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How Ready is DNS for an IPv6-only World?

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Technische Universität München

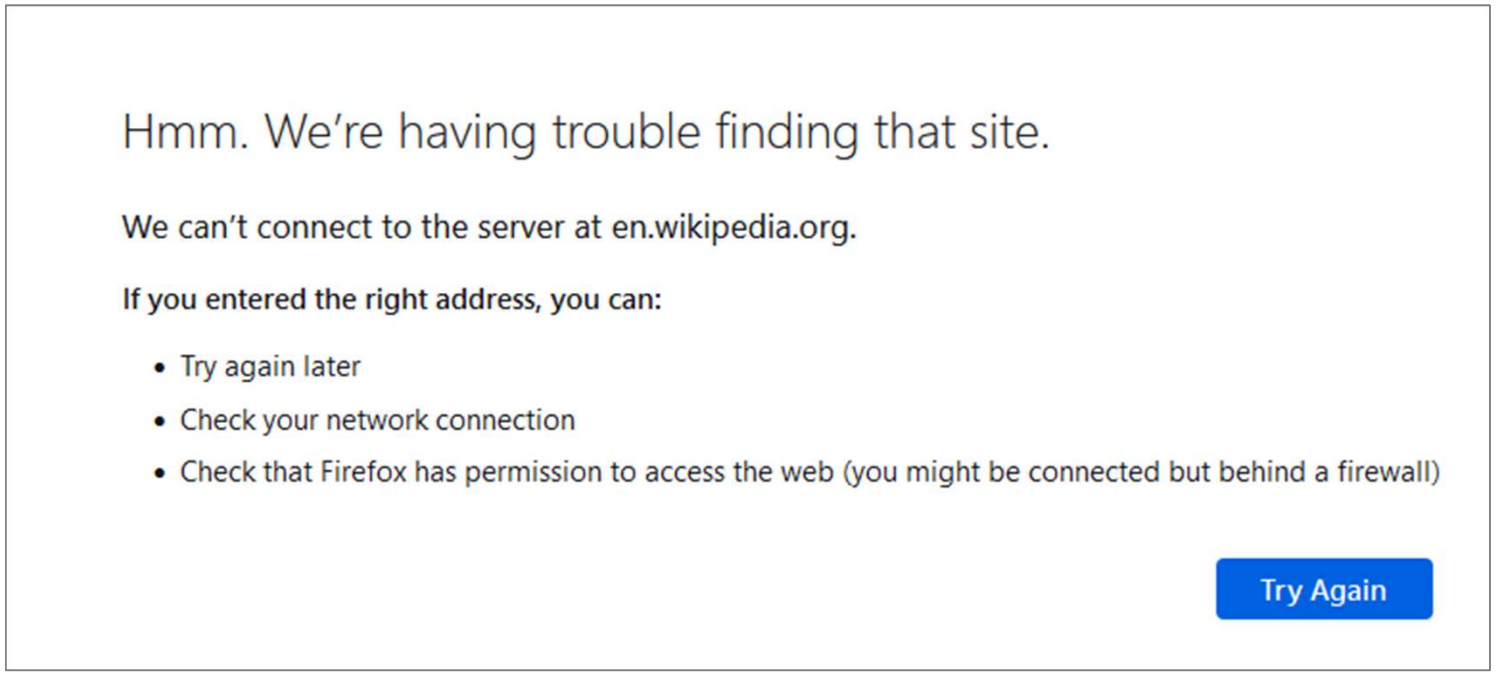
TU Delft

Paper:

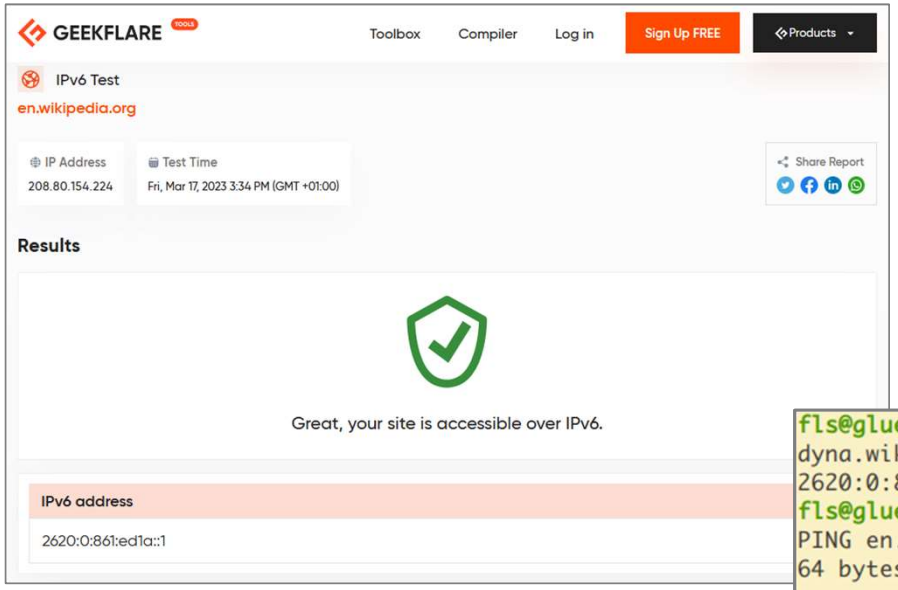
https://hdl.handle.net/21.11116/0000-000C-8817-1

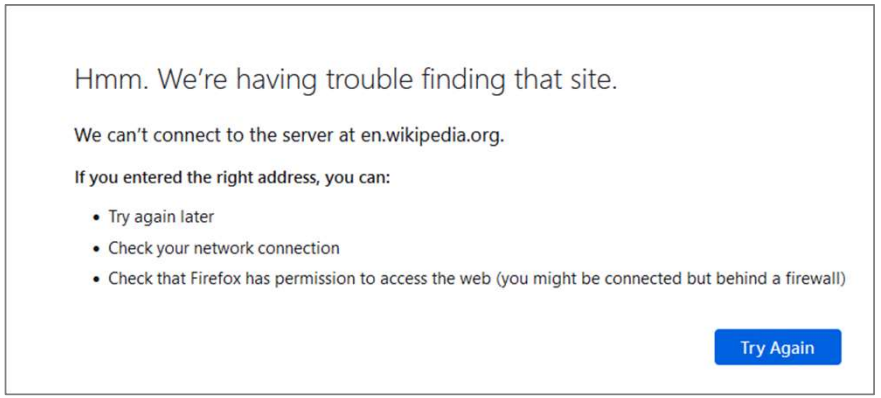
https://link.springer.com/chapter/10.1007/978-3-031-28486-1_22

The IPv6-only Experience



IPv6: Ready or … Not?





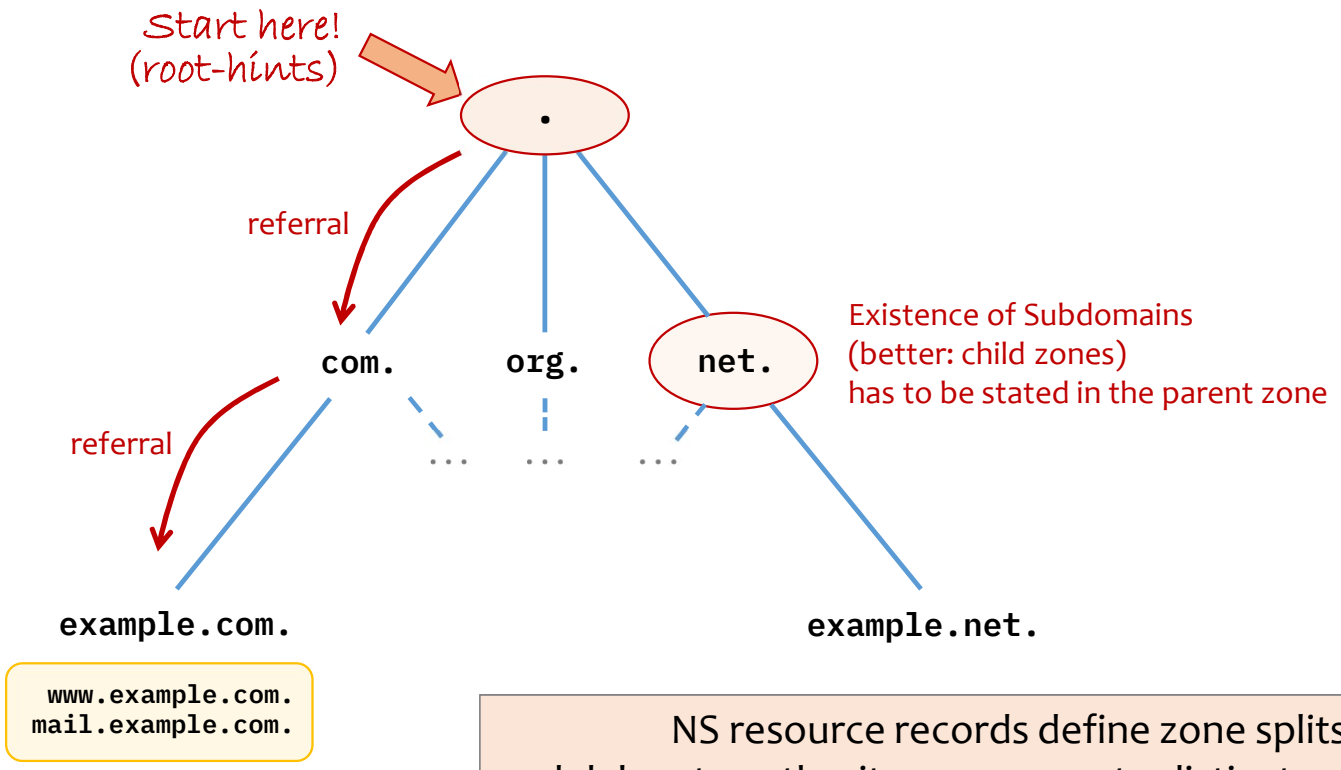

```
fls@glueball:~$ dig +short AAAA en.wikipedia.org
dyna.wikimedia.org.
2620:0:862:ed1a::1
fls@glueball:~$ ping6 -n -c 1 en.wikipedia.org
PING en.wikipedia.org(2620:0:862:ed1a::1) 56 data bytes
64 bytes from 2620:0:862:ed1a::1: icmp_seq=1 ttl=60 time=19.6 ms

--- en.wikipedia.org ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 19.629/19.629/19.629/0.000 ms
fls@glueball:~$
```

Where does it break?


```
fls@glueball:~$ for NS in $(dig +short NS wikipedia.org); do
>  [ -z "$(dig +short AAAA ${NS})" ] && echo "No AAAA for $NS"
> done
No AAAA for ns1.wikimedia.org.
No AAAA for ns2.wikimedia.org.
No AAAA for ns0.wikimedia.org.
fls@glueball:~$
```

BCP 91 (RFC3901) - September 2004
"DNS IPv6 Transport Operational Guidelines"

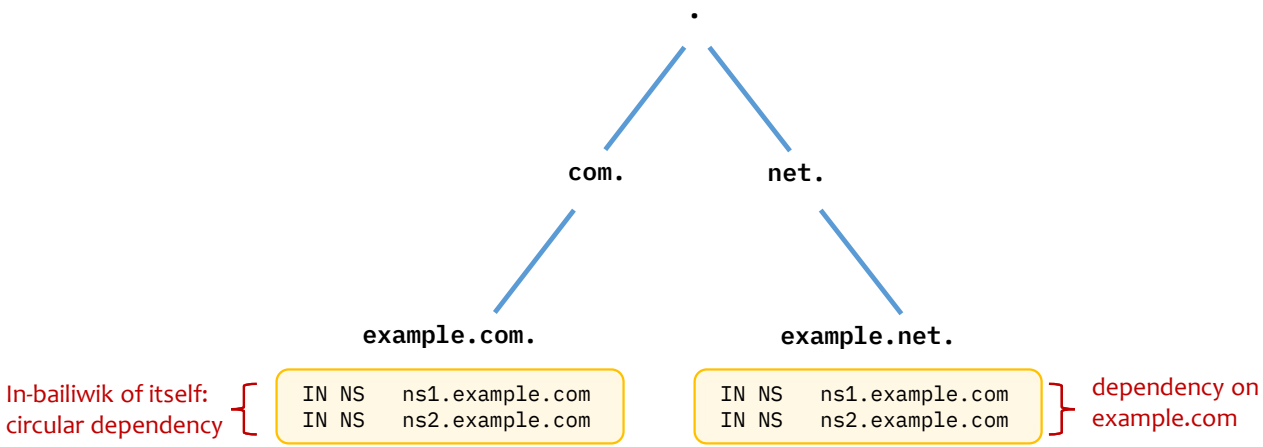
Let's talk about DNS...



Existence of Subdomains
(better: child zones)
has to be stated in the parent zone

NS resource records define zone splits
and delegate authority over zones to distinct nameservers

Caveats



- Circular dependencies are resolved using GLUE records in the parent zone
  Note: requires coordination across organisations (hard!)
- Obvious: ‘external’ nameservers introduce dependencies

What could possibly go wrong?

1. No AAAA records for NS names
2. Missing GLUE in parent zone
3. No AAAA for in-bailiwik NS names
4. **Zone of out-of-bailiwick NSes not resolving**
5. Parent zone not IPv6-resolvable

Original by William Bramhall, NYDN

One misconfigured zone
will break all it's child zones!

Zone of *out-of-bailiwick NSes* not resolving

```
$ORIGIN .com.

example.com.   IN NS   ns1.somedns.tld.
example.com.   IN NS   ns2.somedns.tld.
```

```
$ORIGIN example.com.

@      IN NS    ns1.somedns.tld.
@      IN NS    ns2.somedns.tld.

www    IN A     192.0.2.23
www    IN AAAA  2001:db8::23
```

```
$ORIGIN somedns.tld.

@      IN NS    ns1.ipv6sucks.tld
@      IN NS    ns2.ipv6sucks.tld

ns1    IN A     192.0.2.1
ns1    IN AAAA  2001:db8::1
ns2    IN A     192.0.2.2
ns2    IN AAAA  2001:db8::2
```

Datasets

Passive Dataset: Farsight SIE

- Coverage: global
- Cache misses of recursors
- January 2015 until August 2022

Passive Dataset: Zonefiles

- .com, .net, and other gTLDs (starting mid of 2016)
- ICANN Centralized Zone Data Service for TLDs (from April 2017 onward)

Additionally for the coverage analysis:

- Zone file data from .se, .nu, and .ch that are publicly available

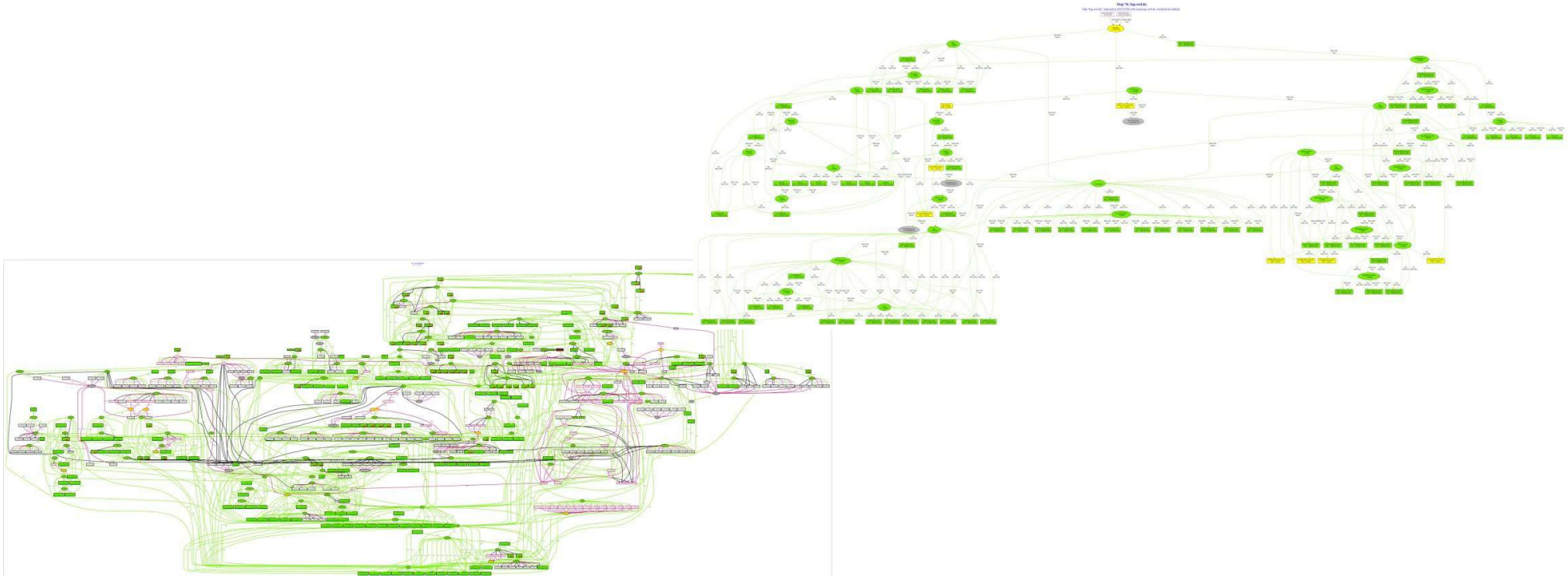
We compare Farsight's data to more than 1.1k zones as of August 2022

Active Measurements

- Alexa Top 1 M, Aug 2022 (498k)
- One vantage point
- 56 M queries
- Oct 11-14 & 22-24 (2022)
- Dataset publicly available

Results...

(Comprehensive visualisation is almost impossible...)



Why do Zones (SERV)Fail?

Note: Here we only look at zones that show "signs of IPv6"!

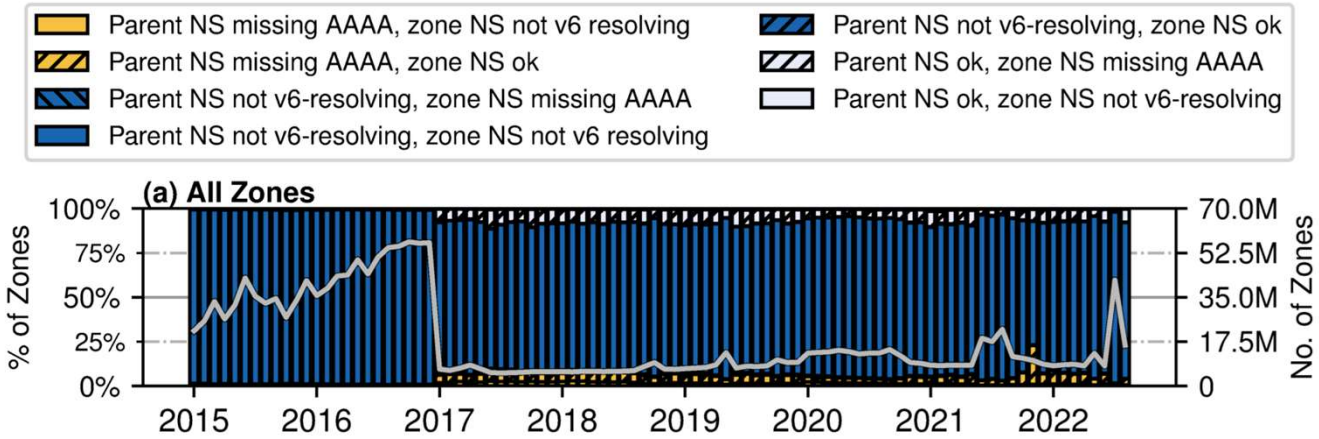


Fig. 5: Per month: # of zones not IPv6-resolvable with AAAA or GLUE for NS (gray line–right y-axis) and causes for IPv6 resolution failure in % (left y-axis).

The majority of zones is not IPv6-only resolvable
because their parent zone(s) fail already

Misconfiguration hidden in plain sight!

- Why are these misconfigurations not noticed?
  → Because they currently have no impact!
- DNS hides problems:
  - Resilience was a design goal
  - Good for user experience, “bad” for operations
- Monitoring needs to take that into account
- This is also true for Happy Eyeballs!

Is this sufficient?

```
# dig www.google.com && echo "DNS works!"
```

Summary

- Passive measurement study with root cause analysis for broken IPv6 delegation in an **IPv6-only** setting
- Confirmation via active measurements
- August 2022: **44.9% of considered zones not IPv6-only resolvable**
  Most common: zone or parent NS unresolvable
- Recommendation: Specifically monitor IPv6 across entire delegation chain
- IPv6 readiness of the web may be impaired
- Happy Eyeballs can trick you – not only with DNS!

Paper:
https://hdl.handle.net/21.11116/0000-000C-8817-1
https://link.springer.com/chapter/10.1007/978-3-031-28486-1_22

Conference talk (pam 2023)
https://www.youtube.com/watch?v=i1kT-NjJZFo

Cats vector graphics:
- https://en.wikipedia.org/wiki/File:Cat_black.svg
- https://commons.wikimedia.org/wiki/File:Cat_silhouette.svg