IPv4 Address Conflict Detection

Status of This Memo

Abstract

   When two hosts on the same link attempt to use the same IPv4 address
   at the same time (except in rare special cases where this has been
   arranged by prior coordination), problems ensue for one or both
   hosts. This document describes (i) a simple precaution that a host
   can take in advance to help prevent this misconfiguration from
   happening, and (ii) if this misconfiguration does occur, a simple
   mechanism by which a host can passively detect, after the fact, that
   it has happened, so that the host or administrator may respond to
   rectify the problem.

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1. Introduction

   Historically, accidentally configuring two Internet hosts with the
   same IP address has often been an annoying and hard-to-diagnose
   problem.

   This is unfortunate, because the existing Address Resolution Protocol
   (ARP) provides an easy way for a host to detect this kind of
   misconfiguration and report it to the user. The DHCP specification
   [RFC2131] briefly mentions the role of ARP in detecting
   misconfiguration, as illustrated in the following three excerpts from
   RFC 2131:

   o the client SHOULD probe the newly received address, e.g., with ARP

   o The client SHOULD perform a final check on the parameters
     (e.g., ARP for allocated network address)

   o If the client detects that the address is already in use
     (e.g., through the use of ARP), the client MUST send a DHCPDECLINE
     message to the server

Unfortunately, the DHCP specification does not give any guidance
to implementers concerning the number of ARP packets to send, the
interval between packets, the total time to wait before concluding
that an address may safely be used, or indeed even which kinds
of packets a host should be listening for, in order to make this
determination. It leaves unspecified the action a host should
take if, after concluding that an address may safely be used, it
subsequently discovers that it was wrong. It also fails to specify
what precautions a DHCP client should take to guard against
pathological failure cases, such as a DHCP server that repeatedly
OFFERs the same address, even though it has been DECLINEd multiple
times.

The authors of the DHCP specification may have been justified in
thinking at the time that the answers to these questions seemed too
simple, obvious, and straightforward to be worth mentioning, but
unfortunately this left some of the burden of protocol design to each
individual implementer. This document seeks to remedy this omission
by clearly specifying the required actions for:

1. Determining whether use of an address is likely to lead to an
   addressing conflict. This includes (a) the case where the address
   is already actively in use by another host on the same link, and
   (b) the case where two hosts are inadvertently about to begin
   using the same address, and both are simultaneously in the process
   of probing to determine whether the address may safely be used
   (Section 2.1.).

2. Subsequent passive detection that another host on the network is
   inadvertently using the same address. Even if all hosts observe
   precautions to avoid using an address that is already in use,
   conflicts can still occur if two hosts are out of communication
   at the time of initial interface configuration. This could occur
   with wireless network interfaces if the hosts are temporarily out
   of range, or with Ethernet interfaces if the link between two
   Ethernet hubs is not functioning at the time of address
   configuration. A well-designed host will handle not only
   conflicts detected during interface configuration, but also
   conflicts detected later, for the entire duration of the time
   that the host is using the address (Section 2.4.).

3. Rate-limiting of address acquisition attempts in the case of
   an excessive number of repeated conflicts (Section 2.1.).

The utility of IPv4 Address Conflict Detection (ACD) is not limited
to DHCP clients. No matter how an address was configured, whether
via manual entry by a human user, via information received from a
DHCP server, or via any other source of configuration information,

detecting conflicts is useful. Upon detecting a conflict, the
configuring agent should be notified of the error. In the case where
the configuring agent is a human user, that notification may take the
form of an error message on a screen, a Simple Network Management
Protocol (SNMP) notification, or an error message sent via text
message to a mobile phone. In the case of a DHCP server, that
notification takes the form of a DHCP DECLINE message sent to the
server. In the case of configuration by some other kind of software,
that notification takes the form of an error indication to the
software in question, to inform it that the address it selected is
in conflict with some other host on the network. The configuring
software may choose to cease network operation, or it may
automatically select a new address so that the host may re-establish
IP connectivity as soon as possible.

Allocation of IPv4 Link-Local Addresses [RFC3927] can be thought of
as a special case of this mechanism, where the configuring agent is
a pseudo-random number generator, and the action it takes upon being
notified of a conflict is to pick a different random number and try
again. In fact, this is exactly how IPv4 Link-Local Addressing was
implemented in Mac OS 9 back in 1998. If the DHCP client failed to
get a response from any DHCP server, it would simply make up a fake
response containing a random 169.254.x.x address. If the ARP module
reported a conflict for that address, then the DHCP client would try
again, making up a new random 169.254.x.x address as many times as
was necessary until it succeeded. Implementing ACD as a standard
feature of the networking stack has the side effect that it means
that half the work for IPv4 Link-Local Addressing is already done.

1.1. Conventions and Terminology 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 "Key words for use in
RFCs to Indicate Requirement Levels" [RFC2119].

Wherever this document uses the term 'sender IP address' or 'target
IP address' in the context of an ARP packet, it is referring to the
fields of the ARP packet identified in the ARP specification [RFC826]
as 'ar$spa' (Sender Protocol Address) and 'ar$tpa' (Target Protocol
Address), respectively. For the usage of ARP described in this
document, each of these fields always contains an IPv4 address.

In this document, the term 'ARP Probe' is used to refer to an ARP
Request packet, broadcast on the local link, with an all-zero 'sender
IP address'. The 'sender hardware address' MUST contain the hardware
address of the interface sending the packet. The 'sender IP address'
field MUST be set to all zeroes, to avoid polluting ARP caches in

other hosts on the same link in the case where the address turns out
to be already in use by another host. The 'target hardware address'
field is ignored and SHOULD be set to all zeroes. The 'target IP
address' field MUST be set to the address being probed. An ARP Probe
conveys both a question ("Is anyone using this address?") and an
implied statement ("This is the address I hope to use.").

In this document, the term 'ARP Announcement' is used to refer to an
ARP Request packet, broadcast on the local link, identical to the ARP
Probe described above, except that both the sender and target IP
address fields contain the IP address being announced. It conveys a
stronger statement than an ARP Probe, namely, "This is the address I
am now using."

The following timing constants used in this protocol are referenced
in Section 2, which describes the operation of the protocol in
detail. (Note that the values listed here are fixed constants; they
are not intended to be modifiable by implementers, operators, or end
users. These constants are given symbolic names here to facilitate
the writing of future standards that may want to reference this
document with different values for these named constants; however,
at the present time no such future standards exist.)

```
PROBE_WAIT           1 second   (initial random delay)
PROBE_NUM            3          (number of probe packets)
PROBE_MIN            1 second   (minimum delay until repeated probe)
PROBE_MAX            2 seconds  (maximum delay until repeated probe)
ANNOUNCE_WAIT        2 seconds  (delay before announcing)
ANNOUNCE_NUM         2          (number of Announcement packets)
ANNOUNCE_INTERVAL    2 seconds  (time between Announcement packets)
MAX_CONFLICTS       10          (max conflicts before rate-limiting)
RATE_LIMIT_INTERVAL 60 seconds  (delay between successive attempts)
DEFEND_INTERVAL     10 seconds  (minimum interval between defensive
                                 ARPs)
```

1.2. Relationship to RFC 826

   This document does not modify any of the protocol rules in RFC 826.
   It does not modify the packet format, or the meaning of any of the
   fields. The existing rules for "Packet Generation" and "Packet
   Reception" still apply exactly as specified in RFC 826.

   This document expands on RFC 826 by specifying:

   (1) that a specific ARP Request should be generated when an interface
       is configured, to discover if the address is already in use, and

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