Clear and Present Danger of IPv6
episode 2: IPv6/IPv4 fallback

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IPv6-enabled hosts are increasing

- Windows Vista has been released!
  - IPv6 enabled by default

- Still IPv6 internet is not widely deployed

- Partially-deployed ipv6 environment is sometimes troublesome...

- IPv6-to-IPv4 fallback is one of the problems
What is ‘IPv6-to-IPv4 fallback’?

  - If destination has both ipv4 and ipv6 address, end host first tries ipv6. And if it fails, then tries ipv4.
Problem is especially significant in TCP-based applications.
- They initially need to establish connection. First they try ipv6 address.
- They have to wait for timeout, and then try ipv4 address, and finally it is established.

From users’ view
- User has to wait approximately 20 seconds, until tcp connection is established and the web page starts to be displayed.
Where does fallback problem occur?

- User deployed ipv6 in their network,
- but the user does not have reachability to global ipv6 internet because:
  - the user does not buy ipv6 connectivity, or
  - upstream does not provide ipv6 connectivity.
Such cases are often?

- At present, it seems rare …
  - Vista PCs which are not assigned ipv6 address do not try ipv6.

- But near future, enterprise and home network may assign ipv6 address for some reason.
  - some ipv6 application starts to be used
  - accidentally assigned ipv6 address due to misconfigured RA.

- At that time, fallback problem will arise in case that service providers do not provide ipv6 connectivity, or users do not buy ipv6 connectivity.
How to solve this problem

The best solution
- Of course, to deploy ipv6 to all the internet; all providers. 😊

Other solutions
- Do not assign ipv6 address until ipv6 connectivity is prepared.
- Do not use ipv6 default route, but only specific routes in user network.
- DNS cache or DNS proxy server in user’s network does not relay AAAA resource record.
How to solve this problem (cont’d)

- From an architectural point of view
  - Network nodes should notify end hosts that there is no route to the destination, and end hosts should fall back from ipv6 to ipv4 according to the notification.
    - ICMPv6 Type1: Destination Unreachable
We compared the behavior of various dual-stack operating systems regarding IPv6-to-IPv4 fallback.

How do they react to the following situation? that is, how long do they take to fall back?

- No error reports from network nodes
  - (1) Timeout of connection

- Error reports from network nodes
  - (2) ICMP error
    - Mainly `ICMP destination unreachable` message

- Force to fall back
  - (3) TCP RST
    - not legitimate solution??
Fallback experiment (2)

- Measuring time required to fall back from IPv6 to IPv4 at client PC when:
  - (1) No response from network
  - (2) ICMPv6 destination unreachable returned
    - no route to dest
    - administratively prohibited
    - address unreachable
    - port unreachable
  - (3) TCP RST returned

![Diagram showing IPv6/IPv4 network with HTTP server, Client PC, Router, and IPv6/IPv4 dual-stack node with both connectivities. Filtering ipv6 packets from client.]

- A and AAAA records registered
- Returning ICMPv6 destination unreachable or TCP reset responding to the IPv6 TCP connection setup
- Filtering ipv6 packets from client.
### Results of experiments 1/3

- **Operating systems**
- **(1) No response from network:** TCP Timeout
- **(2) ICMPv6 error (Type=1: Destination unreachable):**
  - Code=0: No Route
  - Code=3: Addr Unreach
  - Code=1: Admin Prohibit
  - Code=4: Port Unreach
- **(3) Force to fallback: TCP RST**

<table>
<thead>
<tr>
<th>Operating Systems</th>
<th>(1) No response from network: TCP Timeout</th>
<th>(2) ICMPv6 error (Type=1: Destination unreachable)</th>
<th>(3) Force to fallback TCP RST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vista RC2</td>
<td>21.01</td>
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<td>(Build 5744)</td>
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<td>Firefox 1.5</td>
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<tr>
<td></td>
<td>20.98</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Not fallback</td>
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<tr>
<td></td>
<td>0.97</td>
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**Time between first IPv6 TCP SYN packet and IPv4 TCP SYN packet immediately after fallback occurs.**
### Results of experiments 2/3

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<tr>
<td>Fedora-C3(kernel:2.6.9) Mozilla1.7.8</td>
<td>188.98</td>
<td>1.65 1.91 Not fallback 0.23 0.01</td>
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Unit: seconds
# Results of experiments 3/3

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<td>FireFox 1.5</td>
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<tr>
<td>MacOS X Tiger</td>
<td>74.74</td>
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<td>FireFox 1.5</td>
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<tr>
<td>Solaris 10</td>
<td>224.69</td>
<td>224.69 224.69</td>
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<tr>
<td>FireFox 1.5</td>
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**Operating systems**

- FreeBSD 5.4
- MacOS X Tiger
- Solaris 10

**Unit:** seconds
When node receives ICMP error packets, TCP stack behavior is defined in RFC 1122 (for IPv4 ICMP only).

- When node receives an ICMP hard error, TCP aborts connection immediately.
- When node receives ICMP soft error, TCP must not abort connection.

Currently, ICMPv6 destination-unreachable error handling is different in each OS.

The “draft-ietf-tcpm-tcp-soft-errors-03” proposes IPv6 version of ICMPv6 soft error handling....
Summary of IPv6/IPv4 fallback problem

- In some cases, IPv6-enabled network without global ipv6 reachability causes ipv6-to-ipv4 fallback problem
  - User feels a longer time to access web sites.

- Before ipv6 is fully deployed, users should be careful to assign ipv6 address to the network without global ipv6 reachability.
  - If assign, they need some solution such as:
    - not default route, but specific route
    - returning TCP RST to minimize fallback time

- From architectural point of view, we should define the reaction to icmpv6 destination unreachable message.
Thank you!

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