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# Gap Analysis for IPv4 Sunset
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Abstract

Sunsetting IPv4 refers to the process of turning off IPv4 definitively. It can be seen as the final phase of the migration to IPv6. This memo enumerates difficulties arising when sunsetting IPv4, and identifies the gaps requiring additional work.

Table of Contents



## 1. Introduction

The final phase of the migration to IPv6 is the sunset of IPv4, that is turning off IPv4 definitively on the attached networks and on the upstream networks.

Some current implementation behavior makes it hard to sunset IPv4. Additionally, some new features could be added to IPv4 to make its sunsetting easier. This document analyzes the current situation and proposes new work in this area.

The decision about when to turn off IPv4 is out of scope. This document merely attempts to enumerate the issues one might encounter if that decision is made.

## 2. Related Work

[RFC3789], [RFC3790],[RFC3791], [RFC3792], [RFC3793], [RFC3794], [RFC3795] and [RFC3796] contain surveys of IETF protocols with their IPv4 dependencies.

## 3. Remotely Disabling IPv4

### 3.1. Indicating that IPv4 connectivity is unavailable

PROBLEM 1: When an IPv4 node boots and requests an IPv4 address (e.g., using DHCP), it typically interprets the absence of a response as a failure condition even when it is not.

PROBLEM 2: Home router devices often identify themselves as default routers in DHCP responses that they send to requests coming from the LAN, even in the absence of IPv4 connectivity on the WAN.

One way to address these issues is to send a signal to a dual-stack node that IPv4 connectivity is unavailable. Given that IPv4 shall be off, the message must be delivered through IPv6.

### 3.2. Disabling IPv4 in the LAN

PROBLEM 3: IPv4-enabled hosts inside an IPv6-only LAN can auto-configure IPv4 addresses [RFC3927] and enable various protocols over IPv4 such as mDNS [I-D.cheshire-dnsext-multicastdns] and LLMNR [RFC4795]. This can be undesirable for operational or security reasons, since in the absence of IPv4, no monitoring or logging of IPv4 will be in place.

PROBLEM 4: IPv4 can be completely disabled on a link by filtering it on the L2 switching device. However, this may not be possible in all cases or may be too complex to deploy. For example, an ISP is often not able to control the L2 switching device in the subscriber home network.

One way to address these issues is to send a signal to a dual-stack node that auto-configuration of IPv4 addresses is undesirable, or that direct IPv4 communication between nodes on the same link should not take place.

This problem was described in [RFC2563], which standardized a DHCP option to disable IPv4 address auto-configuration. However, using this option requires running an IPv4 DHCP server, which is contrary to the goal of IPv4 sunsetting. An equivalent way of signalling this over IPv6 is necessary, using either Router Advertisements or DHCPv6.

Furthermore, it could be useful to have L2 switches snoop this signalling and automatically start filtering IPv4 traffic as a consequence.

Finally, it could be useful to publish guidelines on how to safely block IPv4 on an L2 switch.

## 4. Client Connection Establishment Behavior

PROBLEM 5: Happy Eyeballs [RFC6555] refers to multiple approaches to dual-stack client implementations that try to reduce connection setup delays by trying both IPv4 and IPv6 paths simultaneously. Some implementations introduce delays which provide an advantage to IPv6, while others do not [Huston2012]. The latter will pick the fastest path, no matter whether it is over IPv4 or IPv6, directing more traffic over IPv4 than the other kind of implementations. This can prove problematic in the context of IPv4 sunsetting, especially for Carrier-Grade NAT phasing out because CGN does not add significant latency that would make the IPv6 path more preferable. Traffic will therefore continue using the CGN path unless other network conditions change.

PROBLEM 6: getaddrinfo() [RFC3493] sends DNS queries for both A and AAAA records regardless of the state of IPv4 or IPv6 availability. The AI_ADDRCONFIG flag can be used to change this behavior, but it relies on programmers using the getaddrinfo() function to always pass this flag to the function. The current situation is that in an IPv6-only environment, many useless A queries are made.

Recommendations on client connection establishment behavior that would facilitate IPv4 sunsetting are therefore appropriate.

## 5. Disabling IPv4 in Operating System and Applications

PROBLEM 7: Completely disabling IPv4 at runtime often reveals implementation bugs. Hard-coded dependencies on IPv4 abound, such as on the 127.0.0.1 address assigned to the loopback interface. It is therefore often operationally impossible to completely disable IPv4 on individual nodes.

PROBLEM 8: In an IPv6-only world, legacy IPv4 code in operating systems and applications incurs a maintenance overhead and can present security risks.

It is possible to completely remove IPv4 support from an operating system as has been shown by the work of Bjoern Zeeb on FreeBSD. [Zeeb] Removing IPv4 support in the kernel revealed many IPv4 dependencies in libraries and applications.

It would be useful for the IETF to provide guidelines to programmers on how to avoid creating dependencies on IPv4, how to discover existing dependencies, and how to eliminate them. Having programs and operating systems that behave well in an IPv6-only environment is a prerequisite for IPv4 sunsetting.

## 6. On-Demand Provisioning of IPv4 Addresses

As IPv6 usage climbs, the usefulness of IPv4 addresses to subscribers will become smaller. This could be exploited by an ISP to save IPv4 addresses by provisioning them on-demand to subscribers and reclaiming them when they are no longer used. This idea is described in [I-D.fleischhauer-ipv4-addr-saving] and [BBF.TR242] for the context of PPP sessions. In these scenarios, the home router is responsible for requesting and releasing IPv4 addresses, based on snooping the traffic generated by the hosts in the LAN, which are still dual-stack and unaware that their traffic is being snooped.

PROBLEM 9: Dual-stack hosts that implement Happy-Eyeballs [RFC6555] will generate both IPv4 and IPv6 traffic even if the algorithm end up chooosing IPv6. This means that an IPv4 address will always be requested by the home router, which defeats the purpose of on-demand provisioning.

PROBLEM 10: Many operating systems periodically perform some kind of network connectivity check as long as an interface is up. Similarly, applications often send keep-alive traffic continuously. This permanent "background noise" will prevent an IPv4 address from being released by the home router.

PROBLEM 11: Hosts in the LAN have no knowledge that IPv4 is available to them on-demand only. If they had explicit knowledge of this fact, they could tune their behaviour so as to be more conservative in their use of IPv4.

PROBLEM 12: This mechanism is only being proposed for PPP even though it could apply to other provisioning protocols (e.g., DHCP).

## 7. IANA Considerations

None.

## 8. Security Considerations

TODO

## 9. Acknowledgements

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