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BOOTP and DHCP on Mixed Media Link-Layer Networks

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Abstract

   RFCs 951 [1], 1541 [2], and 1542 [3] describe the interactions of
   BOOTP [1] and DHCP [2] client, server, and relay agents. However,
   further experience with these protocols has revealed the existence of
   an interoperability issue. The issue occurs when a given IP subnet
   is constructed over one link-layer network inter-connected by
   translational bridges to other dissimilar link-layer networks. The
   following information attempts to address this problem.

   It is impossible for a BOOTP or DHCP client, server, or relay agent
   to know in advance whether or not it will be operating in a mixed
   media link-layer network environment. Given this fact, all BOOTP
   and DHCP client, server, and relay agents SHOULD adopt the
   recommendations defined in this memo.

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1. Introduction

   Some aspects of the BOOTP and DHCP protocols need additional
   definition in order to expand compatibility with certain network
   devices. RFCs 951, 1541, and 1542 do not adequately describe the
   behavior of BOOTP server, client, and relay agent so as to ensure
   compatibility with devices that provide layer 2 forwarding of BOOTP
   and DHCP messages. The client, server, and relay agent need
   additional behavior definition in order to strengthen the current
   standards in these areas. The information in this memo attempts to
   clarify the interaction of BOOTP client, server, and relay agent
   in order to increase compatibility with devices which provide layer 2
   forwarding.

   Note: This document provides additional information to further define
   the behavior of BOOTP and DHCP servers, clients, and relay agents as
   defined in RFCs 951, 1541, and 1542 and should be considered an
   extension of the original documents.

1.1 Requirements

   In this memo, the words that are used to define the significance of
   particular requirements are capitalized. These words are:

      o "MUST"

         This word or the adjective "REQUIRED" means that the item is an
         absolute requirement of the specification.

      o "MUST NOT"

This phrase means that the item is an absolute prohibition of
the specification.

o "SHOULD"

This word or the adjective "RECOMMENDED" means that there may
exist valid reasons in particular circumstances to ignore this
item, but the full implications should be understood and the
case carefully weighed before choosing a different course.

o "SHOULD NOT"

This phrase means that there may exist valid reasons in
particular circumstances when the listed behavior is
acceptable or even useful, but the full implications should be
understood and the case carefully weighed before implementing
any behavior described with this label.

o "MAY"

This word or the adjective "OPTIONAL" means that this item is
truly optional. One vendor may choose to include the item
because a particular marketplace requires it or because it
enhances the product, for example; another vendor may omit the
same item.

1.2 Terminology

This memo uses the following terms:

BOOTREQUEST

A BOOTP message sent from a BOOTP client to a BOOTP server
requesting configuration information.

BOOTREPLY

A BOOTP message sent from a BOOTP server to a BOOTP client
providing configuration information.

'htype' field

An 8 bit field contained in BOOTP and DHCP messages which
represents the client's link-layer network type as specified in
RFC 1700 [4], "Assigned Numbers", except where amended by this
document.

'chaddr' field

A 16 byte field contained in BOOTP and DHCP messages which
represents the link-layer address of the client.

2. **General Issues**

An interoperability issue concerning BOOTP and DHCP messages can occur on networks which connect different link-layer technologies through devices which provide only layer 2 forwarding. The issue can occur when the client is located on a link-layer network that has a different 'htype', as defined in the "Assigned Numbers" RFC, than that of the server or relay agent. Primarily, this issue can occur when the relay agent or server resides on an 'htype' link-layer network of 1 while the client resides on an 'htype' link-layer network of 6. The reverse situation can also pose potential problems.

The key to ensuring proper operation revolves around the 2 fields in BOOTP and DHCP messages known as the 'htype' and 'chaddr'. Therefore, it is necessary to describe in detail how each element should handle these fields and the information derived therefrom.

3. **Client Behavior Extension**

In addition to adhering to all applicable sections of RFCs 951, 1541, and 1542, the client MUST set the 'htype' and 'chaddr' as directed in sections 3.1 and 3.2 of this document for all BOOTP and DHCP messages generated by the client.

3.1 The 'htype' Field

The client MUST set the 'htype' field in accordance with the values defined in this document for the client's link-layer network.

IMPORTANT NOTE: As of the date of publication of this BOOTP/DHCP memo, the current Assigned Numbers document is RFC 1700. RFC 1700 contains the following table (edited for brevity):

```
Value Hardware Type (hrd)
----- -------------------
    1 Ethernet (10Mb)
    6 IEEE 802 Networks
```

The above table suggests that all IEEE 802 networks should use an 'htype' value of 6. However, this does not reflect actual practice, and blindly following the above table will result in serious interoperability problems. The table would be more correctly represented as:

```
Value Hardware Type (hrd)
----- -------------------
    1 IEEE canonical format (Ethernet, IEEE 802.3, FDDI canonical)
```

6 IEEE reverse canonical format (IEEE 802.5 Token Ring
            Networks)

Actual practice dictates that BOOTP and DHCP clients which are directly connected to an IEEE 802.5 Token Ring network MUST set 'htype' to 6, and BOOTP and DHCP clients which are directly connected to a DIX Ethernet, IEEE 802.3 Ethernet, or FDDI network MUST set 'htype' to 1.

3.2 The 'chaddr' Field

The bit ordering used for the link-level hardware addresses in the 'chaddr' field MUST be the same as the ordering used for the ARP protocol [5] on the client's link-level network (assuming ARP is defined for that network).

4. Relay Agent Behavior Extension

In addition to adhering to all applicable sections of RFCs 951, 1541, and 1542, the relay agent MUST adhere to the recommendations in sections 4.1 and 4.2 of this document.

4.1 The 'htype' and 'chaddr' Fields

All relay agents MUST preserve the 'htype' and 'chaddr' fields of all DHCP and BOOTP messages and forward as is. Preservation is necessary in order to allow the final relay agent to properly format a unicast response to the BOOTP client in accordance with RFC 1542 and this document.

4.2 Additional Relay Agent Processes

The final relay agent MUST reference the BOOTREPLY 'htype' field when building unicast BOOTREPLY messages. The relay agent MUST compare the 'htype' contained in the BOOTREPLY message to the 'htype' of the relay agent's network interface from which the outgoing BOOTREPLY message is about to be sent. It MUST then perform any link-layer translation required in order to ensure the appropriate form of the link-layer address is used in the link-layer header of the outgoing BOOTREPLY message and/or corresponding ARP table entries.

Note: The actual value of the 'chaddr' field within the outgoing BOOTREPLY message MUST NOT be modified.

5. DHCP Server Behavior Extension

In addition to adhering to all applicable sections of RFCs 951, 1541, and 1542, the server MUST adhere to the recommendations in sections 5.1 and 5.2 of this document.

5.1 The 'htype' and 'chaddr' Fields

The server MUST copy the 'htype' and 'chaddr' fields of all
BOOTREQUESTs to the corresponding BOOTREPLY. The server MUST do

       this in order to allow the final relay agent to properly format a
       unicast response to the BOOTP client in accordance with RFC 1541
       and this document.

   5.2 Additional Server Processes

       The server MUST consider the 'htype' field when building unicast
       BOOTREPLY messages. Therefore, the server must check the 'htype'
       contained in the BOOTREPLY message and compare it to the 'htype'
       of the server's link-layer interface. The server MUST perform any
       translation required to ensure the correct form of the link-layer
       address is used within the link-layer header of the BOOTREPLY
       message and any ARP table entries. (The actual value of the
       'chaddr' field within the outgoing BOOTREPLY message MUST NOT be
       modified.)

6. **Examples**

   6.1 IEEE 802.5 Token Ring to IEEE 802.3 Ethernet with a Relay

       --------   ----   ----------   -------   --------
       |BOOTP | /   \ |Trans- | ETHERNET |BOOTP| ETHERNET |BOOTP |
       |/DHCP |-|TOKEN |-|lational|----------|/DHCP|----------|/DHCP |
       |Client| \RING/ |Switch | |RELAY| |SERVER|
       --------   ----   ----------   -------   --------

       The Token Ring client's link-layer address, as represented in an
       ARP message, is 00:00:B8:E1:D2:A3. Therefore, the client will
       generate all DHCP and BOOTP messages with the 'htype' set to 6 and
       the 'chaddr' set to 00:00:B8:E1:D2:A3.

       The message will be received by the BOOTP/DHCP relay with the
       'htype' of 6 and the 'chaddr' of 00:00:B8:E1:D2:A3. The relay
       will forward the message in accordance with RFC 1542, preserving
       the 'htype' of 6 and the 'chaddr' of 00:00:B8:E1:D2:A3.

       The BOOTP/DHCP server will receive the BOOTREQUEST and process
       the message in accordance with existing procedures preserving the
       'htype' of 6 and the 'chaddr' of 00:00:B8:E1:D2:A3. At this
       point, the BOOTP/DHCP server determines that there is a relay
       between the client and itself and will direct the BOOTREPLY to
       the BOOTP/DHCP relay.

       The BOOTP/DHCP relay will receive the BOOTREPLY and preserve the
       'htype' of 6 and the 'chaddr' of 00:00:B8:E1:D2:A3. It will check
       to see if a broadcast or a unicast will be used to deliver the
       message to the client. If a broadcast will be used, the relay
       will process the message in accordance with existing procedures.
       If a unicast will be used, the relay will need to translate the

link-layer address attained from the BOOTREPLY message 'chaddr'
field because its transmitting interface 'htype' is 1 and the
BOOTREPLY 'htype' is 6. The result is a link-layer address of

00:00:1D:87:4B:C5 being used to send the unicast to the client and
for any ARP table entry generated. It is important to note that,
in the BOOTREPLY, the 'chaddr' field remains set to
00:00:B8:E1:D2:A3 and the 'htype' remains set to 6.

The client will receive the BOOTREPLY and process it in
accordance with existing procedures.

NOTE: In this example, the client is on IEEE 802.5 Token Ring
while the server is on IEEE 802.3 Ethernet. However, a
translation would still be required if the server were located on
Token Ring and the client on Ethernet or FDDI.

6.2 IEEE 802.5 Token Ring to IEEE 802.3 Ethernet without a Relay

```
--------   ----   ----------          --------
|BOOTP |  /    \  |Trans-  | ETHERNET |BOOTP |
|/DHCP |-|TOKEN |-|lational|----------|/DHCP |
|Client|  \RING/  |Switch  |          |SERVER|
--------   ----   ----------          --------
```

The Token Ring client's link-layer address, as represented in an
ARP message, is 00:00:B8:E1:D2:A3. Therefore, the client will
generate all DHCP and BOOTP messages with the 'htype' set to 6 and
the 'chaddr' set to 00:00:B8:E1:D2:A3.

The BOOTP/DHCP server will receive the BOOTREQUEST and process
the message in accordance with existing procedures, preserving the
'htype' of 6 and the 'chaddr' of 00:00:B8:E1:D2:A3. At this
point, the BOOTP/DHCP server will determine that there is no relay
between the client and itself will itself determine whether a
broadcast or a unicast will be used for the BOOTREPLY. If a
broadcast will be used, the server will process the message in
accordance with the existing procedures. If a unicast will be
used, the server will need to translate the link-layer address
attained from the 'chaddr' field of the corresponding BOOTREQUEST
because it's transmitting interface 'htype' is 1 and the
BOOTREQUEST 'htype' is 6. The result is a link-layer address of
00:00:1D:87:4B:C5 being used to send the unicast to the client.
It is important to note that, in the BOOTREPLY, the 'chaddr'
field remains set to 00:00:B8:E1:D2:A3 and the 'htype' remains set
to 6.

The client will receive the BOOTREPLY and process it in
accordance with existing procedures.

NOTE: In this example, the client is on IEEE 802.5 Token Ring
while the server is on IEEE 802.3 Ethernet. However, a
translation would still be required if the server were located on

Token Ring and the client on Ethernet or FDDI.

References

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