (duid-type)?
          |  |     +--:(duid-llt)
          |  |     |  +--ro duid-llt-hardware-type?      uint16
          |  |     |  +--ro duid-llt-time?               yang:timeticks
          |  |     |  +--ro duid-llt-link-layer-addr?    yang:mac-address
          |  |     +--:(duid-en)
          |  |     |  +--ro duid-en-enterprise-number?   uint32
          |  |     |  +--ro duid-en-identifier?          string
          |  |     +--:(duid-ll)
          |  |     |  +--ro duid-ll-hardware-type?       uint16
          |  |     |  +--ro duid-ll-link-layer-addr?     yang:mac-address
          |  |     +--:(duid-uuid)
          |  |     |  +--ro uuid?                        yang:uuid
          |  |     +--:(duid-unknown)
          |  |        +--ro data?                        binary
          |  +--ro description    enumeration
          +--ro failed-status-turn-up
             +--ro duid
             |  +--ro type-code?                  uint16
             |  +--ro (duid-type)?
             |     +--:(duid-llt)
             |     |  +--ro duid-llt-hardware-type?      uint16
             |     |  +--ro duid-llt-time?               yang:timeticks
             |     |  +--ro duid-llt-link-layer-addr?    yang:mac-address
             |     +--:(duid-en)
             |     |  +--ro duid-en-enterprise-number?   uint32
```

```
|     |  +--ro duid-en-identifier?          string
|     +--:(duid-ll)
|     |  +--ro duid-ll-hardware-type?       uint16
|     |  +--ro duid-ll-link-layer-addr?     yang:mac-address
|     +--:(duid-uuid)
|     |  +--ro uuid?                        yang:uuid
|     +--:(duid-unknown)
|        +--ro data?                        binary
+--ro status-code    enumeration
```

Introduction of important nodes:

- client-config: This container includes the configuration data of the client.

- duid: Each server and client has only one DUID (DHCP Unique Identifier). The DUID here will be carried in the Client ID option to identify a specific DHCPv6 client. This leaf are same as the "duid" leaf in "dhcpv6-server" feature.

- client-if: A client may have several interfaces, it is more reasonable to configure and manage parameters on the interface-level. The list defines a specific client interface and its data. Different interfaces are distinguished by the "ifName" key which is a configurable string value.

- pd-function: Whether the client can act as a requesting router to request prefixes using prefix delegation ([RFC3633]).

- rapid-commit: ’1’ indicates a client can initiate a Solicit-Reply message exchange by adding a Rapid Commit option in Solicit message. ’0’ means the client is not allowed to add a Rapid Commit option to request addresses in a two-message exchange pattern.

- client-configured-options: Similar to the server, the client also need to configure some options to fulfil some desired functions. This container include all the potential options that need to be configured at the client side. The relevant RFCs that define those options include: [RFC3315], [RFC4704], [RFC5970], [RFC6784], [RFC6939].

- option-request-option: This container provide a way to configure the list of options that the client will request in its ORO option.

- client-state: This container includes the state data of the client.

- o if-other-paras: A client can obtain extra configuration data other than address and prefix information through DHCPv6 options. This container describes such data the client was configured through DHCPv6. The potential configuration data may include DNS server parameters, SIP server parameters and etc.

- o packet-stats: A container records all the packet status information of a specific interface.

Information about notifications:

- o ia-lease-event: raised when the client was allocated a new IA from the server or it renew/rebind/release its current IA.

- o invalid-ia-detected: raised when the identity association of the client can be proved to be invalid. Possible condition includes duplicated address, illegal address, etc.

- o retransmission-failed: raised when the retransmission mechanism defined in [RFC3315] is failed.

- o failed-status-turn-up: raised when the client receives a message includes an unsuccessful Status Code option.

3. DHCPv6 YANG Model

3.1. DHCPv6 Server YANG Model

This module imports typedefs from [RFC6991], [RFC7223].

```
<CODE BEGINS> file "ietf-dhcpv6-server.yang"
module ietf-dhcpv6-server {
        yang-version 1.1;
        namespace "urn:ietf:params:xml:ns:yang:ietf-dhcpv6-server";
        prefix "dhcpv6-server";

        import ietf-inet-types {
                prefix inet;
  }
        import ietf-yang-types {
        prefix yang;
        }
        import ietf-dhcpv6-options {
        prefix dhcpv6-options;
  }
  import ietf-dhcpv6-types {
        prefix dhcpv6-types;
  }
```

```
  import ietf-interfaces {
        prefix if;
  }

  organization "DHC WG";
  contact
        "cuiyong@tsinghua.edu.cn
         lh.sunlinh@gmail.com
         ian.farrer@telekom.de
         sladjana.zechlin@telekom.de
         hezihao9512@gmail.com";

        description "This model defines a YANG data model that can be
        used to configure and manage a DHCPv6 server.";

  revision 2018-09-04 {
    description "";
    reference "I-D: draft-ietf-dhc-dhcpv6-yang";
  }

  revision 2018-03-04 {
        description "Resolved most issues on the DHC official
        github";
        reference "I-D: draft-ietf-dhc-dhcpv6-yang";
  }

        revision 2017-12-22 {
                description "Resolve most issues on Ian’s github.";
        reference "I-D: draft-ietf-dhc-dhcpv6-yang";
        }

        revision 2017-11-24 {
        description "First version of the separated server specific
                YANG model.";
        reference "I-D: draft-ietf-dhc-dhcpv6-yang";
        }

        /*
        * Typedef
        */
        typedef threshold {
        type union {
                type uint16 {
                range 0..100;
                }
                type enumeration {
                enum "disabled" {
                        description "No threshold";
```

```
                }
        }
        }
        description "Threshold value in percent";
        }

        /*
        * Data Nodes
        */
        container server {
                presence "Enables the server";
        description "DHCPv6 server portion";

    /*
     * Configuration data
     */
    container server-config {
        description "This container contains the configuration data
            of a server.";
        container serv-attributes {
                    description
                     "This container contains basic attributes of a DHCPv6 serve
r
                     such as IPv6 address, server name  and so on. Some optional
                     functions that can be provided  by the server is also inclu
ded.";
                    container duid {
                      description "Sets the DUID of server";
                      uses dhcpv6-types:duid;
                    }
                    leaf name {
                type string;
                description "server's name";
                    }
                    leaf description {
                type string;
                description "description of the server.";
                    }
                    leaf-list ipv6-address {
                type inet:ipv6-address;
                description "server's IPv6 address.";
                    }
                    leaf-list interfaces-config {
                // Note - this should probably be references to
                // entries in the ietf-interfaces model
                type if:interface-ref;
                description "A leaf list to denote which one or more interfaces
                        the server should listen on. The default value is to lis
ten
                        on all the interfaces. This node is also used to set a u
nicast
                        address for the server to listen with a specific interfa
ce.
```

```
                  For example, if people want the server to listen on a unicast
                  address with a specific interface, he can use the format like
                  'eth1/2001:db8::1'.";
                    }
                                container lease-storage {
                                        description "Indicates how the server st
ores the lease";
                                        choice storage-type {
                                                description "the type of lease s
torage";
                                                // leaf persist {
                                                //              type boolean;
                                                //              mandatory true;
                                                //              description "con
trols whether the new leases and updates to existing leases are
                                                //              written to the f
ile";
                                                // }
                                                case memfile {
                                                        description "the server
stores lease information in a CSV file";

                                                        leaf memfile-name {
                                                                type string;
                                                                description "spe
cifies an absolute location of the lease file in which new leases
                                                                and lease update
s will be recorded";
                                                        }

                                                        leaf memfile-lfc-interva
l {
                                                                type uint64;
                                                                description "spe
cifies the interval in seconds, at which the server will perform a
                                                                lease file clean
up (LFC)";
                                                        }

                                                }
                                                case mysql {
                                                        leaf mysql-name {
                                                                type string;
                                                                description "typ
e of the database";
                                                        }
                                                        leaf mysql-host {
                                                                type string;
                                                                description "If
the database is located
                                                                on a different s
ystem to the DHCPv6 server, the database host name must also be specified.";
                                                        }
                                                        leaf mysql-password {
                                                                type string;
                                                                description "the
 credentials of the account under which the server will access the database";
                                                        }
                                                        leaf mysql-port {
                                                                type uint8;
                                                                description "If
the database is located on a different system, the port number may be specified"
;
```

```
}
```

```
                                                        leaf mysql-lfc-interval
{
                                                                type uint64;
                                                                description "spe
cifies the interval in seconds, at which the server will perform a
                                                                lease file clean
up (LFC)";
                                                        }
                                                        leaf mysql-connect-timeo
ut {
                                                                type uint64;
                                                                description "If
the database is located on a different system, a longer interval needs to be spe
cified";
                                                        }

                                                }
                                                case postgresql {
                                                        leaf postgresql-name {
                                                                type string;
                                                                description "typ
e of the database";
                                                        }
                                                        leaf postgresql-host {
                                                                type string;
                                                                description "If
the database is located
                                                                on a different s
ystem to the DHCPv6 server, the database host name must also be specified.";
                                                        }
                                                        leaf postgresql-password
 {
                                                                type string;
                                                                description "the
 credentials of the account under which the server will access the database";
                                                        }
                                                        leaf postgresql-port {
                                                                type uint8;
                                                                description "If
the database is located on a different system, the port number may be specified"
;
                                                        }
                                                        leaf postgresql-lfc-inte
rval {
                                                                type uint64;
                                                                description "spe
cifies the interval in seconds, at which the server will perform a
                                                                lease file clean
up (LFC)";
                                                        }
                                                        leaf postgresql-connect-
timeout {
                                                                type uint64;
                                                                description "If
the database is located on a different system, a longer interval needs to be spe
cified";
                                                        }
                                                }
                                                case cassandra {
                                                        leaf cassandra-name {
                                                                type string;
                                                                description "typ
e of the database";
```

```
                                                        }
                                                        leaf cassandra-contact-p
oints {
                                                                type string;
                                                                description "Cas
sandra takes a list of comma separated IP addresses to contact the cluster";
                                                        }
```

```
                                                                leaf cassandra-password
{
                                                                        type string;
                                                                        description "the
 credentials of the account under which the server will access the database";
                                                                }
                                                                leaf cassandra-lfc-inter
val {
                                                                        type uint64;
                                                                        description "spe
cifies the interval in seconds, at which the server will perform a
                                                                        lease file clean
up (LFC)";
                                                                }
                                                                leaf cassandra-connect-t
imeout {
                                                                        type uint64;
                                                                        description "If
the database is located on a different system, a longer interval needs to be spe
cified";
                                                                }
                                                        }
                                                }
                                        }
                                uses dhcpv6-types:vendor-infor;
        }

            container option-sets {
                description "DHCPv6 employs various options to carry additional
          information and parameters in DHCP messages. This container defines
          all the possible options that need to be configured at the server
          side. ";
        list option-set {
                        key option-set-id;
                        description "A server may allow different option sets to
 be
                configured for different conditions (i.e. different networks,
                clients and etc). This 'option-set' list enables various sets of
                options being defined and configured in a single server. Differe
nt
                sets are distinguished by the key called 'option-set-id'. All th
e
                possible options discussed above are defined in the list and eac
h
                option is corresponding to a container. Since all the options in
                the list are optional, each container in this list has a 'presen
ce'
                statement to indicate whether this option (container) will be
                included in the current option set or not. In addition, each con
tainer
                also has a 'if-feature' statement to indicate whether the server
                supports this option (container).";
            leaf option-set-id {
                type uint32;
                description "option set id";
            }
          uses dhcpv6-options:server-option-definitions;
          uses dhcpv6-options:custom-option-definitions;
        }
            }

            container network-ranges {
```

```
        description "This model supports a hierarchy
                to achieve dynamic configuration. That is to say we could config
ure the
                server at different levels through this model. The top level is
a global
                level which is defined as the container 'network-ranges'. The fo
llowing
                levels are defined as sub-containers under it. The 'network-rang
es'
                contains the parameters (e.g. option-sets) that would be allocat
ed to
                all the clients served by this server.";

        leaf option-set-id {
          type leafref {
            path "/server/server-config/option-sets/option-set/option-set-id";
          }
          description
                "The ID field of relevant global option-set to be provisioned to
                clients.";
        }
        list network-range {
                key network-range-id;
                description
                "Under the 'network-ranges' container, a 'network-range' list
                 is defined to configure the server at a network level which is
also
                 considered as the second level. Different network are identifie
d by the
                 key 'network-range-id'. This is because a server may have diffe
rent
           configuration parameters (e.g. option sets) for different networks.";
                leaf network-range-id {
                        type uint32;
                        mandatory true;
                        description "equivalent to subnet id";
                }
                leaf network-description {
                        type string;
                        mandatory true;
                        description "description of the subnet";
                }
                leaf network-prefix {
                        type inet:ipv6-prefix;
                        mandatory true;
                  description "subnet prefix";
                }
                leaf option-set-id {
             type leafref {
               path "/server/server-config/option-sets/option-set/option-set-id";
             }
             description "The ID field of relevant option-set to be provisioned t
o
             clients of this network-range.";
                }

                container address-pools {
```

```
            description
            "A container that describes the DHCPv6 server's
             address pools.";
            list address-pool {
                key pool-id;
                description "A DHCPv6 server can be configured with
                several address pools. This list defines such address pools
                which are distinguished by the key called 'pool-id'.";
                leaf pool-id {
                        type uint32;
                mandatory true;
                description "pool id";
                }
                               leaf pool-prefix {
                type inet:ipv6-prefix;
                mandatory true;
                description "pool prefix";
                    }
                leaf start-address {
                type inet:ipv6-address-no-zone;
                mandatory true;
                description "start address";
                }
                leaf end-address {
                type inet:ipv6-address-no-zone;
                mandatory true;
                description "end address";
              }
                leaf valid-lifetime {
                type yang:timeticks;
                mandatory true;
                description "valid liftime for IA";
                }
                leaf renew-time {
                type yang:timeticks;
                mandatory true;
                description "renew time";
              }
                leaf rebind-time {
                type yang:timeticks;
                mandatory true;
                description "rebind time";
                }
                leaf preferred-lifetime {
                      type yang:timeticks;
                      mandatory true;
                      description "preferred lifetime for IA";
                }
```

```
                leaf rapid-commit {
                                        type boolean;
                                        mandatory true;
                                        description "A boolean value specifies w
hether the pool
                                        supports client-server exchanges involvi
ng two messages.";
                                        }
               leaf client-class {
                 type string;
                 description
                 "If this leaf is specified, this pool will only serve
                 the clients belonging to this class.";
               }
                 leaf max-address-count {
                 type threshold;
                 mandatory true;
                 description "maximum count of addresses that can
                         be allocated in this pool. This value may be
                         less than count of total addresses.";
                 }
                 leaf option-set-id {
                 type leafref {
                         path "/server/server-config/option-sets/option-set/optio
n-set-id";
                 }
                 mandatory true;
                 description "The ID field of relevant option-set to be
                                 provisioned to clients of this address-pool.";
                 }
                   }
                 }

                 container pd-pools {
             description "If a server supports prefix delegation function, this
                 container will be used to define  the delegating router's prefix
                 pools.";
             list pd-pool {
                 key pool-id;
                 description "Similar to server's address pools, a delegating
                         router can also be configured with multiple prefix pools
                         specified by a list called 'prefix-pool'.";
                                                 leaf pool-id {
                         type uint32;
                       mandatory true;
                       description "pool id";
                     }
                     leaf prefix {
                         type inet:ipv6-prefix;
                         mandatory true;
                         description "ipv6 prefix";
```

```
                    }
                    leaf prefix-length {
                        type uint8;
                        mandatory true;
                        description "prefix length";
                    }
                    leaf valid-lifetime {
                        type yang:timeticks;
                mandatory true;
                description "valid lifetime for IA";
                    }
                    leaf renew-time {
                type yang:timeticks;
                mandatory true;
                description "renew time";
                    }
                leaf rebind-time {
                type yang:timeticks;
                mandatory true;
                description "rebind time";
                        }
                    leaf preferred-lifetime {
                type yang:timeticks;
                mandatory true;
                description "preferred lifetime for IA";
                    }
                leaf rapid-commit {
                                    type boolean;
                                    mandatory true;
                                    description "A boolean value specifies w
hether the server
                                    support client-server exchanges involvin
g two messages defined.";
                                    }
                                    leaf client-class {
                  type string;
                  description "client class";
                }
                    leaf max-pd-space-utilization {
                  type threshold;
                  mandatory true;
                  description "Maximum utilization of pd space in this pool";
                    }
                    leaf option-set-id {
                        type leafref {
                                path "/server/server-config/option-sets/option-s
et/option-set-id";
                        }
                        mandatory true;
                        description "The ID field of relevant option-set to be
                          provisioned to clients of this prefix-pool.";
```

```
                    }
                  }
                }

          container host-reservations {
            description
                "This container allows the server to make reservations at host l
evel.";
            list host-reservation {
              key cli-id;
              description "This list allows the server to reserve addresses,
              prefixes, hostname and options for different clients.";
              leaf cli-id {
                type uint32;
                mandatory true;
                description "client id";
              }

              choice client-identifier {
                description "When making reservations, the server needs to choos
e a
                identifier to identify the client. Currently 'DUID' and 'hardwar
e
                address' are supported.";
                case duid {
                  description "DUID";
                  uses dhcpv6-types:duid;
                }
                case hw-address {
                  description "hardware address";
                  leaf hardware-address {
                  type yang:mac-address;
                  description "MAC address of client";
                  }
                }
              }

              leaf-list reserv-addr {
                type inet:ipv6-address;
                description "reserved addr";
              }

              list prefix-reservation {
                key reserv-prefix-id;
                description "reserved prefix reservation";
                leaf reserv-prefix-id {
                        type uint32;
                        mandatory true;
                        description "reserved prefix id";
                }
                leaf reserv-prefix {
```

```
                        type inet:ipv6-prefix;
                        mandatory true;
                        description "reserved prefix";
                      }
                  leaf reserv-prefix-len {
                        type uint8;
                        mandatory true;
                        description "reserved prefix length";
                  }
                }

                leaf hostname {
                  type string;
                  description "reserved hostname";
                }

                leaf option-set-id {
                  type leafref {
                    path "/server/server-config/option-sets/option-set/option-set-
id";
                  }
                  description "The ID field of relevant option-set to be provision
ed
                    in the host reservation.";
                }
              }
            }

          }
                        }

          container relay-opaque-paras {
          description "This container contains some opaque values in Relay Agent
                  options that need to be configured on the server side only for v
alue
                  match. Such Relay Agent options include Interface-Id option,
                  Remote-Id option and Subscriber-Id option.";
          list relays {
                  key relay-name;
                  description "relay agents";
                  leaf relay-name {
                  type string;
                  mandatory true;
                  description "relay agent name";
            }
                  list interface-info {
                  key if-name;
                  description "interface info";
                  leaf if-name {
                        type string;
                        mandatory true;
```

```
                        description "interface name";
                    }
                    leaf interface-id {
                    type string;
                    mandatory true;
                        description "interface id";
                    }
                    }
                    list subscribers {
                      key subscriber;
                        description "subscribers";
                        leaf subscriber {
                                type uint32;
                        mandatory true;
                        description "subscriber";
                      }
                    leaf subscriber-id {
                    type string;
                        mandatory true;
                        description "subscriber id";
                    }
                    }
                    list remote-host {
                    key ent-num;
                    description "remote host";
                    leaf ent-num {
                        type uint32;
                        mandatory true;
                        description "enterprise number";
                    }
                    leaf remote-id {
                        type string;
                        mandatory true;
                        description "remote id";
                    }
                    }
                  }
                    }

            container rsoo-enabled-options {
          description "rsoo enabled options";
          list rsoo-enabled-option {
                  key option-code;
                  description "rsoo enabled option";
                  leaf option-code {
                  type uint16;
                  mandatory true;
                  description "option code";
```

```
                }
                leaf description {
                type string;
                mandatory true;
                description "description of the option";
                }
        }
            }

                }

          /*
           * State data
           */
    container server-state {
        config "false";
        description "states of server";
        container network-ranges {
                description "This model supports a hierarchy to achieve dynamic
configuration.
                        That is to say we could configure the server  at differe
nt levels through
                        this model. The top level is a global level which is def
ined as the container
                        'network-ranges'. The following levels are defined as su
b-containers under it.
                        The 'network-ranges' contains the parameters (e.g. optio
n-sets) that  would be
                        allocated to all the clients served by this server.";
                list network-range {
                        key network-range-id;
                description "The ID field of relevant option-set to be provision
ed
                        to clients of this network-range.";
                        leaf network-range-id {
                        type uint32;
                        mandatory true;
                        description "equivalent to subnet id";
                }
                container address-pools {
                        description "A container that describes the DHCPv6 serve
r's address pools";
                        list address-pool {
                                key pool-id;
                                description "A DHCPv6 server can be configured w
ith
                                several address pools. This list defines such ad
dress pools
                                which are distinguished by the key called 'pool-
id'.";
                leaf pool-id {
                        type uint32;
                        mandatory true;
                        description "pool id";
                   }
                                        leaf total-address-count {
                                                type uint64;
                                                mandatory true;
```

```
                                        description "count of total addr
esses in the pool";
                                }
                                leaf allocated-address-conut {
                                        type uint64;
                                        mandatory true;
                                        description "count of allocated
addresses in the pool";
                                }
                        }
                        list binding-info {
                                key cli-id;
                                description "A list that records a binding infor
mation for each DHCPv6
                                        client that has already been allocated I
Pv6 addresses.";
                                leaf cli-id {
                                        type uint32;
                                        mandatory true;
                                        description "client id";
                }
                                container duid {
                                        description "Read the DUID";
                                        uses dhcpv6-types:duid;
                }
                                list cli-ia {
                                        key iaid;
                                        description "client IA";
                                        leaf ia-type {
                                                type string;
                                                mandatory true;
                                                description "IA type";
                                        }
                                        leaf iaid {
                                                type uint32;
                                                mandatory true;
                                                description "IAID";
                                        }
                                        leaf-list cli-addr {
                                                type inet:ipv6-address;
                                                description "client addr";
                                        }
                                        leaf pool-id {
                                                type uint32;
                                                mandatory true;
                                                description "pool id";
                                        }
                                }
                        }
                        }
                        container pd-pools {
                                description "If a server supports prefix delegat
ion function,
```

```
                                        this container will be used to define th
e delegating
                                        router's prefix pools.";
                                list prefix-pool {
                        key pool-id;
                        description "Similar to server's address pools, a delegating
                                router can also be configured with multiple prefix pools
                                specified by a list called 'prefix-pool'.";
                        leaf pool-id {
                                type uint32;
                                mandatory true;
                                description "pool id";
                        }
                        leaf pd-space-utilization {
                                type threshold;
                                mandatory true;
                                description "current PD space utilization";
                        }
                                }
                                list binding-info {
                                        key cli-id;
                                        description "A list records a binding in
formation for each DHCPv6
                                                client that has already been all
oated IPv6 prefixes.";
                                                leaf cli-id {
                                                        type uint32;
                                                        mandatory true;
                                                        description "client id";
                                                }
                                                container duid {
                                                        description "Reads the D
UID";
                                                        uses dhcpv6-types:duid;
                                                }
                                                list cli-iapd {
                                                        key iaid;
                                                        description "client IAPD
";
                                                        leaf iaid {
                                                                type uint32;
                                                                mandatory true;
                                                                description "IAI
D";
                                                        }
                                                        leaf-list cli-prefix {
                                                                type inet:ipv6-p
refix;
                                                                description "cli
ent ipv6 prefix";
                                                        }
                                                        leaf-list cli-prefix-len
 {
                                                                type uint8;
                                                                description "cli
ent prefix length";
                                                        }
                                                        leaf pool-id {
```

```
                                                                type uint32;
                                                                mandatory true;
                                                                description "poo
l id";
                                                        }
                                                }
                                        }
                                }

                container host-reservations {
            description "This container provides host reservations in the host l
evel.";
                                                list binding-info {
                                        key cli-id;
                                        description
                                                "A list records a binding information fo
r each DHCPv6
                                                client that has already been alloated IP
v6 addresses or prefixes
                                                by host reservations.";
                                                leaf cli-id {
                                                        type uint32;
                                                        mandatory true;
                                                        description "client id";
                                                }
                                                container duid {
                                                        description "Reads the DUID";
                                                        uses dhcpv6-types:duid;
                                                }
                                                list cli-ia {
                                                key iaid;
                                                description "client IA";
                                                leaf ia-type {
                                                        type string;
                                                        mandatory true;
                                                        description "IA type, IA_NA or I
A_TA";
                                                }
                                                leaf iaid {
                                                        type uint32;
                                                        mandatory true;
                                                        description "IAID";
                                                }
                                                leaf-list cli-addr {
                                                        type inet:ipv6-address;
                                                        description "client addr";
                                                }
                                        }

                                                list cli-iapd {
                                                        key iaid;
                                                        description "client IAPD";
                                                        leaf iaid {
```

```
                                                        type uint32;
                                                        mandatory true;
                                                        description "IAID";
                                                }
                                                leaf-list cli-prefix {
                                                        type inet:ipv6-prefix;
                                                        description "client ipv6
 prefix";
                                                }
                                                leaf-list cli-prefix-len {
                                                        type uint8;
                                                        description "client pref
ix length";
                                                }
                                        }
                                }
                        }

                                        }
                        }

        container packet-stats {
                description "A container presents the packet statistics related
to
                        the DHCPv6 server.";
          leaf solicit-count {
                                                type uint32;
                                                mandatory true;
                                                description "solicit counter";
          }
          leaf request-count {
                                                type uint32;
                                                mandatory true;
                                                description "request counter";
          }
          leaf renew-count {
                                                type uint32;
                                                mandatory true;
                                                description "renew counter";
          }
          leaf rebind-count {
                                                type uint32;
                                                mandatory true;
                                                description "rebind counter";
          }
          leaf decline-count {
                                                type uint32;
                                                mandatory true;
                                                description "decline count";
          }
          leaf release-count {
```

```
                type uint32;
                mandatory true;
                description "release counter";
            }
            leaf info-req-count {
                type uint32;
                mandatory true;
                description "information request counter";
            }
            leaf advertise-count {
                type uint32;
                mandatory true;
                description "advertise counter";
            }
            leaf confirm-count {
                type uint32;
                mandatory true;
                description "confirm counter";
            }
            leaf reply-count {
                                                type uint32;
                                                mandatory true;
                                                description "reply counter";
            }
            leaf reconfigure-count {
                                                type uint32;
                                                mandatory true;
                                                description "reconfigure counter
";
            }
            leaf relay-forward-count {
                type uint32;
                mandatory true;
                description "relay forward counter";
            }
            leaf relay-reply-count {
                type uint32;
                mandatory true;
                description "relay reply counter";
            }
          }
          }
          }

          /*
          * Notifications
          */

          notification notifications {
```

```
          description "dhcpv6 server notification module";
    container dhcpv6-server-event {
        description "dhcpv6 server event";
        container address-pool-running-out {
        description "raised when the address pool is going to
                run out.  A threshold for utilization ratio of the pool has
                been defined in the server feature so that it will notify the
                administrator when the utilization ratio reaches the
                threshold, and such threshold is a settable parameter";
        leaf total-address-count {
                type uint64;
                mandatory true;
                description "count of total addresses in the pool";
        }
        leaf max-address-count {
                type uint64;
                mandatory true;
                description "maximum count of addresses that can be allocated
                        in the pool. This value may be less than count of total
                        addresses";
        }
        leaf allocated-address-conut {
                type uint64;
                mandatory true;
                description "count of allocated addresses in the pool";
        }
                    container duid {
                        description "server duid";
                        uses dhcpv6-types:duid;
                    }
        leaf serv-name {
                type string;
                description "server name";
        }
        leaf pool-name {
                type string;
                mandatory true;
                description "pool name";
        }
        }
                container pd-pool-running-out {
        description "raised when the address/prefix pool is going to
                run out.  A threshold for utilization ratio of the pool has
                been defined in the server feature so that it will notify the
                administrator when the utilization ratio reaches the
                threshold, and such threshold is a settable parameter";
                        leaf max-pd-space-utilization {
                type threshold;
```

```
                mandatory true;
                description "maximum pd space utilization";
                }
                        leaf pd-space-utilization {
                                type threshold;
                                mandatory true;
                                description "current pd space utilization";
                        }
        container duid {
                description "Sets the DUID";
                uses dhcpv6-types:duid;
        }
        leaf serv-name {
                type string;
                description "server name";
        }
        leaf pool-name {
                type string;
                mandatory true;
                description "pool name";
        }
            }
            container invalid-client-detected {
                description "raised when the server has found a client which
                can be regarded as a potential attacker. Some description
                could also be included.";
        container duid {
                description "Sets the DUID";
                uses dhcpv6-types:duid;
        }
        leaf description {
                type string;
                description "description of the event";
                }
            }
          }
        }
}
<CODE ENDS>
```

3.2. DHCPv6 Relay YANG Model

This module imports typedefs from [RFC6991], [RFC7223].

```
<CODE BEGINS> file "ietf-dhcpv6-relay.yang"
module ietf-dhcpv6-relay {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-dhcpv6-relay";
```

```
  prefix "dhcpv6-relay";

  import ietf-inet-types {
    prefix inet;
  }
  import ietf-dhcpv6-options {
    prefix dhcpv6-options;
  }
  import ietf-dhcpv6-types {
    prefix dhcpv6-types;
  }
  import ietf-interfaces {
    prefix if;
  }

  organization
    "IETF DHC (Dynamic Host Configuration) Working group";

  contact
    "cuiyong@tsinghua.edu.cn
     lh.sunlinh@gmail.com
     ian.farrer@telekom.de
     sladjana.zechlin@telekom.de
     hezihao9512@gmail.com";

  description
    "This model defines a YANG data model that can be
     used to configure and manage a DHCPv6 relay.";

    revision 2018-09-04 {
    description "";
    reference "I-D: draft-ietf-dhc-dhcpv6-yang";
  }

  revision 2018-03-04 {
    description "Resolved most issues on the DHC official
    github";
    reference "I-D: draft-ietf-dhc-dhcpv6-yang";
  }

  revision 2017-12-22 {
    description
      "Resolve most issues on Ian's github.";
    reference
      "I-D: draft-ietf-dhc-dhcpv6-yang";
  }

  revision 2017-11-24 {
```

```
    description
      "First version of the separated relay specific
       YANG model.";
    reference
      "I-D: draft-ietf-dhc-dhcpv6-yang";
  }

  /*
   * Data Nodes
   */

  container relay {
    presence
      "Enables the relay";
    description
      "DHCPv6 relay portion";

    container relay-config {
      description
        "This container contains the configuration data
        of the relay.";
      container relay-attributes {
        description
          "A container describes some basic attributes of the relay
           agent including some relay agent specific options data that
           need to be configured previously.
           Such options include Remote-Id option and Subscriber-Id
           option.";
        leaf name {
          type string;
          description
            "Relay agent name";
        }
        leaf description {
          type string;
          description
            "Textual description of the relay agent";
        }
        leaf-list dest-addrs {
          type inet:ipv6-address;
          description
            "Each DHCPv6 relay agent may be configured with a list
             of destination addresses.
             This node defines such a list of IPv6 addresses that
             may include unicast addresses, multicast addresses or
             other addresses.";
        }
        list subscribers {
```

```
          key subscriber;
          description
            "Subscribers";
          leaf subscriber {
            type uint8;
            mandatory true;
            description
              "Subscriber";
          }
          leaf subscriber-id {
            type string;
            mandatory true;
            description
              "Subscriber id";
          }
        }
        list remote-host {
          key ent-num;
          description
            "Remote host";
          leaf ent-num {
            type uint32;
            mandatory true;
            description
              "Enterprise number";
          }
          leaf remote-id {
            type string;
            mandatory true;
            description
              "Remote id";
          }
        }
        uses dhcpv6-types:vendor-infor;
      }

      container rsoo-option-sets {
        description
         "DHCPv6 relay agent could provide some information that would
          be useful to DHCPv6 client.
          Since relay agent cannot provide options directly to the
          client, RSOO-enabled options are defined to propose options
          for the server to send to the client.
          This container models such RSOO-enabled options.";
        reference
          "RFC6422";
        list option-set {
          key option-set-id;
```

```
          description
            "This list under the 'rsoo-option-sets' container is similar
             to the that defined in server module.
             It allows the relay to implement several sets of RSOO-enabled
             options for different interfaces.
             The list only includes the EAP Re-authentication Protocol
             (ERP) Local Domain Name DHCPv6 Option defined in RFC6440,
             since it is the only one RSOO-enabled options accepted by
             IANA so far.";
          leaf option-set-id {
            type uint32;
            description "Option sed id";
          }
          uses dhcpv6-options:relay-supplied-option-definitions;
        }
      }

      list relay-if {
        // if - This should reference an entry in ietf-interfaces
        key if-name;
        description
        "A relay agent may have several interfaces, we should provide
         a way to configure and manage parameters on the interface-level.
         A list that describes specific interfaces and their corresponding
         parameters is employed to fulfil the configfuration. Here we use
         a string called 'if-name' as the key of list.";
        leaf if-name {
          type if:interface-ref;
          mandatory true;
          description
            "Interface name";
        }
        leaf interface-id {
          type string;
          description
            "Interface id";
        }

        /*
        leaf enable {
          type boolean;
          mandatory true;
          description "whether this interface is enabled";
        }
        */

        leaf ipv6-address {
          type inet:ipv6-address;
```

```
          description
            "IPv6 address for this interface";
        }

        leaf rsoo-option-set-id {
          type leafref {
            path "/relay/relay-config/rsoo-option-sets/option-set/option-set-id"
;
          }
          description "Configured Relay Supplied Option set";
        }

        list next-entity {
          key dest-addr;
          description
            "This node defines a list that is used to describe the
             next hop entity of this relay distinguished by their
             addresses.";
          leaf dest-addr {
            type inet:ipv6-address;
            mandatory true;
            description
              "Destination addr";
          }
          leaf available {
            type boolean;
            mandatory true;
            description
              "Whether the next entity is available or not";
          }
          leaf multicast {
            type boolean;
            mandatory true;
            description
              "Whether the address is multicast or not";
          }
          leaf server {
            type boolean;
            mandatory true;
            description
              "Whether the next entity is a server";
          }
        }
      }
    }


    container relay-state {
      config "false";
```

```
      description
        "State data of relay";
      list relay-if {
        key if-name;
        description
        "A relay agent may have several interfaces, we should provide
         a way to configure and manage parameters on the interface-level.
         A list that describes specific interfaces and their corresponding
         parameters is employed to fulfil the configfuration. Here we use
         a string called 'if-name' as the key of list.";
        leaf if-name{
          type string;
          mandatory true;
          description
            "Interface name";
        }
        list pd-route {
          // if - need to look at if/how we model these. If they are
          // going to be modelled, then they should be ro state
          // entries (we're not trying to configure routes here)
          key pd-route-id;
          description "pd route";
          leaf pd-route-id {
            type uint8;
            mandatory true;
            description
              "PD route id";
          }
          leaf requesting-router-id {
            type uint32;
            mandatory true;
            description
              "Requesting router id";
          }
          leaf delegating-router-id {
            type uint32;
            mandatory true;
            description
              "Delegating router id";
          }
          leaf next-router {
            type inet:ipv6-address;
            mandatory true;
            description
              "Next router";
          }
          leaf last-router {
            type inet:ipv6-address;
```

```
            mandatory true;
            description
              "Previous router";
          }
        }
        list next-entity {
          key dest-addr;
          description "This node defines a list that is used to
            describe the next hop entity of this relay agent.
            Different entities are distinguished by their
            addresses.";
          leaf dest-addr {
            type inet:ipv6-address;
            mandatory true;
            description "destination addr";
          }
          container packet-stats {
            description "packet statistics";
            leaf solicit-rvd-count {
              type uint32;
              mandatory true;
              description "solicit received counter";
            }
            leaf request-rvd-count {
              type uint32;
              mandatory true;
              description "request received counter";
            }
            leaf renew-rvd-count {
              type uint32;
              mandatory true;
              description "renew received counter";
            }
            leaf rebind-rvd-count {
              type uint32;
              mandatory true;
              description "rebind recevied counter";
            }
            leaf decline-rvd-count {
              type uint32;
              mandatory true;
              description "decline received counter";
            }
            leaf release-rvd-count {
              type uint32;
              mandatory true;
              description "release received counter";
            }
```

```
            leaf info-req-rvd-count {
              type uint32;
              mandatory true;
              description "information request counter";
            }
            leaf relay-for-rvd-count {
              type uint32;
              mandatory true;
              description "relay forward received counter";
            }
            leaf relay-rep-rvd-count {
              type uint32;
              mandatory true;
              description "relay reply received counter";
            }
            leaf packet-to-cli-count {
              type uint32;
              mandatory true;
              description "packet to client counter";
            }
            leaf adver-sent-count {
              type uint32;
              mandatory true;
              description "advertisement sent counter";
            }
            leaf confirm-sent-count {
              type uint32;
              mandatory true;
              description "confirm sent counter";
            }
            leaf reply-sent-count {
              type uint32;
              mandatory true;
              description "reply sent counter";
            }
            leaf reconfig-sent-count {
              type uint32;
              mandatory true;
              description "reconfigure sent counter";
            }
            leaf relay-for-sent-count {
              type uint32;
              mandatory true;
              description "relay forward sent counter";
            }
            leaf relay-rep-sent-count {
              type uint32;
              mandatory true;
```

```
            description "relay reply sent counter";
          }
        }
      }
    }
    container relay-stats {
      config "false";
      description
        "Relay statistics";
      leaf cli-packet-rvd-count {
        type uint32;
        mandatory true;
        description
          "Client packet received counter";
      }
      leaf relay-for-rvd-count {
        type uint32;
        mandatory true;
        description
          "Relay forward received counter";
      }
      leaf relay-rep-rvd-count {
        type uint32;
        mandatory true;
        description
          "Relay reply recevied counter";
      }
      leaf packet-to-cli-count {
        type uint32;
        mandatory true;
        description
          "Packet to client counter";
      }
      leaf relay-for-sent-count {
        type uint32;
        mandatory true;
        description
          "Relay forward sent counter";
      }
      leaf relay-rep-sent-count {
        type uint32;
        mandatory true;
        description
          "Relay reply sent counter";
      }
      leaf discarded-packet-count {
        type uint32;
        mandatory true;
```

```
          description
            "Discarded packet counter";
        }
      }
    }
  }

  /*
   * Notifications
   */

  notification notifications {
    description "DHCPv6 relay notification module";
    container dhcpv6-relay-event {
      description
        "DHCPv6 relay event";
      container topo-changed {
        description
        "Raised when the topology of the relay agent is changed.";
        leaf relay-if-name {
          type string;
          mandatory true;
          description
            "Relay interface name";
        }
        leaf first-hop {
          type boolean;
          mandatory true;
          description
            "First hop";
        }
        leaf last-entity-addr {
          type inet:ipv6-address;
          mandatory true;
          description
            "Last entity address";
        }
      }
    }
  }
}
<CODE ENDS>
```

3.3. DHCPv6 Client YANG Model

This module imports typedefs from [RFC6991], [RFC7223].

```
<CODE BEGINS> file "ietf-dhcpv6-client.yang"
```

```
module ietf-dhcpv6-client {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-dhcpv6-client";
  prefix "dhcpv6-client";

  import ietf-dhcpv6-options {
    prefix dhcpv6-options;
  }
  import ietf-dhcpv6-types {
    prefix dhcpv6-types;
  }
  import ietf-interfaces {
    prefix if;
  }

  organization "DHC WG";
  contact
   "cuiyong@tsinghua.edu.cn
    wangh13@mails.tsinghua.edu.cn
    lh.sunlinh@gmail.com
    ian.farrer@telekom.de
    sladjana.zechlin@telekom.de
    hezihao9512@gmail.com  ";

  description "This model defines a YANG data model that can be
    used to configure and manage a DHCPv6 client.";

  revision 2018-09-04 {
    description "";
    reference "I-D: draft-ietf-dhc-dhcpv6-yang";
  }

  revision 2018-03-04 {
    description "Resolved most issues on the DHC official
    github";
    reference "I-D: draft-ietf-dhc-dhcpv6-yang";
  }

  revision 2017-12-22 {
    description "Resolve most issues on Ian’s github.";
    reference "I-D: draft-ietf-dhc-dhcpv6-yang";
  }

  revision 2017-11-24 {
      description "First version of the separated client specific
        YANG model.";
      reference "I-D: draft-ietf-dhc-dhcpv6-yang";
  }
```

```
  /*
   * Data Nodes
   */

  container client {
    presence "Enables the client";
    description "dhcpv6 client portion";

    container client-config {
      description "configuration tree of client";
      container duid {
        description "Sets the DUID";
        uses dhcpv6-types:duid;
      }
      list client-if {
        key if-name;
        description "A client may have several interfaces, it is more reasonable
 to
          configure and manage parameters on the interface-level. The list defin
es
          specific client interfaces and their data. Different interfaces are
          distinguished by the key which is a configurable string value.";
        leaf if-name {
          type if:interface-ref;
          mandatory true;
          description "interface name";
        }

        leaf cli-id {
          type uint32;
          mandatory true;
          description "client id";
        }

        /*
        leaf description {
          type string;
          description "description of the client interface";
        }
        */

        leaf pd-function {
          type boolean;
          mandatory true;
          description "Whether the client can act as a requesting router
            to request prefixes using prefix delegation ([RFC3633]).";
        }
        leaf rapid-commit {
          type boolean;
          mandatory true;
```

```
          description "'1' indicates a client can initiate a Solicit-Reply messa
ge
            exchange by adding a Rapid Commit option in Solicit message. '0' mea
ns
            the client is not allowed to add a Rapid Commit option to request
            addresses in a two-message exchange pattern.";
        }

        /*
        container mo-tab {
          description "The management tab label indicates the operation mode of
the
            DHCPv6 client.
            'm'=1 and 'o'=1 indicate the client will use DHCPv6 to  obtain all t
he configuration
            data.
            'm'=1 and 'o'=0 are a meaningless combination.
            'm'=0 and 'o'=1 indicate the client will use stateless DHCPv6 to obt
ain configuration
            data apart from addresses/prefixes data.
            'm'=0 and 'o'=0 represent the client will not use DHCPv6 but use SLA
AC to
            achieve configuration.";

            // if - not sure about the intended use here as it seems
            // to be redfining what will be received in the PIO. Is
            // the intention to be whether they PIO options will be
            // obeyed as received or overridden?
          leaf m-tab {
            type boolean;
            mandatory true;
            description "m tab";
          }
          leaf o-tab {
            type boolean;
            mandatory true;
            description "o tab";
          }
        }
        */

        container client-configured-options {
          description "client configured options";
          uses dhcpv6-options:client-option-definitions;
        }
      }
    }

    container client-state {
      config "false";
      description "state tree of client";
      container if-other-paras {
        description "A client can obtain extra configuration
          data other than address and prefix information through
```

```
          DHCPv6. This container describes such data the client
          was configured. The potential configuration data may
          include DNS server addresses, SIP server domain names, etc.";
        uses dhcpv6-options:server-option-definitions;
      }
    container packet-stats {
       config "false";
       description "A container records
         all the packet status information
         of a specific interface.";
       leaf solicit-count {
         type uint32;
         mandatory true;
         description "solicit counter";
       }
       leaf request-count {
         type uint32;
         mandatory true;
         description "request counter";
       }
       leaf renew-count {
         type uint32;
         mandatory true;
         description "renew counter";
       }
       leaf rebind-count {
         type uint32;
         mandatory true;
         description "rebind counter";
       }
       leaf decline-count {
         type uint32;
         mandatory true;
         description "decline counter";
       }
       leaf release-count {
         type uint32;
         mandatory true;
         description "release counter";
       }
       leaf info-req-count {
         type uint32;
         mandatory true;
         description "information request counter";
       }
       leaf advertise-count {
         type uint32;
         mandatory true;
```

```
          description "advertise counter";
        }
        leaf confirm-count {
          type uint32;
          mandatory true;
          description "confirm counter";
        }
        leaf reply-count {
          type uint32;
          mandatory true;
          description "reply counter";
        }
        leaf reconfigure-count {
          type uint32;
          mandatory true;
          description "recofigure counter";
        }
      }
    }

  }

  /*
   * Notifications
   */

  notification notifications {
    description "dhcpv6 client notification module";
    container dhcpv6-client-event {
      description "dhcpv6 client event";

      container ia-lease-event {
        description "raised when the client was allocated
          a new IA from the server or it renew/rebind/release
          its current IA";
        leaf event-type {
          type enumeration {
            enum "allocation" {
              description "allocate";
            }
            enum "rebind" {
              description "rebind";
            }
            enum "renew" {
              description "renew";
            }
            enum "release" {
              description "release";
```

```
            }
          }
          mandatory true;
          description "event type";
        }
        container duid {
          description "Sets the DUID";
          uses dhcpv6-types:duid;
        }
        leaf iaid {
          type uint32;
          mandatory true;
          description "IAID";
        }
        leaf serv-name {
          type string;
          description "server name";
        }
        leaf description {
          type string;
          description "description of event";
        }
      }

      container invalid-ia-detected {
        description "raised when the identity association of the
          client can be proved to be invalid.  Possible condition
          includes duplicated address, illegal address, etc.";
        container duid {
          description "Sets the DUID";
          uses dhcpv6-types:duid;
        }
        leaf cli-duid {
          type uint32;
          mandatory true;
          description "duid of client";
        }
        leaf iaid {
          type uint32;
          mandatory true;
          description "IAID";
        }
        leaf serv-name {
          type string;
          description "server name";
        }
        leaf description {
          type string;
```

```
          description "description of the event";
        }
      }

      container retransmission-failed {
        description "raised when the retransmission mechanism defined
          in [RFC3315] is failed.";
        container duid {
          description "Sets the DUID";
          uses dhcpv6-types:duid;
        }
        leaf description {
          type enumeration {
            enum "MRC failed" {
              description "MRC failed";
            }
            enum "MRD failed" {
              description "MRD failed";
            }
          }
          mandatory true;
          description "description of failure";
        }
      }

      container failed-status-turn-up {
        description "raised when the client receives a message includes
          an unsuccessful Status Code option.";
        container duid {
          description "Sets the DUID";
          uses dhcpv6-types:duid;
        }
        leaf status-code {
          type enumeration {
            enum "1" {
              description "UnspecFail";
            }
            enum "2" {
              description "NoAddrAvail";
            }
            enum "3" {
              description "NoBinding";
            }
            enum "4" {
              description "NotOnLink";
            }
            enum "5" {
              description "UseMulticast";
```

```
            }
          }
          mandatory true;
          description "employed status code";
        }
      }

    }
  }
}
<CODE ENDS>
```

3.4. DHCPv6 Options YANG Model

This module imports typedefs from [RFC6991], [RFC7223].

```
<CODE BEGINS> file "ietf-dhcpv6-options.yang"
module ietf-dhcpv6-options {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-dhcpv6-options";
  prefix "dhcpv6-options";

  import ietf-inet-types {
    prefix inet;
  }
  import ietf-yang-types {
    prefix yang;
  }
  import ietf-dhcpv6-types {
    prefix dhcpv6-types;
  }

  organization "DHC WG";
  contact
   "cuiyong@tsinghua.edu.cn
    wangh13@mails.tsinghua.edu.cn
    lh.sunlinh@gmail.com
    ian.farrer@telekom.de
    sladjana.zechlin@telekom.de
    hezihao9512@gmail.com";

  description "This model defines a YANG data model that can be
    used to configure DHCPv6 options.";

  revision 2018-09-04 {
    description "";
    reference "I-D: draft-ietf-dhc-dhcpv6-yang";
  }
```

```
  revision 2018-03-04 {
    description "Resolved most issues on the DHC official
    github";
    reference "I-D: draft-ietf-dhc-dhcpv6-yang";
  }

  revision 2017-12-22 {
          description "Resolve most issues on Ian's github.";
          reference "I-D: draft-ietf-dhc-dhcpv6-yang";
  }

  revision 2017-11-24 {
    description "First version of the separated DHCPv6 options
      YANG model.";
    reference "I-D:draft-ietf-dhc-dhcpv6-yang";
  }

  /*
   * Features
   */

  //  features for server options
        feature server-unicast-op {
                description "Support for Server Unicast option";
        }
        feature sip-server-domain-name-list-op {
                description "Support for SIP Server Domain Name List option";
        }
        feature sip-server-address-list-op {
                description "Support for SIP Server Address List option";
        }
  feature dns-servers-op {
    description "Support for DNS Servers Option";
  }
        feature domain-searchlist-op {
                description "Support for Domain Search List Option";
        }
        feature nis-config-op {
                description "Support for Network Information Service (NIS)
                        Servers option";
        }
        feature nis-plus-config-op {
                description "Support for Network Information Service V2 (NIS+)
                        Servers option";
        }
        feature nis-domain-name-op {
                description "Support for Network Information Service (NIS)
                        Domain Name option";
```

```
        }
        feature nis-plus-domain-name-op {
                description "Support for Network Information Service V2 (NIS+)
                        Server option";
        }
        feature sntp-server-op {
                description "Support for Simple Network Protocol Configuration
                        (SNTP) Servers option";
        }
        feature info-refresh-time-op {
                description "Support for Information Refresh Time option";
        }
        feature client-fqdn-op {
                description "Support for Client FQDN option";
        }
        feature posix-timezone-op {
                description "Support for New POIX Timezone option";
        }
        feature tzdb-timezone-op {
                description "Support for New TZDB Timezone option";
        }
        feature ntp-server-op {
                description "Support for Network Time Protocol (NTP)
                        Server option";
        }
        feature boot-file-url-op {
                description "Support for Boot File URL option";
        }
        feature boot-file-param-op {
                description "Support for Boot File Parameters option";
        }
        feature aftr-name-op {
                description "Support for Address Family Transition
                        Router (AFTR) option";
        }
        feature kbr-default-name-op {
                description "Support for Kerberos Default Name
                        Option";
        }
        feature kbr-kdc-op {
                description "Support for Kerberos KDC option";
        }
        feature sol-max-rt-op {
                description "Support for SOL_MAX_RT option";
        }
        feature inf-max-rt-op {
                description "Support for INF_MAX_RT option";
        }
```

```
        feature addr-selection-op {
                description "Support for Address Selection opiton";
        }
        feature pcp-server-op {
                description "Support for Port Control Protocol (PCP)
                        option";
        }
        feature s46-rule-op {
                description "Support for S46 Rule option";
        }
        feature s46-br-op {
                description "Support for S46 Border Relay (BR) option";
        }
        feature s46-dmr-op {
                description "Support for S46 Default Mapping Rule
                        (DMR) option";
        }
        feature s46-v4-v6-binding-op {
                description "Support for S46 IPv4/IPv6 Address
                        Bind option";
        }

        // features for relay-supplied options
        feature erp-local-domain-name-op {
                description "Support for ERP Local Domain Name option";
        }

        // features for client options
        feature option-request-op {
                description "Support for Option Request option";
        }
        feature rapid-commit-op {
                description "Support for Rapid Commit option";
        }
        feature user-class-op {
                description "Support for User Class option";
        }
        feature vendor-class-op {
                description "Support for Vendor Class option";
        }
        feature client-arch-type-op {
                description "Support for Client System Architecture
                        Type option";
        }
        feature client-network-interface-identifier-op {
                description "Support for Client Network Interface
                        Identifier option";
        }
```

```
        feature kbr-principal-name-op {
                description "Support for Kerberos Principal
                        Name option";
        }
        feature kbr-realm-name-op {
                description "Support Kerberos Realm Name option";
        }
        feature client-link-layer-addr-op {
                description "Support for Client Link-Layer Address
                        Option";
        }

        // features for custom options
        feature operator-op-ipv6-address {
                description "Support for Option with IPv6 Addresses";
        }
        feature operator-op-single-flag {
                description "Support for Option with Single Flag";
        }
        feature operator-op-ipv6-prefix {
                description "Support for Option with IPv6 Prefix";
        }
        feature operator-op-int32 {
                description "Support for Opion with 32-bit
                        Integer Value";
        }
        feature operator-op-int16 {
                description "Support for Opion with 16-bit Integer Value";
        }
        feature operator-op-int8 {
                description "Support for Opion with 8-bit Integer Value";
        }
        feature operator-op-uri {
                description "Support for Opion with URI";
        }
        feature operator-op-textstring {
                description "Support for Opion with Text String";
        }
        feature operator-op-var-data {
                description "Support for Opion with Variable-Length Data";
        }
        feature operator-op-dns-wire {
                description "Support for Opion with DNS Wire
                        Format Domain Name List";
        }

  /*
   * Groupings
```

```
   */

  grouping server-option-definitions {
    description "Contains definitions for options configured on the
      DHCPv6 server which will be supplied to clients.";

    container server-unicast-option {
      if-feature server-unicast-op;
      presence "Enable this option";
      description "OPTION_UNICAST (12) Server Unicast Option";
      reference "RFC3315: Dynamic Host Configuration Protocol for
        IPv6 (DHCPv6)";
      leaf server-address {
        type inet:ipv6-address;
        description "server ipv6 address";
      }
    }

    container sip-server-domain-name-list-option {
      if-feature sip-server-domain-name-list-op;
      presence "Enable this option";
      description "OPTION_SIP_SERVER_D (21) SIP Servers Domain Name List";
      reference "RFC3319: Dynamic Host Configuration Protocol
        (DHCPv6) Options for Session Initiation Protocol (SIP) Servers";
      leaf sip-serv-domain-name {
        type string;
        mandatory true;
        description "sip server domain name";
      }
    }

    container sip-server-address-list-option {
      if-feature sip-server-address-list-op;
      presence "Enable this option";
      description "OPTION_SIP_SERVER_A (22) SIP Servers IPv6 Address List";
      reference "RFC3319: Dynamic Host Configuration Protocol (DHCPv6)
        Options for Session Initiation Protocol (SIP) Servers";
      list sip-server {
        key sip-serv-id;
        description "sip server info";
        leaf sip-serv-id {
          type uint8;
          mandatory true;
          description "sip server id";
        }
        leaf sip-serv-addr {
          type inet:ipv6-address;
          mandatory true;
```

```
          description "sip server addr";
        }
      }
    }

    container dns-servers-option {
      if-feature dns-servers-op;
      presence "Enable this option";
      description "OPTION_DNS_SERVERS (23) DNS recursive Name Server option";
      reference "RFC3646: DNS Configuration options for Dynamic Host Configurati
on
        Protocol for IPv6 (DHCPv6)";
      list dns-server {
        key dns-serv-id;
        description "dns server info";
        leaf dns-serv-id {
          type uint8;
          mandatory true;
          description "DNS server list entry ID.";
        }
        leaf dns-serv-addr {
          type inet:ipv6-address;
          mandatory true;
          description "DNS server address.";
        }
      }
    }

    container domain-searchlist-option {
      if-feature domain-searchlist-op;
      presence "Enable this option";
      description "OPTION_DOMAIN_LIST (24) Domain Search List Option";
      reference "RFC3646: DNS Configuration options for Dynamic
        Host Configuration Protocol for IPv6 (DHCPv6)";
      list domain-searchlist {
        key domain-searchlist-id;
        description "dns server info";
        leaf domain-searchlist-id {
          type uint8;
          mandatory true;
          description "Domain seachlist entry ID.";
        }
        leaf domain-search-list-entry {
          type string;
          mandatory true;
          description "Domain search list entry.";
        }
      }
    }
```

```
    container nis-config-option {
      if-feature nis-config-op;
      presence "Enable this option";
      description "OPTION_NIS_SERVERS (27) Network Information Service (NIS)
        Servers Option.";
      reference "RFC3898: Network Information Service (NIS) Configuration
        Options for Dynamic Host Configuration Protocol for IPv6 (DHCPv6)";
      list nis-server {
        key nis-serv-id;
        description "nis server info";
        leaf nis-serv-id {
          type uint8;
          mandatory true;
          description "nis server id";
        }
        leaf nis-serv-addr {
          type inet:ipv6-address;
          mandatory true;
          description "nis server addr";
        }
      }
    }

    container nis-plus-config-option {
      if-feature nis-plus-config-op;
      presence "Enable this option";
      description "OPTION_NISP_SERVERS (28): Network Information Service V2
        (NIS+) Servers Option.";
      reference "RFC3989: Network Information Service (NIS) Configuration
        Options for Dynamic Host Configuration Protocol for IPv6 (DHCPv6)";
      list nis-plus-server {
        key nis-plus-serv-id;
        description "NIS+ server information.";
        leaf nis-plus-serv-id {
          type uint8;
          mandatory true;
          description "nisp server id";
        }
        leaf nis-plus-serv-addr {
          type inet:ipv6-address;
          mandatory true;
          description "nisp server addr";
        }
      }
    }

    container nis-domain-name-option {
      if-feature nis-domain-name-op;
```

```
      presence "Enable this option";
      description "OPTION_NIS_DOMAIN_NAME (29) Network Information
        Service (NIS) Domain Name Option";
      reference "RFC3989: Network Information Service (NIS)
        Configuration Options for Dynamic Host Configuration Protocol
        for IPv6 (DHCPv6)";
      leaf nis-domain-name {
        type string;
        description "The Network Information Service (NIS) Domain Name
          option is used by the server to convey client's NIS Domain Name
          info to the client.";
      }
    }

    container nis-plus-domain-name-option {
      if-feature nis-plus-domain-name-op;
      presence "Enable this option";
      description "OPTION_NISP_DOMAIN_NAME (30) Network Information
        Service V2 (NIS+) Domain Name Option";
      reference "RFC3989: Network Information Service (NIS)
        Configuration Options for Dynamic Host Configuration Protocol
        for IPv6 (DHCPv6)";
      leaf nis-plus-domain-name {
        type string;
        description "The Network Information Service V2 (NIS+) Domain Name
        option is used by the server to convey client's NIS+ Domain Name
        info to the client.";
      }
    }


    container sntp-server-option {
      if-feature sntp-server-op;
      presence "Enable this option";
      description "OPTION_SNTP_SERVERS (31) Simple Network Time Protocol
        (SNTP) Servers Option";
      reference "RFC4075: Simple Network Time Protocol (SNTP) Configuration
        Option for DHCPv6";
      list sntp-server {
        key sntp-serv-id;
        description "sntp server info";
        leaf sntp-serv-id {
          type uint8;
          mandatory true;
          description "sntp server id";
        }
        leaf sntp-serv-addr {
          type inet:ipv6-address;
```

```
          mandatory true;
          description "sntp server addr";
        }
      }
    }

    container info-refresh-time-option {
      if-feature info-refresh-time-op;
      presence "Enable this option";
      description "OPTION_INFORMATION_REFRESH_TIME (32) Information Refresh
        Time option.";
      reference "RFC4242: Information Refresh Time Option for Dynamic Host
        Configuration Protocol for IPv6 (DHCPv6";
      leaf info-refresh-time {
        type yang:timeticks;
        mandatory true;
        description "The refresh time.";
      }
    }

    container client-fqdn-option {
      if-feature client-fqdn-op;
      presence "Enable this option";
      description "OPTION_CLIENT_FQDN (39) DHCPv6 Client FQDN Option";
      reference "RFC4704: The Dynamic Host Configuration Protocol for IPv6
        (DHCPv6) Client Fully Qualified Domain Name (FQDN) Option";
      leaf server-initiate-update {
        type boolean;
        mandatory true;
        description "server initiate";
      }
      leaf client-initiate-update {
        type boolean;
        mandatory true;
        description "client initiate";
      }
      leaf modify-name-from-cli {
        type boolean;
        mandatory true;
        description "modify by client";
      }
    }

    container posix-timezone-option {
      if-feature posix-timezone-op;
      presence "Enable this option";
      description "OPTION_NEW_POSIX_TIMEZONE (41) Posix Timezone option";
      reference "RFC4833: Timezone Options for DHCP";
```

```
      leaf tz-posix {
        type string;
        mandatory true;
        description "TZ Posix IEEE 1003.1 String";
      }
    }

    container tzdb-timezone-option {
      if-feature tzdb-timezone-op;
      presence "Enable this option";
      description "OPTION_NEW_TZDB_TIMEZONE (42) Timezone Database option";
      reference "RFC4822: Timezone Options for DHCP";
      leaf tz-database {
        type string;
        mandatory true;
        description "Reference to the TZ Database";
      }
    }

    container ntp-server-option {
      //This option looks like it needs work to correctly model the
      //option as defined in the RFC.

      // Zihao - Re-modelled so it only contains one time source suboption

      if-feature ntp-server-op;
      presence "Enable this option";
      description "OPTION_NTP_SERVER (56) NTP Server Option for DHCPv6";
      reference "RFC5908: Network Time Protocol (NTP) Server Option for
        DHCPv6";
      list ntp-server {
        key ntp-serv-id;
        description "ntp server info";
        leaf ntp-serv-id {
          type uint8;
          mandatory true;
          description "NTP server id";
        }
        choice ntp-time-source-suboption {
                description "Select a NTP time source suboption.";
                case server-address {
                leaf-list ntp-serv-addr-suboption {
                  type inet:ipv6-address;
                  description "NTP server addr";
              }
          }
                case server-multicast-address {
                        leaf-list ntp-serv-mul-addr-suboption {
```

```
              type inet:ipv6-address;
                    description "NTP server multicast addr";
            }
                }
                case server-fqdn {
                        leaf-list ntp-serv-fqdn-suboption {
              type string;
              description "NTP server fqdn";
            }
                }
        }
      }
    }

        container boot-file-url-option {
                if-feature boot-file-url-op;
                presence "Enable this option";
                description "OPT_BOOTFILE_URL (59) Boot File URL Option";
                reference "RFC5970: DHCPv6 Options for Network Boot";
                list boot-file {
                        key boot-file-id;
                        description "boot file info";
                        leaf boot-file-id {
                                type uint8;
                                mandatory true;
                                description "boot file id";
                        }
        leaf-list suitable-arch-type {
          type uint16;
          description "architecture type";
        }
        leaf-list suitable-net-if {
                type uint32;
                description "network interface";
        }
                        leaf boot-file-url {
                                type string;
                                mandatory true;
                                description "url for boot file";
                        }
                }
        }

        container boot-file-param-option {
                if-feature boot-file-param-op;
                presence "Enable this option";
                description "OPT_BOOTFiLE_PARAM (60) Boot File Parameters Option
";
                reference "RFC5970: DHCPv6 Options for Network Boot";
```

```
      list boot-file-paras {
        key para-id;
        description "boot file parameters";
        leaf para-id {
          type uint8;
          mandatory true;
          description "parameter id";
        }
        leaf parameter {
          type string;
          mandatory true;
          description "parameter value";
        }
      }
        }

    container aftr-name-option {
      if-feature aftr-name-op;
      presence "Enable this option";
      description "OPTION_AFTR_NAME (64) AFTR-Name DHCPv6 Option";
      reference "RFC6334: Dynamic Host Configuration Protocol for IPv6
        (DHCPv6) Option for Dual-Stack Lite";
      leaf tunnel-endpoint-name {
        type string;
        mandatory true;
        description "aftr name";
      }
    }

    container kbr-default-name-option {
        if-feature kbr-default-name-op;
        presence "Enable this option";
        description "OPTION_KRB_DEFAULT_REALM_NAME (77) Kerberos Default Realm N
ame Option";
        reference "RFC6784: Kerberos Options for DHCPv6";
      leaf default-realm-name {
        type string;
        mandatory true;
        description "default realm name";
      }
    }

    container kbr-kdc-option {
        if-feature kbr-kdc-op;
        presence "Enable this option";
        description "OPTION_KRB_KDC (78) Kerberos KDB Option";
        reference "RFC6784: Kerberos Options for DHCPv6";
      list kdc-info {
        key kdc-id;
```

```
        description "kdc info";
        leaf kdc-id {
          type uint8;
          mandatory true;
          description "kdc id";
        }
        leaf priority {
          type uint16;
          mandatory true;
          description "priority";
        }
        leaf weight {
          type uint16;
          mandatory true;
          description "weight";
        }
        leaf transport-type {
          type uint8;
          mandatory true;
          description "transport type";
        }
        leaf port-number {
          type uint16;
          mandatory true;
          description "port number";
        }
        leaf kdc-ipv6-addr {
          type inet:ipv6-address;
          mandatory true;
          description "kdc ipv6 addr";
        }
        leaf realm-name {
          type string;
          mandatory true;
          description "realm name";
        }
      }
    }

    container sol-max-rt-option {
      if-feature sol-max-rt-op;
      presence "Enable this option";
      description "OPTION_SOL_MAX_RT (82) sol max rt option";
      reference "RFC7083: Modification to Default Values of
        SOL_MAX_RT and INF_MAX_RT";
        leaf sol-max-rt-value {
          type yang:timeticks;
          mandatory true;
```

```
          description "sol max rt value";
        }
    }

    container inf-max-rt-option {
      if-feature inf-max-rt-op;
      presence "Enable this option";
      description "OPTION_INF_MAX_RT (83) inf max rt option";
      reference "RFC7083: Modification to Default Values of
        SOL_MAX_RT and INF_MAX_RT";
      leaf inf-max-rt-value {
        type yang:timeticks;
        mandatory true;
        description "inf max rt value";
      }
    }

    container addr-selection-option {
      if-feature addr-selection-op;
      presence "Enable this option";
      description "OPTION_ADDRSEL (84) and OPTION_ADDRSEL_TABLE (85)";
      reference "RFC7078: Distributing Address Selection Policy Using
        DHCPv6";
      // if - Needs checking to see if this matches the RFC - there
      // are two options here.
      // Zihao - I think this matches RFC7078
      leaf a-bit-set {
        type boolean;
        mandatory true;
        description "a bit";
      }
      leaf p-bit-set {
        type boolean;
        mandatory true;
        description "p bit";
      }
      list policy-table {
        key policy-id;
        description "policy table";
        leaf policy-id {
          type uint8;
          mandatory true;
          description "policy id";
        }
        leaf label {
          type uint8;
          mandatory true;
          description "label";
```

```
        }
        leaf precedence {
          type uint8;
          mandatory true;
          description "precedence";
        }
        leaf prefix-len {
          type uint8;
          mandatory true;
          description "prefix length";
        }
        leaf prefix {
          type inet:ipv6-prefix;
          mandatory true;
          description "prefix";
        }
      }
    }

    container pcp-server-option {
      if-feature pcp-server-op;
      presence "Enable this option";
      description "OPTION_V6_PCP_SERVER (86) pcp server option";
      reference "RFC7291: DHCP Options for the Port Control
        Protocol (PCP)";
      list pcp-server {
        key pcp-serv-id;
        description "pcp server info";
        leaf pcp-serv-id {
          type uint8;
          mandatory true;
          description "pcp server id";
        }
        leaf pcp-serv-addr {
          type inet:ipv6-address;
          mandatory true;
          description "pcp server addr";
        }
      }
    }

    container s46-rule-option {
      if-feature s46-rule-op;
      presence "Enable this option";
      description "OPTION_S46_RULE (89) S46 rule option";
      reference "RFC7598: DHCPv6 Options for Configuration of
        Softwire Address and Port-Mapped Clients";
      list s46-rule {
```

```
        key rule-id;
        description "s46 rule";
        leaf rule-id {
          type uint8;
          mandatory true;
          description "rule id";
        }
        leaf rule-type {
          type enumeration {
            enum "BMR" {
              description "BMR";
            }
            enum "FMR" {
              description "FMR";
            }
          }
          mandatory true;
          description "rule type";
        }
        leaf prefix4-len {
          type uint8;
          mandatory true;
          description "ipv4 prefix length";
        }
        leaf ipv4-prefix {
          type inet:ipv4-prefix;
          mandatory true;
          description "ipv4 prefix";
        }
        leaf prefix6-len {
          type uint8;
          mandatory true;
          description "ipv6 prefix length";
        }
        leaf ipv6-prefix {
          type inet:ipv6-prefix;
          mandatory true;
          description "ipv6 prefix";
        }
        uses dhcpv6-types:portset-para;
      }
    }

    container s46-br-option {
      if-feature s46-br-op;
      presence "Enable this option";
      description "OPTION_S46_BR (90) S46 BR Option";
      reference "RFC7598: DHCPv6 Options for Configuration of
```

```
        Softwire Address and Port-Mapped Clients";
      list br {
        key br-id;
        description "br info";
        leaf br-id {
          type uint8;
          mandatory true;
          description "br id";
        }
        leaf br-ipv6-addr {
          type inet:ipv6-address;
          mandatory true;
          description "br ipv6 addr";
        }
      }
    }

    container s46-dmr-option {
      if-feature s46-dmr-op;
      presence "Enable this option";
      description "OPTION_S46_DMR (91) S46 DMR Option";
      reference "RFC7598: DHCPv6 Options for Configuration of
        Softwire Address and Port-Mapped Clients";
      list dmr {
        key dmr-id;
        description "dmr info";
        leaf dmr-id {
          type uint8;
          mandatory true;
          description "dmr id";
        }
        leaf dmr-prefix-len {
          type uint8;
          mandatory true;
          description "dmr prefix length";
        }
        leaf dmr-ipv6-prefix {
          type inet:ipv6-prefix;
          mandatory true;
          description "dmr ipv6 prefix";
        }
      }
    }

    container s46-v4-v6-binding-option {
      if-feature s46-v4-v6-binding-op;
      presence "Enable this option";
      description "OPTION_S46_V4V6BIND (92) S46 IPv4/IPv6 Address
```

```
        Binding option";
      reference "RFC7598: DHCPv6 Options for Configuration of
        Softwire Address and Port-Mapped Clients";
      list ce {
        key ce-id;
        description "ce info";
        leaf ce-id {
          type uint8;
          mandatory true;
          description "ce id";
        }
        leaf ipv4-addr {
          type inet:ipv4-address;
          mandatory true;
          description "ce ipv4 addr";
        }
        leaf bind-prefix6-len {
          type uint8;
          mandatory true;
          description "bind ipv6 prefix
            length";
        }
        leaf bind-ipv6-prefix {
          type inet:ipv6-address;
          mandatory true;
          description "bind ipv6 prefix";
        }
        uses dhcpv6-types:portset-para;
      }
    }

  }
  //if - NB - The list of options needs to be updated.


  grouping relay-supplied-option-definitions {
    // if - The structure here needs to be checked and probably reworked.
    description "OPTION_RSOO (66) Relay-Supplied Options option";
    reference "RFC6422: Relay-Supplied DHCP Options";
    container erp-local-domain-name-option {
      if-feature erp-local-domain-name-op;
      presence "Enable this option";
      description "OPTION_ERP_LOCAL_DOMAIN_NAME (65) DHCPv6 ERP Local
        Domain Name Option";
      reference "RFC6440: The EAP Re-authentication Protocol (ERP)
        Local Domain Name DHCPv6 Option";
      list erp-for-client {
        key cli-id;
```

```
        description "erp for client";
        leaf cli-id {
          type uint32;
          mandatory true;
          description "client id";
        }
        container duid {
          description "Sets the DUID";
          // uses duid;
          // if - Maybe DUID definition needs to be moved to this module.
          uses dhcpv6-types:duid;
        }
        leaf erp-name {
          type string;
          mandatory true;
          description "erp name";
        }
      }
    }
  }

  grouping client-option-definitions {
    description "Contains definitions for options configured on the
      DHCPv6 client which will be sent to the server.";

    list new-or-standard-cli-option {
      key option-code;
      description "new or standard client option";
      leaf option-code {
        type uint16;
        mandatory true;
        description "option code";
      }
      leaf option-name {
        type string;
        mandatory true;
        description "option name";
      }
      leaf option-description {
        type string;
        mandatory true;
        description "description of client
          option";
      }
      leaf option-reference {
        type string;
        description "the reference of option";
      }
```

```
      leaf option-value {
        type string;
        mandatory true;
        description "the option value";
      }
    }

    container option-request-option {
      if-feature option-request-op;
      presence "Enable this option";
      description "OPTION_ORO (6) Option Request Option";
      reference "RFC3315: Dynamic Host Configuration Protocol for
      IPv6 (DHCPv6)";
      list oro-option {
        key option-code;
        description "oro option";
        leaf option-code {
          type uint16;
          mandatory true;
          description "option code";
        }
        leaf description {
          type string;
          mandatory true;
          description "description of oro
            options";
        }
      }
    }

    container user-class-option {
      if-feature user-class-op;
      presence "Enable this option";
      description "OPTION_USER_CLASS (15) User Class Option";
      reference "RFC3315: Dynamic Host Configuration Protocol
        for IPv6 (DHCPv6)";
      list user-class {
        key user-class-id;
        description "user class";
        leaf user-class-id {
          type uint8;
          mandatory true;
          description "user class id";
        }
        leaf user-class-data {
          type string;
          mandatory true;
          description "The information contained in the data area
```

```
            of this option is contained in one or more opaque
            fields that represent the user class or classes of
            which the client is a member. ";
        }
      }
    }

    container vendor-class-option {
      if-feature vendor-class-op;
      presence "Enable this option";
      description "OPTION_VENDOR_CLASS (16) Vendor Class Option";
      reference "RFC3315: Dynamic Host Configuration Protocol
        for IPv6 (DHCPv6)";
      leaf enterprise-number {
        type uint32;
        mandatory true;
        description "enterprise number";
      }
      list vendor-class {
          key vendor-class-id;
          description "vendor class";
        leaf vendor-class-id {
          type uint8;
          mandatory true;
          description "vendor class id";
        }
        leaf vendor-class-data {
          type string;
          mandatory true;
          description "The vendor-class-data is composed of a series of
            separate items, each of which describes some characteristic
            of the client's hardware configuration. Examples of
            vendor-class-data instances might include the version of the
            operating system the client is running or the amount of memory
            installed on the client.";
        }
      }
    }

    container client-fqdn-option {
      if-feature client-fqdn-op;
      presence "Enable this option";
      description "OPTION_CLIENT_FQDN (39) The Dynamic Host
        Configuration Protocol for IPv6 (DHCPv6) Client Fully
        Qualified Domain Name (FQDN) Option";
      reference "RFC4704: The Dynamic Host Configuration Protocol
        for IPv6 (DHCPv6) Client Fully Qualified Domain Name (FQDN)
        Option";
```

```
      leaf fqdn {
        type string;
        mandatory true;
        description "fqdn";
      }
      leaf server-initiate-update {
        type boolean;
        mandatory true;
        description "whether server initiate";
      }
      leaf client-initiate-update {
        type boolean;
        mandatory true;
        description "whether client initiate";
      }
    }

    container client-arch-type-option {
      if-feature client-arch-type-op;
      presence "Enable this option";
      description "OPTION_CLIENT_ARCH_TYPE (61) Client System
        Architecture Type Option";
      reference "RFC5970: DHCPv6 Options for Network Boot";
      list architecture-types {
        key type-id;
        description "architecture types";
        leaf type-id {
          type uint16;
          mandatory true;
          description "type id";
        }
        leaf most-preferred {
          type boolean;
          mandatory true;
          description "most preferred flag";
        }
      }
    }

    container client-network-interface-identifier-option {
      if-feature client-network-interface-identifier-op;
      presence "Enable this option";
      description "OPTION_NII (62) Client Network Interface
          Identifier Option";
      reference "RFC5970: DHCPv6 Options for Network Boot";
      leaf type {
        type uint8;
        mandatory true;
```

```
        description "type";
      }
      leaf major {
        type uint8;
        mandatory true;
        description "major";
      }
      leaf minor {
        type uint8;
        mandatory true;
        description "minor";
      }
    }

    container kbr-principal-name-option {
      if-feature kbr-principal-name-op;
      presence "Enable this option";
      description "OPTION_KRB_PRINCIPAL_NAME (75) Kerberos
        Principal Name Option";
      reference "RFC6784: Kerberos Options for DHCPv6";
      list principle-name {
          key principle-name-id;
          description "principle name";
          leaf principle-name-id {
                  type uint8;
                  mandatory true;
                  description "principle name id";
          }
          leaf name-type {
                  type int32;
                  mandatory true;
                  description "This field specifies the type of name that follow
s.";
          }
          leaf name-string {
                  type string;
                  mandatory true;
                  description "This field encodes a sequence of components that
form
                          a name, each component encoded as a KerberoString";
          }
      }
    }

    container kbr-realm-name-option {
        if-feature kbr-realm-name-op;
        presence "Enable this option";
        description "OPTION_KRB_REALM_NAME (76) Kerberos Realm Name Option";
        reference "RFC6784: Kerberos Options for DHCPv6";
        leaf realm-name {
```

```
                type string;
                mandatory true;
                description "realm name";
            }
        }

        container client-link-layer-addr-option {
          if-feature client-link-layer-addr-op;
          presence "Enable this option";
          description "OPTION_CLIENT_LINKLAYER_ADDR (79) DHCPv6 Client
            Link-Layer Address Option";
          reference "RFC6939: Client Link-Layer Address Option in
            DHCPv6";
          leaf link-layer-type {
            type uint16;
            mandatory true;
            description "Client link-layer address type. The link-layer
              type MUST be a valid hardware type assigned by the IANA,
              as described in [RFC0826]";
          }
          leaf link-layer-addr {
            type string;
            mandatory true;
            description "Client link-layer address";
          }
        }

      }


      grouping custom-option-definitions {
        description "operator customized options";

        container operator-option-ipv6-address {
          if-feature operator-op-ipv6-address;
          presence "Enable this option";
          description "operator ipv6 address option";
          reference "RFC7227: Guidelines for Creating New DHCPv6 Options";
          list operator-ipv6-addr {
            key operator-ipv6-addr-id;
            description "operator ipv6 address info";
            leaf operator-ipv6-addr-id {
              type uint8;
              mandatory true;
              description "operator ipv6 address id";
            }
            leaf operator-ipv6-addr {
              type inet:ipv6-address;
```

```
          mandatory true;
          description "operator ipv6 address id";
        }
      }
    }

    container operator-option-single-flag {
      if-feature operator-op-single-flag;
      presence "Enable this option";
      description "operator single flag";
      reference "RFC7227: Guidelines for Creating New DHCPv6
        Options";
      list flag {
        key flag-id;
        description "operator single flag info";
        leaf flag-id {
          type uint8;
          mandatory true;
          description "operator single flag id";
        }
        leaf flag-value{
          type boolean;
          mandatory true;
          description "operator single flag value";
        }
      }
    }

    container operator-option-ipv6-prefix {
      if-feature operator-op-ipv6-prefix;
      presence "Enable this option";
      description "operator ipv6 prefix option";
      reference "RFC7227: Guidelines for Creating New DHCPv6
        Options";
      list operator-ipv6-prefix {
        key operator-ipv6-prefix-id;
        description "operator ipv6 prefix info";
        leaf operator-ipv6-prefix-id {
          type uint8;
          mandatory true;
          description "operator ipv6 prefix id";
        }
        leaf operator-ipv6-prefix6-len {
          type uint8;
          mandatory true;
          description "operator ipv6 prefix length";
        }
        leaf operator-ipv6-prefix {
```

```
          type inet:ipv6-prefix;
          mandatory true;
          description "operator ipv6 prefix";
        }
      }
    }

    container operator-option-int32 {
      if-feature operator-op-int32;
      presence "Enable this option";
      description "operator integer 32 option";
      reference "RFC7227: Guidelines for Creating New DHCPv6
        Options";
      list int32val {
        key int32val-id;
        description "operator integer 32 info";
        leaf int32val-id {
          type uint8;
          mandatory true;
          description "operator integer 32 id";
        }
        leaf int32val {
          type uint32;
          mandatory true;
          description "operator integer 32 value";
        }
      }
    }

    container operator-option-int16 {
      if-feature operator-op-int16;
      presence "Enable this option";
      description "operator integer 16 option";
      reference "RFC7227: Guidelines for Creating New DHCPv6
        Options";
      list int16val {
        key int16val-id;
        description "operator integer 16 info";
        leaf int16val-id {
          type uint8;
          mandatory true;
          description "operator integer 16 id";
        }
        leaf int16val {
          type uint16;
          mandatory true;
          description "operator integer 16 value";
        }
```

```
      }
    }

    container operator-option-int8 {
      if-feature operator-op-int8;
      presence "Enable this option";
      description "operator integer 8 option";
      reference "RFC7227: Guidelines for Creating New DHCPv6
        Options";
      list int8val {
        key int8val-id;
        description "operator integer 8 info";
        leaf int8val-id {
          type uint8;
          mandatory true;
          description "operator integer 8 id";
        }
        leaf int8val {
          type uint8;
          mandatory true;
          description "operator integer 8 value";
        }
      }
    }

    container operator-option-uri {
      if-feature operator-op-uri;
      presence "Enable this option";
      description "operator uri option";
      reference "RFC7227: Guidelines for Creating New DHCPv6 Options";
      list uri{
        key uri-id;
        description "operator uri info";
        leaf uri-id {
          type uint8;
          mandatory true;
          description "operator uri id";
        }
        leaf uri {
          type string;
          mandatory true;
          description "operator uri value";
        }
      }
    }

    container operator-option-textstring {
      if-feature operator-op-textstring;
```

```
      presence "Enable this option";
      description "operator itext string option";
      reference "RFC7227: Guidelines for Creating New DHCPv6 Options";
      list textstring{
        key textstring-id;
        description "operator text string info";
        leaf textstring-id {
          type uint8;
          mandatory true;
          description "operator text string id";
        }
        leaf textstring {
          type string;
          mandatory true;
          description "operator text string value";
        }
      }
    }

    container operator-option-var-data {
      if-feature operator-op-var-data;
      presence "Enable this option";
      description "operator variable length data option";
      reference "RFC7227: Guidelines for Creating New DHCPv6 Options";
      list int32val {
        key var-data-id;
        description "operator ivariable length data info";
        leaf var-data-id {
          type uint8;
          mandatory true;
          description "operator variable length id";
        }
        leaf var-data {
          type binary;
          mandatory true;
          description "operator variable length value";
        }
      }
    }

    container operator-option-dns-wire {
      if-feature operator-op-dns-wire;
      presence "Enable this option";
      description "operator dns wire format domain name list option";
      reference "RFC7227: Guidelines for Creating New DHCPv6
        Options";
      list operator-option-dns-wire {
        key operator-option-dns-wire-id;
```

```
        description "operator dns wire format info";
        leaf operator-option-dns-wire-id {
          type uint8;
          mandatory true;
          description "operator dns wire format id";
        }
        leaf operator-option-dns-wire{
          type binary;
          mandatory true;
          description "operator dns wire format value";
        }
      }
    }

  }
}
```

<CODE ENDS>

3.5. DHCPv6 Types YANG Model

This module imports typedefs from [RFC6991].

```
<CODE BEGINS> file "ietf-dhcpv6-types.yang"
module ietf-dhcpv6-types {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-dhcpv6-types";
  prefix "dhcpv6-types";

  import ietf-inet-types {
    prefix inet;
  }
  import ietf-yang-types {
    prefix yang;
  }

  organization "DHC WG";
  contact
   "cuiyong@tsinghua.edu.cn
    lh.sunlinh@gmail.com
    ian.farrer@telekom.de
    sladjana.zechlin@telekom.de
    hezihao9512@gmail.com";

  description "This model defines a YANG data model that can be
    used to define some commonly used DHCPv6 types";

  revision 2018-09-04 {
```

```
    description "";
    reference "I-D: draft-ietf-dhc-dhcpv6-yang";
  }

  revision 2018-01-30 {
    description "Initial revision";
    reference "I-D: draft-ietf-dhc-dhcpv6-yang";
  }

  /*
  * Grouping
  */
  grouping vendor-infor {
    description "Vendor information.";
    container vendor-info {
      description "";
      leaf ent-num {
        type uint32;
        mandatory true;
        description "enterprise number";
      }
      leaf-list data {
        type string;
        description "specific vendor info";
      }
    }
  }

  grouping duid {
    description
      "Each server and client has only one DUID (DHCP Unique Identifier).
      The DUID here identifies a unique DHCPv6 server for clients. DUID
      consists of a two-octet type field and an arbitrary length (no more
      than 128 bytes) content field. Currently there are four defined types
      of DUIDs in RFC3315 and RFC6355 - DUID-LLT, DUID-EN, DUID-LL and
      DUID-UUID. DUID-Uknown represents those unconventional DUIDs.";
    reference "RFC3315: Section 9 and RFC6355: Section 4";
    leaf type-code {
      type uint16;
      default 65535;
      description "Type code of this DUID";
    }
    choice duid-type {
    default duid-unknown;
      description "Selects the format for the DUID.";
      case duid-llt {
        description "DUID Based on Link-layer Address Plus Time
          (Type 1 - DUID-LLT)";
```

```
        reference "RFC3315 Section 9.2";
        leaf duid-llt-hardware-type {
          type uint16;
          description "Hardware type as assigned by IANA (RFC826).";
        }
        leaf duid-llt-time {
          type yang:timeticks;
          description "The time value is the time that the DUID is
          generated represented in seconds since midnight (UTC),
          January 1, 2000, modulo 2^32.";
        }
        leaf duid-llt-link-layer-addr {
          type yang:mac-address;
          description "Link-layer address as described in RFC2464";
        }
      }
      case duid-en {
        description "DUID Assigned by Vendor Based on Enterprise Number
          (Type 2 - DUID-EN)";
        reference "RFC3315 Section 9.3";
        leaf duid-en-enterprise-number {
          type uint32;
          description "Vendor's registered Private Enterprise Number as
            maintained by IANA";
        }
        leaf duid-en-identifier {
          type string;
          description "Indentifier, unique to the device that is
          using it";
        }
      }
      case duid-ll {
          description "DUID Based on Link-layer Address (Type 3 - DUID-LL)";
          reference "RFC3315 Section 9.4";
          leaf duid-ll-hardware-type {
            type uint16;
            description "Hardware type as assigned by IANA (RFC826).";
          }
          leaf duid-ll-link-layer-addr {
            type yang:mac-address;
            description "Link-layer address as described in RFC2464";
        }
      }
      case duid-uuid {
        description "DUID Based on Universally Unique Identifier
          (Type 4 - DUID-UUID)";
        reference "RFC6335 Defination of the UUID-Based Unique Identifier";
        leaf uuid {
```

```
          type yang:uuid;
          description "A Universally Unique IDentifier in the string
            representation defined in RFC 4122. The canonical
            representation uses lowercase characters";
        }
      }
      case duid-unknown {
        description "DUID based on free raw bytes";
        leaf data {
          type binary;
          description "The bits to be used as the identifier";
        }
      }
    }
  }

  grouping portset-para {
    description "portset parameters";
    container port-parameter {
      description "port parameter";
      leaf offset {
        type uint8;
        mandatory true;
        description "offset in a port set";
      }
      leaf psid-len {
        type uint8;
        mandatory true;
        description "length of a psid";
      }
      leaf psid {
        type uint16;
        mandatory true;
        description "psid value";
      }
    }
  }

  grouping iaid {
    description "IA is a construct through which a server and a
        client can identify, group, and manage a set of related IPv6
        addresses. The key of the list is a 4-byte number IAID defined
        in [RFC3315].";
    list identity-association {
      config "false";
      description "IA";
      leaf iaid {
        type uint32;
```

```
        mandatory true;
        description "IAID";
      }
      leaf ia-type {
        type string;
        mandatory true;
        description "IA type";
      }
      leaf-list ipv6-addr {
        type inet:ipv6-address;
        description "ipv6 address";
      }
      leaf-list ipv6-prefix {
        type inet:ipv6-prefix;
        description "ipv6 prefix";
      }
      leaf-list prefix-length {
        type uint8;
        description "ipv6 prefix length";
      }
      leaf t1-time {
        type yang:timeticks;
        mandatory true;
        description "t1 time";
      }
      leaf t2-time {
        type yang:timeticks;
        mandatory true;
        description "t2 time";
      }
      leaf preferred-lifetime {
        type yang:timeticks;
        mandatory true;
        description "preferred lifetime";
      }
      leaf valid-lifetime {
        type yang:timeticks;
        mandatory true;
        description "valid lifetime";
      }
    }
  }
}
<CODE ENDS>
```

4. Security Considerations (TBD)

TBD

5. IANA Considerations (TBD)

This document registers the following YANG modules in the "YANG Module Names" registry [RFC6020].

```
name:           ietf-dhcpv6
namespace:      urn:ietf:params:xml:ns:yang:ietf-dhcpv6
prefix:         dhcpv6
reference:      TBD
```

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DHCPv6 options for MQTT client configuration
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Abstract

This document defines Dynamic Host Configuration Protocol and Dynamic Host Configuration Protocol version 6 (DHCPv6) Options for MQTT client configuration information, which are used to carry Uniform Resource Locater of MQTT broker and MQTT topic prefix that should be used as prefix for any topic published by MQTT client.

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 April 23, 2018.

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1. Introduction

The Message Queue Telemetry Transport (MQTT) protocol is a light-weight IoT protocol, based on the publish/subscribe communication model. MQTT clients, that can be publishers or subscribers, communicate with each other via a broker. The broker hosts a set of "topics" and clients can publish and subscribe to these topics. All data published to a topic is delivered to all clients who are subscribed to the same topic. In communications network using MQTT clients commonly use a preconfigured address information, such as Uniform Resource Identifier (URI), to register with a MQTT broker. The URI might be configured by a user or an operator through a local device interface. Alternatively, the URI might be provided as a hardcoded value by manufacturer of the MQTT client device.

Hard coding configuration by device manufacturer forces device operator to use same configuration as hard coded. It is possible that reachability information of MQTT broker that is hard coded may be outdated and MQTT broker reachability might fail during first use of device. In such cases connectivity with MQTT broker is possible only through device software upgrade.

Subscribers who are interested in specific data of a specific topic registers the topic with the MQTT broker. MQTT clients acting as publishers register/create topics, and MQTT clients acting as subscribers register for a specific existing topic. In general

terms, a topic can represented by a hierarchical string defined by MQTT service or device operator. Before operation every MQTT client that wishes to publish data on a specific topic should be aware of the corresponding hierarchical strings that are supposed to be used for the topics for the MQTT client to publish topic specific data.

However, uniqueness of topics in the MQTT network is not guaranteed as there is no standard guideline that guarantees uniqueness. In the same MQTT network, using the same MQTT broker, different MQTT clients can accidentally use the same topic to publish data, which results in invalid operation. In such scenarios, subscribers might receive wrong data and publishers may change data they were not supposed to change. Network or device operators therefore have to take care of the topic name space across the MQTT network so that topic identities are unique across the MQTT network. This manual operation is error-prone and costly.

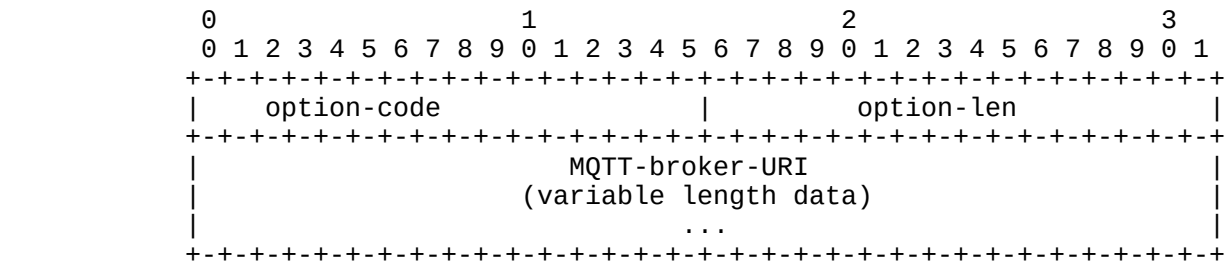
This draft propose DHCP and DHCPv6 options to dynamically configure MQTT client with MQTT broker URI and one or more topic prefixs to guarantee uniqueness of topic used across MQTT network.

2. MQTT client configuration through DHCP

MQTT broker URI and topic prefix can be collected during dynamic host configuration phase. DHCPv4 and DHCPv6 options can be extended to collect MQTT broker URI and MQTT topic prefix for IPv4 and IPv6 networks respectively. DHCPv4 or DHCPv6 client requests MQTT broker URI and MQTT topic prefix using new options proposed in sections below

2.1. DHCPv6 option for MQTT broker URI

DHCPv6 option OPTION_MQTT_BROKER_URI conveys URI through which MQTT client can reach MQTT broker in IPv6 network. The format of MQTT broker URI option is as shown below:



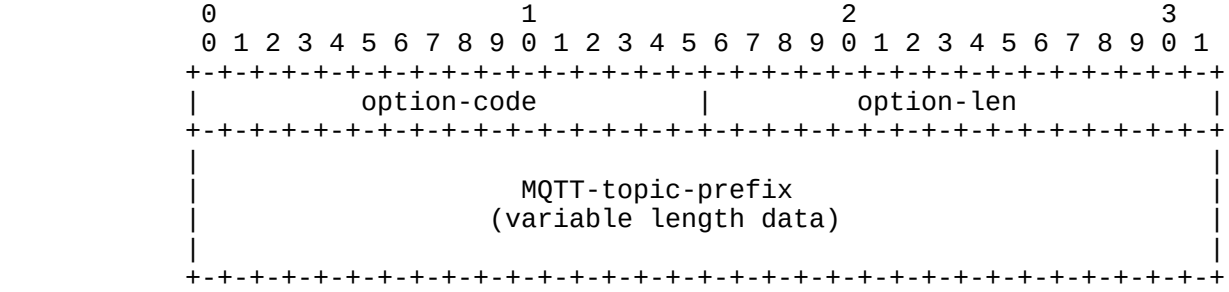
option-code: OPTION_MQTT_BROKER_URI

option-len: Length of the 'MQTT-broker-URI' field in octets

MQTT-broker-URI: This string is URI of MQTT broker. The string is not null-terminated.

2.2. DHCPv6 option for MQTT topic prefix

DHCPv6 option OPTION_MQTT_TOPIC_PREFIX conveys prefix string which can be used by MQTT client as prefix of each topic used for publishing data. The format of MQTT topic prefix option is as shown below:



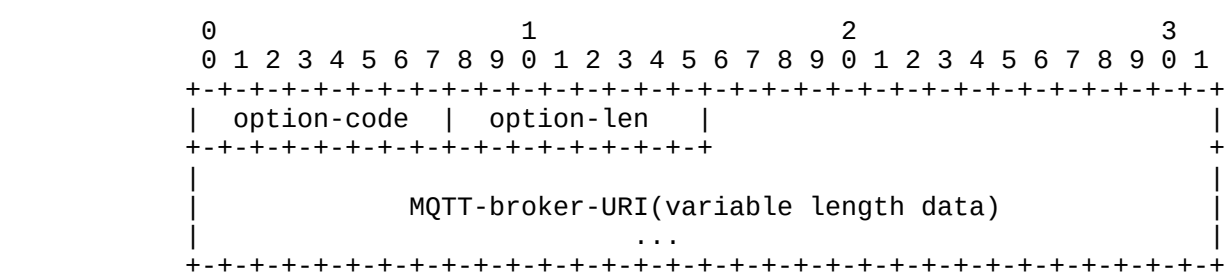
option-code: OPTION_MQTT_TOPIC_PREFIX

option-len: Length of the 'MQTT-topic-prefix' field in octets

MQTT-topic-prefix: MQTT topic prefix string that can be used by MQTT client as prefix to each topic used for publishing data

2.3. DHCPv4 option for MQTT broker URI

DHCPv4 option OPTION_MQTT_BROKER_URI conveys URI through which MQTT client can reach MQTT broker that is reachable through IPv4 network. The format of MQTT broker URI option is as shown below:



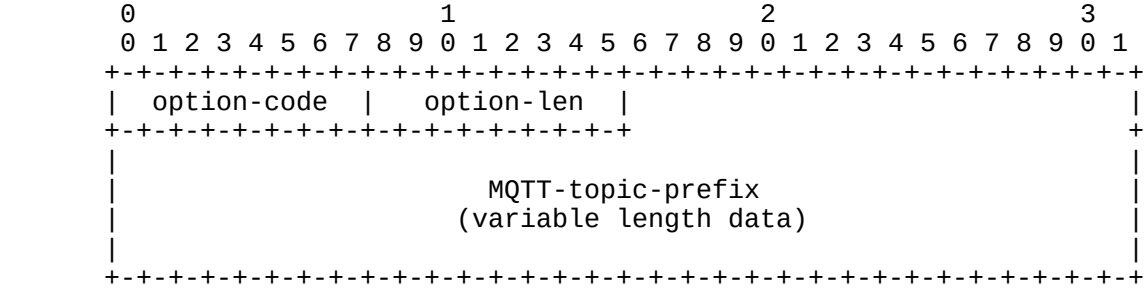
option-code: OPTION_MQTT_BROKER_URI

option-len: Length of the 'MQTT-broker-URI' field in octets

MQTT-broker-URI: This string is URI of MQTT broker. The string is not null-terminated.

2.4. DHCPv4 option for MQTT topic prefix

DHCPv4 option OPTION_MQTT_TOPIC_PREFIX conveys prefix string which can be used by MQTT client as prefix of each topic used for publishing data. The format of MQTT topic prefix option is as shown below:



option-code: OPTION_MQTT_TOPIC_PREFIX

option-len: Length of the 'MQTT-topic-prefix' field in octets

MQTT-topic-prefix: MQTT topic prefix string that can be used by MQTT client as prefix to each topic used for publishing data

3. Appearance of Option

3.1. Appearance of options in DHCPv6 control messages

The OPTION_MQTT_BROKER_URI and OPTION_MQTT_TOPIC_PREFIX options MUST NOT appear in messages other than the following: SOLICIT (1), ADVERTISE (2), REQUEST (3),REPLY (4) RENEW (5), REBIND (6), INFORMATION-REQUEST (11). If this option appears in messages other than those specified above, the receiver MUST ignore it.

The option number for OPTION_MQTT_BROKER_URI and OPTION_MQTT_TOPIC_PREFIX options MAY appear in the "Option Request" option [RFC3315] in the following messages: SOLICIT (1), REQUEST (3), RENEW (5), REBIND (6), INFORMATION-REQUEST (11) and RECONFIGURE (10). If this option number appears in the "Option Request" option in messages other than those specified above, the receiver SHOULD ignore it.

3.2. Appearance of options in DHCPv4 control messages

The OPTION_MQTT_BROKER_URI and OPTION_MQTT_TOPIC_PREFIX options MUST NOT appear in messages other than the following: DHCPDISCOVER (1), DHCPOFFER (2), DHCPREQUEST (3), DHCPACK (5) and DHCPINFORM (8). If this option appears in messages other than those specified above, the receiver MUST ignore it.

The option number for OPTION_MQTT_BROKER_URI and OPTION_MQTT_TOPIC_PREFIX options MAY appear in the "Parameter Request List" option [RFC2132] in the following messages: DHCPDISCOVER (1), DHCPOFFER (2), DHCPREQUEST (3), DHCPACK (5) and DHCPINFORM (8). If this option number appears in the "Parameter Request List" option in messages other than those specified above, the receiver SHOULD ignore it.

Maximum possible value of DHCPv4 "option-len" is 255. MQTT-topic-prefix MAY be of length more than 255. To accommodate larger certificate, DHCP server SHOULD follow encoding as mentioned in [RFC3396].

4. Configuration Guidelines for the Server

DHCPv4 or DHCPv6 server that supports OPTION_MQTT_BROKER_URI and OPTION_MQTT_TOPIC_PREFIX SHOULD be configured with one or more MQTT broker URI, and one or moretopic prefix for each MQTT client. DHCP server may use statically configured topic prefixes or algorithem genrated topic prefixes. Algorithems to generate MQTT topic prefix for an MQTT client might use client attributes like data link layer address. Details of algorithems to generate topic prefix and guidelines to manage topic prefixes are not included in the scope of this draft

In the absence of MQTT broker URI configuration, DHCP server SHOULD ignore option OPTION_MQTT_BROKER_URI, and SHOULD continue processing of DHCP control message

In the absence of MQTT topic prefix configuration and topic prefix generation algorithem, DHCP server SHOULD ignore option OPTION_MQTT_TOPIC_PREFIX, and SHOULD continue processing of DHCP control message

5. DHCPv4/DHCPv6 Client Behavior

DHCP or DHCPv6 client MAY decide need for inclusion of OPTION_MQTT_BROKER_URI and OPTION_MQTT_TOPIC_PREFIX options in DHCPv4 or DHCPv6 control messages if device is capable of supporting MQTT client functionality irrespective of state of MQTT client. It is

possible that MQTT client MAY not be active before DHCPv4 or DHCPv6 message exchanges happens. In such scenario, DHCPv4 or DHCPv6 client MAY collect MQTT broker URI and MQTT topic prefix and keep ready for MQTT client initialization

DHCPv4 or DHCPv6 client MAY prefer collecting MQTT broker URI and MQTT topic prefix by including OPTION_MQTT_BROKER_URI and OPTION_MQTT_TOPIC_PREFIX options in DHCPINFORM or INFORMATION-REQUEST message which MAY be send during MQTT client initialization

MQTT client devices running with IPv6 stack MAY use stateless auto address configuration to get IPv6 address. Such clients MAY use DHCPv6 INFORMATION-REQUEST to get MQTT broker URI and MQTT topic prefix through options OPTION_MQTT_BROKER_URI and OPTION_MQTT_TOPIC_PREFIX

6. Relay agent Behavior

This draft does not impose any new requirements on DHCPv4 or DHCPv6 relay agent functionality

7. Security Considerations

OPTION_MQTT_BROKER_URI option could be used by an intruder to advertise the URI of a malicious MQTT broker which results in data reporting by MQTT clients to an unwanted MQTT broker. As an example, an attacker could collect data from secure locations by deploying malicious servers.

Intuders might use OPTION_MQTT_TOPIC_PREFIX option to advertise unwanted topic prefixes which results in duplicate MQTT topics As an example, an attacker could collect data from secure locations by deploying malicious servers.

To prevent these attacks, it is strongly advisable to secure the use of these options by either:

- Using authenticated DHCP as described in [RFC3315], Section 21.
- Using options OPTION_MQTT_BROKER_URI and OPTION_MQTT_TOPIC_PREFIX only with trusted DHCP server

The security considerations documented in [RFC3315] are to be considered.

8. Acknowledgement

Particular thanks to A. Keraenen and S. Krishnan for inputs and review.

9. IANA Considerations

IANA is requested to assign new DHCPv6 option codes in the registry maintained in http://www.iana.org/assignments/dhcpv6-parameters:

Option Name	Value
OPTION_MQTT_BROKER_URI	TBA
OPTION_MQTT_TOPIC_PREFIX	TBA

IANA is requested to assign new DHCPv4 option codes in the registry maintained in http://www.iana.org/assignments/bootp-dhcp-parameters:

Option Name	Value
OPTION_MQTT_BROKER_URI	TBA
OPTION_MQTT_TOPIC_PREFIX	TBA

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