IPv4 Sunset

All good (legacy) things must come to an end

Carsten Strotmann

CREATED: 2025-01-30 THU 09:51

Agenda

- The costs of dual-stack operation
- Going IPv6-only
- Islands of IPv4
- IPv4 sunset in the Internet
- Purchase

The cost of dual stack operation

Dual-Stack = Dual-Costs

- Running a network in "Dual-Stack" mode with both IPv6 and IPv4 enabled creates additional costs
    - Additional network and routing configuration
    - Almost double the cost for network security (additional Firewall configuration, security audit, patches, more complexity = bad for security)
    - Extra work for troubleshooting, network issues can appear in either IPv6 or IPv4 or can be a interaction between the two protocols

Move IPv4 to "historic" status

- While there has been attempts in the IETF to deprecate IPv4 (see ↪IETF: End Work on IPv4), IPv4 is still needed in the Internet
  - The Internet will be "dual-stack" for a long time
  - External Services (Web-Server, E-Mail-Server, DNS-Server ...) will require Dual-Stack connectivity for the foreseeable future

- However it is possible to remove IPv4 in some (possibly not all) internal networks

Going "IPv6-only"

How to remove IPv4 from the network

- In most networks, it is not feasible to remove IPv4 entirely
    - There are devices that don't (fully) support IPv6 and probably never will (e.g. older medical equipment, expensive factory machines, long living infrastructure devices)
    - But every network segment without IPv4 reduces the operational costs
    - Compare the costs of modernizing parts of the network infrastructure vs the costs of operating a "dual-stack" network

Selecting IPv6-only networks

- Watch out for networks that …
    - have a low diversity in the devices operating systems and applications
    - have a high level of operational/administrative control over the devices in the network

Find "low hanging fruits"

- Wireless Networks
  - Dedicated IPv6-only wireless network for the administration team
    - Good way to gain experience with IPv6-only networks

  - IPv6-only network for application developer
    - Developer of Apple iOS application require this, as they need to test applications in IPv6-only networks as demanded by the Apple App-Store

Find "low hanging fruits"

- Guest-Wireless-Networks
  - Mobile devices (Phones, Tablets, Laptops) with "standard" applications (E-Mail, MS Office, Web-Browser) work fine in an IPv6-only environment
  - Use DNS64/NAT64 to allow access to IPv4-only resources on the Internet

Find "low hanging fruits"

- Phone/VoIP networks
    - Limited number of device types
    - High level of operational control
    - Work with the vendor towards an IPv6-only VoIP network

Find "low hanging fruits"

- Data-center networks
    - Data-Center networks are usually a very controlled environment (unless you offer hosting services)
    - IPv4 traffic can be terminated at the entry gateway to the data-center and "converted" to IPv6 (via protocol-proxy or application-proxy)

Find "low hanging fruits"

- All data-center internal traffic will be IPv6
- The IETF have published some documents about transition technologies that help with IPv6-only data-center
    - ↪SIIT-DC: Stateless IP/ICMP Translation for IPv6 Data Center Environments
    - ↪Stateless IP/ICMP Translation for IPv6 Internet Data Center Environments (SIIT-DC): Dual Translation Mode
    - ↪Explicit Address Mappings for Stateless IP/ICMP Translation

Find "low hanging fruits"

- Administration networks (dedicated networks that are separate from the production networks)
    - Highly controlled
    - Limited number of users with higher-than-normal networking skills
    - be aware of monitoring applications
        - The Monitoring should still be able to reach IPv4 devices and services

Find "low hanging fruits"

- Office Networks can be a candidate for IPv6-only networks
    - degree of "control" and "device diversity" differs between organizations
    - Case study: ↪IPv6-only at Microsoft

IPv6 "mostly"

IPv6 "mostly"

- Internet Draft: ↪IPv6-Mostly Networks: Deployment and Operations Considerations
- An IPv6-mostly network is very much similar to a dual-stack one with two additional key elements:
    - The network provides NAT64 functionality, enabling IPv6-only clients to communicate with IPv4-only destinations
    - The DHCPv4 server infrastructure offers DHCPv4 Option 108 (↪RFC 8925 - "IPv6-Only Preferred Option for DHCPv4").

- A client indicates (via DHCP) that it does not need an IPv4 address if the network provides IPv6-only connectivity

IPv6 "mostly"

- Being a client/server protocol, DHCPv4 allows IPv4 to be selectively disabled on a per-host basis on a given network segment
- Statistics from the DHCP server allow the admin to see the percentage of IPv6-only capable hosts (or if IPv4 is still needed in a particular network segment)

IPv6 "mostly" benefits

- Drastically reduced IPv4 consumption
- Controlled and incremental phase-out of IPv4
- Reduced dependency on DHCPv4
- Simplified troubleshooting due reduced impact of Happy Eyeballs

IPv6 "mostly" - Support for "IPv6-Only Preferred Option"

- Kea DHCP since version 2.2
- FreeBSD "dhcpd"
- Trivial to implement this option in almost any DHCP server

IPv6 "mostly" - Support for "IPv6-Only Preferred Option"

- Apple macOS versions starting with version 12.01
- Apple iOS
- Linux with Systemd since version 255
- Microsoft plans to support the "IPv6-Only Preferred Option"
  ↪in a future version of Windows 11

Keeping islands of IPv4 where needed

IPv4 in IPv6-only networks

- Devices and applications that require IPv4 connectivity can operate in an IPv6-only network with the help of IPv6-to-IPv4 translation services (aka "IPv4 as a Service" or IPv4aaS):
    - ↪RFC 6877 - 464XLAT: Combination of Stateful and Stateless Translation
    - ↪RFC 6146 - "Stateful NAT64: Network Address and Protocol Translation from IPv6 Clients to IPv4 Servers

IPv4 in IPv6-only networks

- RFC 8925 defines a new DHCPv4 option that helps implementing IPv6-mostly (or IPv4-on-demand) segments where IPv6-only hosts coexist with legacy dual-stack devices: ↪IPv6-Only Preferred Option for DHCPv4
  - Modern client machines can indicate that they can operate in an IPv6-only environment
  - DHCPv4 server can inform the DHCPv4 clients that the current attached network permits/prefers IPv6-only operation

Protocol Switch with the help of Application-Proxies

- Application Proxies can be used to switch an TCP/IP connection from IPv4 to IPv6 or back
    - This is an application level gateway type of service
    - It can negatively affect performance and latency of a network or a service
    - Examples:
        - HTTP/Web-Proxy from an IPv6-only LAN towards the Dual-Stack Internet
        - HTTP Reverse-Proxy to offer a website on an IPv6-only web-server towards IPv4 clients

- Application Proxies break end-to-end encryption and might not work with all protocols

Protocol Switch with the help of Protocol-Proxies

Protocol Switch with the help of Protocol-Proxies

- Proxies can be set up separately from target systems and applications
    - They are transparent to most applications (i.e., no customization, such as a special proxy configuration, is required on either the client side or the target system)

    - Application and protocol proxies are available as open source Software (e.g. HA-Proxy, NGINX, OpenBSD "relayd") and as commercial solutions (mostly appliances).

IPv4 sunset on the Internet

Quality of IPv4

- Because of the use of IPv4-in-IPv6 tunneling, the quality of IPv4 connectivity is decreasing
  - DS-Lite
  - 464XLAT

- IPv4 might be broken for users on the Internet

IPv6 Service offerings must work IPv6-only

- Internet-User with broken IPv4 are using an IPv6-only Internet
- Websites and other Internet Services must work in this IPv6-only scenario
- Test external facing services in IPv6-only mode
    - Websites (do all resources load over IPv6?)
    - API Endpoints
    - Authoritative DNS server
    - SMTP Mail

Purchase of ITC Equipment

Purchase of ITC Equipment

- RFPs, Contracts, etc: All products, support sites, etc MUST NOT require IPv4
    - Communicate to vendors early to give them time to find and fix problems
    - Get confirmation about IPv6(-only) support (RFC 8504) in writing from vendors

Purchase of ITC Equipment

- Documents that help with ITC RFPs:
    - ↪RFC 8504 - IPv6 Node Requirements
    - ↪RIPE 772 "Requirements for IPv6 in ICT Equipment"

Questions?