

Happy Eyeballs

Better Connectivity Using Concurrency

Carsten Strotmann

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Agenda

- Why "Happy Eyeballs"
- Happy Eyeballs vs. traditional IP connections
- Microsoft Windows NCSI
- Happy Eyeballs v3

Happy Eyeballs

Why

- Traditionally, IPv6 capable operating systems prefer IPv6 over IPv4
 - If IPv6 is available, it is tried first
 - If the connection cannot be established, IPv4 will be used after an timeout on the IPv6 connection
- This results in non-optimal user experience

Traditional IPv6 connections

Traditional IPv6 connections (1/9)

Web-Server
www.example.com



www.example.com AAAA?



DNS Server
with zone
example.com

www.example.com AAAA?



Firewall blocking
ICMPv6

www.example.com AAAA?



Happy Eyeballs

Traditional IPv6 connections (2/9)

Web-Server
www.example.com



www.example.com AAAA
2001:db8:1::80



DNS Server
with zone
example.com

www.example.com AAAA
2001:db8:1::80



Firewall blocking
ICMPv6

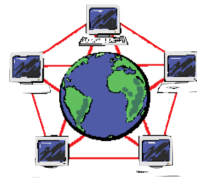
www.example.com AAAA
2001:db8:1::80



Happy Eyeballs

Traditional IPv6 connections (3/9)

Web-Server
www.example.com



DNS Server
with zone
example.com



TCP connect to
2001:db8:1::80



Firewall blocking
ICMPv6

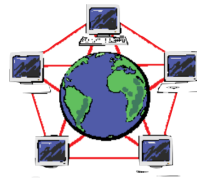
TCP connect to
2001:db8:1::80



Happy Eyeballs

Traditional IPv6 connections (4/9)

Web-Server
www.example.com



ICMPv6 parameter issue



Firewall blocking
ICMPv6

DNS Server
with zone
example.com



Happy Eyeballs



Traditional IPv6 connections (5/9)

Web-Server
www.example.com



DNS Server
with zone
example.com



Firewall blocking
ICMPv6

timeout



Happy Eyeballs

Traditional IPv6 connections (6/9)

Web-Server
www.example.com



www.example.com A?



DNS Server
with zone
example.com

www.example.com A?



Firewall blocking
ICMPv6

www.example.com A?



Happy Eyeballs

Traditional IPv6 connections (7/9)

Web-Server
www.example.com



www.example.com A
192.0.2.80



DNS Server
with zone
example.com

www.example.com A
192.0.2.80



Firewall blocking
ICMPv6

www.example.com A
192.0.2.80



Happy Eyeballs

Traditional IPv6 connections (8/9)

Web-Server
www.example.com



TCP connect to
192.0.2.80



DNS Server
with zone
example.com



TCP connect to
192.0.2.80



Firewall blocking
ICMPv6

TCP connect to
192.0.2.80



Happy Eyeballs

Traditional IPv6 connections (9/9)

Web-Server
www.example.com



TCP data



TCP data



Firewall blocking
ICMPv6

TCP data



Happy Eyeballs



DNS Server
with zone
example.com

Happy Eyeballs

Happy Eyeballs

RFC 8305 "Happy Eyeballs Version 2: Better Connectivity Using Concurrency" brings a solution

- Try IPv6 and IPv4 connections simultaneously
- IPv6 has a slight head start
- Take the first connection that is established (IPv6 or IPv4)
 - User gets always the fast connection

Happy Eyeballs Implementation

Example implementation:

- Call `getaddrinfo()`, which returns a list of IP addresses sorted by the host's address preference policy.
- Initiate a connection attempt with the first address in that list (e.g., IPv6).
- If that connection does not complete within a short period of time, initiate a connection attempt with the first address belonging to the other address family (e.g., IPv4).
- The first connection that is established is used. The other connection is discarded.

Happy Eyeball in operation (1/4)

Web-Server
www.example.com



www.example.com AAAA?
www.example.com A?



DNS Server
with zone
example.com

www.example.com A?

www.example.com AAAA?



Firewall blocking
ICMPv6

www.example.com A?

www.example.com AAAA?



Happy Eyeballs

Happy Eyeball in operation (2/4)

Web-Server
www.example.com



www.example.com AAAA
2001:db8:1::80
www.example.com A
192.0.2.80



DNS Server
with zone
example.com

www.example.com A
192.0.2.80

www.example.com AAAA
2001:db8:1::80



Firewall blocking
ICMPv6

www.example.com A
192.0.2.80

www.example.com AAAA
2001:db8:1::80



Happy Eyeballs

Happy Eyeball in operation (3/4)

Web-Server
www.example.com



TCP connect to
192.0.2.80



DNS Server
with zone
example.com



TCP connect to
2001:db8:1::80

TCP connect to
192.0.2.80



Firewall blocking
ICMPv6

TCP connect to
2001:db8:1::80

TCP connect to
192.0.2.80



Happy Eyeballs

Happy Eyeball in operation (4/4)

Web-Server
www.example.com



TCP data



DNS Server
with zone
example.com

TCP data



Firewall blocking
ICMPv6

TCP data



Happy Eyeballs

Happy Eyeball Implementations

- Google Chrome 11+
- Mozilla Firefox version 13+
- Apple macOS
 - CFSocketStream() Framework
 - Safari
- Apple iOS
- Vivaldi/Brave/Edge/Opera Browser
- Windows 8/10/11

Microsoft Windows "NCSI"

NCSI

Microsoft has developed a slightly different solution for their Windows OS (Version 8+):

- The Windows OS tests IPv6 connectivity on every network change and saves the result per network
- In case no direct IPv6 connection is detected, the IPv6 default route is downgraded (e.g. IPv4 will be preferred for all connections)
- The IPv6 connectivity test is part of the NCSI (Network Connection Status Indicator) network-Icon in the Windows status bar

NCSI (1/7)

Web server
ipv6.msftncsi.com



dns.msftncsi.com AAAA?
dns.msftncsi.com A?



DNS server
hosting DNS zone
msftncsi.com

dns.msftncsi.com AAAA?
dns.msftncsi.com A?



Firewall with
IPv6 issue

dns.msftncsi.com AAAA?
dns.msftncsi.com A?



↑ IPv4 ↑ IPv6

NCSI (2/7)

Web server
ipv6.msftncsi.com



dns.msftncsi.com AAAA
fd3e:4f5a:5b81::1
dns.msftncsi.com A
131.107.255.255



DNS server
hosting DNS zone
msftncsi.com

dns.msftncsi.com AAAA
fd3e:4f5a:5b81::1
dns.msftncsi.com A
131.107.255.255



Firewall with
IPv6 issue

dns.msftncsi.com AAAA
fd3e:4f5a:5b81::1
dns.msftncsi.com A
131.107.255.255



↑ IPv4 ↑ IPv6

NCSI (3/7)

Web server
ipv6.msftncsi.com



ipv6.msftncsi.com AAAA?



DNS server
hosting DNS zone
msftncsi.com

ipv6.msftncsi.com AAAA?



Firewall with
IPv6 issue

ipv6.msftncsi.com AAAA?

↑ IPv4
↑ IPv6



NCSI (4/7)

Web server
ipv6.msftncsi.com



dns.msftncsi.com AAAA
....



DNS server
hosting DNS zone
msftncsi.com

;; ANSWER SECTION:

```
ipv6.msftncsi.com.      3600 IN    CNAME ipv6.msftncsi.com.edgesuite.net.  
ipv6.msftncsi.com.edgesuite.net. 21600 IN CNAME  a978.i6g1.akamai.net.  
a978.i6g1.akamai.net.  20    IN      AAAA   2a02:26f0:10::5c7a:d423  
a978.i6g1.akamai.net.  20    IN      AAAA   2a02:26f0:10::5c7a:d433
```



Firewall with
IPv6 issue

dns.msftncsi.com AAAA
....

↑ IPv4
↑ IPv6

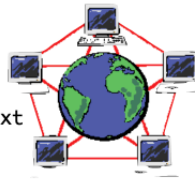


NCSI (5/7)

Web server
ipv6.msftncsi.com



<http://ipv6.msftncsi.com/ncsi.txt>



DNS server
hosting DNS zone
msftncsi.com

<http://ipv6.msftncsi.com/ncsi.txt>



Firewall with
IPv6 issue

<http://ipv6.msftncsi.com/ncsi.txt>

↑ IPv4
↑ IPv6



NCSI (6/7)

Web server
ipv6.msftncsi.com



Microsoft NCSI



Microsoft NCSI



Firewall with
IPv6 issue



DNS server
hosting DNS zone
msftncsi.com

↑
IPv4

↑
IPv6



NCSI (7/7)

Web server
ipv6.msftncsi.com



DNS server
hosting DNS zone
msftncsi.com



Firewall with
IPv6 issue

↑
IPv4

↑
IPv6



timeout
IPv6 default Route is
downgraded

IPv6 NCSI test

- The result of a successful IPv6 NCSI connectivity test is stored per network for 30 days
- Negative results are not stored, the test will be repeated once a network configuration parameter changes
- Leaving a "captive WLAN-Portal" triggers a new NCSI test
- If proxy-servers are configured, the NCSI test is skipped

IPv6 NCSI test

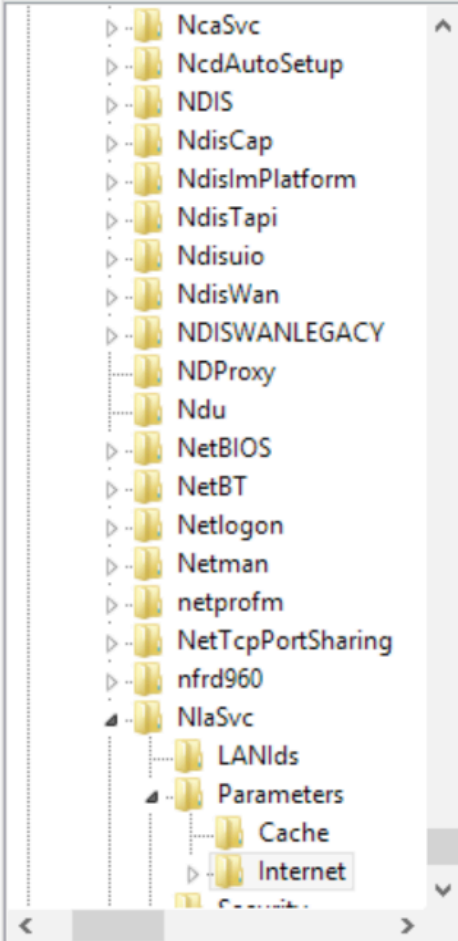
- Downgrading the IPv6 "default" route has an effect on all application (not only on the web browser)
- In enterprise environments, the NCSI-test can be redirected to local DNS and Web servers
- Or adjusted using PowerShell Set-NCSIPolicyConfiguration:
[↪http://technet.microsoft.com/en-us/library/hh848620\(v=wps.620\).aspx](http://technet.microsoft.com/en-us/library/hh848620(v=wps.620).aspx)
- Or disabled with a policy registry setting

NCSI Registry settings



Registry Editor

File Edit View Favorites Help



Name	Type	Data
(Default)	REG_SZ	(value not set)
ActiveDnsProbeContent	REG_SZ	131.107.255.255
ActiveDnsProbeContentV6	REG_SZ	fd3e:4f5a:5b81::1
ActiveDnsProbeHost	REG_SZ	dns.msftncsi.com
ActiveDnsProbeHostV6	REG_SZ	dns.msftncsi.com
ActiveWebProbeContent	REG_SZ	Microsoft NCSI
ActiveWebProbeContentV6	REG_SZ	Microsoft NCSI
ActiveWebProbeHost	REG_SZ	www.msftncsi.com
ActiveWebProbeHostV6	REG_SZ	ipv6.msftncsi.com
ActiveWebProbePath	REG_SZ	ncsi.txt
ActiveWebProbePathV6	REG_SZ	ncsi.txt
EnableActiveProbing	REG_DWORD	0x00000001 (1)
PassivePollPeriod	REG_DWORD	0x0000000f (15)
StaleThreshold	REG_DWORD	0x0000001e (30)
WebTimeout	REG_DWORD	0x00000023 (35)

Computer\HKEY_LOCAL_MACHINE\SYSTEM\ControlSet001\Services\NlaSvc\Parameters\Internet

Windows NCSI IPv6 test

- Advantages over "IETF" Happy Eyeballs:
 - Works for all applications
 - Easier to troubleshoot
- Possible downsides
 - Some IPv6 issues could not be detected (some ICMPv6 issues)
 - "Privacy" concerns over "phoning home"
 - NCSI request might be blocked (for privacy reasons) - IPv6 will be downgraded despite full IPv6 connectivity

Happy Eyeballs v3, QUIC and the HTTPS DNS- Record

Happy Eyeballs v3, QUIC and the HTTPS DNS-Record

- HTTP/3 capable clients (Browser, Apps) need to decide to connect to a web server via HTTP3/UDP or HTTP2/TCP
- This decision is similar to the Happy Eyeball IPv6 vs. IPv4 decision

Happy Eyeballs v3, QUIC and the HTTPS DNS-Record

- The HTTPS-Record (↪[RFC 9460](#)) in DNS can give applications guidance on what protocol to choose
- The IETF is working on a 3rd iteration on Happy Eyeballs to take HTTP/3 and the HTTPS record into account: "Happy Eyeballs Version 3: Better Connectivity Using Concurrency"
↪<https://datatracker.ietf.org/doc/draft-pauly-v6ops-happy-eyeballs-v3/>

Ressources

- RFC 8305 - Happy Eyeballs Version 2: Better Connectivity Using Concurrency ↪ <https://www.rfc-editor.org/rfc/rfc8305>
- Lazy Eye Inspection: Capturing the State of Happy Eyeballs Implementations (2024) ↪ <https://arxiv.org/pdf/2412.00263>
- What is NCSI: ↪ [http://technet.microsoft.com/en-us/library/cc766017\(v=ws.10\).aspx](http://technet.microsoft.com/en-us/library/cc766017(v=ws.10).aspx)

Questions?

