# TsuNAME: exploiting misconfiguration and vulnerability to DDoS DNS

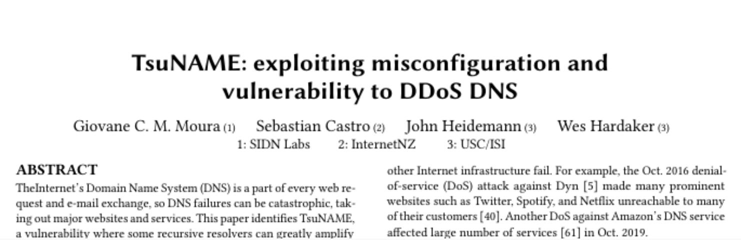
**Giovane C. M. Moura**[1], Sebastian Castro[2],
John Heidemann[3], Wes Hardaker[3]

1: SIDN Labs, 2: InternetNZ, 3: USC/ISI

**IETF 112**
**MAPRG**
*Virtual Meeting*
2021-11-09

# Prelude

1. Our paper appeared at ACM IMC 2021:
   - PDF: https://www.isi.edu/~johnh/PAPERS/Moura21b.pdf



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### ABSTRACT

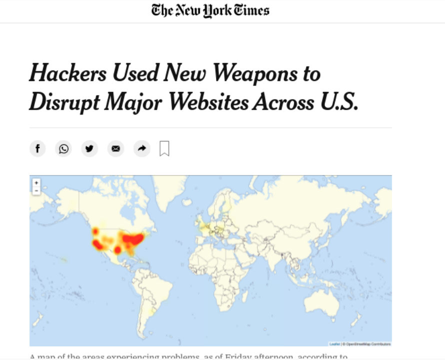
TheInternet's Domain Name System (DNS) is a part of every web request and e-mail exchange, so DNS failures can be catastrophic, taking out major websites and services. This paper identifies TsuNAME, a vulnerability where some recursive resolvers can greatly amplify

other Internet infrastructure fail. For example, the Oct. 2016 denial-of-service (DoS) attack against Dyn [5] made many prominent websites such as Twitter, Spotify, and Netflix unreachable to many of their customers [40]. Another DoS against Amazon's DNS service affected large number of services [61] in Oct. 2019.

2. We identify problems and propose solutions for current RFCs:
   - New draft: draft-moura-dnsop-negative-cache-loop

# Introduction

- The DNS is one of the **core** services on the Internet
- People notice it when it **breaks**:
  - 2016 DDoS against Dyn DNS 2016 [1, 6]
    - affected Netflix, Spotify, Airbnb, Reddit, and others.
  - 2019 DDoS against Amazon AWS [7]

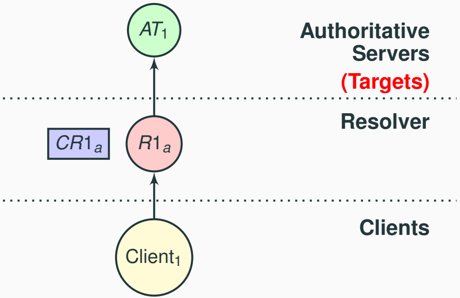


The New York Times

*Hackers Used New Weapons to Disrupt Major Websites Across U.S.*

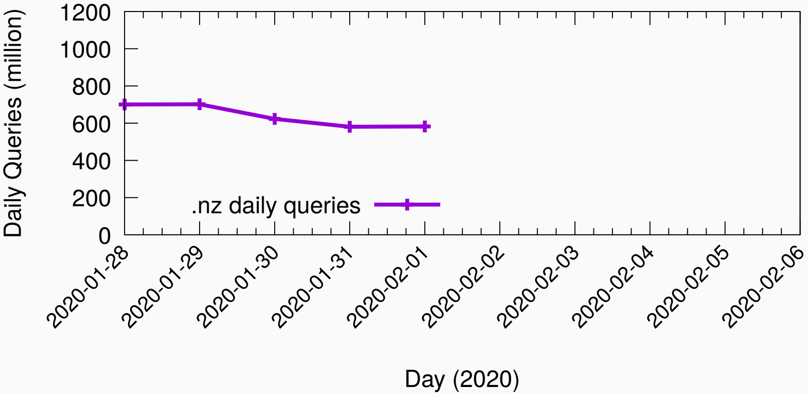
A map of the areas experiencing problems, as of Friday afternoon, according to

# Two main type of DNS servers



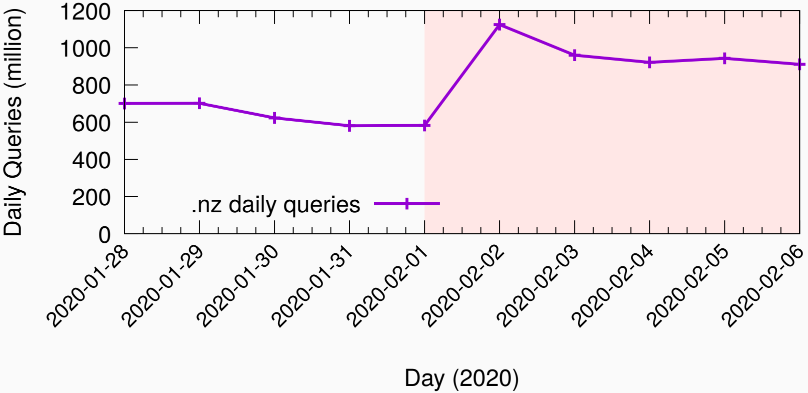
TsuNAME affects **traffic to authoritative servers**

# New Zealand's `.nz` event



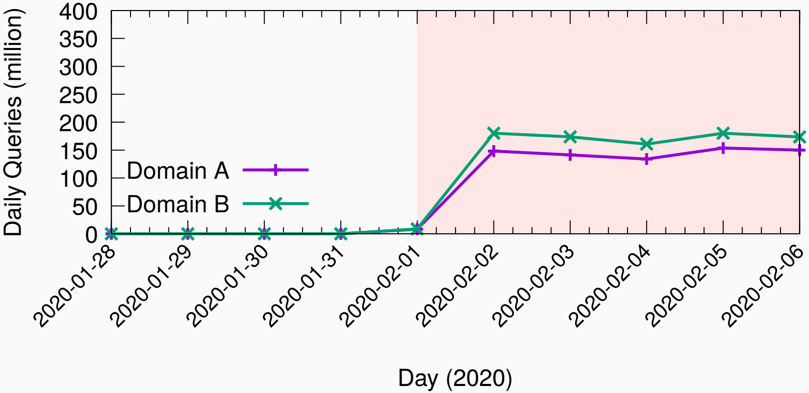
- Normal traffic on `.nz` authoritative servers

# Big traffic increase



- Operators see something strange:
  - 50 % traffic **surge** on `.nz` authoritative servers

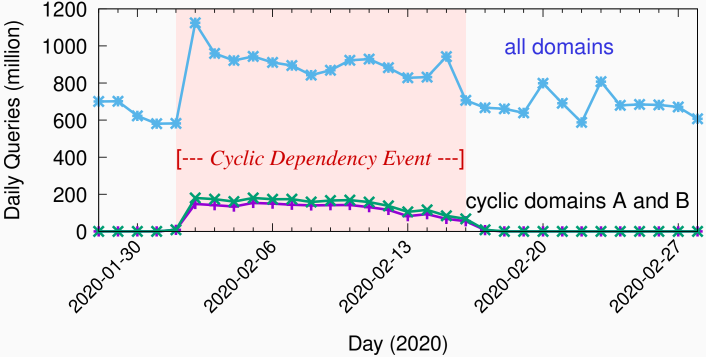
# New Zealand's `.nz` event: an accident?



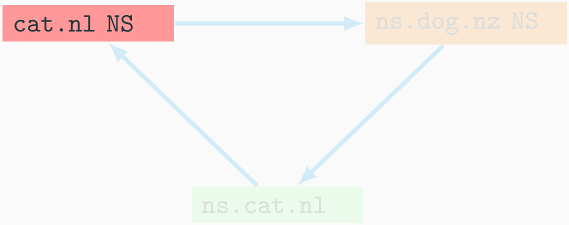
- Two domain names suddenly start to receive millions of queries
- **a DDoS attack?**

# Cause: DNS Loops (cyclic dependency)

## Loop: domainA → domainB → domainA



# Cyclic Dependency is a loop; an error



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- Such names can never be resolved

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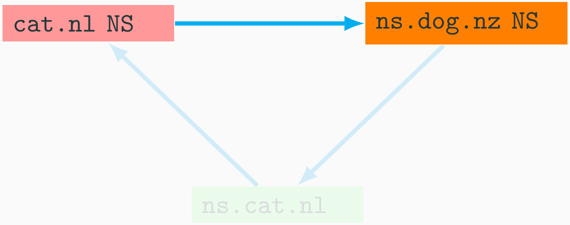

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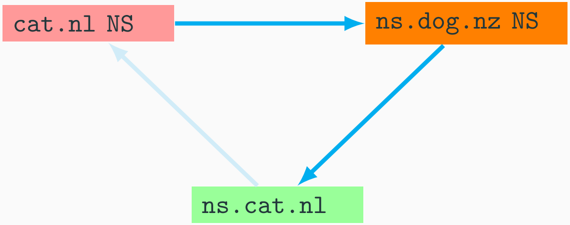

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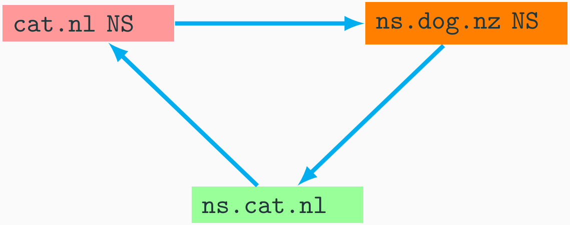

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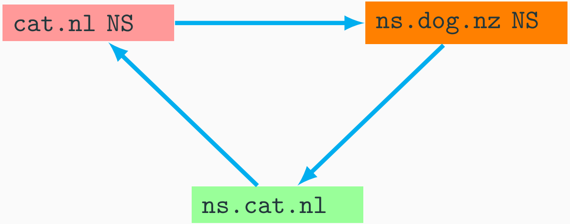

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# Contributions

1. **Understanding**: show how TsuNAME can be weaponized (§3 and §4)
2. **Prevention**: provide tool for DNS ops (§5)
   - `CycleHunter`: so they can detect loops in their zones
   - identifying what's missing in RFCs
3. **Fixing Bugs** (§6):
   - Responsible disclosure
   - **Google** fixed their Public DNS 🙂
   - **Cisco** fixed OpenDNS 🙂

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# The Real Threat: weaponization

- 2 domains in .nz → 50% total traffic surge
- **The threat:**
  - Adversary holds many domains
  - Reconfigure to create loops of NS records
  - Trigger recursive resolvers from a botnet

This got us very **concerned**.

- How many anycast providers/TLDs can withstand that?

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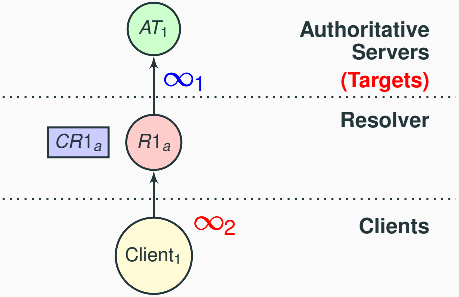
# TsuNAME in practice: Root Causes



A client sends a query to the recursive. We found three cases:

1. Resolvers that loop indefinitely ($\infty_1$)
2. Clients that loop indefinitely ($\infty_2$)
3. Both

**We will see solutions later**

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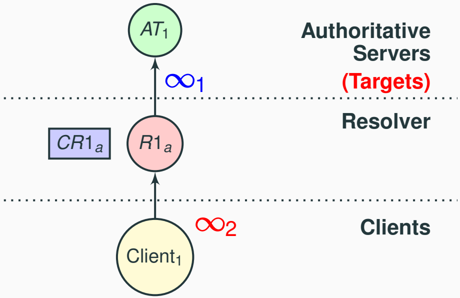

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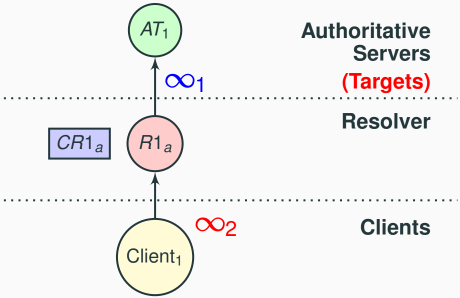

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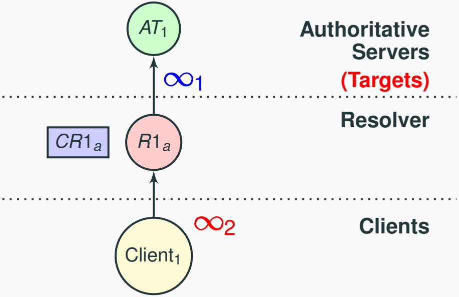

1. RFC1034 [3] is very **vague**
    - “resolvers should bound the amount of work” to avoid infinite loops
2. Offers no protection from looping clients ($\infty_2$)
    - amplification is proportional to client query rate

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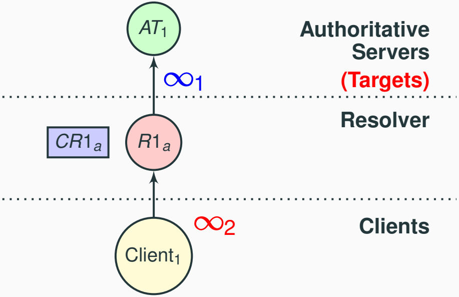

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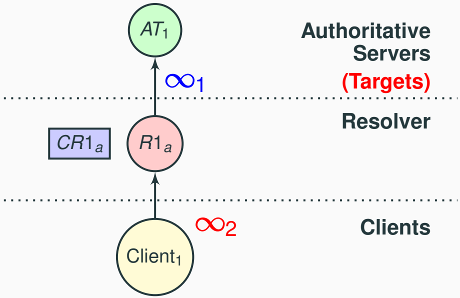

2. RFC1035 [4] (§7.2) **set counters**:
   - “the resolver should have a global per-request counter to limit work on a single request.”

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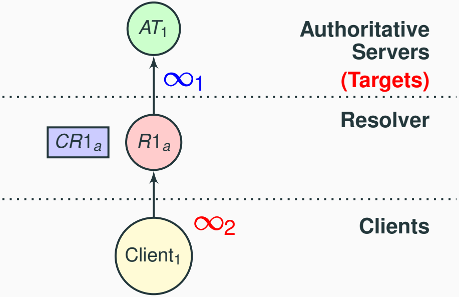

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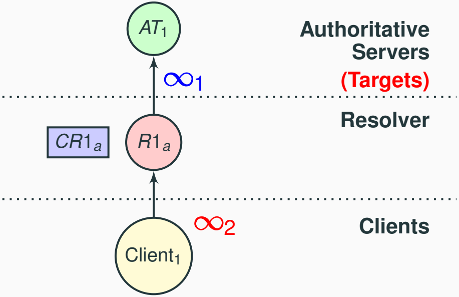

3. RFC1536 [2](§2) warns that **loops can occur** :
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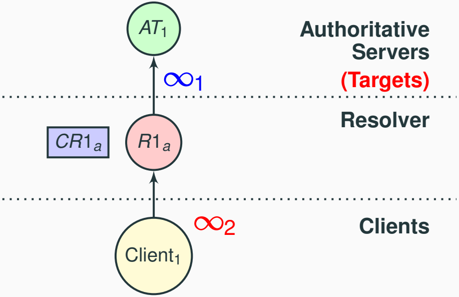

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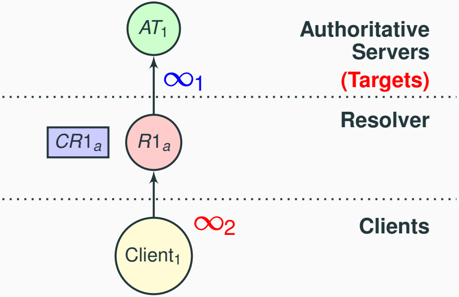

**Solution:** detect loops and don't repeat them (**negative caching**)

- Not in any RFC at the moment.
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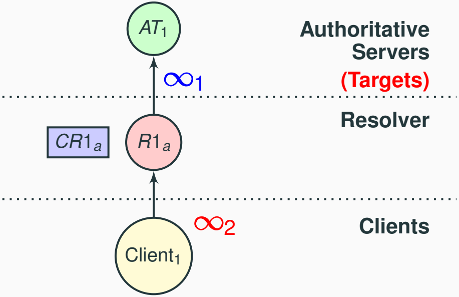

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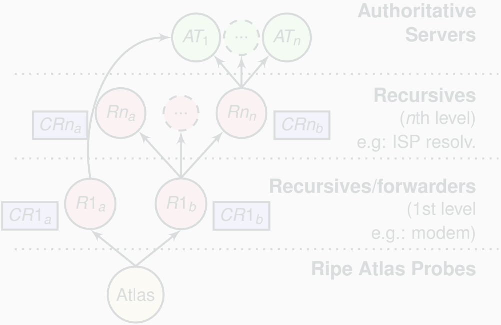
# Reproducing TsuNAME: a controlled experiment

- We run our authoritative servers
- Each Atlas probe sends 1 query
  - to each local resolver
- **Goal**: determine if we can trigger loops with 1 query only
- We collect traffic and analyze it



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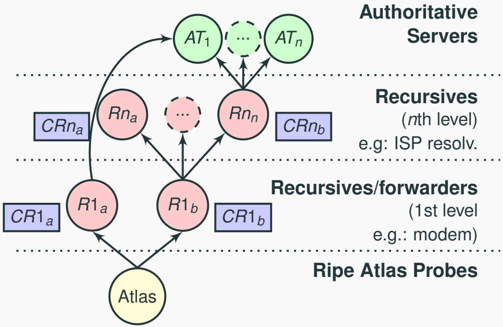

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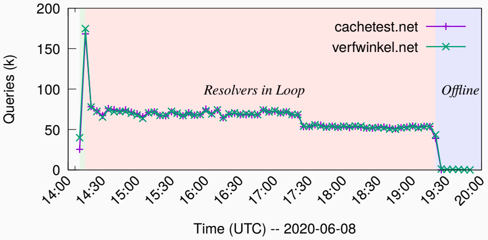

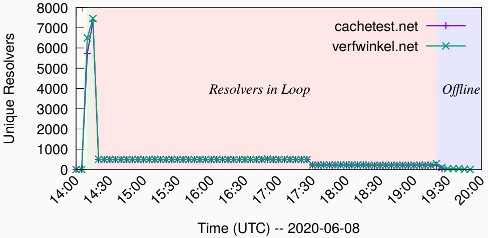

- 574 recursives looped (34 ASes)
  - Including Google Public DNS and Cisco Open DNS
- It lasted for **hours**
- (we had to stop the experiment)
- Paper: more complex scenarios
  - Using non-Atlas vantage points

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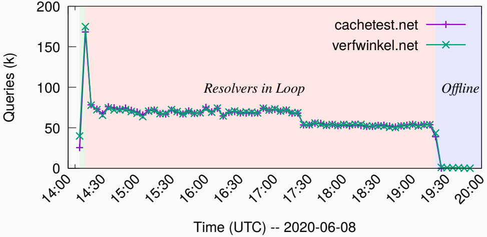

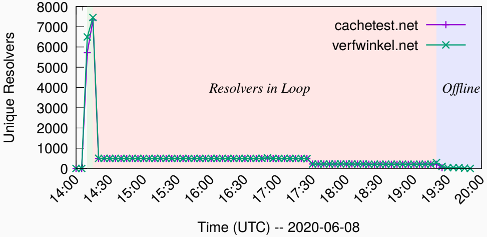

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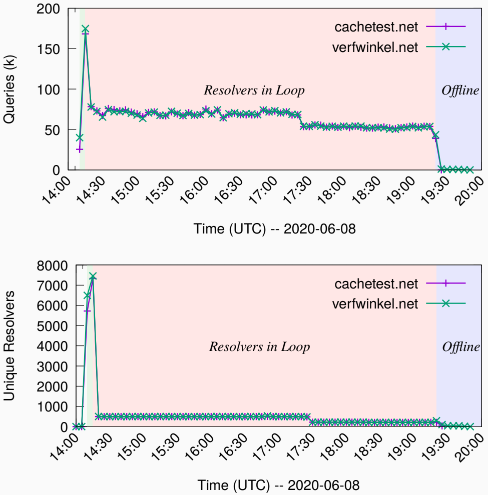

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# Prevention: DNS Ops can use `CycleHunter`

To protect Authoritative Servers OPs

- `https://github.com/SIDN/CycleHunter`

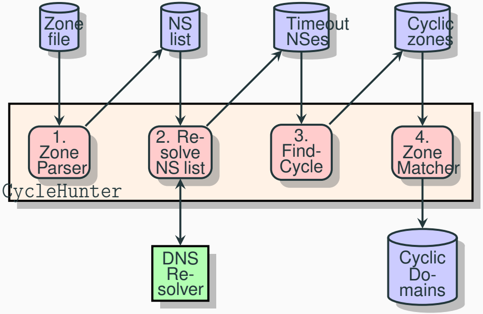

**Figure 2:** `CycleHunter` workflow

# CycleHunter in the wild: not many cyclic domains

| zone | Size | NSSet | Cyclic | Affec. | Date |
|---|---:|---:|---:|---:|---:|
| .com | 151445463 | 2199652 | 21 | 1233 | 2020-12-05 |
| .net | 13444518 | 708837 | 6 | 17 | 2020-12-10 |
| .org | 10797217 | 540819 | 13 | 121 | 2020-12-10 |
| .nl | 6072961 | 79619 | 4 | 64 | 2020-12-03 |
| .se | 1655434 | 27540 | 0 | 0 | 2020-12-10 |
| .nz | 718254 | 35738 | 0 | 0 | 2021-01-11 |
| .nu | 274018 | 10519 | 0 | 0 | 2020-12-10 |
| Root | 1506 | 115 | 0 | 0 | 2020-12-04 |
| **Total** | 184409371 | 3602839 | 44 | 1435 | |

**Table 1:** CycleHunter: evaluated DNS Zones

- Human error plays a role

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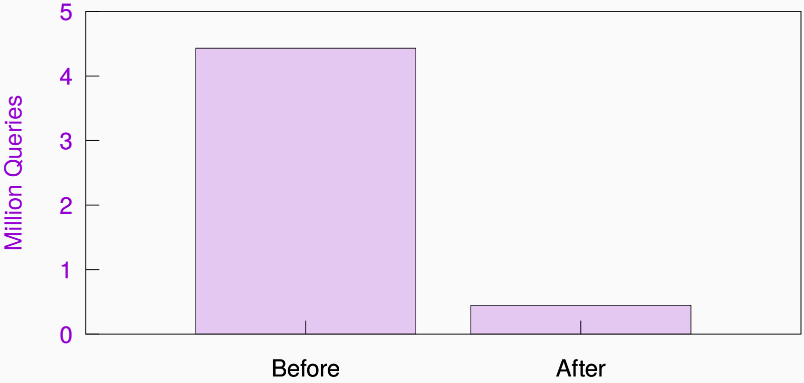
# Responsible Disclosure

| Date | Type | Group |
|---|---|---|
| 2020-12-10 | Private Disclosure | Google Notification |
| 2020-12-10 | Private Disclosure | SIDN DNSOPs |
| 2021-02-05 | Private Disclosure | OARC34 |
| 2021-02-22 | Private Disclosure | APTLD |
| 2021-02-22 | Private Disclosure | NCSC-NL |
| 2021-02-23 | Private Disclosure | CENTR |
| 2021-03-04 | Private Disclosure | LACTLD |
| 2021-02-18–2021-05-05 | Private Disclosure | Private |
| 2021-05-06 | Public Disclosure | OARC35 |
| 2021-05-06 | Public Disclosure | `https://tsuname.io` |

**Table 2:** TsuNAME disclosure timeline

# We confirmed Google fixed its Public DNS



# Post-disclosure: A European ccTLD saw it too

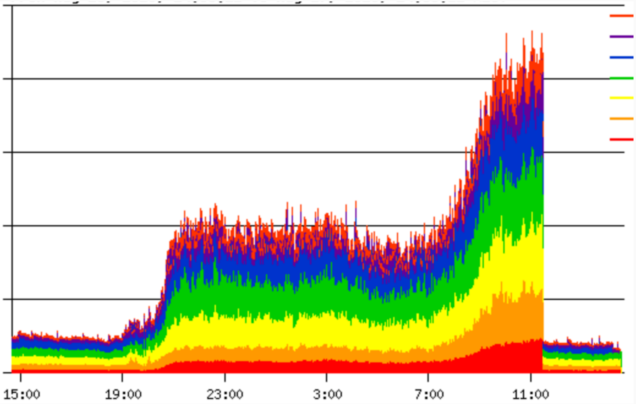


**Figure 3:** TsuNAME event at an EU-based ccTLD operator. **10x traffic growth**

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# Conclusions

- NS loops are an old problem for DNS
  - we show we **MUST** address it now
- Current standards do not fully address it
  - draft-moura-dnsop-negative-cache-loop
- **What do to**?
  - DNS operators: run `CycleHunter`
  - Developers of DNS resolver: negative caching of loops

https://tsuname.io

# References i

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