

DHC WG
Internet-Draft
Intended status: Standards Track
Expires: October 6, 2014

Y. Cui
Q. Sun
Tsinghua University
I. Farrer
Deutsche Telekom AG
Y. Lee
Comcast
Q. Sun
China Telecom
M. Boucadair
France Telecom
April 4, 2014

Dynamic Allocation of Shared IPv4 Addresses
draft-ietf-dhc-dynamic-shared-v4allocation-00

Abstract

This memo describes the dynamic allocation of shared IPv4 addresses to clients using DHCPv4. Address sharing allows a single IPv4 address to be allocated to multiple, active clients simultaneously, each client being differentiated by a unique set of transport source port numbers. The necessary changes to existing DHCPv4 client and server behavior are described and a new DHCPv4 option for provisioning clients with shared IPv4 addresses is included.

Due to the nature of IP addresses sharing, some limitations to their applicability are necessary. This memo describes these limitations and recommends suitable architectures and technologies where address sharing may be utilized.

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 [RFC 2119](#) [[RFC2119](#)].

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <http://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on October 6, 2014.

Copyright Notice

Copyright (c) 2014 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](http://trustee.ietf.org/license-info) and the IETF Trust's Legal Provisions Relating to IETF Documents (<http://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

Table of Contents

1.	Introduction	3
2.	Functional Overview	3
3.	Terminology	4
4.	Client-Server Interaction	4
5.	Server Behavior	5
5.1.	Leasing Shared and Non-Shared IPv4 Addresses from a Single DHCP 4o6 Server	6
6.	Client Behavior	6
6.1.	Restrictions to Client Usage of a Shared IPv4 Address . .	7
7.	DHCPv4 Port Parameters Option	7
8.	Security Considerations	9
8.1.	Denial-of-Service	9
8.2.	Port Randomization	9
9.	IANA Considerations	9
10.	Acknowledgements	10
11.	References	10
11.1.	Normative References	10
11.2.	Informative References	11
	Authors' Addresses	12

1. Introduction

The shortage of available public IPv4 addresses means that it is not always possible for operators to allocate a full IPv4 address to every connected device. This problem is particularly acute whilst an operator is migrating from their existing, native IPv4 network to a native IPv6 network with IPv4 provided as an overlay service. During this phase, public IPv4 addresses are needed to provide for both existing and transition networks.

Two main types of solutions have emerged to address the problem (see [Appendix A of \[RFC6269\]](#)):

1. Deploying Carrier Grade Network devices (CGNs, [\[RFC6888\]](#)).
2. Distributing the same public IPv4 address to multiple clients using non-overlapping layer 4 port sets.

This memo focuses on the second category of solutions.

[I-D.ietf-dhc-dhcpv4-over-dhcpv6] introduces a "DHCP 4o6 Server", which is capable of servicing both DHCPv6 [\[RFC3315\]](#) and DHCPv4-over-DHCPv6 requests, and offers dynamic leasing for IPv4 addresses to clients as in DHCPv4 [\[RFC2131\]](#). This memo specifies a new DHCPv4 option, called `OPTION_V4_PORTPARAMS`, and describes how it can be used to achieve dynamic leasing for shared IPv4 addresses.

This extension is only suitable for specific architectures based on the Address plus Port model (A+P) [\[RFC6346\]](#).

Although DHCPv4 over DHCPv6 is used as the underlying DHCPv4 transport mechanism throughout this document, `OPTION_V4_PORTPARAMS` as a DHCPv4 option may also be used in other solutions such as DHCPv4 over IPv6 [\[I-D.ietf-dhc-dhcpv4-over-ipv6\]](#). The usage of `OPTION_V4_PORTPARAMS` in these cases is out of scope of this document.

2. Functional Overview

Functionally, the dynamic allocation of shared IPv4 addresses by the DHCP 4o6 Server is similar to the DHCPv4 server dynamic allocation process for 'full' IPv4 addresses described in [\[RFC2131\]](#). The essential difference is that the DHCP 4o6 Server MAY allocate the same IPv4 address to more than one DHCP 4o6 client simultaneously, providing that each shared address allocation also includes a range of layer 4 source ports unique to that address (i.e., the combined tuple of IPv4 address and Port Set ID MUST be unique for each active lease).

The DHCP 4o6 client includes `OPTION_V4_PORTPARAMS` (described below) within the Parameter Request List option [[RFC2132](#)] in the DHCPDISCOVER message to indicate to the DHCP 4o6 server that it supports shared IPv4 addressing. `OPTION_V4_PORTPARAMS` is also used by the server to convey the allocated PSID to the client.

`OPTION_V4_PORTPARAMS` is also implemented by the server to enable it to identify clients which support shared, dynamic address leasing. With this option, the server can dynamically maintain shared IPv4 address leases. The server must also manage unique client leases based on both the IPv4 address and PSID tuple, instead of using only the IPv4 address.

3. Terminology

This document makes use of the following terms:

Shared IPv4 address: An IPv4 address with a restricted layer 4 port set. Connections sourced from the shared address must use source ports within the assigned port set.

Port Set ID (PSID): Identifier for a range of ports assigned to a DHCP client.

4. Client-Server Interaction

Using DHCPv4 over DHCPv6, the following DHCPv4 message flow is transported within the DHCPv4-query and DHCPv4-response messages (the DHCPv6 messages used for carrying DHCPv4 messages).

1. When the client constructs its DHCPv4 DHCPDISCOVER message to be transported within the DHCPv4-query message, the DHCPDISCOVER message MUST include the following options: A client identifier (constructed as per [[RFC4361](#)] and `OPTION_V4_PORTPARAMS` (described below). The client MAY insert a non-zero value in the PSID-Len field within `OPTION_V4_PORTPARAMS` to indicate the preferred size of the restricted port set to the DHCP 4o6 Server.
2. Each DHCP 4o6 Server that receives the DHCPDISCOVER message within the DHCPv4-query message and supports shared IPv4 addresses responds with a DHCPOFFER message containing an available IPv4 address in the 'yiaddr' field. The response MUST also include `OPTION_V4_PORTPARAMS` containing a restricted port set. If the received `OPTION_V4_PORTPARAMS` field contains a non-zero PSID-Len field, the DHCP 4o6 Server MAY allocate a port set of the requested size to the client (depending on policy). The DHCPOFFER message is included in the DHCPv4-response message and sent to the client.

3. The client evaluates all received DHCP`OFFER` messages and selects one (e.g. based on the configuration parameters received, such as the size of the offered port set). The client then sends a DHCP`REQUEST` encapsulated in the DHCPv4-query message, containing the selected DHCP server's server identifier and the corresponding `OPTION_V4_PORTPARAMS` received in the DHCP`OFFER` message.
4. The server identified in the DHCP`REQUEST` message (via the `siaddr` field) creates a binding for the client. The binding includes the client identifier, the IPv4 address and the PSID. These parameters are used by both the server and the client to identify a lease in any DHCP messages. The server responds with a DHCP`ACK` message containing the configuration parameters for the requesting client. Optionally, the server MAY also store the IPv6 address that the client has bound the received IPv4 parameters to.
5. On receipt of the DHCP`ACK` message with the configuration parameters, the client MUST NOT perform a final check on the address, such as ARPing for a duplicate allocated address.
6. If the client chooses to relinquish its lease by sending a DHCP`RELEASE` message, the client MUST include the original client identifier, the leased network address and the allocated restricted port set in `OPTION_V4_PORTPARAMS`.

In the case that the client has stored the previously allocated address and restricted port set, the process described in [section 3.2 of \[RFC2131\]](#) must be followed to reuse the previously allocated shared IPv4 address. `OPTION_V4_PORTPARAMS` MUST be included in the message flow, with the client's requested port set being included in the DHCP`DISCOVER` message.

5. Server Behavior

The DHCP 4o6 Server MUST NOT reply with the `OPTION_V4_PORTPARAMS` until the client has explicitly listed the option code in the Parameter Request List (Option 55) [\[RFC2132\]](#).

The DHCP 4o6 Server SHOULD reply with `OPTION_V4_PORTPARAMS` if the client includes the `OPTION_V4_PORTPARAMS` in its Parameter Request List. In order to achieve the dynamic management the shared IPv4 address, the server MUST run an address and port-set pool that provides the same function as the address pool in a regular DHCP server. The server MUST use the combination of address and PSID as the key for maintaining the state of a lease, and for searching for an available lease for assignment. The leasing database MUST include the IPv4 address, PSID and client identifier of the requesting client.

When a server receives a DHCPDISCOVER message with OPTION_V4_PORTPARAMS in the Parameter Request List, the server determines an IPv4 address with a port-set for the requesting client. The logic for selection is similar to that in [Section 4.3.1 of \[RFC2131\]](#).

When the server receives a DHCPREQUEST message with OPTION_V4_PORTPARAMS, the server MUST determine the client's state according to related parameters ([Section 4.3.2 of \[RFC2131\]](#)) and the value of OPTION_V4_PORTPARAMS.

Upon receipt of a DHCPRELEASE message with OPTION_V4_PORTPARAMS, the server searches for the lease using the address in the 'ciaddr' field and the PSID information in the OPTION_V4_PORTPARAMS, and marks the lease as unallocated.

The port-set assignment MUST be coupled with the address assignment process. Therefore server MUST assign the address and port set in the same DHCP messages. The lease information for the address is applicable to the port-set as well.

When defining the pools of IPv4 addresses and PSIDs which are available to lease to clients, the server SHOULD implement a mechanism to reserve some port ranges (e.g. 'well-known-ports' 0-1023) from allocation to clients.

5.1. Leasing Shared and Non-Shared IPv4 Addresses from a Single DHCP 4o6 Server

A single DHCP 4o6 server may serve clients that do not support OPTION_PORTPARAMS as well as those that do. As the rules for the allocation of shared addresses differ from the rules for full IPv4 address assignment, the DHCP 4o6 server MUST implement a mechanism to ensure that clients which do not support OPTION_PORTPARAMS do not receive shared addresses. For example, two separate IPv4 addressing pools could be used, one of which allocates IPv4 addresses and PSIDs only to clients that have requested them.

If the server is only configured one address pool for shared address allocation, it MUST discard requests that do not contain OPTION_V4_PORTPARAMS in the Parameter Request List option.

6. Client Behavior

The DHCP 4o6 client applying for a shared IPv4 address MUST include the OPTION_V4_PORTPARAMS code in the Parameter Request List (Option 55). The client retrieves a port set using the value contained in OPTION_V4_PORTPARAMS.

The client MAY use a non-zero value for the PSID-len field within `OPTION_PORTPARAMS` in the `DHCPDISCOVER` message. This is used to request a specific size of port-set (i.e., the number of source ports that it will be allocated).

The client MUST NOT probe a newly received IPv4 address (e.g., with ARP) to see if it is in use by another host.

When the client renews or releases the DHCP lease, it MUST put the values of offset, PSID length and PSID into the `OPTION_V4_PORTPARAMS`, and send to the server within corresponding DHCPv4 messages that are conveyed through DHCPv4-query message.

6.1. Restrictions to Client Usage of a Shared IPv4 Address

As a single IPv4 address is being shared between a number of different clients, the allocated shared address is only suitable for certain uses. The client MUST implement a function to ensure that only the allocated layer 4 ports of the shared IPv4 address are used for sourcing new connections, or accepting inbound connections.

The client MUST apply the following rules for any traffic to or from the shared IPv4 address:

- o Only port-aware protocols or ICMP implementing [[RFC5508](#)] MUST be used.
- o All connections originating from the shared IPv4 address MUST use a source port taken from the allocated restricted port set.
- o The client MUST NOT accept inbound connections on ports outside of the allocated restricted port set.

In order to prevent addressing conflicts which could arise from the allocation of the same IPv4 address, the client MUST NOT configure the received restricted IPv4 address on-link.

The mechanism by which a client implements the above rules is outside of the scope of this document.

In the event that the DHCPv4 over DHCPv6 configuration mechanism fails for any reason, the client MUST NOT configure an IPv4 link-local address [[RFC3927](#)] (taken from the 169.254.0.0/16 range).

7. DHCPv4 Port Parameters Option

The Port Parameters Option for DHCPv4 is specified to convey the restricted set of layer 4 source ports that are necessary to dynamically allocate a shared address. The option uses the same fields as the Port Parameters Option described in [Section 4.5](#) of

8. Security Considerations

The security considerations in [RFC2131] and [I-D.ietf-dhc-dhcpv4-over-dhcpv6] are to be considered. Additional considerations are elaborated in the following sub-sections.

8.1. Denial-of-Service

The solution is vulnerable to DoS attacks when used on a shared medium or when access network authentication is not a prerequisite to IP address assignment. The solution SHOULD only be used on point-to-point links, tunnels, and/or in environments where authentication at the link layer is performed before IP address assignment. It is not suitable for network access over shared mediums.

8.2. Port Randomization

Preserving port randomization [RFC6056] may be more or less difficult depending on the address sharing ratio (i.e., the size of the port space assigned to a CPE). The host can only randomize the ports inside a fixed port range [RFC6269].

More discussion to improve the robustness of TCP against Blind In-Window Attacks can be found at [RFC5961]. Other means than the (IPv4) source port randomization to provide protection against attacks should be used (e.g., use [I-D.vixie-dnsext-dns0x20] to protect against DNS attacks, [RFC5961] to improve the robustness of TCP against Blind In-Window Attacks, use IPv6).

A proposal to preserve the entropy when selecting port is discussed in [I-D.bajko-pripaddrassign].

9. IANA Considerations

IANA is requested to assign the following new DHCPv4 Option Code in the registry maintained in <http://www.iana.org/assignments/bootp-dhcp-parameters/>:

Option Name	Value	Data length	Meaning
OPTION_V4_PORTPARAMS	TBA	4	This option is used to configure a set of ports bound to a shared IPv4 address.

10. Acknowledgements

This document is merged from [[I-D.sun-dhc-port-set-option](#)] and [[I-D.farrer-dhc-shared-address-lease](#)].

The authors would like to thank Peng Wu, Gabor Bajko, Teemu Savolainen, Ted Lemon, Tina Tsou, Pierre Levis, Cong Liu for Marcin Siodelski, for their contribution to this work.

11. References

11.1. Normative References

- [I-D.ietf-dhc-dhcpv4-over-dhcpv6]
Sun, Q., Cui, Y., Siodelski, M., Krishnan, S., and I. Farrer, "DHCPv4 over DHCPv6 Transport", [draft-ietf-dhc-dhcpv4-over-dhcpv6-06](#) (work in progress), February 2014.
- [I-D.ietf-softwire-map]
Troan, O., Dec, W., Li, X., Bao, C., Matsushima, S., Murakami, T., and T. Taylor, "Mapping of Address and Port with Encapsulation (MAP)", [draft-ietf-softwire-map-10](#) (work in progress), January 2014.
- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997.
- [RFC2131] Droms, R., "Dynamic Host Configuration Protocol", [RFC 2131](#), March 1997.
- [RFC2132] Alexander, S. and R. Droms, "DHCP Options and BOOTP Vendor Extensions", [RFC 2132](#), March 1997.
- [RFC4361] Lemon, T. and B. Sommerfeld, "Node-specific Client Identifiers for Dynamic Host Configuration Protocol Version Four (DHCPv4)", [RFC 4361](#), February 2006.
- [RFC5961] Ramaiah, A., Stewart, R., and M. Dalal, "Improving TCP's Robustness to Blind In-Window Attacks", [RFC 5961](#), August 2010.
- [RFC6056] Larsen, M. and F. Gont, "Recommendations for Transport-Protocol Port Randomization", [BCP 156](#), [RFC 6056](#), January 2011.
- [RFC6269] Ford, M., Boucadair, M., Durand, A., Levis, P., and P. Roberts, "Issues with IP Address Sharing", [RFC 6269](#), June 2011.

11.2. Informative References

- [I-D.bajko-pripaddrassign]
Bajko, G., Savolainen, T., Boucadair, M., and P. Levis,
"Port Restricted IP Address Assignment", [draft-bajko-pripaddrassign-04](#) (work in progress), April 2012.
- [I-D.farrer-dhc-shared-address-lease]
Farrer, I., "Dynamic Allocation of Shared IPv4 Addresses
using DHCPv4 over DHCPv6", [draft-farrer-dhc-shared-address-lease-00](#) (work in progress), June 2013.
- [I-D.ietf-dhc-dhcpv4-over-ipv6]
Cui, Y., Wu, P., Wu, J., Lemon, T., and Q. Sun, "DHCPv4
over IPv6 Transport", [draft-ietf-dhc-dhcpv4-over-ipv6-08](#)
(work in progress), October 2013.
- [I-D.ietf-softwire-lw4over6]
Cui, Y., Qiong, Q., Boucadair, M., Tsou, T., Lee, Y., and
I. Farrer, "Lightweight 4over6: An Extension to the DS-
Lite Architecture", [draft-ietf-softwire-lw4over6-08](#) (work
in progress), March 2014.
- [I-D.ietf-softwire-map-dhcp]
Mrugalski, T., Troan, O., Farrer, I., Perreault, S., Dec,
W., Bao, C., leaf.yeh.sdo@gmail.com, l., and X. Deng,
"DHCPv6 Options for configuration of Softwire Address and
Port Mapped Clients", [draft-ietf-softwire-map-dhcp-07](#)
(work in progress), March 2014.
- [I-D.sun-dhc-port-set-option]
Qiong, Q., Lee, Y., Sun, Q., Bajko, G., and M. Boucadair,
"Dynamic Host Configuration Protocol (DHCP) Option for
Port Set Assignment", [draft-sun-dhc-port-set-option-02](#)
(work in progress), October 2013.
- [I-D.vixie-dnsext-dns0x20]
Vixie, P. and D. Dagon, "Use of Bit 0x20 in DNS Labels to
Improve Transaction Identity", [draft-vixie-dnsext-dns0x20-00](#) (work in progress), March 2008.
- [RFC3315] Droms, R., Bound, J., Volz, B., Lemon, T., Perkins, C.,
and M. Carney, "Dynamic Host Configuration Protocol for
IPv6 (DHCPv6)", [RFC 3315](#), July 2003.
- [RFC3927] Cheshire, S., Aboba, B., and E. Guttman, "Dynamic
Configuration of IPv4 Link-Local Addresses", [RFC 3927](#), May
2005.

- [RFC5508] Srisuresh, P., Ford, B., Sivakumar, S., and S. Guha, "NAT Behavioral Requirements for ICMP", [BCP 148](#), [RFC 5508](#), April 2009.
- [RFC6335] Cotton, M., Eggert, L., Touch, J., Westerlund, M., and S. Cheshire, "Internet Assigned Numbers Authority (IANA) Procedures for the Management of the Service Name and Transport Protocol Port Number Registry", [BCP 165](#), [RFC 6335](#), August 2011.
- [RFC6346] Bush, R., "The Address plus Port (A+P) Approach to the IPv4 Address Shortage", [RFC 6346](#), August 2011.
- [RFC6888] Perreault, S., Yamagata, I., Miyakawa, S., Nakagawa, A., and H. Ashida, "Common Requirements for Carrier-Grade NATs (CGNs)", [BCP 127](#), [RFC 6888](#), April 2013.

Authors' Addresses

Yong Cui
Tsinghua University
Beijing 100084
P.R.China

Phone: +86-10-6260-3059
Email: yong@csnet1.cs.tsinghua.edu.cn

Qi Sun
Tsinghua University
Beijing 100084
P.R.China

Phone: +86-10-6278-5822
Email: sunqi@csnet1.cs.tsinghua.edu.cn

Ian Farrer
Deutsche Telekom AG
CT0-ATI, Landgrabenweg 151
Bonn, NRW 53227
Germany

Email: ian.farrer@telekom.de

Yiu L. Lee
Comcast
One Comcast Center
Philadelphia PA 19103
USA

Email: yiul_lee@cable.comcast.com

Qiong Sun
China Telecom
Room 708, No.118, Xizhimennei Street
Beijing 100035
P.R.China

Phone: +86-10-58552936
Email: sunqiong@ctbri.com.cn

Mohamed Boucadair
France Telecom
2330 Central Expressway
Rennes 35000
France

Email: mohamed.boucadair@orange.com