IPv6 Keynote
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Per-Country IPv6 adoption

Slovenia
IPv6 Adoption: 6.8%
Latency / impact: 0ms / -0.01%
Use of IPv6 for Slovenia (SI)
The IESG has approved the following document:
- 'Internet Protocol, Version 6 (IPv6) Specification'
  (draft-ietf-6man-rfc2460bis-13.txt) as Internet Standard

This document is the product of the IPv6 Maintenance Working Group.

The IESG contact persons are Suresh Krishnan and Terry Manderson.

A URL of this Internet Draft is: https://datatracker.ietf.org/doc/draft-ietf-6man-rfc2460bis/
This talk

• Why is IPv6 what it is…
• The tussle
• The compromises
• Where we go from here
Why IPv6 is what it is…

• The Problem: We’re running out of IPv4 addresses

• A balance of changing too *much* or changing too *little*

• Internet architecture goals and principles

• The tussle
“Why isn’t IPv6 backwards compatible with IPv4?”
“Because IPv4 offered no forward compatibility”

–Steve Deering
Lost features of the Internet

- transparency
- robustness through “fate sharing”
- dynamic routing
- unique addresses
- stable addresses
- connectionless service
- always-on service
- peer-to-peer communication model
- application independence
“IP should be as ubiquitous as electricity”
Steve Deering: Watching the waste of the protocol hourglass, IETF51
Putting on Weight

- requires more functionality from underlying networks
Mid-Life Crisis

- doubles number of service interfaces
- requires changes above & below
- creates interoperability problems
Oops!
An Accident

- NATs & ALGs used to glue the broken pieces
- lots of kinds of new glue being invented—ruins predictability
- some apps remain broken, since repairs are incomplete
More Fattening Temptations

- TCP “helpers”
- reliable multicast assists
- packet-intercepting caches
- “content-based routing”
- active networking
Threatened by Youths

- danger: creeping dependencies on specific link-layers inhibit flexibility and evolution
- will never fully supplant IP, so end up with complicated hybrid & more address plans
But Still Supple

- IP-over-IP tunneling has become more and more common
- this is not so bad: retains benefits of hourglass model
A Fitness Goal

• perhaps we can trim down from an hourglass to a wineglass

• promising signs: IP-over-SONET, IP-over-WDM

• IPv6 to restore simplicity and functionality
IPv6 Solution

• No magic just 96 more bits - Simple evolution of IPv4 (SIP)

• 128 bit addressing

• Fixed size header (IPv4 has variable length). Optimized header (remove fragment information, checksum…)

• Replace IPv4 options with IPv6 Extension headers

• Generalise link-specific address resolution / host configuration into the network layer
  IPCP, ARP

• Limit changes to the network layer. No changes to transport protocols
• There are many players involved in the Internet with interests directly at odds with each other

• The technical architecture must accommodate societies tussle. While continuing to solve the traditional goals (i.e. solve problems)
The players

- Users
- Internet Service Providers
- Content and services providers
- Governments
- Intellectual property holders
- ...

...
Dealing with the tussle

- Modularise the design around tussle boundaries
- Flexible design to permit different players to express their differences
- Tilting the playing field
Tussle spaces

- Economics
  - Consumers tussle with providers to the services they want at a low price
    - Lock in with IP addresses
    - Residential broadband access
- Trust
  - Open end to end communication in a low-trust environment
  - Users don’t trust the parties they want to talk with either
  - Nor trust the software they have to run
  - Content providers want to monetise information about the user, while the user wants privacy
- Openness
  - ISPs dislike and fear openness
  - Openness to innovation
Protocol Politics

- Internet protocols are not value neutral
- Separation of policy and mechanism
  - Isolate parts of the system against the tussle
- End to end argument
  - State that a mechanism should not be placed in the network if it can be placed on the end node
- Cost and benefit must be aligned
- New protocols aren’t deployed if they don’t offer opportunity for competition
- **Keeping the net open and transparent for new applications is the most important goal**
- Peeking is irresistible
Compromises

• Addressing

• Extension headers

• Host configuration (DHCP, ND)

• Minimise changes to network layer
Tussle #1 - Addressing

• 64 bit addresses are clearly enough

• VLA vs 64-bit proponents => 128 bit addresses
  Variable length addresses decay to fixed length anyway
  Performance in routing lookup

• 8+8 proposal led to half of the bits to the hosts and half to the network. Resurfaced as ILNP

• Fifty eight ways of getting an IID
64 bit boundary (RFC7421)

<table>
<thead>
<tr>
<th>n bits</th>
<th>m bits</th>
<th>128-n-m bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>global routing prefix</td>
<td>subnet ID</td>
<td>interface ID</td>
</tr>
</tbody>
</table>

• 64 bit boundary ensures users would always get enough addresses. By numbering links providers can not give less than a /64

• Allow for 8+8, now ILNP

• Technically justifiable when IID was based on EUI-64… what about now?

• What about new proposals like instead of /64 to the link, /64 to the host? Or addressing of applications or addressing of chunks of data?

• Conundrum: Ensure implementations do the right thing, while at the same time…
Tussle #2: Host configuration

- SLAAC vs DHCP
  - Control in the network or Control by the host?
- ND RA or DHCP Default router configuration
- DNS recursive resolver configuration
- Duplicate all functions?
Tussle #3 Extension headers

+---------------+------------------------
|  IPv6 header  | TCP header + data      |
|               |                        |
| Next Header = | TCP                    |
| TCP           |                        |
+---------------+------------------------

+---------------+-----------------+------------------------
|  IPv6 header  | Routing header  | TCP header + data      |
|               |                |                        |
| Next Header = | Next Header =   | TCP                    |
| Routing       | Routing        |                         |
+---------------+-----------------+------------------------

+---------------+-----------------+-----------------+------------------------
|  IPv6 header  | Routing header  | Fragment header | fragment of TCP        |
|               |                |                 | header + data          |
| Next Header = | Next Header =   | Next Header =   |                         |
| Routing       | Fragment       | TCP             |                         |
+---------------+-----------------+-----------------+------------------------
In hindsight...

• Made “NAT” a part of the architecture. ILNP
• Removed fragmentation from the network layer
• Multi-access links are gone
• Not sure what to do with extension headers
• Required a session-layer / modified transport. Fundamental for multi-homing, mobility…
• Push the hard problems to transport
• Not expose IP addresses to the transport layer and above
Is the IPv6 transition a tussle?

IPv4 only => IPv6 over IPv4 => Dual stack => IPv4 over IPv6 => IPv6 only
IPv4 in the face of address exhaustion

- Sharing public IPv4 addresses among more and more users
- Network routing on IP addresses + UDP/TCP ports (A+P)
- What do you think will happen with packets without the L4 information? IP fragments…
32 + 16 > 128
Current Status

- IPv6 deployment growing healthily
- IPv6 becoming native transport and IPv4 as a service
- But no clear view on when IPv4 can be turned off. Perhaps IPv4 is just an “application” of the network forever, like any other “VPN”.
- IPv4 is evolving into A+P with new transport protocols on top.
- Lots of new development e.g. in open source land are IPv4 only
Future of networking

- Everything is becoming programmable
- Decomposition of the network functions
- Open source vs open standards
- The end to end Internet?
DFIU: Deploy IPv6