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IP over Ethernet (IPoE) Session Health Checking
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Abstract

PPP over Ethernet clients have the functionality to detect path unavailability by using PPP Keepalives. IP over Ethernet does not have this functionality, and it is not specified in the IETF when an IP over Ethernet client should consider its WAN connectivity down, unless there is a physical layer link down event.

This document describes a mechanism for IP over Ethernet clients to achieve connectivity validation, similar to that of PPP over Ethernet, by using BFD Echo, or ARP and Neighbor Discovery functions.

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1. Introduction

PPP [[RFC1661](#)] makes use of regular LCP echos and replies to continually test the data link layer, if the peer fails to respond to a predetermined number of LCP echos, the PPP session is terminated and will return to the Link Dead phase, ready for reestablishing. IPoE currently lacks this functionality.

Physical link state change on an IPoE client can trigger the renewing of a DHCP lease, however any indirect upstream network changes are not visible to the IPoE client.

An outage or planned maintenance work on, for example, a Broadband Network Gateways (BNG) or intermediate DHCP Relay, can leave an IPoE client with a stale DHCP lease for up to the Valid Lifetime.

IPoE Session Health Check allows for an IPoE client to proactively or passively monitor the state of upstream connectivity, and defines several actions that may be taken to help the client recover.

[[TR-146](#)], Section 6.2 describes this problem, while [[TR-124](#)] identifies some requirements to solve the problem.

Several vendors have implemented subscriber connectivity checking on their BNG, using ARP and Neighbor Discovery as per Sections [6.2.4](#) and [6.2.5](#) of [[TR-146](#)]. This allows the BNG to detect loss of connectivity and to update local session state and DHCP lease bindings. Without reciprocal checking, this puts the CE at further risk of being in a stale state.

1.1. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [BCP 14](#) [[RFC2119](#)] [[RFC8174](#)] when, and only when, they appear in all capitals, as shown here.

[1.2.](#) Terminology

This document makes use of the following terms:

- o BNG: Broadband Network Gateway. Often also running a DHCP server or relay.
- o CE: Customer Equipment. aka. Customer Premise Equipment (CPE), Residential Gateway (RG).
- o IPoE: IP over Ethernet.

- o IPoE Client: A network device, often a CE, running a DHCPv4 and/or DHCPv6 client.
- o IPoE Health Check: The name of the process described in this document.

[2.](#) Alternative Mitigations

- o Short DHCP lease times reduce the time a client may be left in a stale state, but scale poorly, putting extra load on the DHCP server.
- o Broadband Forum's [\[TR-146\]](#) and [\[TR-124\]](#) discuss this problem and recommend the use of BFD echo [\[RFC5880\]](#). This document acknowledges TR-146 and recommends the use of BFD echo for health checks, but like the Broadband Forum, acknowledges that it is not widely available within consumer CEs. This document also introduces alternative actions, as the renew approach taken in TR-146 is susceptible to the issues described in Behaviour 0 ([Section 5.1](#)).
- o For planned maintenance, network engineers could include DHCPv4 Force Renew [\[RFC3203\]](#) or DHCPv6 Reconfigure [\[RFC3315\]](#)-bis in their maintenance plans, however neither of these have been widely adopted by CE or BNG vendors due to authentication complexity.

[3.](#) IPoE Health Checks

[3.1.](#) Parameters

IPoE Health Check uses the following parameters:

- o Interval (Integer): The frequency in seconds, which health checks are sent by the IPoE client. Default value: 120 seconds.
- o Retry Interval (Integer): The frequency in seconds, which health checks are sent by the IPoE client, after a failure. Default value: 10 seconds.
- o Limit (Integer): The number of failed consecutive checks before an action is taken. Default value: 3.
- o Behaviour (Integer): Specifies what actions are to be taken when triggered. Default value: 0.
- o Passive (Boolean): Forces passive health checks instead of active. Default: False.

- o Layer2 (Boolean): Forces layer 2 health checks instead of BFD echo. Default: False.
- o Alternative Target Address (IP address): Overrides the default target of health checks.

An IPoE client supporting IPoE Health Check SHOULD begin sending health checks at the Interval specified, upon successful binding of a lease that contains a valid IPoE Health Check DHCP Option ([Section 4](#)).

An IPoE client MAY be statically configured for IPoE health checks. Non-default static parameters SHOULD override any signalled via a dynamic means (e.g, DHCP or TR-69).

An IPoE client MAY use default parameters in lieu of manually configured, or dynamically signalled parameters (DHCP for example). Statically configured or dynamically signalled parameters SHOULD override any default parameters.

[3.2.](#) BFD Echo

Unless instructed otherwise, an IPoE client SHOULD use BFD Echo [[RFC5880](#)] as the health check mechanism.

The use of BFD Echo as the health check mechanism provides the added benefit of validating the DHCP lease state, proving layer 3 as well as layer 2 connectivity.

If BFD echo messages are used, the destination IP address MUST be locally bound on the IPoE client and SHOULD be from the lease triggering the IPoE Health Check.

[3.3.](#) Neighbor Discovery

If an IPoE client with active DHCPv6 leases is unable to send BFD echo messages or IPoE client is explicitly configured, it MUST send Neighbor Solicits ([Section 4.3 of \[RFC4861\]](#)) for the target address. If no Alternative Target Address is set, the target address SHOULD be the default gateway as obtained from the Operating System. Neighbor Solicits SHOULD be sent at the frequency set by the Interval parameter under normal conditions or Retry Interval when a failure is encountered ([Section 3.1](#)).

[3.4.](#) ARP

If an IPoE client with active DHCPv4 leases is unable to send BFD echo messages or IPoE client is explicitly configured, it MUST send ARP requests [[RFC0826](#)] for the target address. If no Alternative

Target Address is set, the target address SHOULD be the client's default gateway, as received within the DHCPv4 Option 3 Router option of the lease [[RFC2132](#)].

ARP requests SHOULD be sent at the frequency set by the Interval parameter under normal conditions or Retry Interval when a failure is encountered ([Section 3.1](#)).

[3.5.](#) Alternative Target

An alternative target IP address MAY be included in the IPoE health check DHCP option, or statically configured. If an alternative target address is specified, it MUST be used as the target for health checks instead of the default gateway.

If an Alternative Target Address provided is outside of a locally

attached route, health checks SHOULD implicitly fail until a matching local route is installed. If a matching locally attached route is subsequently installed, health checks SHOULD continue as normal.

The Alternative Target IP Address MUST be a valid IP address. An IPoE client MUST silently discard loopback and multicast addresses.

[3.6.](#) Passive Checks

If an IPoE client is unable to proactively send health checks itself, it SHOULD passively check the operating system's ARP and Neighbor cache tables.

In IPoE Health Check passive mode, alternate target addresses outside of locally attached routes MUST NOT be supported.

Passive IPoE health checks SHOULD use the health check parameters signalled by DHCP or configured statically ([Section 3.1](#)). The IPoE client SHOULD passively check the ARP or Neighbor cache tables for the target address, every Interval seconds. If the neighbor entry is in state INCOMPLETE, subsequent checks SHOULD BE made every Retry Interval seconds. When Limit checks have failed, the specified IPoE Health Check Action MUST be taken.

Passive-only mode can be forced either by local configuration, or by a DHCP server setting the Passive flag in the DHCP option. If passive-only mode has been set, the IPoE client MUST only use passive checking for that particular lease health check.

[4.](#) IPoE Health Check DHCP Options

This document defines a new option for both DHCPv4 and DHCPv6 servers to signal suggested health check parameters to clients.

IPoE clients SHOULD use these values when no statically configured parameters have been defined.

The option data fields are common between DHCPv6 and DHCPv4, with the

exception of the alternate target address field, which is 32 bits in the DHCPv4 option and 128 bits in the DHCPv6 option.

4.1. DHCPv6

For DHCPv6, this option (Figure 1) MUST be within a specific Identity Association as an IPoE client MAY have multiple IAs with different health check parameters.

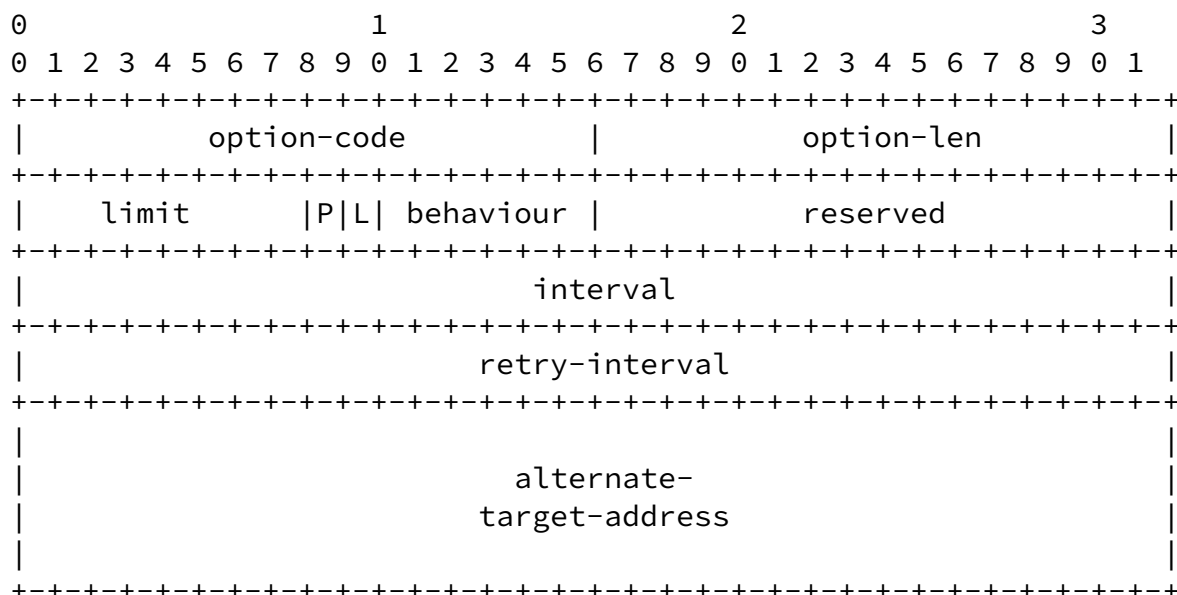


Figure 1: DHCPv6 IPoE Check Option Format

The description of the fields is as follows:

option-code: OPTION_IPOE_HEALTH (TBA1).

option-len: 28.
limit: Consecutive failed checks, before an action is taken.
P: Passive Flag. Force passive-only health checks.
L: Layer 2 Flag. Force ARP/ND-only health checks.
behaviour: The following behaviours are defined:
0: Trigger Renew ([Section 5.1](#)).
1: Trigger Rebind ([Section 5.2](#)).
2: Expire lease, start solicit phase ([Section 5.3](#)).
3: Release ([Section 5.4](#)).
4 - 63: Unassigned.
New behaviour codes can be assigned in the future.
interval: Indicates how often a health check should be sent when no failure is encountered. Expressed in units of seconds.
retry-interval: Indicates how often a health check should be sent after a previous failure. Expressed in units of seconds.
alternate-target-address: Optional health check target address. MUST always present; it MUST be set to zero if no alternate IP address is to be used. This field MUST NOT include loopback or multicast addresses.

4.2. DHCPv4

The DHCPv4 client can retrieve IPoE Health Check information by including OPTION_IPOE_HEALTH in a Parameter Request List option [[RFC2132](#)].

Figure 2 shows the DHCPv4 IPoE Health Check option.

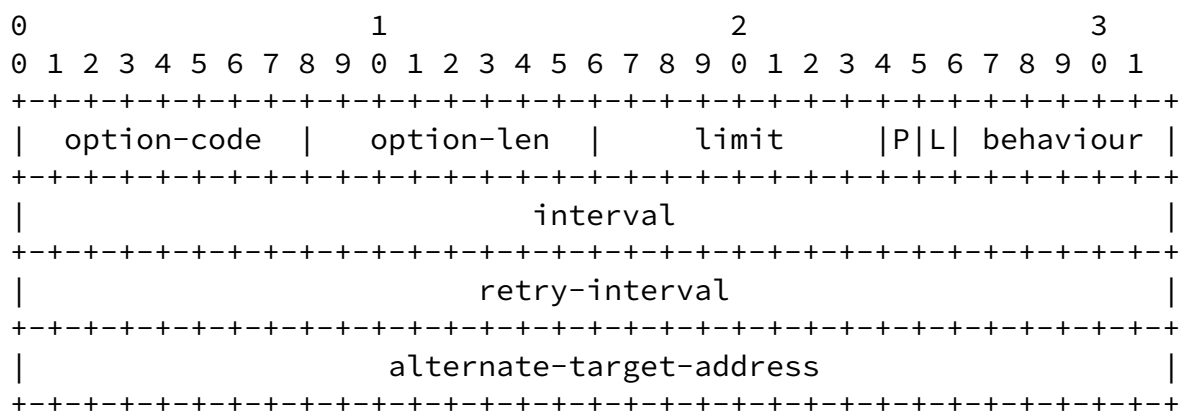


Figure 2: DHCPv4 IPoE Health Check Option Format

The description of the fields is as follows:

option-code: OPTION_IPOE_HEALTH (TBA2).
option-len: 14.
limit: Consecutive failed checks, before an action is taken.
P: Passive Flag. Force passive-only health checks.
L: Layer 2 Flag. Force ARP/ND-only health checks.
behaviour: The following behaviours are defined:
 0: Trigger Renew ([Section 5.1](#)).
 1: Trigger Rebind ([Section 5.2](#)).
 2: Expire lease, start solicit phase ([Section 5.3](#)).
 3: Release ([Section 5.4](#)).
 4 - 63: Unassigned.
 New behaviour codes can be assigned in the future.
interval: Indicates how often a health check should be sent when
 no failure is encountered. Expressed in units of seconds.
retry-interval: Indicates how often a health check should be sent
 after a previous failure. Expressed in units of seconds.
alternate-target-address: Optional health check target address.
 MUST always be present; it MUST be set to zero if no
 alternate IP address is to be used. This field MUST NOT
 include loopback or multicast addresses.

5. Action Behaviours

IPoE Health Check defines four configurable behaviours once the timeout threshold has been reached. All these behaviours make use of existing procedures outlined in [\[RFC2131\]](#), [Section 4.4.5](#) for DHCPv4, and [\[RFC3315\]](#)-bis, [Sections 18.2.4](#), [18.2.5](#) for DHCPv6.

The IPoE Health Check behaviour MAY be signalled per lease by DHCP, or statically configured. Statically configured, non-default, behaviour settings SHOULD take precedence over those signalled by DHCP.

When triggering a DISCOVER or SOLICIT, an IPoE client may also choose to use Rapid Commit [\[RFC4039\]](#), [\[RFC3315\]](#), [Section 22.14](#) to help expedite the recovery process.

5.1. Behaviour 0: Renew (Default)

After Limit ([Section 3.1](#)) consecutive check failures, the IPoE client MUST set T1 of the specified lease, to zero. This will trigger a RENEW to the original DHCP server, as per [\[RFC3315\]](#)-bis and [\[RFC2131\]](#).

If connectivity to the original DHCP server has recovered, and the server can satisfy the request, the lease may be renewed and timers

updated.

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If the original DHCP server cannot satisfy the request, it may reject the request, to which the DHCP client should begin discovery or solicit phase anew.

Neither of the above two responses are guaranteed, and as such, an administrator may elect to use one of the below additional behaviours to help expedite the IPoE client's recovery process.

Unless specified otherwise, additional actions **MUST** also be taken if the IPoE Health Check DHCP option Behaviour bits are non-zero. Some behaviours may offer alternative actions instead of compound ones, they will state this specifically.

[5.2.](#) Behaviour 1: Rebind

If the Behaviour field is set to 1, T2 **MUST** also be set to zero, along with T1. This tells the IPoE client to immediately move to the rebind phase, attempting to renew the lease from any available server.

This method can be useful in a resilient layer 2 access topology, with multiple active DHCP servers.

[5.3.](#) Behaviour 2: Solicit

If the Behaviour field is set to 2, T1 and T2 **MUST** both be set to zero as per previous behaviours.

The IPoE client **MUST** skip the renew and rebind phases, moving straight to the discovery or solicit phase.

The IPoE client **MUST NOT** send a DHCP RELEASE.

The IPoE client **MUST** keep the address or prefix in the preferred state until the preferred lifetime expires, and **MUST** keep the address or prefix until the valid lifetime expires.

The IPoE client **SHOULD** include the lease address or prefix in the DISCOVER or SOLICIT.

The DUID and IAID MUST be the same as used in the current lease.

This method can be useful when using DHCP servers that silently discard unknown renew attempts instead of sending back a DHCPv4 NAK or DHCPv6 Reply.

[5.4.](#) Behaviour 3: Expire & Release

If the Behaviour field is set to 3, T1, T2, and Valid Lifetime MUST all be set to 0, and the IPoE Client MUST send a DHCP RELEASE message as per [\[RFC2131\], Section 3.1](#) for DHCPv4 and [\[RFC3315\]-bis, Section 18.2.7](#)

Once the RELEASE process has completed, the client returns to the discovery or solicit phase.

If the IPoE client is already in the renew or rebind state when Behaviour 3 is triggered, the client MUST cease renew or rebind attempts and wait for any outstanding messages to time out before sending a RELEASE. If an outstanding renew or rebind attempt is successful, the IPoE client MUST update T1, T2 and lease lifetimes appropriately, and MUST NOT continue with Behaviour 3.

This method can be useful to clean out state within the network. For example, a DHCP relay may be left with stale lease information after an outage or maintenance on a DHCP server.

[5.5.](#) LAN Considerations

If all DHCPv6 leases have expired, either naturally or proactively with IPoE health checks, it is expected that an IPoE client acting as a router, would withdraw itself as a default router on the LAN, following requirement G-5 of [\[RFC7084\], Section 4.1](#).

[6.](#) Multihomed Clients

An IPoE client may have multiple leases from the same, or different DHCP servers. These leases may have different IPoE health check

parameters, and health checks MUST be treated distinctly, tracking the particular lease that they belong to.

Each distinct IPoE health check MUST use an appropriate target address as per IPoE Health Check ([Section 3](#)).

If an IPoE client is configured with multiple IPoE Health Checks that use the same target address, it SHOULD suppress additional checks, preferring the parameters with the lowest timeout value.

I.e. $\text{Timeout} = \text{Interval} + \text{Retry Interval} * (\text{Limit} - 1)$

Local network administrators may choose to override DHCP-signalled parameters in order to facilitate appropriate IPoE Health Check operation in a multihomed environment.

[6.1.](#) Neighbor Discovery

As DHCPv6 does not convey default gateway or other routing information, an IPoE client using the ND health check method SHOULD obtain the target address by querying the operating system for default routes.

If multiple default routes exist, ND-based IPoE health checks SHOULD attempt to match the target address to the lease by the interface the lease is bound to.

If only a single default route exists, and that default route is not routed out the interface the lease was bound to, ND-based health checks for that particular lease SHOULD be paused.

[6.2.](#) ARP

ARP-based IPoE health checks for DHCPv4 make use of the default gateway address specified in the lease. As a route for each gateway should exist regardless of current route preference, health checks SHOULD be run for each lease that is configured for IPoE health check.

[7.](#) Security Considerations

IPoE Health Check frequency would typically be controlled by the network using DHCP options, but overly aggressive, statically configured IPoE Health Checks, could have an adverse impact. For example, this may induce an overload on the IP access nodes.

ARP and Neighbor Discovery may be subject to protections outlined in [RFC6192]; Interval and Retry Interval values SHOULD NOT be set too aggressively and upstream routers SHOULD ensure that sufficient quantities of this traffic are permitted to safely ingress the control plane.

Unlike ARP and ND, BFD echo uses an IP packet destined for the IPoE client, the peer forwards the packet back to the IPoE client without any local processing.

Behaviour 2 ([Section 5.3](#)) introduces a privacy risk, possibly leaking lease information if the IPoE client has been moved to a different network, e.g., from one fixed line provider to another.

8. IANA Considerations

IANA is requested to assign a new DHCPv6 Option Code in the registry maintained in <http://www.iana.org/assignments/dhcpv6-parameters> [1]:

Option Name	Value
OPTION_IPOE_HEALTH	TBA1

Also, IANA is requested to assign the following new DHCPv4 Option Code in the registry maintained in <http://www.iana.org/assignments/bootp-dhcp-parameters> [2]:

Option Name	Tag	Data Length	Meaning
OPTION_IPOE_HEALTH	TBA2	14	Provides a set of IPoE check configuration information.

This document requests IANA to create a new registry called "IPoE Check Behaviours" (under <https://www.iana.org/assignments/dhcpv6-parameters/dhcpv6-parameters.xhtml>).

This registry is initially populated with the following values:

Value	Description	Reference
0	Trigger Renew	[ThisRFC]
1	Trigger Rebind	[ThisRFC]
2	Expire lease	[ThisRFC]
3	Release	[ThisRFC]

Values in the range 4-63 are assigned via the "IETF Review" policy defined in [RFC8126].

The same registry is used for both DHCPv4 and DHCPv6.

9. Acknowledgements

The authors would like thank Ian Farrer, Dusan Mudric, Mohamed Boucadair, Jean-Yves Cloarec, Bernie Volz, Dave Freedman, and Job Snijders for their review and comments on this and previous versions of this document.

10. Appendix A. Changes from -00

This section should be removed by the RFC Editor.

- o Added reference to TR-146.

- o Added BFD Echo section, and wording to prefer it as the health check mechanism over ARP/ND, if available.

11. Appendix B. Changes from -01

This section should be removed by the RFC Editor.

- o Emphasised preference for use of BFD echo as the health check mechanism.
- o Removed lifetime expiration from Behaviour 2 and clarified usage.

- o Updated Behaviour 3 with instructions for whilst mid-renew/rebind.
- o Reworded multihoming section.
- o Added Acknowledgements.

12. Appendix C. Changes from -02

This section should be removed by the RFC Editor.

- o Added DHCP option flag to force ARP/ND for health checks.
- o Populated IANA Considerations.
- o Added Retry Interval distinct timer for between failed checks.
- o Added default parameter values.

13. Appendix D. Changes from -03

This section should be removed by the RFC Editor.

- o Reduced default Limit value.
- o Formatting and minor cosmetic changes.

14. References

14.1. Normative References

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- [TR-124] "Functional Requirements for Broadband Residential Gateway Devices", 2006, <<https://www.broadband-forum.org/technical/download/TR-124.pdf>>.
- [TR-146] "Subscriber Sessions", 2013, <<https://www.broadband-forum.org/technical/download/TR-146.pdf>>.

[14.3](#). URIs

- [1] <http://www.iana.org/assignments/dhcpv6-parameters>
- [2] <http://www.iana.org/assignments/bootp-dhcp-parameters>

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