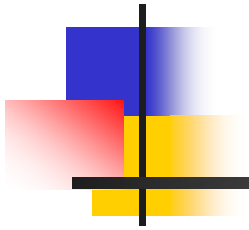
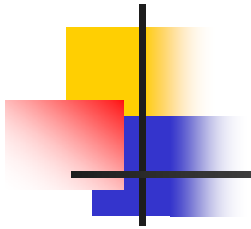


Clear and Present Danger of IPv6
episode 2: IPv6/IPv4 fallback

Katsuyasu TOYAMA
Tomohiro FUJISAKI
Arifumi MATSUMOTO
Shiro NIINOBE

NTT Labs.

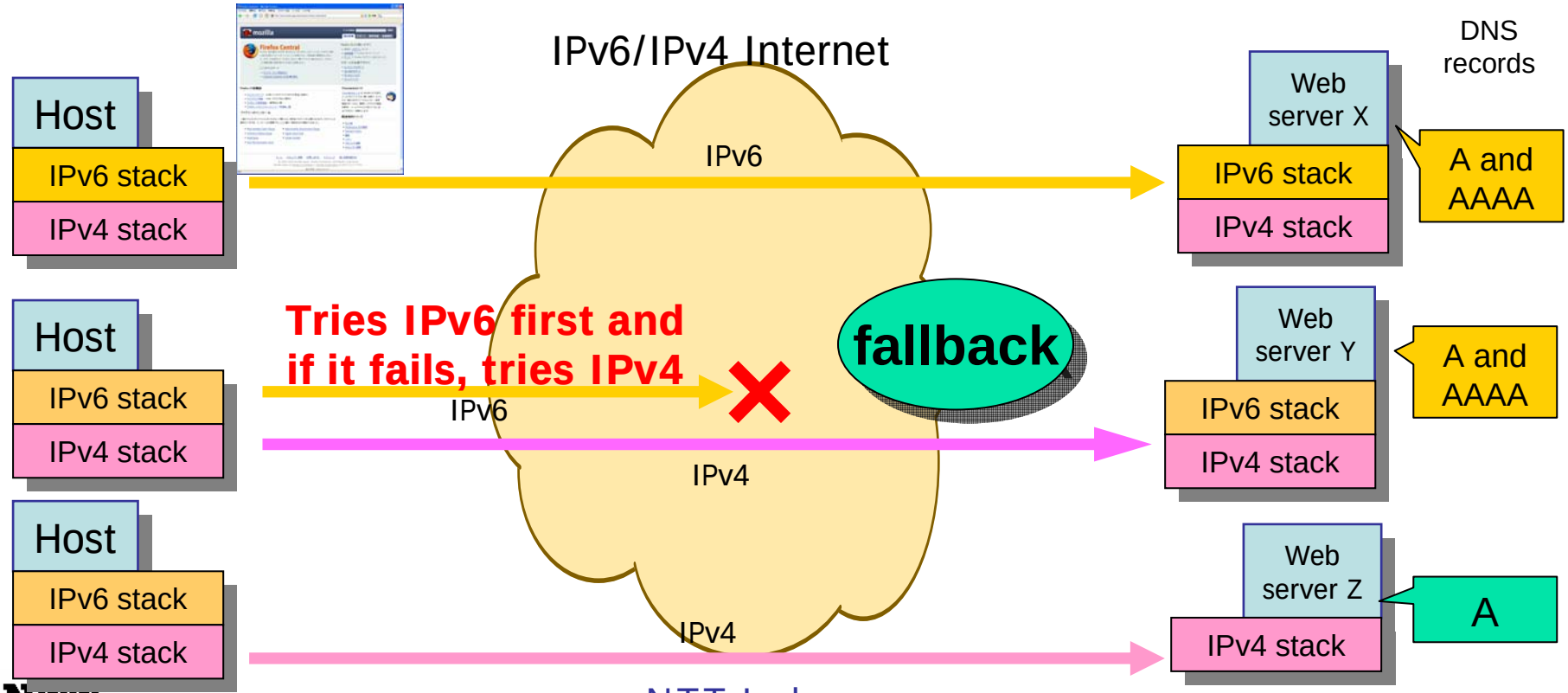


IPv6-enabled hosts are increasing

- 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’?

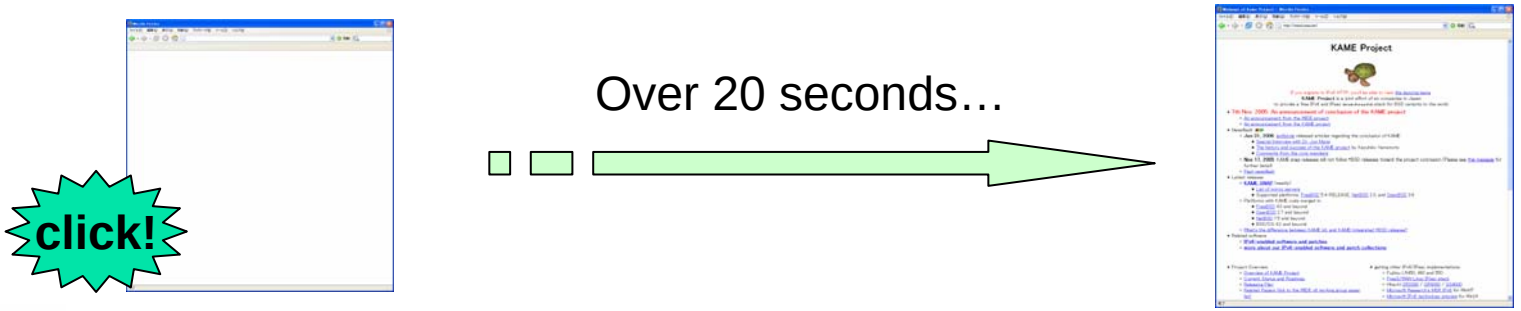
- Many current IPv6/IPv4 dual-stack operating systems start their communication using IPv6.
  - If destination has both ipv4 and ipv6 address, end host first tries ipv6. And if it fails, then tries ipv4.



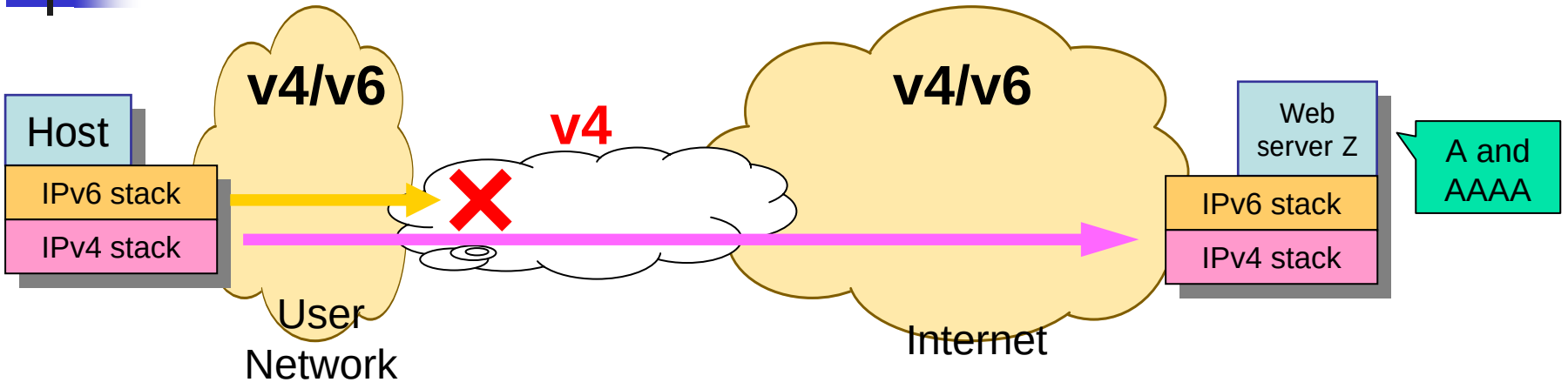
IPv6/IPv4 fallback problem

IPv6-to-IPv4 fallback sometimes takes a long time.

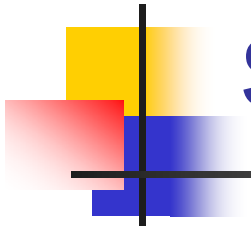
- Problem is especially significant in TCP-based applications.
  - They initially need to establish connection. First they try ipv6 address.
  - They have to wait for timeout, and then try ipv4 address, and finallly it is established.
- From users' view
  - User has to wait approximately 20 seconds, 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?

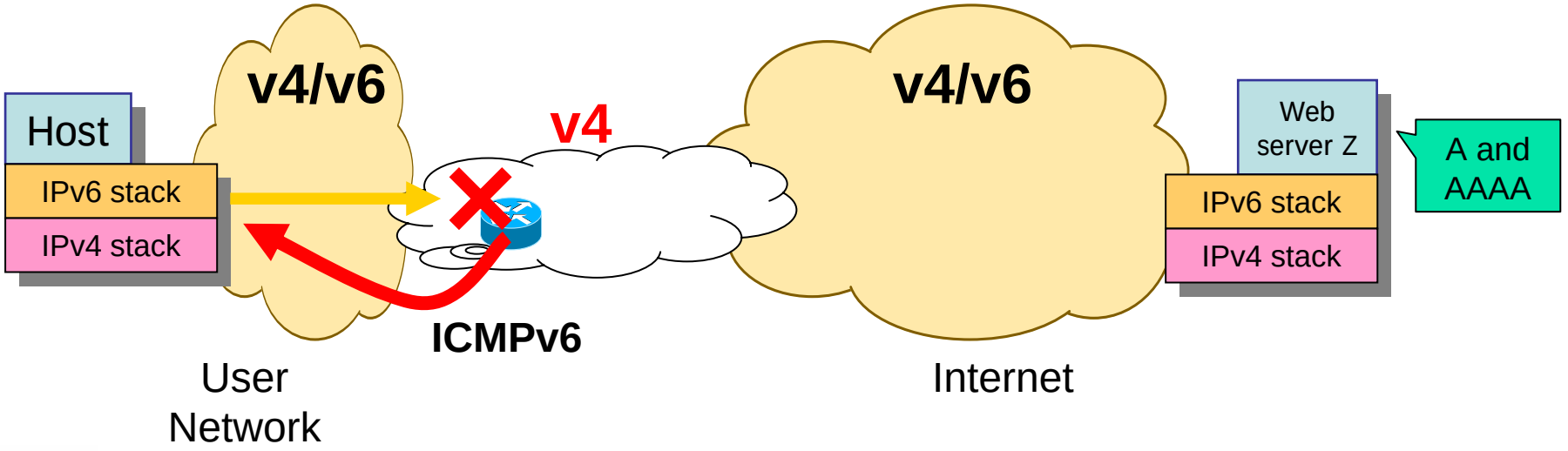
- At present, it seems rare …
  - Vista PCs which are not assigned ipv6 address do not try ipv6.
- But near future, enterprise and home network may assign ipv6 address for some reason.
  - some ipv6 application starts to be used
  - accidentally assigned ipv6 address due to misconfigured RA.
- At that 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 architectual 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



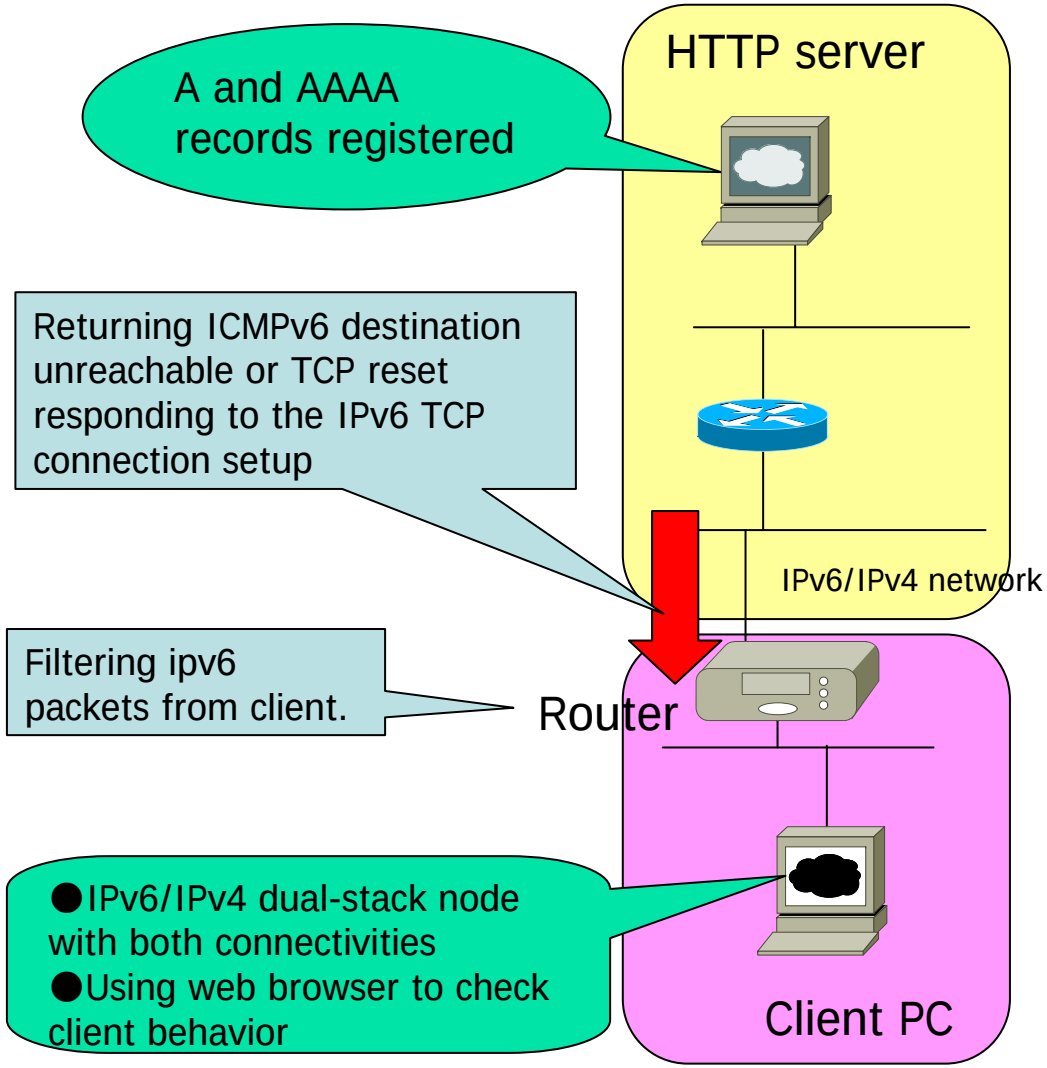
Fallback experiment

- 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



Results of experiments 1/3

unit: seconds

Operating systems	(1) No response from network: TCP Timeout	(2) ICMPv6 error (Type=1: Destination unreachable)				(3) Force to fall back TCP RST
		Code=0 No Route	Code=3 Addr Unreach	Code=1 Admin Prohibit	Code=4 Port Unreach	
Vista RC2 (Build 5744) IE 7.0.5600. (2006.10.11)	**21.01**	**21.00**	**21.00**	**21.00**	**21.00**	**1.01**
WinXP (SP2) IE 6.x	**22.87**	**22.91**	**22.92**	**22.95**	**22.93**	**1.06**
WinXP (SP2) Firefox 1.5	**20.99**	**20.96**	**20.96**	**20.98**	**Not fallback**	**0.97**

Time between first IPv6 TCP SYN packet and IPv4 TCP SYN packet immediately after fallback occurs.

Results of experiments 2/3

unit: seconds

Operating systems	(1) Timeout	(2) ICMPv6 Error (Type=1: Destination unreachable)				(3) TCP RST
		Code=0 No Route	Code=3 Addr Unreach	Code=1 Admin Prohibit	Code=4 Port Unreach	
Fedora-C3(kernel:2.6.9) Mozilla1.7.8	188.98	1.65	1.91	Not fallback	0.23	0.00
Fedora-C3(kernel:2.6.11) FireFox1.5	186.41	0.01	0.00	0.00	0.01	0.01
FreeBSD-R5.4 Mozilla1.7.8	75.01	12.60	Not fallback	12.60	12.60	1.38
FreeBSD-R5.4 Mozilla1.7.12	75.01	12.61	Not fallback	12.60	12.60	0.01
FreeBSD-R5.4 (with 20050620 kame) Mozilla1.7.8	75.00	1.78	Not fallback	12.61	12.61	0.90
FreeBSD-R5.4 (with 20060116 kame) Mozilla1.7.12	75.00	0.02	Not fallback	12.62	12.60	0.03
MacOS X Tiger Safari2.0.3	149.58	11.89	11.85	11.55	11.99	0.08
Solaris10 Mozilla1.7.12	224.29	224.69	224.69	224.69	0.01	1.05

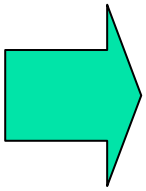
Results of experiments 3/3

unit : seconds

Operating systems	(1) Timeout	(2) ICMPv6 Error (Type=1: Destination Unreachable)				(3) TCP RST
		Code=0 No Route	Code=3 Addr Unreach	Code=1 Admin Prohibit	Code=4 Port Unreach	
FreeBSD-R5.4 FireFox1.5	**75.00**	**12.60**	**Not fallback**	**12.60**	**12.61**	**0.01**
FreeBSD-R5.4 (with 20060116 kame) FireFox1.5	**75.00**	**0.01**	**Not fallback**	**12.60**	**12.60**	**0.02**
MacOS X Tiger FireFox1.5	**74.74**	**11.80**	**Not fallback**	**11.72**	**11.63**	**0.01**
Solaris10 FireFox1.5	**224.69**	**224.69**	**224.69**	**224.69**	**0.02**	**0.02**

TCP stack behavior when ICMP errors are returned

- 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 architectual point of view, we should define the reaction to icmpv6 destination unreachable message.

- Thank you!

{toyama, fujisaki, arifumi, nin} at NTTv6 dot net