Experiences from an IPv6-Only World at Ericsson

What if there was no IPv4?

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Moving to an IPv6-Only Network

Our sites had been in dual stack for years.
It all worked very well, so clearly we had to try something else.

› At some point someone will move to this type of a network.

We had several goals:

› Find out what works or breaks with IPv6-only
› Build an understanding to recommend dual stack and IPv6-only for the right situations
› Test our implementations
The IPv6-Only Experience

Three sites, a small group of opt-in users
IPv6-only network design
  - NAT64 + DNS64 in various configurations on the different sites
  - IPv6 was already in 24x7 use, dual stack retained as alternate
Plenty of things work well
  - Browsing, e-mail, software updates, streaming, many chat systems
On some handsets, 100% functionality
Some issues in general environments
  - Host OS testing issues, usability, some applications fail, some appliances have no IPv6, some firewall issues
### Example Issues in Messaging and Gaming

<table>
<thead>
<tr>
<th>Messaging System</th>
<th>Works?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facebook on the web (http)</td>
<td>Yes</td>
</tr>
<tr>
<td>Facebook via a client (xmpp)</td>
<td>Yes</td>
</tr>
<tr>
<td>Jabber.org chat service (xmpp)</td>
<td>Yes</td>
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<tr>
<td>Gmail chat on the web (http)</td>
<td>Yes</td>
</tr>
<tr>
<td>Gmail chat via a client (xmpp)</td>
<td>Yes</td>
</tr>
<tr>
<td>Gtalk client</td>
<td>No</td>
</tr>
<tr>
<td>AIM (AOL)</td>
<td>No</td>
</tr>
<tr>
<td>ICQ (AOL)</td>
<td>No</td>
</tr>
<tr>
<td>Skype</td>
<td>No</td>
</tr>
<tr>
<td>MSN</td>
<td>No</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Game</th>
<th>Works in LAN/NW mode?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web-based (e.g. armorgames)</td>
<td>Yes</td>
</tr>
<tr>
<td>Runescape (on the web)</td>
<td>No</td>
</tr>
<tr>
<td>Flat out 2</td>
<td>No</td>
</tr>
<tr>
<td>Battlefield</td>
<td>No</td>
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<tr>
<td>Secondlife</td>
<td>No</td>
</tr>
<tr>
<td>Guild Wars</td>
<td>No</td>
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<tr>
<td>Age of Empires</td>
<td>No</td>
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<tr>
<td>Star Wars: Empire at War</td>
<td>No</td>
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<tr>
<td>Crysis</td>
<td>No</td>
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<tr>
<td>Lord of the Rings: Conquest</td>
<td>No</td>
</tr>
<tr>
<td>Rome Total War</td>
<td>No</td>
</tr>
<tr>
<td>Lord of the Rings: Battle for Middle Earth 2</td>
<td>No</td>
</tr>
</tbody>
</table>
3.2% of Alexa top 1M web site list has an AAAA record somewhere (www.example.com, ipv6.example.com, etc.)

If we eliminate Google, this number drops to 1.1%

IPv6-only alone is a very limited experience!

NAT64 helps with this
Measured failures with IPv4 and dual stack to Alexa sites

- Base IPv4 failure rates are relatively high – over 1%
  - Due to routing, server, temporary glitch, bankruptcy, authority intervention, ...

- With dual stack to destinations with both A and AAAA records, IPv6 failure rate was double that of IPv4
  - Likely a technical issue – DNS/server state mismatch, firewall blocks IPv6, etc.

- We've seen content providers reluctant to turn IPv6 on for fear of bad IPv6 connectivity at the end user side – but this seems to work the other way, too...
Failure rates through NAT64 are similar to those with dual stack (1% / 2% for IPv4/IPv6 destinations)
- But unlike our measurement, real applications tend to allow for fallback, though not always with reasonable timeouts
- There is no such fallback in IPv6-only through a NAT64 per RFC (but this could of course still be done)

Interestingly, a NAT64 that always forces IPv4 is best!
- DNS64 never asks for AAAA and lets NAT64 always translate

This degenerate configuration has just 1% error rate
IPv4 and IPv6 delays in dual stack are very similar.

IPv4 vs. IPv6 mean RTT differences: abs(IPv6-RTT - IPv4-RTT)  
sorted by difference; negative values mirrored
IPv4 and IPv6 delays in dual stack are very similar

Percentiles show when IPv6 is slower

Notice the 5% with a significant difference

Could be packet loss or just bad IPv6 routing

IPv4 vs. IPv6 mean RTT differences: \( \text{abs}(\text{IPv6-RTT} - \text{IPv4-RTT}) \)
sorted by difference; negative values mirrored

- 50th percentile (0.09ms) for TCP
- 75th percentile (1.17ms) for TCP
- 90th percentile (2.62ms) for TCP
- 95th percentile (37.24ms) for TCP
NAT64 introduces a small delay, comparable to router/NAT44 hop (note: absolute values not very interesting)

Middle point shifts to left (but real change is minor)

This test was done with the degenerate NAT64 config: notice the small variation
With 100 top sites, 0% needed an IPv4 literal to render all components in their top page.

Beyond 100, this number increases to 2%.

Real effect unclear.

Personal experience is that the effect is negligible.
We hope that this data helps better understanding of issues and performance in various network configurations.

Specific configurations have a significant effect on failure rates, for delays there does not seem to be a big impact.

In general, dual stack should still be our preferred mode.

IPv6-only can also be recommended today:
- Particularly for early adopters, mobile networks, …
- The degenerate config would help problems with bad IPv6

And tomorrow for everyone, but this needs some work:
- Fixing bugs, DNS discovery, cleaning IPv4 literals, Skype, messaging, gaming... and much of this is a one time-effort.

More information: draft-arkko-ipv6-only-experience, Carpenter @ IEPG, Comcast IPv6 adoption monitor, IETF network IPv6-only experiment results, ...