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DHCPv6_PD, PDP and NDP Implementation in IoT Router (DANIR)
draft-shytyi-v6ops-danir-04.txt

Abstract

This document provides a description of the implementation of Dynamic Host Configuration Protocol version 6 Prefix Delegation, Neighbour Discovery Protocol and of the use of the Packet Data Protocol in an Internet of Things Router. This Internet of Things Router is connected on a cellular network; it is a DHCPv6-PD Client and it requests a /56 pool of prefixes from the server; the DHCPv6-PD server is placed in the PGW and is a part of the cellular infrastructure. After the pool of prefixes is delegated, the Internet of Things Router derives sub-prefixes from the prefix pool; each one of these sub-prefixes is aimed at one ingress interface.

After the Internet of Things Router finishes the network prefix assignment procedure, it advertises the network prefixes on the ingress links by using the Neighbour Discovery protocol. Finally, when Hosts receive the sub-prefixes via Router Adverticement messages, they configure the Global Unique Address with the Stateless Address Auto-configuration protocol.

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 21, 2020.

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1. Introduction

This document describes the implementation of the Dynamic Host Configuration Protocol vestion 6 with Prefix Delegation (DHCPv6_PD), Neighbour Discovery Protocol (NDP) and usage of the Packet Data Protocol (PDP) in an Internet of Things (IoT) Router.

The use of DHCPv6 Prefix Delegation in LTE networks is overviewed in [RFC6653]. It misses several important aspects.

The router MUST be a node that forwards IP version 6 packets not explicitly addressed to itself [RFC8200]. Thus, it has more than one link to perform the forwarding. With multiple links, the need of multiple global unique network prefixes (GUNPs) , assigned to those links, appears. To assign the GUNPs to the links, the Requesting IoT Router Solicits the pool of GUNPs.

First, the Requesting IoT Router solicits the pool of the GUNP from the Delegating Router.

After the pool is received, the Requesting IoT Router (1) derives GUNPs and (2) performs address autoconfiguration. During the autoconfiguration process the Requesting IoT Router assigns the GUNPs to the links. When the IoT Router finishes the GUNPs assignment procedure, it starts to advertise the GUNPs on the links with NDP [RFC4861]. Meanwhile, the Hosts that are connected to the Requesting IoT Router run the SLAAC mechanism to perform the GUA IP version 6 autoconfiguration.

2. Terminology

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

IoT Router - a device of class IoT. It has several wired and wireless interfaces. One wireless interface is of type cellular, like 4G or 5G. This cellular interface is egress. The other interfaces are ingress. There are at least two ingress interfaces. There is at least one set of two interfaces that can not be bridged together, for example 802.11b and Bluetooth. If all ingress interfaces in the IoT Router can be bridged, for example 802.11b and Ethernet, then there is at least one other router in the same local network as the IoT Router, that can not be bridged to this IoT Router. The IoT Router needs more than one /64 prefix. An example of IoT Router is Sierra Wirelss mangOH Red, or Maestro Wireless E220.

Delegating Router - is a node, DHCPv6 server, that chooses prefix(es) for delegation and advertises them to the Requesting Router [RFC3633].

Requesting IoT Router - is a node that behaves as DHCPv6 client. It requests the network prefix(es) and assigns network prefix(es) to the interfaces [RFC6653].

Host - is a node that is not a router.

Link - is an entity that enables link layer communication of nodes.

Interface - node connection to the link.

Link-local address - is an address with usage that is limited by a link.

Global Unique Address (GUA) - is an address that is globally available and globally unique.

3. Related Work

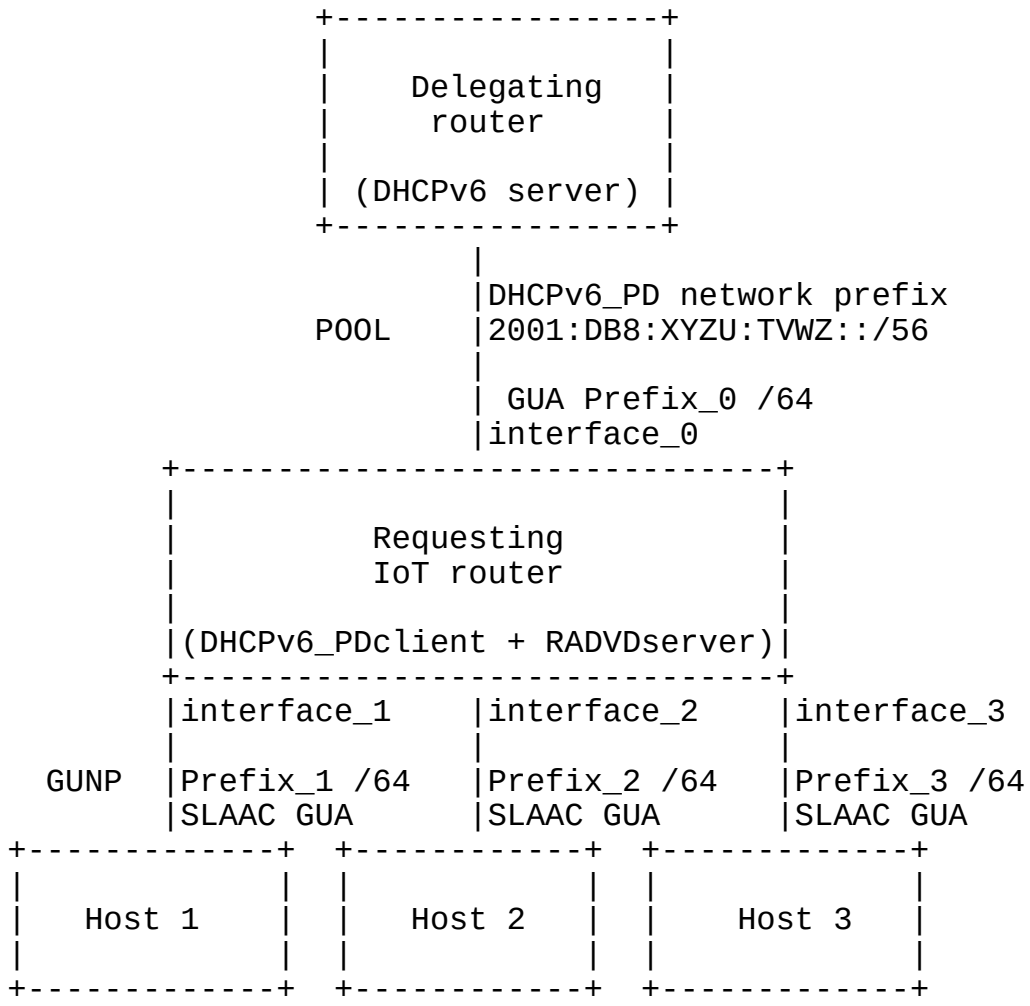
Earlier work considered the use of DHCPv6 Prefix Delegation for Hosts, such as for a smartphone, or for a portable User Equipment. The operation and the implementaiton experience are described in draft-templin-v6ops-pdhost-24.txt.

The method of sharing a /64 prefix between the upstream (egress) and downstream (ingress) interface(s) is described in RFC 7278 "64share". This method is used for tethering on millions of Android and Apple devices and smartphones. This method considers that an alternative based on DHCPv6-PD is a solution to a problem that users/providers/ the market does not have. This method may have some issues with existing models and protocols, because it is half way between full routing between interfaces and bridging between interfaces.

ND Proxy of RFC 4389 is a potential tool to use a single /64 that is shared between the egress interface and the other interfaces of an IoT Router.

4. Overview

This section provides an overview of the actions performed on the Delegating Router, Requesting IoT Router and host to perform address assignment on the interfaces with different GUNP. The process of IP version 6 address assignment starts with advertising of the GUNP pool from the Delegating Router to the Requesting IoT Router. To perform such a solicitation, the Requesting IoT Router runs the DHCPv6_PD.



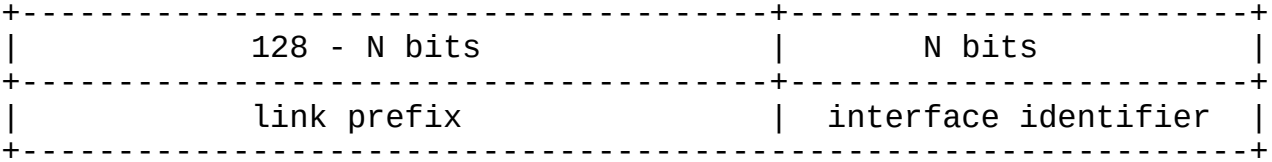
(In the above figure the scenario with 3 hosts connected to the Requesting IoT router is presented. Normally there are no number limitations of connected hosts.)

When the DHCPv6 message exchange is performed, the Requesting IoT Router receives the pool of IPv6 GUNPs. After the pool of GUNPs is received, the Requesting IoT Router performs the autoconfiguration. Precisely, when the Requesting IoT Router’s interface is attached on the link, the Requesting IoT Router assigns to this link the GUNP taken from GUNP pool. The Requesting IoT Router performs the GUNP assignment procedure for multiple links over the interfaces. Finally, this mechanism offers the automated assignment of GUNPs to the links. At the moment of autoconfiguration, the Requesting IoT Router’s interfaces are already assigned with link local addresses.

The next step of the autoconfiguration phase SHOULD be performed using the Neighbor Discovery protocol. The latter advertises the

network’s configuration on the links with different interfaces thus with different GUNPs. To perform the GUNPs advertisement, the Requesting IoT ROuter sends the "Router Advertisement Messages" via its interfaces. The Router Avertisement Messages carry the GUNPs that are further used by the stateless autoconfiguration mechanism (SLAAC). There exists an open source implementation of Neighbor Discovery protocol - RADVD sever. With RADVD it is possible to configure hosts interfaces connected to the router’s interfaces in automatic manner. It MAY be possible thanks to the fact that hosts run the SLAAC.

The IP version 6 stateless autoconfiguration mechanism enables hosts to perform the address autoconfiguration. The SLAAC mechanism SHOULD be used when it is enough to have random unique IP version 6 addresses [RFC4862]. The length of the IP version 6 address is N bytes. The first part of the address (128-N bits) consists of the GUNP information associated with a link. The network prefix is advertised by the IoT Router on the link. The second part of the address (8 bytes) consists of interface identifier on the link. The interface identifier SHOULD be generated locally and randomly.



(In the above figure, an IP version 6 address scheme is presented [RFC4862].)

4.1. Environment

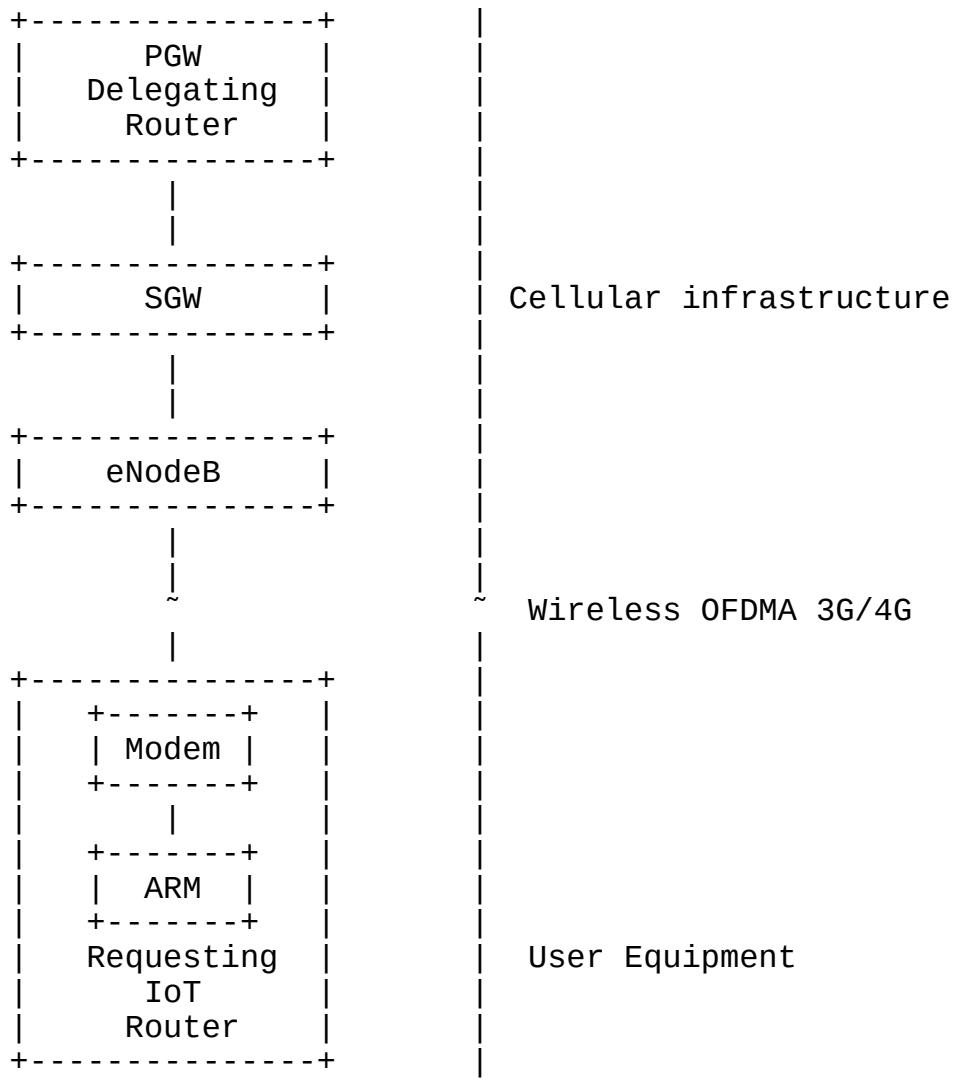
This section describes the location of the Delegating Router and the Requesting IoT Router in the cellular provider’s infrastructure model. The model is not a real cellular provider infrastructure.

After the DHCPv6 packet leaves the cellular interface of the IoT Requesting Router via wireless OFDMA link, it reaches the element of the access network which connects to the user equipment (UEs) - eNodeB station.

Further, the packet MAY be transmitted to the Serving Gateway (SGW), as all the user’s IP packets. SGW is used to enable the UE movement between eNodeBs. When the UE moves between eNodeBs, the SGW keeps information about the bearers.

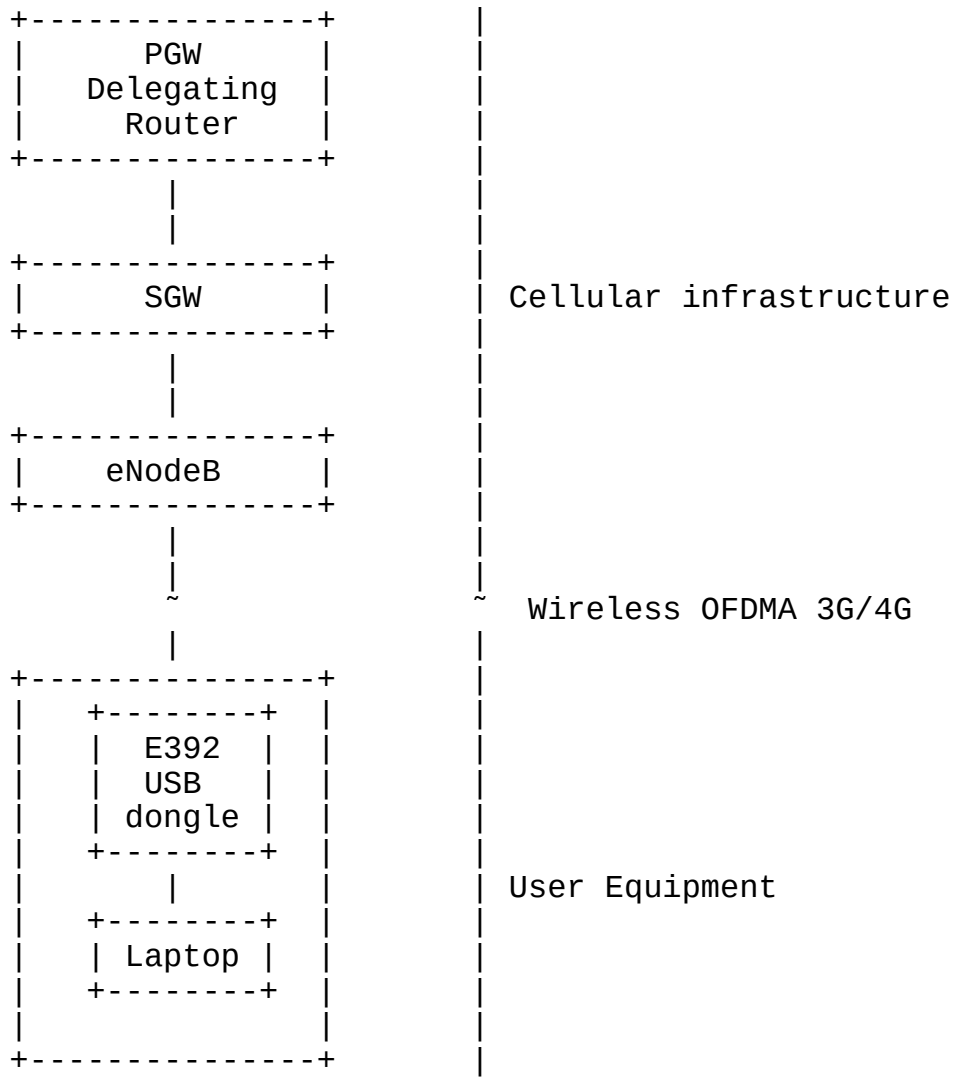
The final destination of the DHCPv6 packet is the Packet Data Network Gateway, that is responsible for IP address allocation for the UE and for filtering of down-link user's IP packets into the different QoS-based bearers.

The model of the infrastructure described in this this section is a simplified example. Real infrastructure construction could contain multiple SGW and eNodeBs and network equipment (that is not described in the current example) with respect of existing standards [RFC6459].



(The above figure descibes the model of the path followed by a DHCPv6 packet from IoT requesting router to the Delegating PGW router. The model is not a real infrastructure.)

Additional experiments with using of USB dongle were performed. The following figure illustrates the successful DHCPv6-PD test on Orange with dongle. It uses a Huawei E392 USB dongle on laptop (and not the Sierra Wireless mangOH Red).



5. Specification

This section presents the process that starts with delegation of Network Prefix pool 2001:DB8:XXXX:XX::/56 from the Delegation Router and finishes with the configuration of IPv6 prefixes on the hosts interfaces. Each Requesting IoT router’s interface acts on a unique link. The Host’s interfaces, connected to the Requesting IoT router,

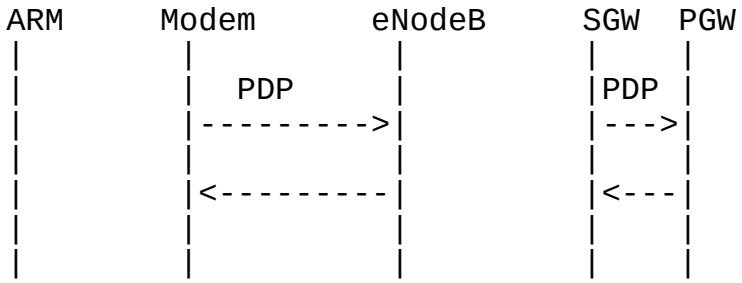
acts on the same unique links as the Requesting IoT router's interfaces.

5.1. Solicitation of the network prefix pool

5.1.1. The Packet Data Protocol

This section describes how the Requesting IoT Router obtains the GUA address on the Recipient Interface (RI) (OFDMA interface, 3GPP interface). The message "Activate PDP context Accept" is useful for forming the Globally Unique Address on the RI.

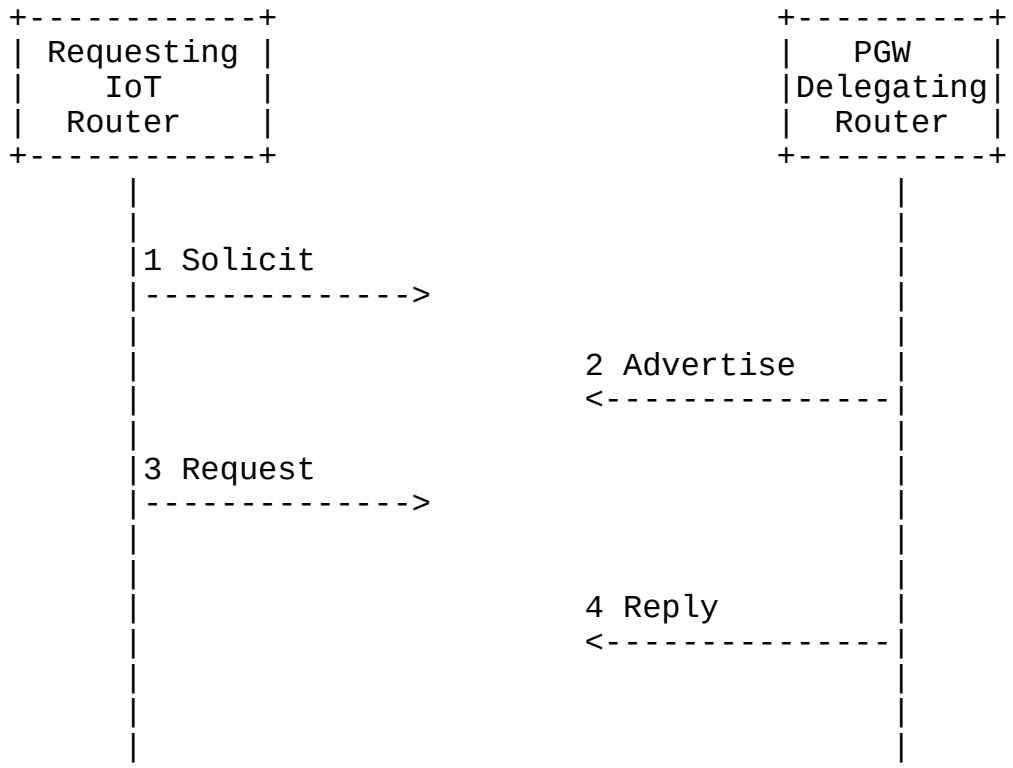
The Packet Data Protocol [ETSI102361] contains the following types of DLL (Data Link Layer) bearer service data transmissions: unconfirmed data transmission; confirmed data (data transmission; response transmission.) The Packet Data Protocol contains the following types of layer 3 bearer service data transmissions: Internet Protocol; Short Data. These layer 3 bearer services are built on the top of DLL services.



5.1.2. The Dynamic Host Configuration Protocol version 6 with Prefix Delegation

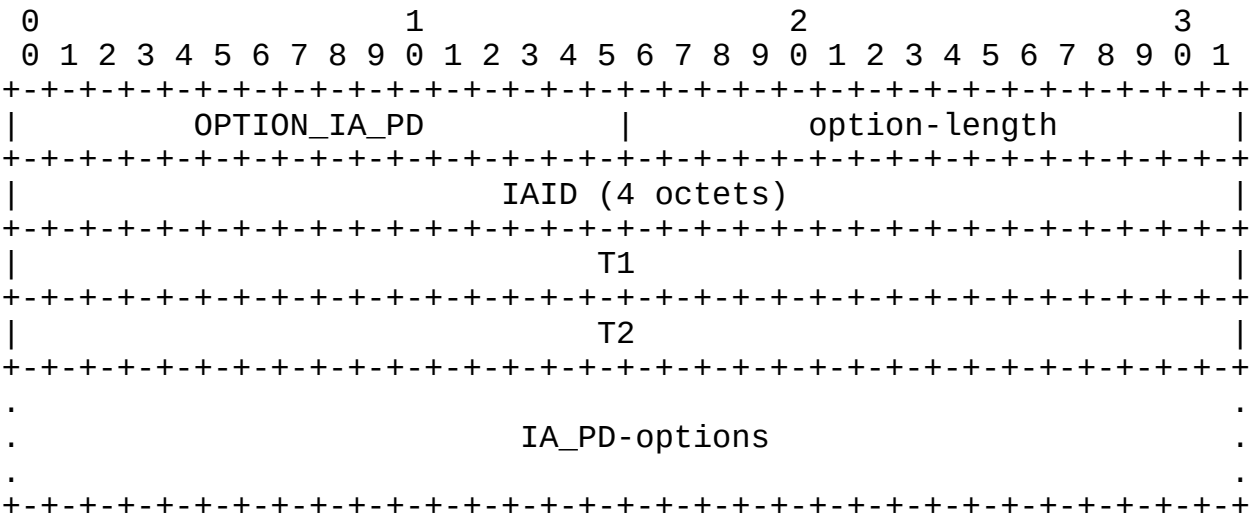
To perform the pool solicitation, the Prefix Delegation options of the Dynamic Host Configuration Protocol version 6 (DHCPv6) are used [I-D.ietf-dhc-rfc3315bis].

The Requesting IoT Router sends the DHCPv6 "Solicit" packet to the Delegating Router via the wireless link. The DHCPv6 "Solicit" packet consists of Client Identifier, Transaction ID, Elapsed time and Identity Association for Prefix Delegation (IA_PD) options. The initial "Solicit" packet triggers the 4 message exchange, that finishes with the reception of the GUNPs pool by the Requesting IoT Router.



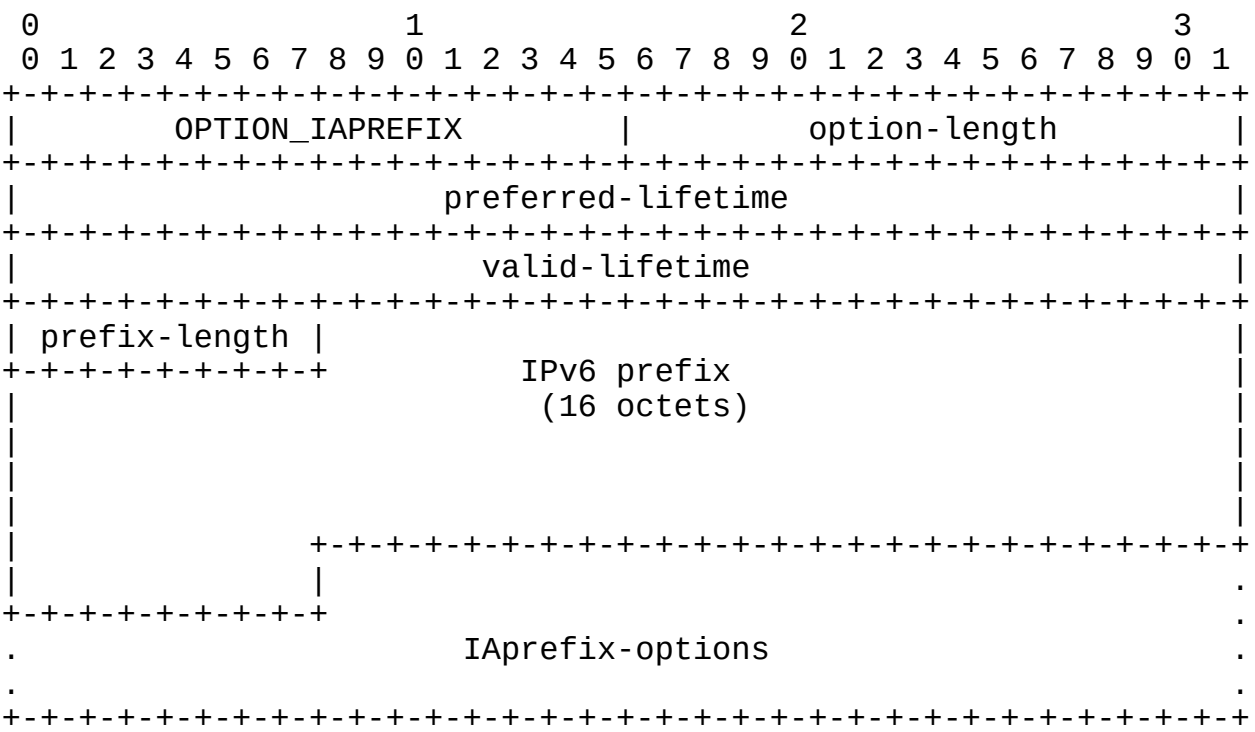
(In the above figure the full DHCPv6 message exchange mechanism between the ARM part of UE and PGW is presented.)

The IA_PD option consists of the Identity Association (IA) - group identifier [RFC3633], parameters (IA id, times to extend the lifetimes of prefixes and prefixes allocated to the IA). The full description of the IA_PD option is presented in the RFC3633 [RFC3633].



(in the above figure the DHCPv6 IA_PD option format [RFC3633].)

The IA_PD-options field carries the IA_PD Prefix Option. The IA_PD Prefix Option carries the recommended preferred/valid life time and IPv6 prefix with prefix length. The additional fields allocated for the options for the advertised GUNP [RFC3633].



(in the above figure the DHCPv6 IA_PD Prefix option format is presented [RFC3633].

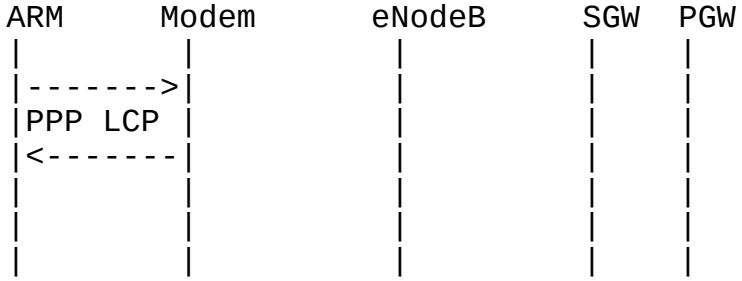
The PGW (Delegating Router) advertises, through the usage of a DHCPv6 packet, an IPv6 pool 2001:DB8::/56 to the Requesting IoT Router. The packet SHOULD be sent from the cellular infrastructure to the Requesting IoT Router, via the wireless link. The full message exchange consists of: Solicit, Advertise, Request and Reply messages.

The "Request", "Reply" messages are used to add/remove/update the assigned prefixes to IA_PDs.

The Hop Limit of packets that contain the DHCPv6 data MUST be 255 to satisfy the properties of the cellular infrastructure. To reach the PGW from the UE the DHCPv6 packets are encapsulated by SGW into UDP/ IPv4 packets; this encapsulation is for the GTP-U tunnel. The corresponding decapsulation mechanism decreases the Hop Limit; when the Hop Limit reaches value 0 the packet is discarded; to avoid this situation it is required to put the Hop Limit value of the DHCPv6 Solicit equal to 255.

5.1.3. Option: PPP use

It is possible to use IPv6-over-PPP protocol [RFC1661], with LCP, between the ARM and the modem. This protocol helps with forming an IPv6 link-local address on the IoT Router’s RI.



5.2. Assignment of the network prefixes on the links

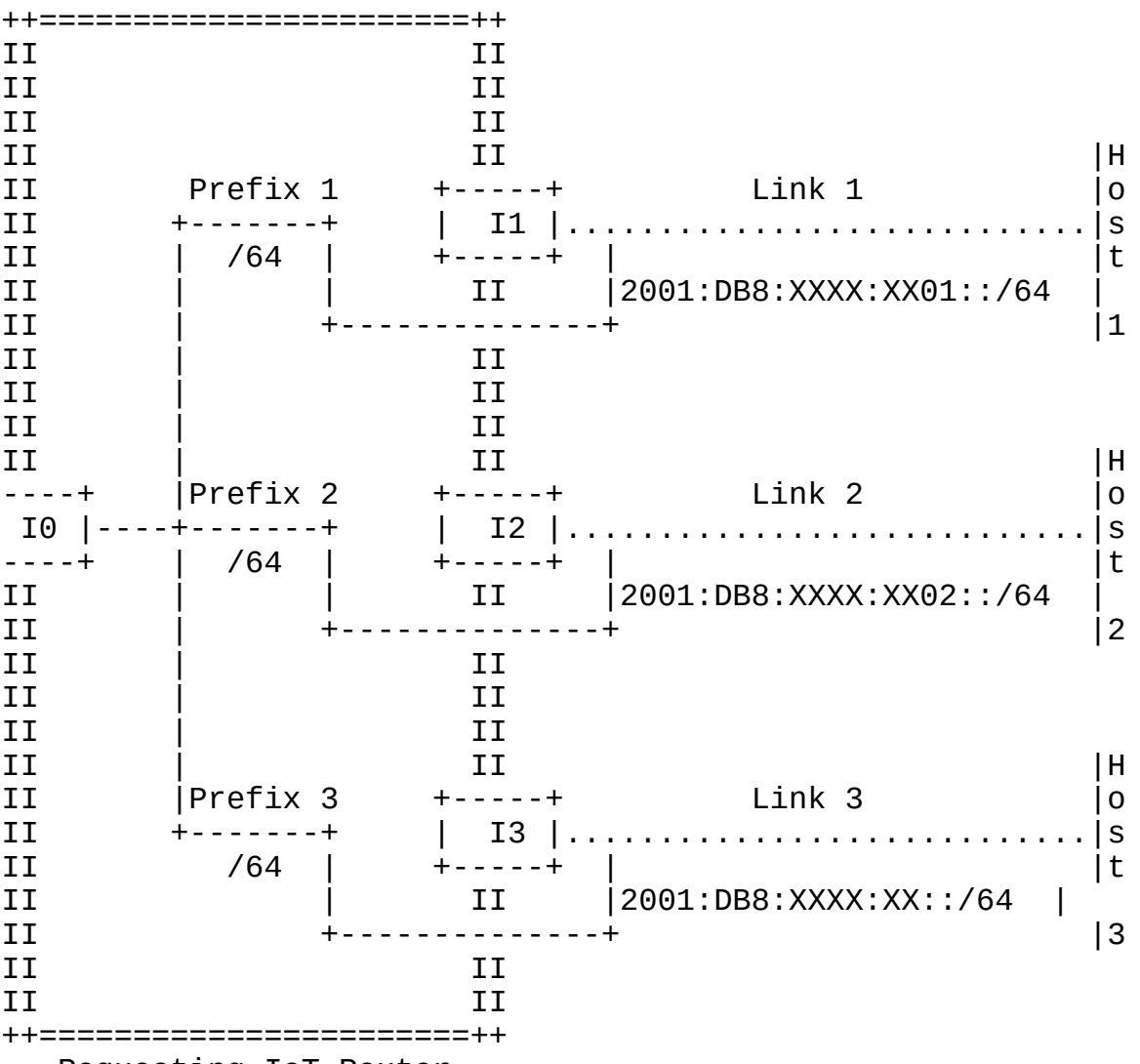
The receipt of the IA_PD Prefix option triggers the GUA autoconfiguration on the Requesting IoT Router’s interfaces. The Recipient Interface (RI) receives a message with the IA_PD prefix option and does not perform the autoconfiguration on the current stage.

All interfaces, except RI, now follow the GUA autoconfiguration procedure. The number of interfaces that should follow the procedure could be specified in the configuration file of the Requesting IoT Router.

The GUA interface autoconfiguration procedure in the Requesting IoT Router is done by assigning the network addresses from different GUNPs to the links. The assignment of network addresses is performed using the 2001:DB8:XXXX:XX::/56 network pool. Therefore, the Requesting IoT Router operates on multiple links (ingress links).

The IoT Router derives several GUNPs from the received pool. For example, from the pool 2001:db8:XYZU:TVWZ::/56 the GUNPs 2001:db8:XYZU:TV01::/64 and 2001:db8:XYZU:TV02::/64 are derived.

Further, the GUNPs are aimed at links. For example, the GUNP 2001:DB8:XXXX:XX01::/64 is aimed at the interface 1, and 2001:DB8:XXXX:XX02::/64 at the interface 2; further, 2001:DB8:XXXX:XXff::/64 corresponds to the interface interface 256.



(In the above figure the Requesting IoT Router, with 4 links, is presented).

There are 2 cases that could be considered. The first one is: all interfaces (except the RI) of the Requesting IoT Router could be assigned with the corresponding GUNPs. In the second case, a list of manually selected interfaces is obtained. Finally interfaces in the list are assigned with GUNPs. The interfaces numbers represent their position in alphabetically ordered list by the names that operating system assigned to them during the initialization.

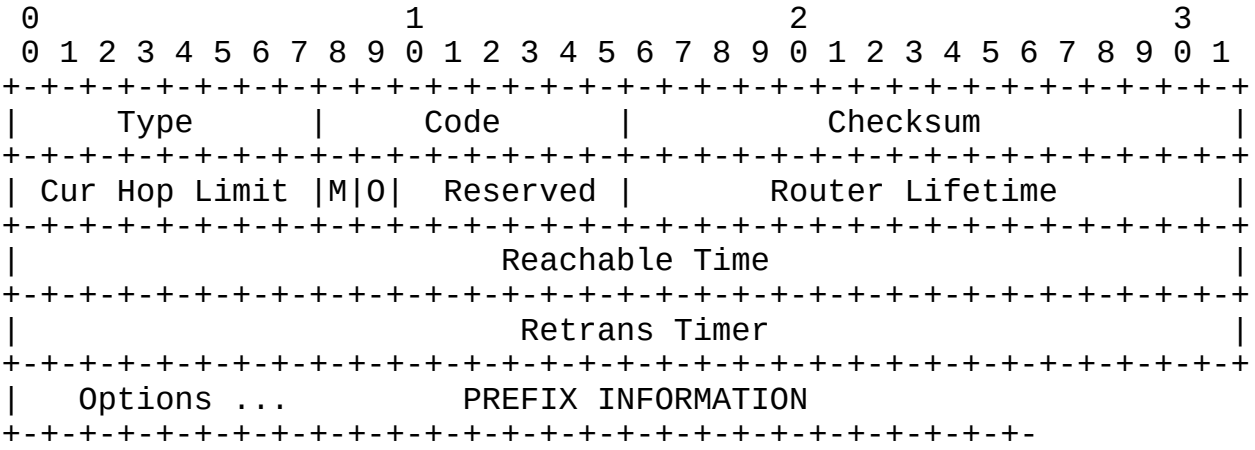
During the final step of the GUA autoconfiguration in the Requesting IoT Router, the assignment of the IPv6 network addresses to the interfaces is performed. The IPv6 network addresses have the current

format: 2001:DB8::XXXX:XXYY:1/56, where YY - is a value that represents the number of the interface. When the GUA autoconfiguration on the Requesting IoT Router is finished, the Requesting IoT Router advertises via its interfaces the GUNPs to the Hosts.

5.3. Advertisement of the network prefixes

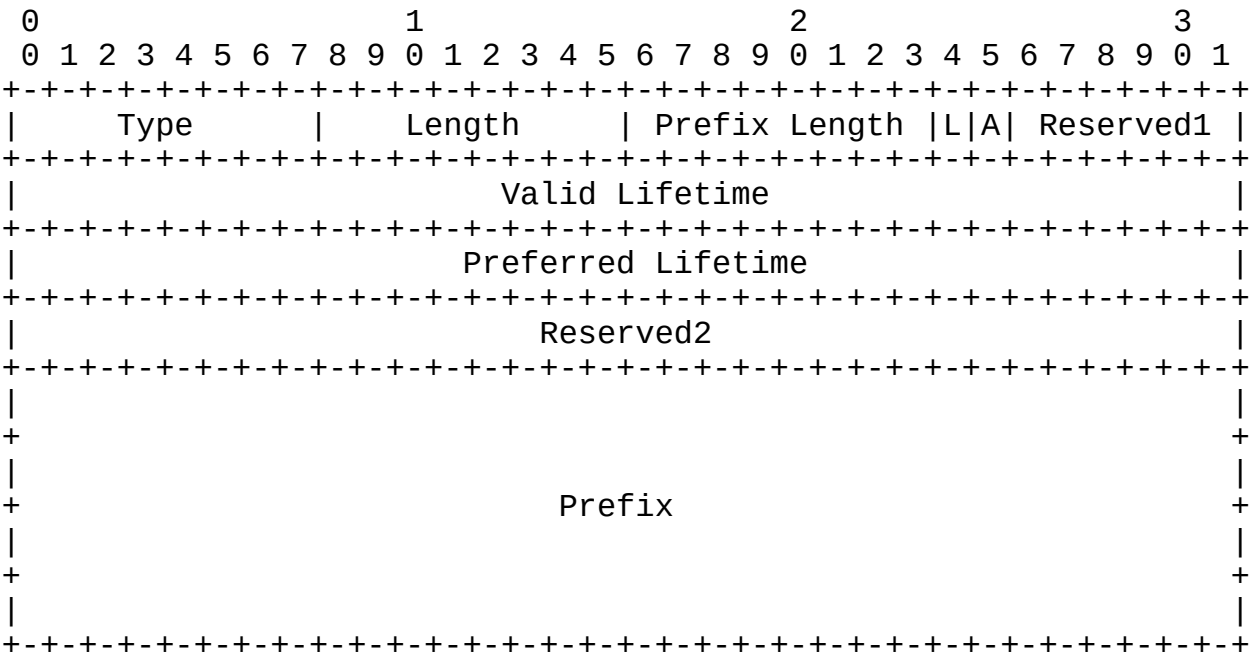
Finally, the Requesting IoT Router runs the Neighbour Discovery Protocol. The Neighbour Discovery Protocol messages allow to advertise the configuration to the hosts. To send the configuration parameters from the Requesting IoT Router to the hosts, the "Router Advertisement" type messages are used [RFC4861]. Usually the "Router Advertisement" messages are triggered by the "Router Solicit" messages sent from the Hosts to the Requesting IoT Router [RFC4861].

The "Router Advertisement" message includes the "Prefix Information" option. It is located in the "Options part" of the "Router Advertisement" message. The position of the "Prefix Information" option is presented in the figure below.



(Figure above presents the Router Advertisement message format [RFC4861])

The "Prefix Information" option carries the GUNP value and length. These configuration parameters provide on-link GUNPs, used for SLAAC auto configuration. The Prefix Length is a number that describes the number of bits which are used to identify the GUNP. And each GUNP represents the sub-network.



5.4. DHCPv6 Port range

Due to the blockage of the standard port in particular cases there is a need to provide a solution that may overcome this issue.

5.4.1. Client support

On the client side the port range supported in the modified sowtware. The DHCPv6 client MAY have the list of dhcpv6 server ports. Client send the "SOLICIT" message to the specific port and after [timeout | number of retries] the port is changed to the next one in the list.

5.4.2. Server support

On the server side the port rage support is provided with multiple standard DHCPv6 server instances that are running in linux containers and listen on different ports.

5.5. Recommendations

First recommendation we suggest for DHCP is to use port different from 547 because it is blocked in many cases. Insted we propose to use another one, like 25474. Different approach to address this problem is to develop a method to dynamically negotiate such port number.

Second recommendation may have to do with Hop Limit and multicast scope in DHCP Solicit messages. It is reasonable to set the value of Hop Limit to 16. It will allow to put DHCP servers _outside_ the cellular network domain.

Third recommendation is that link layer protocol used to make IPv6 addresses in 3GPP network should be documented - and agreed - at IETF, not only at 3GPP. Thus document will be a base for disscussions about IPv6 and User Equipments (UE).

6. Implementation Aspects

The implementation of DANIR is open source. It is available on github at the following address, as of September 18th, 2019: https://github.com/dmytroshytyi/KD6-DHCPv6-PD-DANIR

7. Security Considerations

At this time, no security considerations are addressed by this memo.

8. IANA Considerations

No request to IANA at this time.

9. Acknowledgements

The authors would like to thank Michael Mathias Boc, Giorgio Campo, David Frey and Artiol Kalca for their valuable comments related to the Linux Network stack, the Legato OS recipies and the cross-compilation for the ARM architecture. Also the authors would like to acknowledge the contribution of Fred Baker, Michele Russo, Ole Troan, Mark Smith, Gert Doering, Cameron Byrne, Fred Templin for valuable comments.

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