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DHCP Options for Conveying Port Mask and Port Range Router IP Address
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Abstract

This draft defines two new DHCP (Dynamic Host Configuration Protocol, [\[RFC2131\]](#)) Options to be used in the context of Provider-Provisioned CPE solution (a.k.a. Port Range solution or Fractional Address). The first option is used to convey a Port Mask and the second one may be used to convey a list of Port Range Router IP addresses.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",

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Port Range Options

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"SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC 2119](#) [[RFC2119](#)].

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1. Introduction

Recently, in the context of IPv4 address depletion, several solutions have been disseminated within IETF to propose viable alternative solutions to Carrier Grade NAT (CG-NAT). [[ID.boucadair](#)] is an example of these solutions which propose to share the same IP address among several devices and to constraint the values used as port sources to a limited set of values. As described in [[ID.boucadair](#)], a new DHCP is required to notify remote devices about the allowed port values. This is mainly achieved owing to the Port Mask DHCP Option.

This proposal tackles the issue of assigning Port Ranges in a different way than that of [[ID.bajko](#)]. The proposed DHCP option only applies to the allocation of ports and not of IP addresses. Therefore the allocation of IP addresses and the allocation of ports are decorrelated from a DHCP point of view. Consequently, this draft does not introduce a conflict to manage existing DHCP options and the new ones (especially with those options including a "requested address" defined in [[RFC2132](#)]). In addition, the proposed option allows the definition of Port Ranges in a very flexible way; non contiguous values are possible, which prevents for instance to allocate all well-known ports to the same customer.

This draft defines the notion of Port Mask which is generic and flexible. Several allocation schemes may be implemented owing to a Port Mask. This draft proposes a basic mechanism allowing to allocate a unique Port Mask. The Annex describes a variant permitting a more sophisticated allocation of ports such as: allocate a Port Range except some values (e.g. All well-known port values except 80 and 8080), allocate only a set of discrete values together with a Port Range (e.g. 3000 to 32000 and port 80), etc.

According to [[ID.dhcpguide](#)], the formats of the herein proposed DHCP options are similar to the ones defined in [[RFC2132](#)].

IP exhaustion is only provided as an example of usage of the DHCP options defined in this draft. Other usages may be considered.

[2.](#) Mask Port Option

This section defines the Port Mask DHCP Option.

[2.1.](#) Definition

For making the distinction between a Port Range containing a continuous span of port numbers and a Port Range with non continuous

port numbers, the following denominations are used:

- Continuous Port Range: a set of port values which form a continuous sequence.
- Non Continuous Port Range: a set of ports values which does not form a continuous sequence.

Moreover, unless explicitly mentioned, Port Mask refers to the couple (Port Mask, Port Locator).

[2.2.](#) Purpose and Usage

This option is used to notify a remote DHCP client about the Port Mask to be applied when selecting a port value as a source port. The Port Mask option is used to infer a set of allowed port values.

A Port Mask defines a set of ports that all have in common a subset of pre-positioned bits. This ports set is also called Port Range.

Two port numbers are said to belong to the same Port Range if and only if, they have the same Port Mask. In the rest, for easing the denomination, we will call CPE (Customer Premises Equipment) the equipment which applies the port restriction when communicating. But it could be any other kind of equipment (e.g. a terminal).

The code for this DHCP option is to be assigned by IANA. The minimum length of this option is 4, and the length MUST be a multiple of 4.

The format of Port Mask DHCP option is illustrated in the figure hereafter:

Code	Len	Port Mask 1	Mask Locator 1
-----+-----+-----+-----+			
TBA	n	MP1	ML1
-----+-----+-----+-----+			

TBA means to be assigned by IANA.

Port Mask indicates the value of the mask to be applied and Mask Locator indicates the position of the bits which are used to build the mask.

Port Mask and Mask Locator are encoded as 16 bits.

The "1" values in the Mask Locator indicate by their position the significant bits of the Port Mask (the pattern of the Port Mask).

For example,

- o a Mask Locator equal to 1000000000000000 indicates that the first bit (the most significant one) is used as a pattern of the Port Mask;
- o a Mask Locator equal to 0000101000000000 indicates that the 5th and the 7th most significant bits are used as a pattern of the Port Mask.

The pattern of the Port Mask is all the fixed bits in the Port Mask. All the ports the CPE is allowed to use as source ports must have their number in accordance with the pattern.

The Port Mask is coded as follows:

- The pattern bits of the Port Mask are those where "1" values are set in the Mask Locator. These bits may take a value of 0 or 1.
- All the other bits are set to "0".

[2.3.](#) Illustration Examples

This section provides a set of examples to illustrate the usage of the Port Mask DHCP Option:

1. Single Port Mask to assign one Continuous Port Range to a given device;
2. Single Port Mask used to assign 128 Port Ranges with two Port Ranges within the well-known Port Range to a given device;.
3. Single Port Mask to assign two long Port Ranges to a given device;
4. Single Port Mask to allocate to a given device 64 Port Ranges with a Port Range within the well-known Port Range.

[2.3.1.](#) One continuous Port Range

This section provides an example of a Port Mask used to assign a unique Continuous Port Range to a given customer's device.

For illustration purposes, the following Mask Locator and Port Mask are conveyed using DHCP to assign a Port Range (from 2048 to 4095) to a given device:

- Port Mask : 0000100000000000 (2048)
- Mask Locator : 1111100000000000 (63488)

In this example, 2⁵ customers can share the same IP address.

[2.3.2.](#) Non Continuous Port Range: Single Mask Port, 128 Port Ranges

Unlike the previous example, this one illustrates the case where a non Continuous Port Range is assigned to a given customer's device.

In this example, the Port Mask defines 128 Continuous Port Ranges, each one with a length of 16 port values. Note that the two first Port Ranges are both in the well-known ports span (i.e. 0-1023) but these two ranges are not adjacent.

The following Mask Locator and Port Mask are conveyed in DHCP messages:

- Port Mask : 0000000001010000 (80)
- Mask Locator : 0000000111110000 (496)

This means that the 128 following Continuous Port Ranges are assigned to the same customer's device:

- from 80 to 95
- from 592 to 607
- ...
- ...
- from 65104 to 65119

[2.3.3.](#) Two Long Port Ranges: Single Port Mask, two Port Ranges

In this example, the Port Mask defines two Continuous Port Ranges, each one being 1024 ports long:

- Port Mask : 0000000000000000 (0)
- Mask Locator : 1111010000000000 (62464)

This means that the two following Continuous Port Ranges are assigned to the same device:

- from 0 to 1023, and
- from 2048 to 3071

[2.3.4.](#) Single Mask Port, 64 Port Ranges

This example shows the flexibility of allocating allowed port values using a Port Mask. In the following example, 64 Continuous Port

Ranges are allocated to each CPE (among a set of 4 CPEs sharing the same IPv4 address).

Among the 64 continuous Port Ranges to each CPE, there is always one within the span of the first 1024 well-known port values. Hereafter is provided the Port Mask and Port Locator assigned to 2 CPEs:

1. CPE#0

- Port Mask: 0000000000000000 (0)
- Mask Locator: 0000001100000000 (768)

The CPE#0 has therefore the 64 following Continuous Port Ranges:

- 1st range: 0-255
- ...
- 64th range: 64512-64767

2. CPE#2

- Port Mask: 0000001100000000 (768)
- Mask Locator: 0000001100000000 (768)

The CPE#2 has therefore the 64 following Continuous Port Ranges:

- 1st range: 768-1023
- ...
- 64th range: 65280-65535

[3.](#) Port Range Router IP address DHCP Option (PRR IP Address DHCP Option)

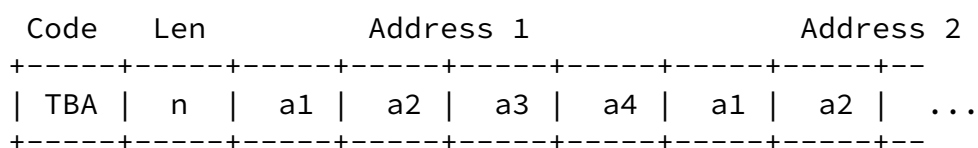
This section defines the Port Range Router IP Address DHCP Option.

[3.1.](#) Purpose and Usage

The PRR IP Address DHCP option specifies a list of routers (represented as IPv4 addresses) which maintains a binding table as defined in [\[ID.boucadair\]](#). Routers SHOULD be listed in order of preference.

The code for the PRR IP Address DHCP option is to be assigned by IANA. The minimum length for this option is 4 octets, and the length MUST always be a multiple of 4.

The format of the PRR IP Address DHCP option is depicted in the following figure:



This format assumes that an IPv4 address is encoded as a1.a2.a3.a4.

This option can be used for instance when a CPE-Provisioned PRR model is adopted (Refer to [\[ID.boucadair\]](#) for more details about this mode).

Once this option is received by a given customer's device (particularly embedded DHCP Client), an appropriate message is sent to the IP address conveyed in this option. This message aims at notifying the remote Port Range Router about the assigned Port Mask and IP address. An entry is consequently instantiated in the binding table maintained by that PRR.

As stated above, this option encloses at least one IP address, which represents the PRR. If several IP addresses are conveyed, these PRR are contacted in a priority-based scheme. Thus, if no acknowledgment message is received for the issued message, the next PRR in the list is contacted, etc.

[3.2.](#) Illustration Example

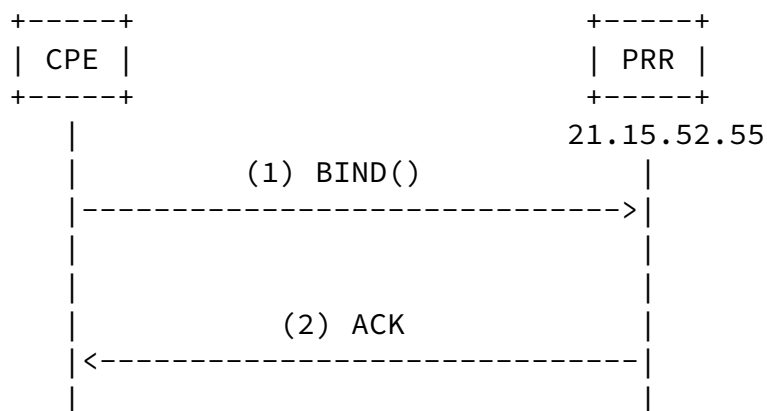
This section provides an example of the configuration data conveyed in a Port Range Router DHCP Option.

Let's suppose that the configuration data is retrieved by a CPE using DHCP. This configuration contains a Port Range Router Option illustrated in the following figure:

Code	Len	Address 1			
-----+	-----+	-----+	-----+	-----+	-----+
TBA	4	21	15	52	55
-----+	-----+	-----+	-----+	-----+	-----+

Within this example, this option carries one single IP address: 21.15.52.55.

Once this data is received by the CPE, the following call flow is experienced:



As a result, PRR (21.21.52.55) is aware about the required information to route unambiguously all received IP packets to that CPE. This process is achieved each time DHCP configuration data change.

[4.](#) IANA Considerations

This document requests the assignment of two DHCP Options:

- Port Mask Option;
- Port Range Router IP Address Option.

[5.](#) Security Considerations

This document does not introduce any security issue.

[6.](#) Acknowledgements

TBC

[7.](#) References

[7.1.](#) Normative References

- [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.

[7.2.](#) Informative References

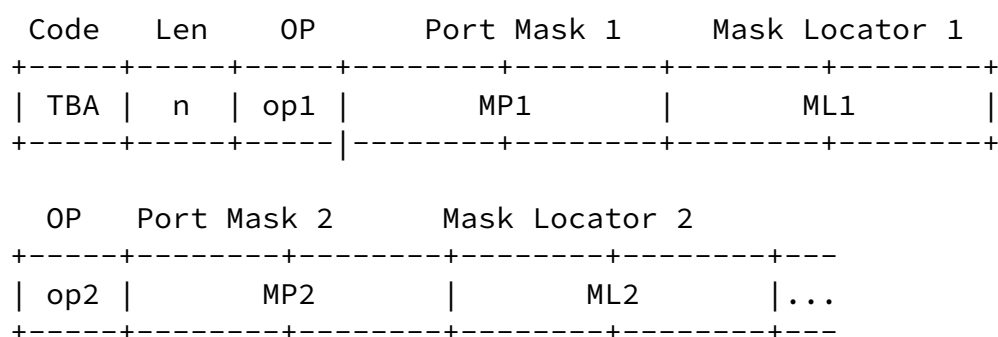
- [ID.bajko] Bajko, G. and T. Savolainen, "Dynamic Host Configuration Protocol (DHCP) Options for Port Restricted IP Address Assignment", September 2008.
- [ID.boucadair] Boucadair, M., "Provider-Provisioned CPE: IPv4 Connectivity Access in the context of IPv4 address exhaustion", October 2008.
- [ID.dhcpguide] Hankins, D., "Guidelines for Creating New DHCP Options", October 2008.

[Appendix A.](#) Enhanced Port Range DHCP Option

This appendix defines a variant which allows a more sophisticated allocation of ports.

The format of the Port Mask DHCP Option is slightly more complicated than the basic one defined above.

The format of the enhanced Port Mask DHCP Option is illustrated in the figure hereafter:



As shown above, several Port Masks may be enclosed in the Port Mask DHCP Option.

The minimum length of this option is 5, and the length MUST be a multiple of 5.

As shown above, several Port Masks and Mask Locators may be enclosed in a single option.

The OP (Operand) field encodes in one octet the way the Port Mask is to be applied. Two values are defined in this draft:

- OP = 0: This means that the Port Mask and Mask Locator which follow define a set of ports which can be used by the CPE. This is exactly the working of the basic mechanism described in the core of this memo.

- OP = 1: This means that the Port Mask and Mask Locator which follow define a set of ports which must NOT be used by the CPE. Therefore OP = 1 excludes ports specified by the associated Port Mask.

The set of excluded ports defined by a sequence (OP=1, Port Mask_y, Mask Locator_y) has the precedence over any sequence (OP=0, Port Mask_x, Mask Locator_x) within the Port Mask DHCP Option. That means that the final ports set defined by the Port Mask DHCP option is :

union of the sets defined by all the sequences (OP=0, Port Mask_x, Mask Locator_x) minus all the sets defined by the sequences (OP=1, Port Mask_y, Mask Locator_y).

The order of sequence (OP, Port Mask, Mask Locator) within the Port Mask DHCP Option is not important. OP=0 sequences can precede OP=1

sequences or the contrary. OP=0 sequences can be mixed with OP=1 sequences.

Two examples are provided hereafter.

[A.1.](#) Two continuous Port Ranges of different sizes

One could notice from the examples given for the basic mechanism (see [Section 2.3](#). Illustration Examples) that with a single Port Mask it is not possible to allocated several Continuous Port Ranges of different sizes. In the scope of this present variant this is feasible.

The use case can be, for example, a CPE to which has been already allocated a Continuous Port Range (e.g. 2048 ports from 16384 to 18431) outside the well-known port values span (0-1023). If at a later stage, the customer wishes to enable some servers behind its CPE and then uses a well-known ports (i.e. a values within 0 to 1023 ranges) and if this Port Range (0-1023) is not yet allocated to another CPE, it can be allocated to that CPE owing to a second Port Mask.

Therefore, the Port Mask DHCP Option would contain two (OP, Port Mask, Mask Locator) sequences as shown below:

- First (OP, Port Mask, Mask Locator):

* OP = 0

* Port Mask: 0100000000000000 (16384)

* Mask Locator : 1111100000000000 (63488)

This yields the following 2048 long Continuous Port Range: from 16384 to 18431

- Second (OP, Port Mask, Mask Locator):

* OP = 0

* Port Mask: 0000000000000000 (0)

* Mask Locator : 1111110000000000 (64512)

This yields the following Continuous Port Range: from 0 to 1023

[A.2.](#) Two Port Ranges with some ports excluded from the first range

This example is the same as the previous one but the port 80 is not allocated to the CPE.

There are three (OP, Port Mask, Mask Locator) sequences. The first two ones are the same ones as in the previous example.

The third sequence is as follows:

- OP = 1

- Port Mask: 0000000001010000 (80)

- Mask Locator : 1111111111111111 (65535)

This third (OP, Port Mask, Mask Locator) sequence excludes port 80 from the allowed port values to that device.

[Appendix B](#). Changes since 00 version

1. Some editorial changes
2. Correct the example provided in [Section 2.3.3](#)

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