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Hierarchical Prefix Delegation Protocol for Internet Protocol Version 6 (IPv6)

Status of this Memo

Abstract

Stateless Autoconfiguration enables IPv6 hosts to send a request for a prefix, a network identifier to a router on the subnet. Using this ability a host can configure its IPv6 address. Likewise, by defining a way to request for a prefix to an upper level router, a router can get a prefix to be assigned to its subnet.

This document describes a protocol for prefix delegation between routers. It allows routers get prefixes from its upstream routers, enabling the entire network and its belonging hosts autoconfigure their own addresses.

Conventions used in this document

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].

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1. Terminology

This document uses the terminology defined in [RFC 2460] and [RFC 2461] with the following new terms:

Requesting Router

The router requesting prefixes to be assigned for its subnets.

Delegating Router

The router responding to the Prefix request.

Root Router

The Root Router is placed on top of the network hiearchy where the Hierarchical Prefix Delegation begins. Only the Root

Router requires manual administration and is assumed to have an interface to the Global Internet. The Root Router is a Delegating Router.

2. Introduction

This specification defines the Hierarchical Prefix Delegation (HPD) protocol for Internet Protocol Version 6 (IPv6). It is an extended prefix delegation protocol based on Automatic Prefix Delegation Protocol first introduced by B. Haberman and J. Martin [APD]. It retains basic prefix delegation abilities of its predecessor with a couple of following extensions:

Extended Prefix Delegation - Prefix Delegation is not limited to a leaf router. Once a Requesting Router receives a prefix from its upstream router, it can play the role of the Delegating Router. It provides its downstream routers with parts of its address space by delegating longer level prefixes, enabling multiple-level hierarchical prefix delegation.

Built-in Routing capability - The Hierarchical Prefix Delegation protocol (HPD) provides routing capability that enables routing on "HPDed" routers without external routing protocols such as RIP or OSPF.

3. Protocol Overview

The Hierarchical Prefix Delegation protocol defines two new ICMPv6 message types, the Prefix Request and the Prefix Delegation. The Prefix Request is used by the Requesting Router to send requests to the Delegating Router. Conversely, the Prefix Delegation is used by the Delegating Router to send prefixes and other information to the Requesting Router. The actual prefix delivery is made by Prefix Information Option included in these messages.

3.1 Prefix Negotiation

The Requesting Router begins the Hierarchical Prefix Delegation protocol by sending a Prefix Request message of code "Delegator Query" to the All-routers link-local multicast address (FF02::2). The Requesting Router SHOULD specify the number of prefixes it wishes to receive.

Upon receiving the "Delegator Query" the Delegating Router determines if it has enough available prefixes. If so, it unicasts a Prefix

Delegation message of code "Prefix Delegator" back to the Requesting Router. The message MUST contain the number of available prefixes, their prefix length and the prefix length difference. If more than one reply is received from multiple Delegating Routers, the Requesting Router SHOULD choose the one with the shorter prefix length.

Note that these messages are for negotiation purpose only. Actual prefix delivery is not provided in this phase.

3.2 Prefix Delegation

Once a Delegating Router is chosen, the Requesting Router sends a Prefix Request message of code "Initial Request" to the unicast IP address of the Delegating Router. The Requesting Router MUST confirm the prefix length and the prefix difference by sending back these parameters in the message. The number of requesting prefixes MUST be less than or equal to the number of prefixes in the received "Prefix Delegator."

Upon receiving the "Initial Request" the Delegating Router replies by sending Prefix Delegation message with a code of "Prefix Delegated." The message MUST include one or more Prefix Information Options.

3.3 Router Authentication

Depending on local administration policy, the Delegating Router can mandate the use of Cryptographically Generated Address (CGA) as a Source Address. For "Initial Request" without an authorized Source Address, the Delegating Router returns Prefix Delegation message with a code of "Authentication Required." A Requesting Router receiving this message MAY reinitiate the request by sending Prefix Request message with a valid CGA address.

A Delegating Router who has received a message with a CGA as a source address MUST verify its validity. For messages with invalid CGA the Delegating Router SHOULD reply back a Prefix Delegation message with a code of "Authentication Failed."

3.4 Prefix Return

A Requesting Router SHOULD return the delegated prefixes when it does not need them any more. It sends Prefix Request message with a code of "Prefix Returned" to Delegating Router. Returning prefixes MUST be stored in Prefix Information Options included in the message.

Once a prefix is returned, the Delegating Router replies back with a Prefix Delegation message with code "Prefix Returned." Returning

prefixes SHOULD be contained in Prefix Information Options for confirmation. Once a prefix is returned, the prefix belongs to the Delegating Router and the Delegating Router recycles it.

A Requesting Router can extend the life time of a prefix by sending Prefix Request message with a code of "renewal Request." Expired prefixes MUST NOT be used anymore and SHOULD be considered to be returned by the Delegate Router.

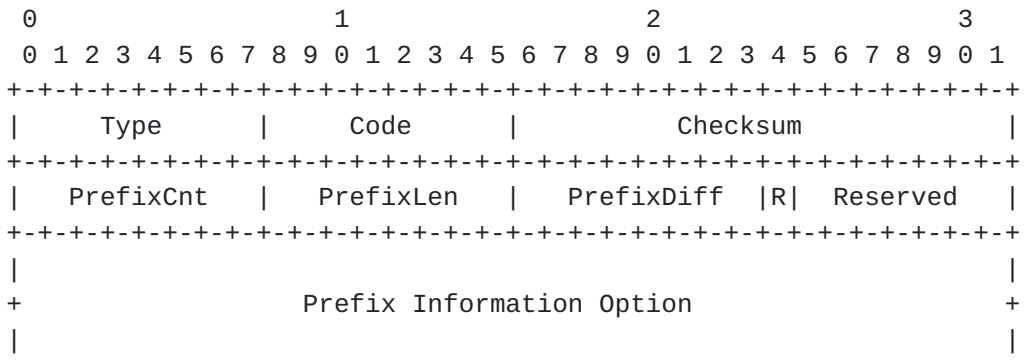
3.5 Built-in Routing

The Root Router MAY run with a built-in routing option. When this option is turned on, the Root Router and its all subsidiary Delegating Routers keep track of delegated prefixes, being aware of which subnet is being used on which interface.

Using longest matching, packets with a source address of delegated prefix will be forwarded to the corresponding downstream router. Packets with an unidentified destination will be sent to the upstream router. This option MUST be set initially by the administrator when the Root Router starts bootstrapping and SHOULD be inherited to its subsidiary routers.

4. Messages

All messages have the following general format:



4.1 Prefix Request Message

The Prefix Request Message is used to request, renew, or return prefixes.

IP Fields

Source Address

A Cryptographically Generated Address (CGA) or an ordinary IP address assigned to the sending interface.

Destination Address
The All-Routers link-local multicast address (FF02::2) for Delegator Query messages. All other Prefix Request messages should be sent to a unicast address of the Delegating Router.

ICMP Fields

Type
TBD <To be assigned by IANA>

Code
The Type of code:

Delegator Query (0)
The Delegator Query is used by the Requesting Router to identify potential Delegating Routers. It is sent to the all-routers link-local multicast address. The requesting router MAY specify the number of prefixes it is requesting in PrefixCnt field.

Initial Request (1)
The Initial Request is to initiate the request process. It is sent to the unicast IP address of the Delegating Router. The PrefixLen and PrefixDiff fields MUST have the same value received through the Prefix Delegator message while PrefixCnt has less or equal value as the Prefix Delegator message.

Renewal Request (2)
The Renewal Request is to renew the lifetime of prefixes that have been previously allocated. It is sent to the unicast IP address of the Delegating Router. One or more Prefix Information Options MUST be included for this message.

Prefix Return (3)
The Prefix Return is used to return prefixes to the Delegating Router. It is sent to a unicast IP address of the Delegating Router. One or more Prefix Information Options MUST be included for this message.

Checksum
The ICMP checksum as defined in RFC [2463].

PrefixCnt

For messages with the code of "Delegator Query" or "Initial Request," The PrefixCnt indicates the number of prefixes the Requesting Router is requesting for. Otherwise, it denotes the number of Prefix Information options attached to the message.

PrefixLen
The PrefixLen indicates the length of the prefix. For a "Prefix Request" message with a code of "Initial Request," it must be the same value as the PrefixLen received through the previously received Prefix Delegation message with code of "Prefix Delegator." For other Prefix Request messages, it MUST be set to zero.

PrefixDiff
The PrefixDiff is used to confirm the PrefixDiff value received through the Prefix Delegation message with code of "Prefix Delegator." For other Prefix Request messages it MUST be set to zero.

R
The R flag is not used in this message.

Reserved
Reserved for future use. Must be set to zero.

4.2 Prefix Delegation Message

The Prefix Delegate Message is used to provide the Requesting Router with prefixes and other valuable information like error returns.

IP Fields

Source Address
A Cryptographically Generated Address (CGA) or an ordinary IP address assigned to the sending interface.

Destination Address
The IP address of the Requesting Router specified by the Source Address in the Prefix Request message.

ICMP Fields

Type
TBD <To be assigned by IANA>

Code
The Type of Response Code:

Prefix Delegator (0)
The Prefix Delegator is to inform the Requesting Router the number of available prefixes. It is sent to the unicast IP address specified in the Source Address portion of the Prefix Request message. The number of available prefixes is specified in the PrefixCnt field. The PrefixCnt of zero indicates that Prefix Delegator does not have available prefix at all. The Delegating Router MUST specify the length of the available prefixes and the difference of the prefix lengths between the Delegating Router and the Requesting Router as well.

Authentication Required (1)
The Authentication Required is use to inform the Requesting Router that a Cryptographically Generated Address must be used as a source address. It is sent to the unicast IP address in the Source Address portion of the Prefix Request message. Unused fields must be initialized to zero.

Authorization Failed (2)
The Authorization Failed is use to inform the Requesting Router that its source address is failed to be verified. It is sent to the unicast IP address in the Source Address portion of the Prefix Request message. Unused fields must be initialized to zero.

Prefix Delegated (3)
The Prefix Delegated delivers the actual prefixes the Requesting Router has requested. It is sent to the unicast IP address in the Source Address portion of the Prefix Request message. One or more Prefix Information Options MUST be included for this message.

Prefix Returned (4)
The Prefix Returned is used to confirm the return of the prefixes. It is sent to the unicast IP address in the Source Address portion of the Prefix Request message. One or more Prefix Information Options MUST be included for this message.

Checksum
The ICMP checksum as defined in [RFC 2463].

PrefixCnt
For the message with a code of "Prefix Delegator," The PrefixCnt indicates the number of prefixes the Delegating

Router is to offer. Otherwise, it denotes the number of Prefix Information options attached to the Prefix Delegation message.

PrefixLen
The PrefixLen indicates the length of the prefix. For a message with a code of "Prefix Delegator," The PrefixLen indicates the length of prefixes the Delegating Router is to offer. For other Prefix Delegation messages it MUST be set to zero.

PrefixDiff
The PrefixDiff indicates the prefix length difference between the Requesting Router and the Delegating Router, configured by an administrator. Initially it is set by the administrator on the Root Router and will be inherited over routers down to the leaf routers.

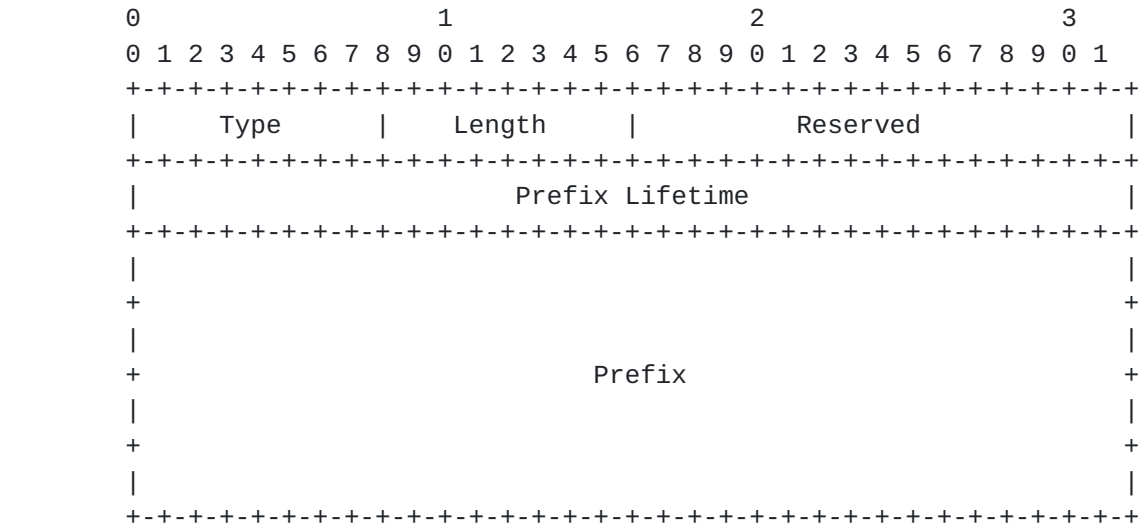
R
The R flag is used to inform the Requesting Router to use built-in routing.

Reserved
Reserved for future use. Must be set to zero.

4.3 Prefix Information Option

The Prefix Information Option is used to relay prefix between Requesting Router and Delegating Router. A message doing prefix delievery contains exact the same number of the options as specified in the PrefixCnt field.

It has the following format:



Prefix Option Fields

Type
TBD <To be assigned by IANA>
This field indicates the presence of a Prefix Information.

Length
The length of the prefix contained in this option.

Reserved
Reserved for future use. This field must be set to zero.

Prefix Lifetime
The lifetime of the prefix contained in the option.

Prefix
This field contains an IPv6 Prefix. The portion of bits longer than the specified length MUST be filled with zero.

5. Security Consideration

Prefix Delegation opens up several vulnerabilities. A node may attempt to request prefixes to deplete Delegating Router's prefix pool. On the other hand a node may reply to the Delegation Request with certain short-length prefixes to disrupt the delegation.

In order to prevent illicit nodes, Routers using Hierarchical Prefix Delegation Protocol need an authentication method. Using Cryptographically Generated Address as a Source Address is suggested for this purpose. Using CGA option and signature option devised by Secure Neighbor Discovery working group [SEND] is RECOMMENDED in this case. Employing other options being articulated in the working group is also preferable for better security.

6. IANA considerations

This document defines two new ICMP message types and one ICMP Option type. They must be assigned ICMPv6 type numbers.

7. Acknowledgements

We would like to acknowledge B. Haberman and J. Martin for their invention of the Automatic Prefix Delegation Protocol which this

draft is based on. We would also like to thank Wan-Jik Lee and Seok-Yeul Heo for their implementation efforts on Hierarchical Prefix Delegation Protocol on Linux OS.

8. Copyright

The following copyright notice is copied from RFC 2026 [Bradner, 1996], Section 10.4, and describes the applicable copyright for this document.

9. References

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