

IPv6 Prefix Delegation

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IPv6 Prefix Delegation

Table 1: Feature History

Feature Name	Release Information	Description
IPv6 Prefix Delegation Support to the requesting UE or CPE	2024.04.0	UPF supports IPv6 Prefix Delegation to the requesting User Equipment (UE) or Customer Premises Equipment (CPE). This feature ensures efficient and dynamic allocation of IPv6 prefixes, facilitating seamless connectivity and address management for devices within the network. This feature requires a valid license. Contact your Cisco account representative for more information. **Command Introduced**: The existing CLI **ipv6 address alloc-method no-dynamic allow-prefix-delegation pd-alloc-method no-dynamic** in the APN Configuration mode must be configured to enable this feature. Additionally, DHCP service should also be associated to the APN configuration. **Default Setting**: Disabled – Configuration Required to Enable

The IPv6 Prefix Delegation feature allows a User Equipment (UE) or Customer Premises Equipment (CPE) to obtain an IPv6 prefix, which it can then use to assign IPv6 addresses to devices within its network.

The UPF relies on the SMF for Prefix allocation since the UPF does not manage an IP pool locally. In UPF, the IPv6 Prefix delegation feature is controlled at the DNN (APN) level to ensure that the correct network context is applied.

Licensing

The DHCPv6 PD Prefix & IPv6 Interface-ID via Radius 1K License is required for the IPv6 Prefix Delegation feature. Contact your Cisco account representative for more information.

Guidelines and Limitations of IPv6 Prefix Delegation

The following are the prerequisites for the IPv6 Prefix delegation feature:

- A Packet Data Unit (PDU) session for the UE or CPE must be successfully established, and an IPv6 address must be allocated before a request for IPv6 Prefix Delegation is initiated by UE.
- Support for IPv6 Prefix Delegation is present on SMF.

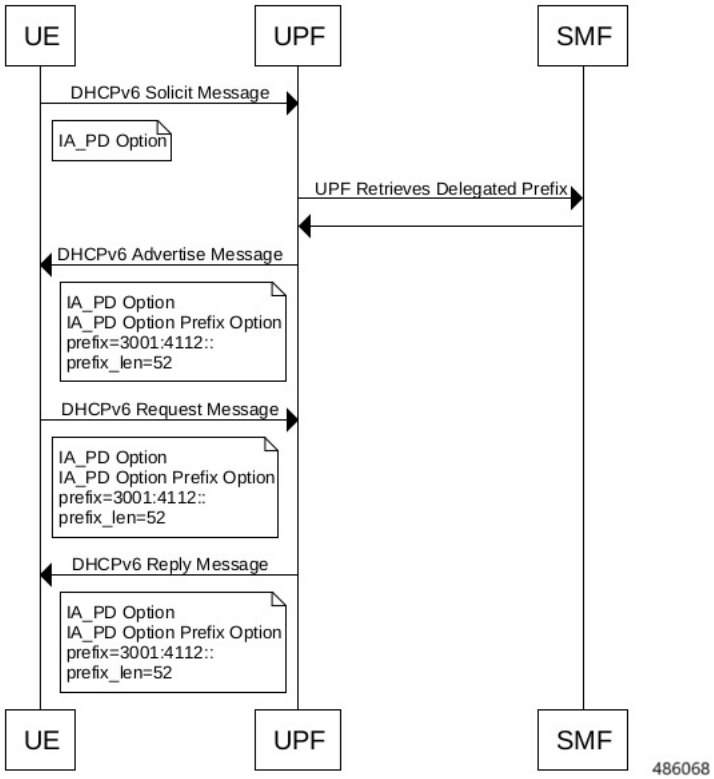
The limitations are:

- Delegated prefix is assigned to UE only if Prefix length received in DHCPv6 Solicit message from UE matches with Prefix length configured on SMF. UE request for a Preferred Prefix sent in Solicit message will not be considered.
- Prefix Exclude Option for DHCPv6-based Prefix (RFC 6603) is not supported.
- Rapid commit option is not supported.
- IPv6 prefix delegation feature will not interwork with IP source violation feature on SxA. Uplink packets coming from devices behind UE will get dropped at SxA.
- UPF doesn't support parsing of retransmitted UE initiated DHCPv6 messages such as Solicit, Request or Release.
- UPF doesn't support DHCPv6 Renew and Rebind procedures as the respective timers are set to infinite.
- UPF doesn't support in-service Downgrade with the feature enabled. MOP should be followed to clear the existing IPv6 prefix delegated session from SMF and UPF and related SMF configurations and IP chunks should be removed before any UPF downgrade.

Delegation of IPv6 Prefix

This section describes the call flow and stages in Delegation of IPv6 prefix.

Figure 1: Delegation of IPv6 Prefix



The following stages describe interactions between SMF (Session Management Function) and UPF (UserPlane Function) for allocating and managing delegated prefixes.

1. The UE/CPE sends DHCPv6 Solicit messages to the UPF. The UE/CPE can include a prefix length inIA_PD Prefix option.
2. UPF receives the requested messages over N3 or S1U/S5U interface on the GTPU tunnel that was created when the PDN session for the UE was established. Since UPF does not manage IP pool locally, UPF acts as a proxy DHCP server and receives the prefix from SMF. SMF provides delegated prefix as per the DNN configuration. SMF rejects the request, if DHCP solicit is received with a prefix length different from the configured prefix length value. If prefix length is not received, SMF allocates as per the configured prefix length
3. UPF sends response to the DHCPv6 Solicit message with a DHCP advertise message containing the delegated prefix in the IA_PD option.

   SMF allocates delegated prefix from the local IPAM pool.

Note When UPF fails to allocate a prefix requested by the UE/CPE, it responds to the DHCPv6 Solicit with an DHCPv6 Advertise message containing IA_PD option with Status Code: NoPrefixAvail.

IPv6 Prefix Release

UPF sends DHCPv6 Reply in response to the DHCPv6 Release message received from UE/CPE confirming the release of prefix address at UPF.

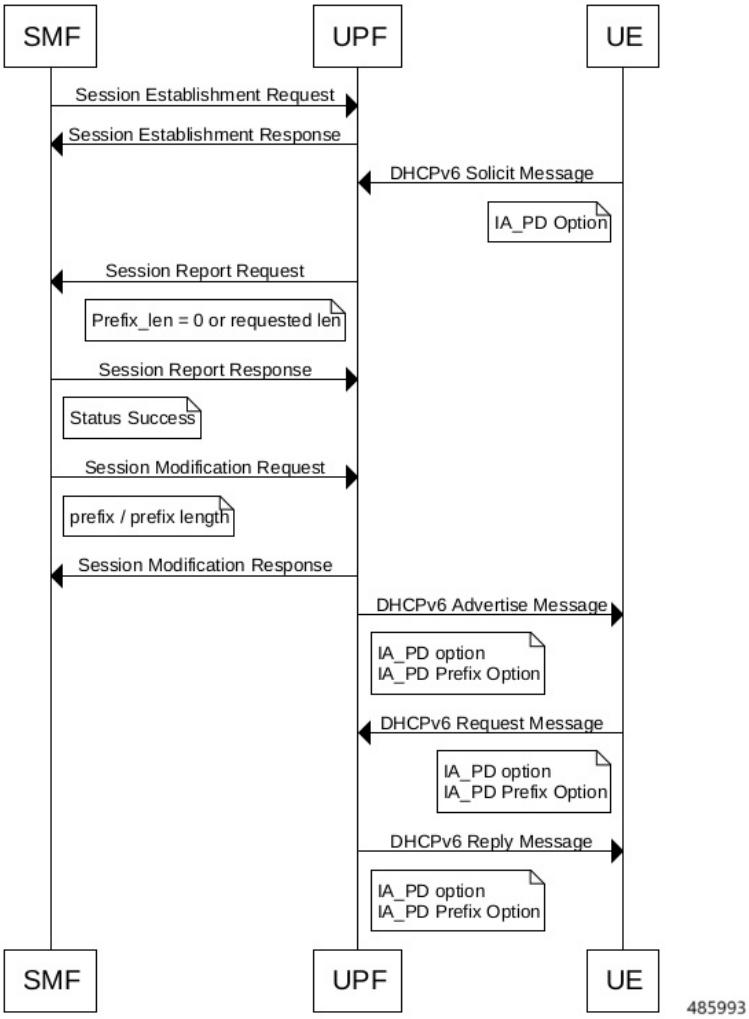
How IPv6 Prefix Delegation Works

The delegated IPv6 prefix is either pushed by the SMF to UPF during session establishment or pulled by UPF post session establishment. UPF allocates the IPv6 Prefix Delegation to the UE / CPE through either of the following flows:

1. Session Establishment and Prefix Request
2. Session Modification Request

Session Modificaiton Request based Prefix Allocaiton

Figure 2: Prefix Received in Session Modification Request Workflow



The following process describes how prefix received from SMF in the Session Modification Request is allocated to UE / CPE.

1. If SMF does not send the delegated prefix during PDN Session Establishment, UPF requests the prefix from SMF by triggering a Session Report Request towards the SMF on receiving a DHCPv6 Solicit message from the UE/CPE. UPF sends the prefix length requested by the UE / CPE in the Session Report or sets it to 0 if no IA_PD Prefix option is received in DHCPv6 Solicit message.
2. If the requested prefix length matches to the prefix length configured on SMF, SMF responds with a successful Session Report Response followed by Session Modification Request with the prefix address and prefix length.
3. UPF sends a DHCPv6 Advertise message containing the delegated prefix address and prefix length in the IA_PD Prefix Options as part of IA_PD Option in response to the DHCPv6 Solicit message to indicate

prefix allocation after receiving Session Modificaiton Request from SMF with prefix address and prefix length.

4. UE/CPE sends DHCPv6 Request message with the received prefix address and prefix length to confirm the allocated prefixes and UPF replies with DHCPv6 Reply message containing same prefix address and prefix length.

Note

- If the UE/CPE requested prefix length does not match with the configured prefix length on SMF, SMF responds with a Session Report Response containing failure cause code.
- If the feature is not enabled on SMF and when UPF sends Session Report Request for prefix delegation, SMF responds with a Session Report Response containing failure cause code.
- When UPF fails to allocate a prefix requested by the UE/CPE, it responds to the DHCPv6 Solicit with an DHCPv6 Advertise message containing IA_PD option with Status Code: NoPrefixAvail.

If..	Then..
If SMF does not send the delegated prefix during PDN Session Establishment	UPF requests the prefix from SMF by triggering a Session Report towards SMF on receiving a DHCP solicit message from the UE/CPE. In the Session report request specify the requested prefix_len. UPF uses DIPR bit and PD-Parameters IE to communicate the requested information in the Session Report Request.
If the requested prefix length matches to the prefix length configured on SMF	SMF responds with a session report response followed by Session Modify Request with the PD_Parameters in the PDI of update PDR for the rulebase PDR.
If prefix allocation is successful on SMF	The PD_Parameters contains a valid Prefix and prefix_length.
If the requested prefix length does not match the configured prefix length on SMF	• SMF responds with a session report response containing failure cause code. • UPF responds to the DHCP Solicit with a DHCP Advertise containing an IA_PD with status code in the IA_PD option as NoPrefixAvail.

Configure DHCP Service Name for Prefix Delegation

Use this procedure to enable DHCP service in server-mode for Prefix delegation.

Procedure

Step 1 Log in to the Context Configuration mode.

Step 2 Enter the **dhcpv6 service-name** *dhcp_service_name* command to enable the DHCP service for Prefix delegation and **bind address** with *valid interface IP | loopback address*. The bind-address for the DHCP service is the IP assigned to a loopback interface configured in the context.

Example:

```
config
context ingress
        dhcpv6-service dhcp_service_name
             bind address {valid interface IP | loopback address }
      exit
```

Step 3 Enter the **apn** *apn_name* command to specify a APN name associated by the UPF node.

Example:

```
config
context ingress
dhcpv6-service dhcp_service_name
             bind address {valid interface IP | loopback address }
      exit
      apn intershat
          ipv6 address alloc-method no-dynamic allow-prefix-delegation pd-alloc-method no-dynamic
      dhcpv6-service dhcp_service_name
exit

exit
```

Step 4 Enter the **ipv6 address alloc-method no-dynamic allow-prefix-delegation pd-alloc-method no-dynamic** command to configure the APN to allow DHCPv6 prefix-delegation.

Example:

```
config
context ingress
dhcpv6-service dhcp_service_name
             bind address {valid interface IP | loopback address }
      exit
      apn intershat
          ipv6 address alloc-method no-dynamic allow-prefix-delegation pd-alloc-method no-dynamic
        dhcpv6-service dhcp_service_name
      exit

exit
```

Step 5 Enter the **exit** command to end the current configuration mode.

Verify IPv6 Prefix Delegation

This section provides information about show commands and their outputs for the IPv6 Prefix delegation feature.

show subscribers user-plane-only full all callid

The **show subscribers user-plane-only full all callid** *call_id* output includes the prefix delegated to the subscriber.

```
…
NAT Policy NAT64: n/a
Converged Session: No    Converged Peer Callid:      n/a
Visited Call: No
Prefix Delegation:
  IPv6 Delegated Prefix: 3001::/48 Sent to UE: Yes
  Preferred Lifetime: 0xFFFFFFFF
  Valid Lifetime: 0xFFFFFFFF
Subscriber Parameters:
IMSI: 404019011037182
IMEI: 1122334455667788
 …
```

Note If the UE does not request the IPv6 Prefix, the show command displays the **Sent to UE: No** value.

If the IPv6 Prefix delegation is not configured or supported on UPF and no Prefix is received from SMF, following output details is displayed.

```
NAT Policy NAT64: n/a
Converged Session: No    Converged Peer Callid:      n/a
Visited Call: No
Prefix Delegation:
  IPv6 Delegated Prefix Not Received
Subscriber Parameters:
IMSI: 404019011037182
IMEI: 1122334455667788 …
```

Note If the UE releases the prefix via DHCPv6 Release, the show command displays the above output.

show dhcpv6 statistics

When APN is configured to receive Delegated Prefix from the local pool, the sessions statistics is visible under the CLI command output of **show dhcpv6 statistics** and displays the following output.

```
DHCPv6 Session Stats:

  Total Current:                  0
     DHCP Proxy:                  0
     DHCP Server:                 0
```

```
   DHCP PD:                    0
   Radius/SMF PD:              0
   Local PD :                  0

Total Setup:                   0
   DHCP Proxy:                 0
   DHCP Server:                0
   DHCP PD:                    0
   Radius/SMF PD:              0
   Local PD :                  0

Total Released:                0
   DHCP Proxy:                 0
   DHCP Server:                0
   DHCP PD:                    0
   Radius/SMF PD:              0
   Local PD :                  0

Session Release Reasons:(dhcp-proxy)
   Admin Releases:                     0   Bearer Call Terminated:          0
   Lease Exp Policy:                   0   No Address Available:            0
   IP Address mismatch:                0   Unspecified Failure:             0
   Not on link status:                 0   Other Reasons:                   0

Session Release Reasons:(dhcp-prefix-delegation)
   PDNs Released:                      0   Lease Exp Policy:                0
   UE Initiated Release:               0   Other Reasons:                   0
```