**Maynard Koch <maynard.koch@tu-dresden.de>**
Florian Dolzmann <florian.dolzmann@mailbox.tu-dresden.de>
Marcin Nawrocki <marcin.nawrocki@netscout.com>
Matthias Wählisch <m.waehlisch@tu-dresden.de>
Thomas C. Schmidt <t.schmidt@haw-hamburg.de>

# Transparent DNS Forwarders

## A (still) unnoticed component of the ODNS infrastructure

OARC 43, Prague // October 27, 2024

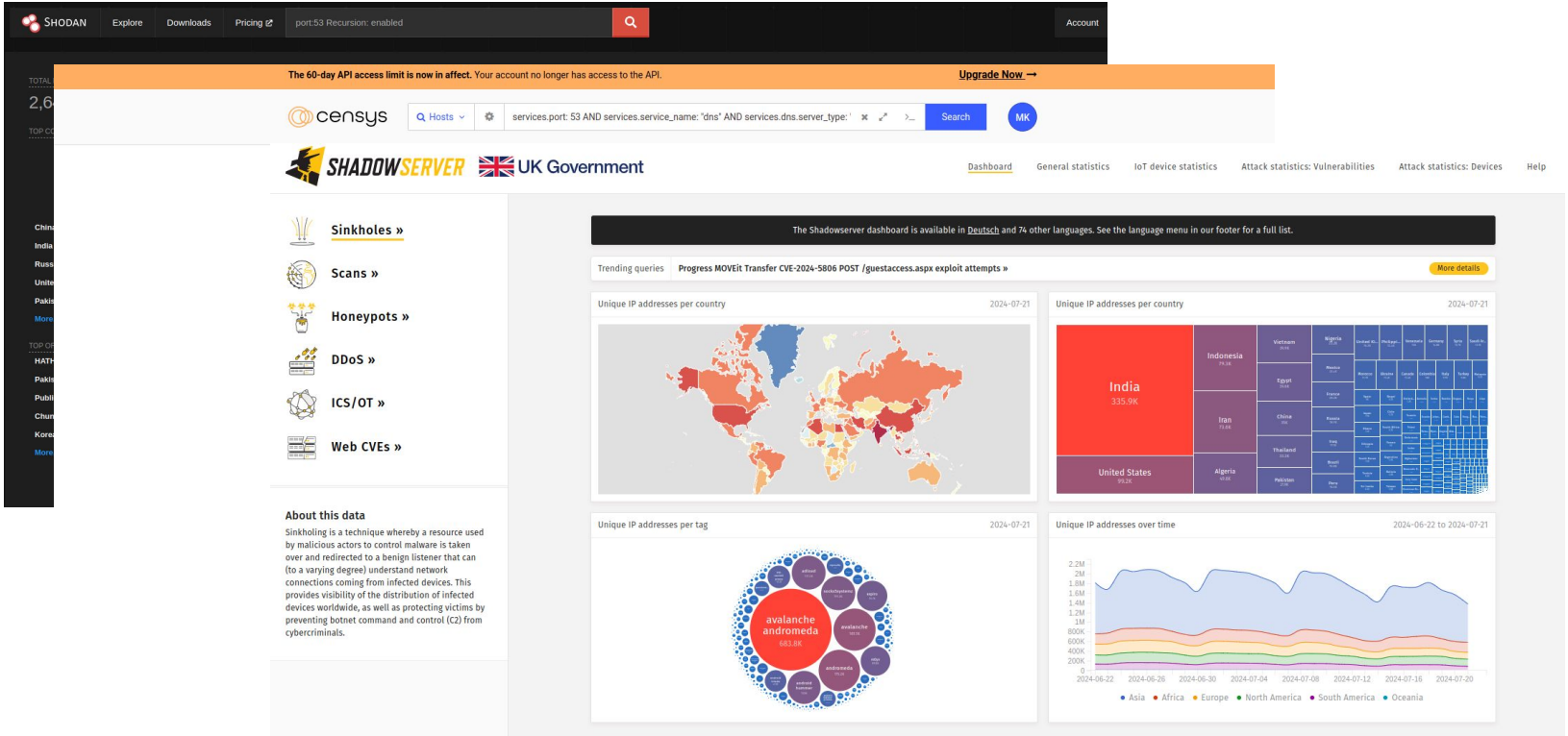
# Why should we care? Open DNS enables amplification attacks!

Leading to unwanted traffic and unexpected traffic shifts.


https://www.flaticon.com/free-icon/loupe_622669 | https://www.flaticon.com/premium-icon/dns_1183595
https://www.flaticon.com/free-icon/devil_725040 | https://www.flaticon.com/premium-icon/sad_3129281

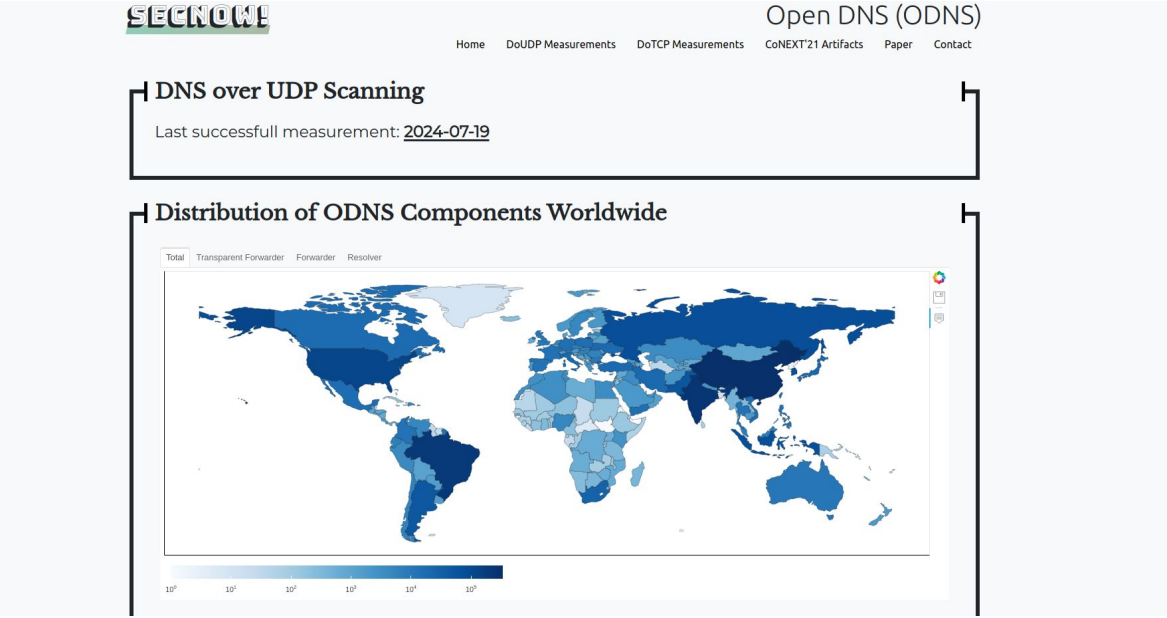
# Monitoring the Open DNS Infrastructure

Identify open resolvers to mitigate DDoS. Popular scanning campaigns.



# Monitoring the Open DNS Infrastructure

## Our campaign, https://odns.secnow.net




## Why yet another scanning campaign?

# Monitoring the Open DNS Infrastructure

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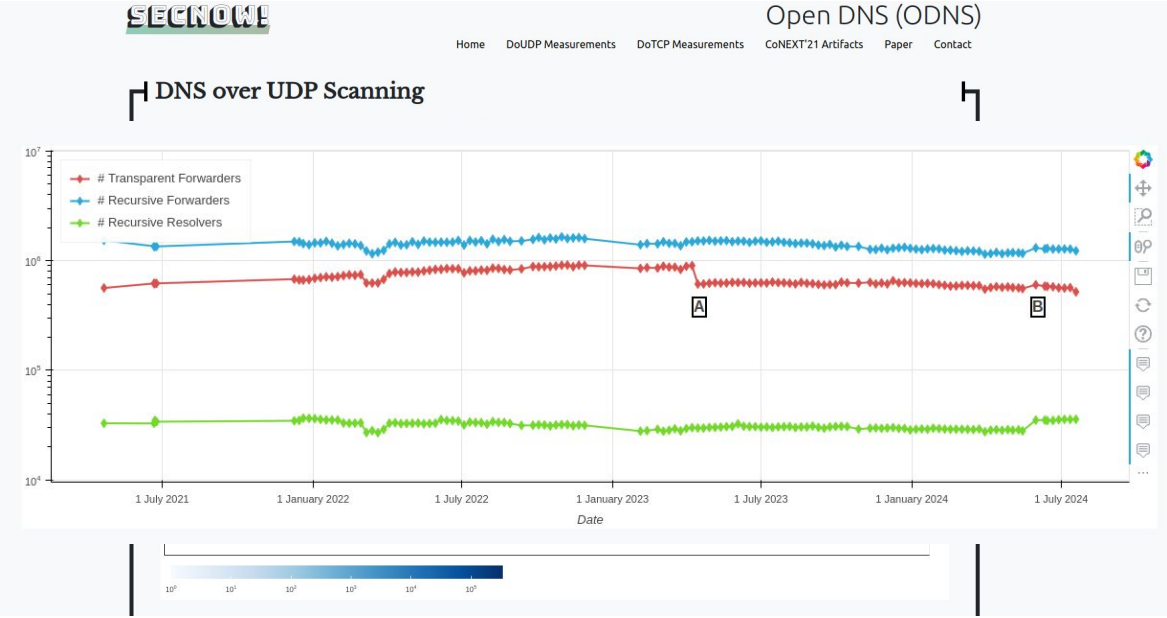



**Why yet another scanning campaign?**

**We also monitor transparent DNS forwarders!**

They account for **~30%** of the ODNS infrastructure.

These devices are **missed completely** by other campaigns.

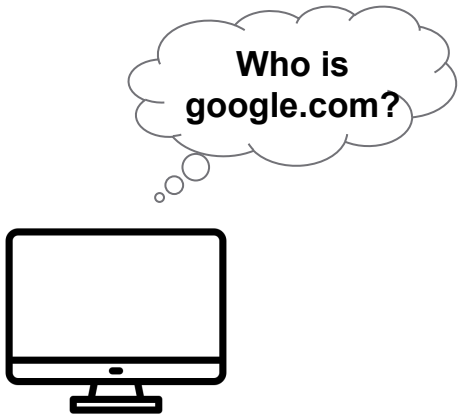
# Our controlled experiment confirms that transparent DNS forwarders fell of the radar.

Details, see paper.

| | Censys | Shadowserver | Shodan | Our Scans |
|---|---|---|---|---|
| # ODNS | 1.75M | 1.7M | 1.6M | 1.8M |
| Transparent forwarders detected | ✗ | ✗ | ✗ | ✓ (30% transp. fwd.) |

M. Nawrocki, M. Koch, T. C. Schmidt, M. Wählisch, ACM CoNEXT, 2021, https://doi.org/10.1145/3485983.3494872

# How do transparent forwarders work?




**Client**
(7.7.7.7)

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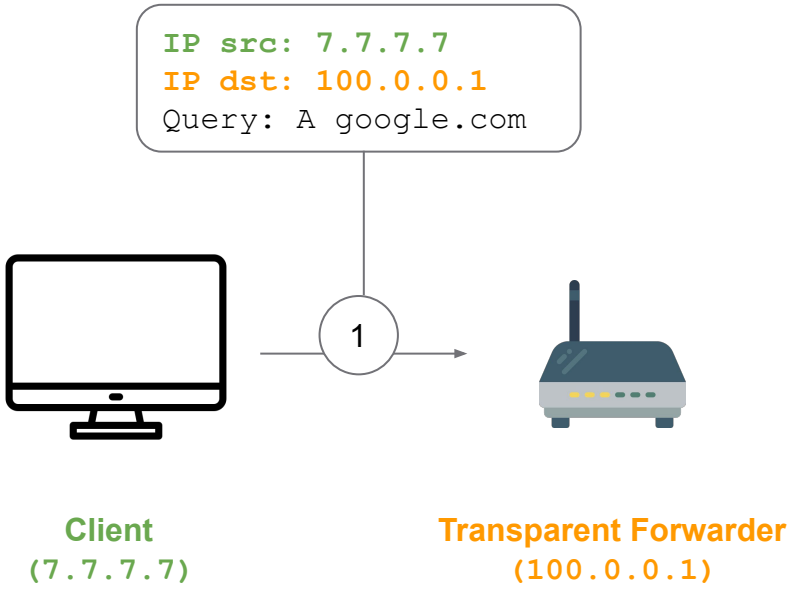


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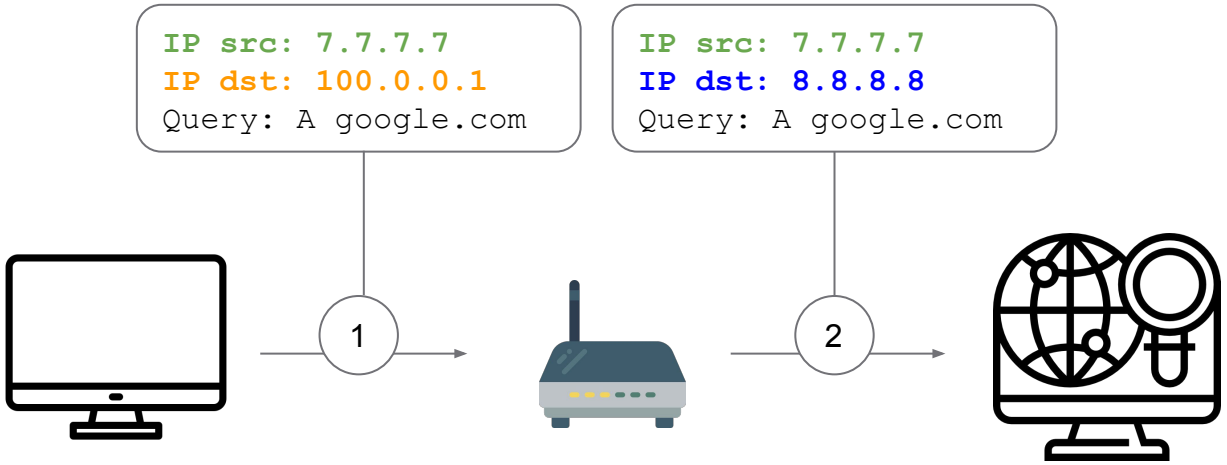


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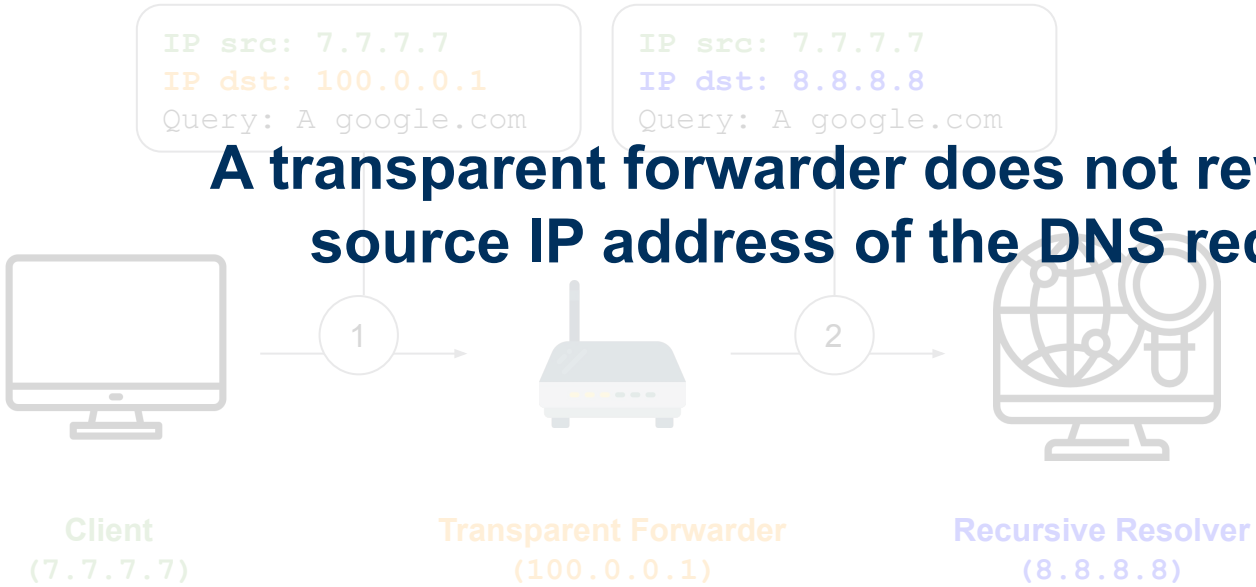


**A transparent forwarder does not rewrite the source IP address of the DNS request**

https://www.flaticon.com/free-icons/computer | https://www.flaticon.com/free-icons/dns | https://www.flaticon.com/free-icons/router | https://www.flaticon.com/free-icons/server

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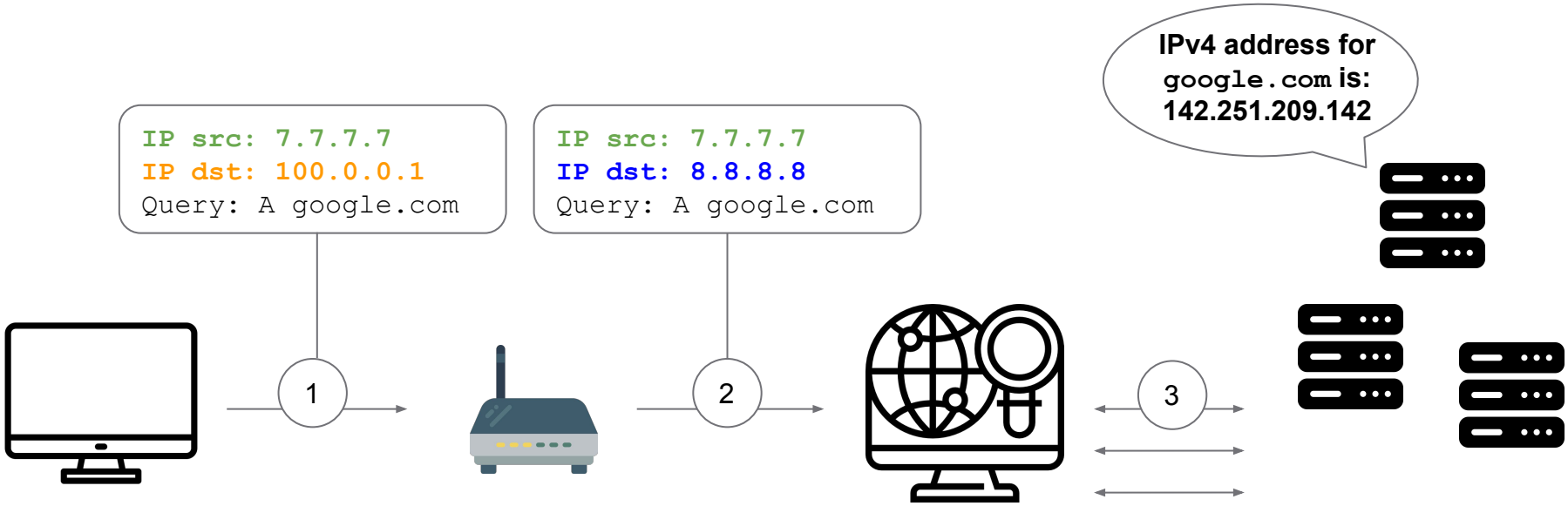


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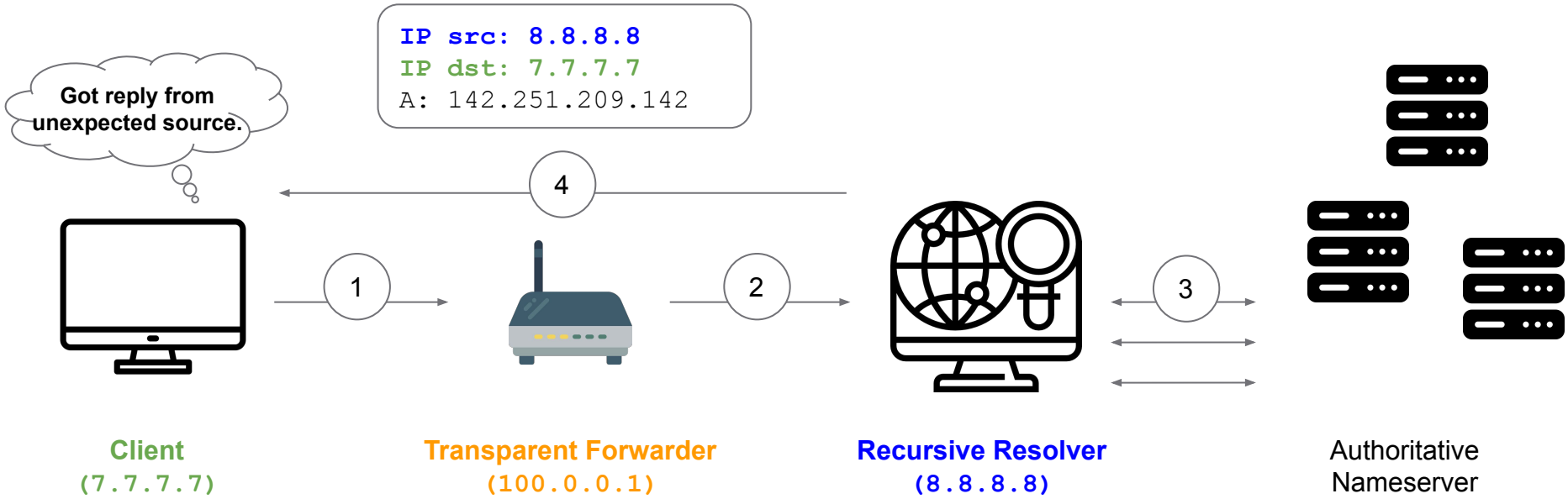


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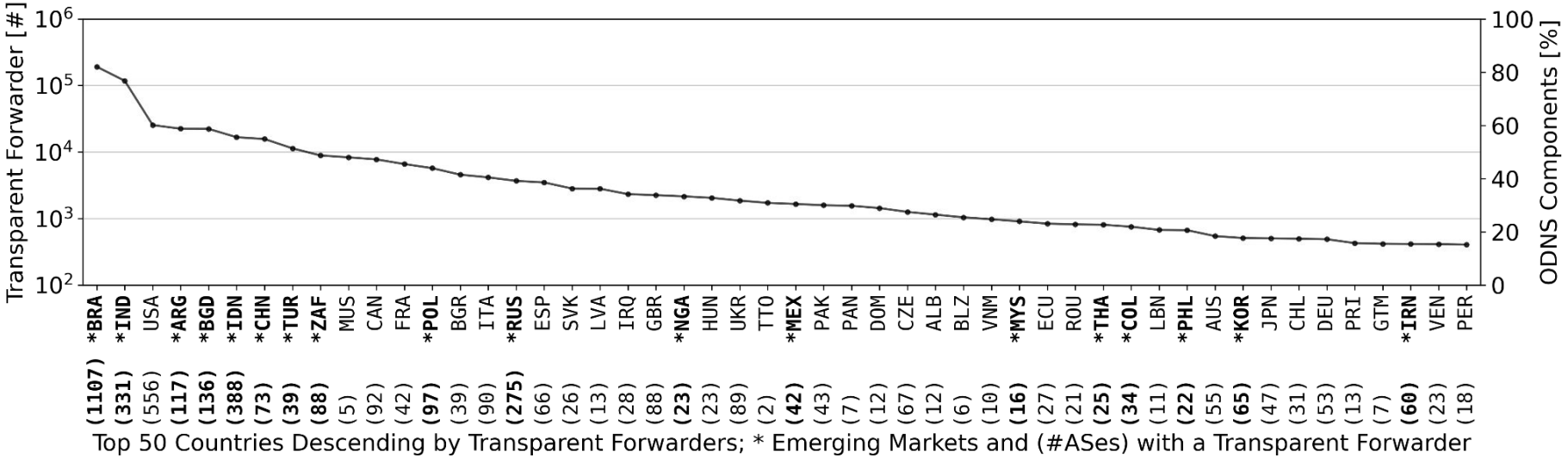
# Where is transparent forwarder deployment most popular?

## An overview of current results

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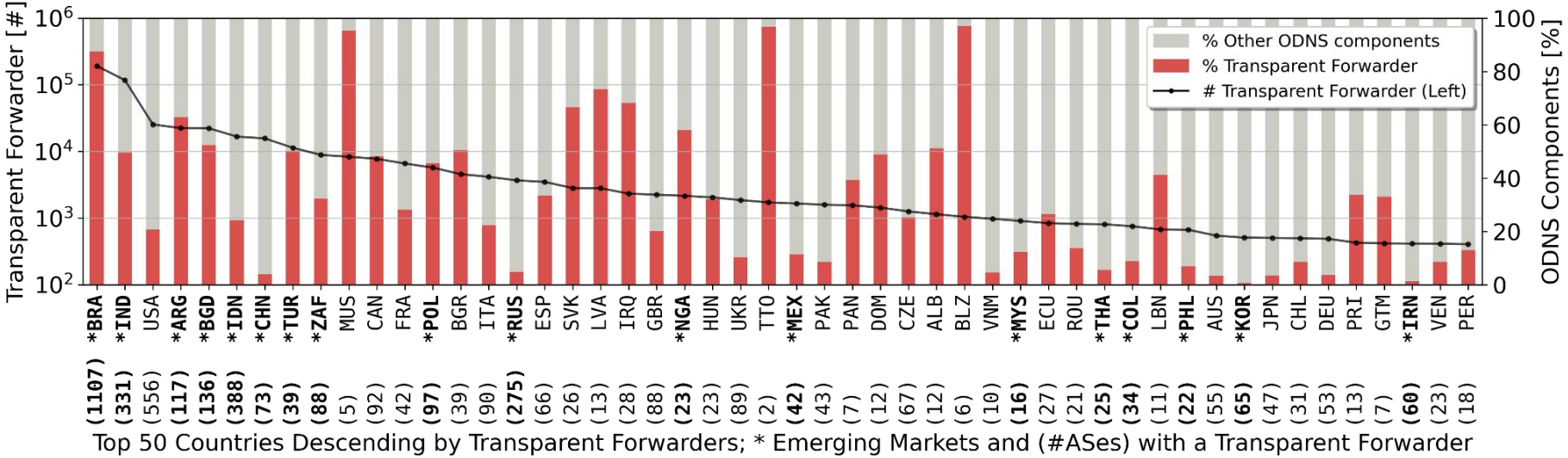


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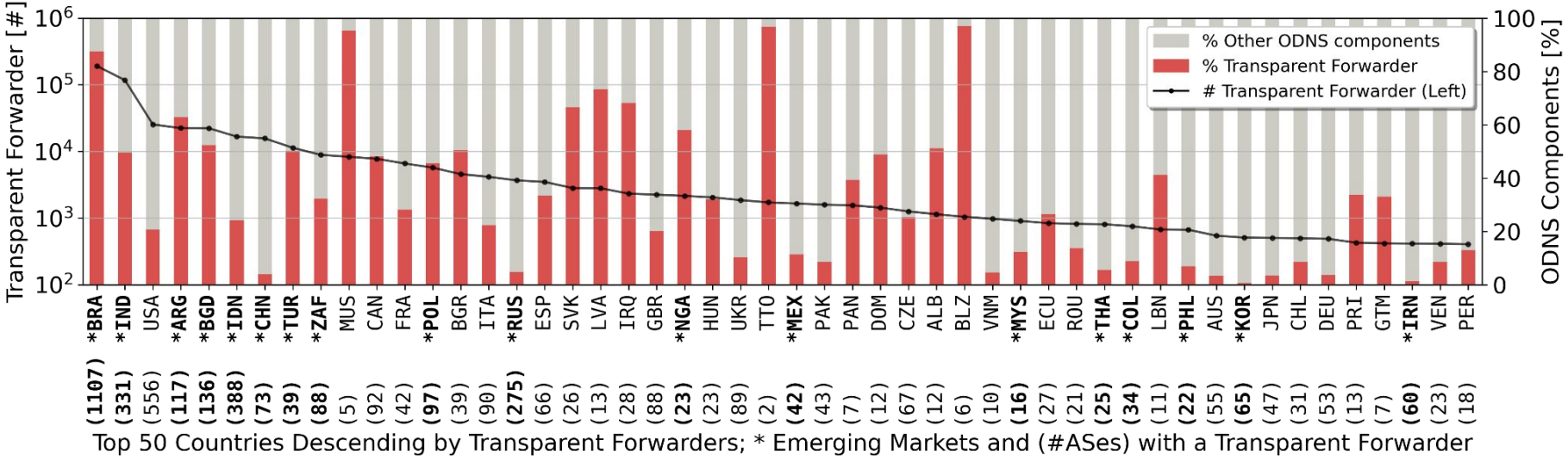


1. Countries classified as emerging markets are more likely to host transparent forwarders
2. In each country, multiple ASes host forwarders.
3. In some countries, the ODNS consists almost exclusively of transparent forwarders.

# Why do common scan campaigns miss transparent forwarders?

Due to efficiency reasons, scans use static queries and **only evaluate incoming traffic**.

This means that many scanning campaigns just consider the replying source address.

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This means that many scanning campaigns just consider the replying source address.

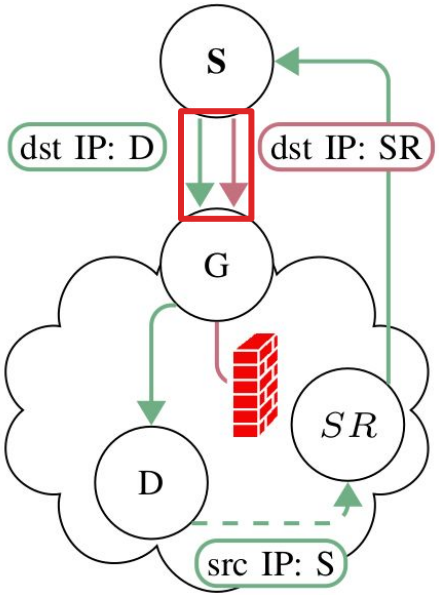
**This is short sighted and here is a simple example why…**


[ http://bilder.hifi-forum.de/medium/610438/homer-simpson-doh_204826.gif ]

**“The consensus that we came to was that since these systems couldn’t do amplification on their own and merely forwarded packets, they were out of scope.” -** Reply to our request why [scanning company] does not include transparent forwarders

# Why should transparent forwarders be included in ODNS scans?

## Transparent forwarders allow the use of restricted resolvers




- Transparent forwarders **unveil access to restricted/shielded resolvers**

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**D** Queried Device
**G** Gateway
**SR** Shielded Resolver

DNS Transaction
Transp. Forwarding
Firewall

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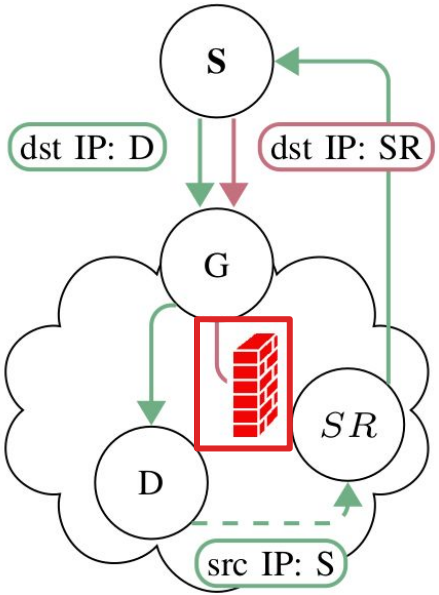


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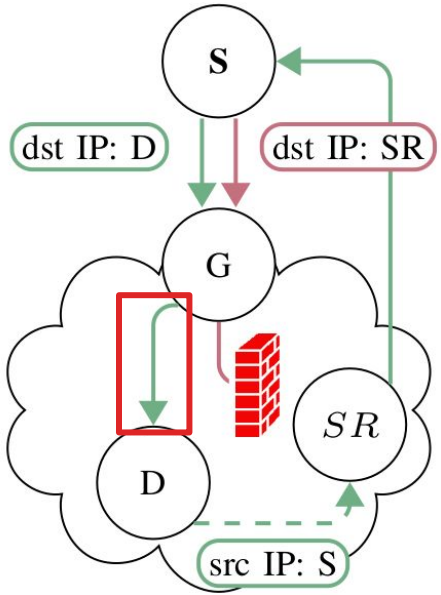


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**Querying a transparent forwarder circumvents the firewall!**

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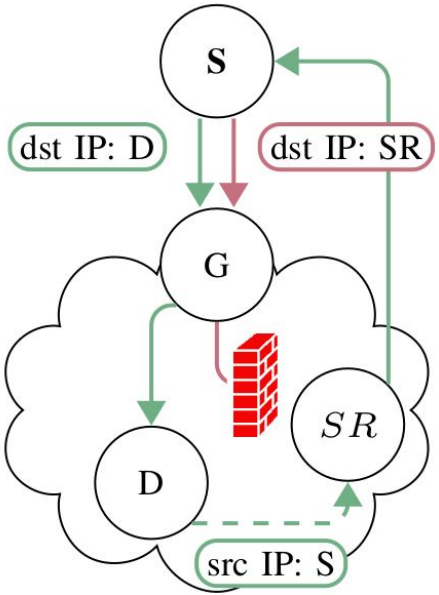


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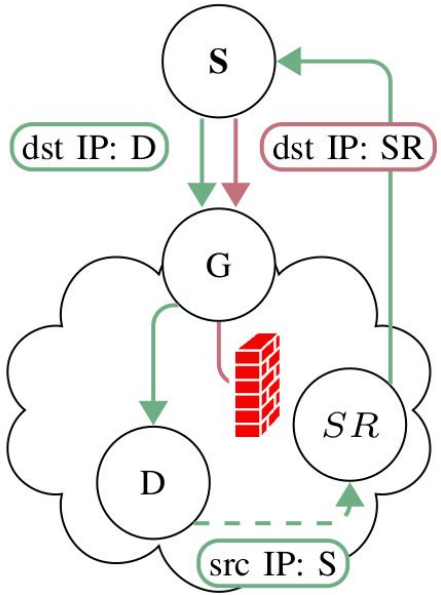


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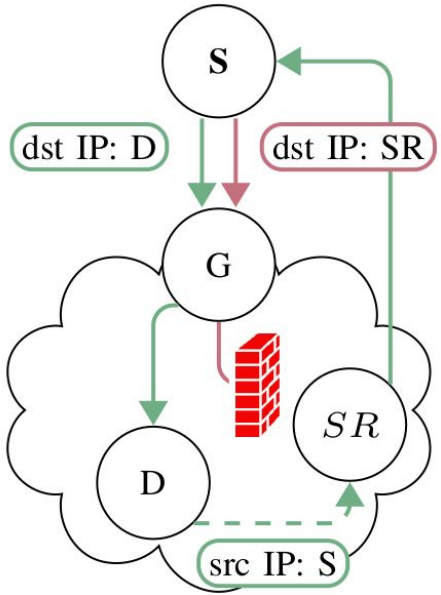


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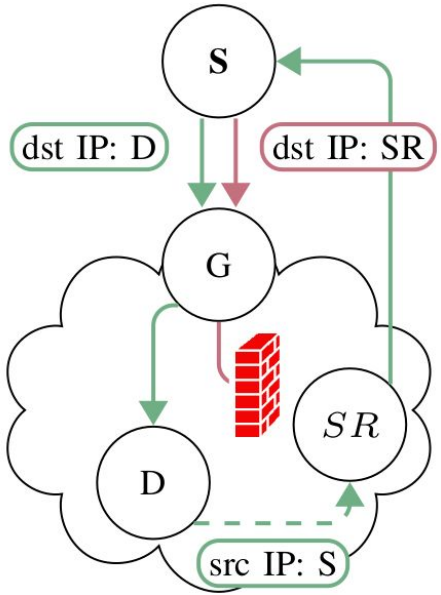


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**Transparent forwarders are, indeed, a threat and should be removed completely but at least monitored.**

# In a nutshell

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   Even worse compared to recursive resolver

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**(1) Update filter rules, or**
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**...and also include transparent forwarders in your scanning campaigns!**

# Transparent Forwarders: An Unnoticed Component of the Open DNS Infrastructure


Marcin Nawrocki
marcin.nawrocki@fu-berlin.de
Freie Universität Berlin
Germany

Maynard Koch
maynard.k@fu-berlin.de
Freie Universität Berlin
Germany

Thomas C. Schmidt
t.schmidt@haw-hamburg.de
HAW Hamburg
Germany

Matthias Wählisch
m.waehlisch@fu-berlin.de
Freie Universität Berlin
Germany



## ABSTRACT

In this paper, we revisit the open DNS (ODNS) infrastructure and, for the first time, systematically measure and analyze transparent forwarders, DNS components that transparently relay between stub resolvers and recursive resolvers. Our key findings include four takeaways. First, transparent forwarders contribute 26% (563k) to the current ODNS infrastructure. Unfortunately, common periodic scanning campaigns such as Shadowserver do not capture transparent forwarders and thus underestimate the current threat potential of the ODNS. Second, we find an increased deployment of transparent forwarders in Asia and South America. In India alone, the ODNS consists of 80% transparent forwarders. Third, many transparent forwarders relay to a few selected public resolvers such as Google and Cloudflare, which confirms a consolidation trend of DNS stakeholders. Finally, we introduce DNSRoute++, a new traceroute approach to understand the network infrastructure connecting transparent forwarders and resolvers.



## CCS CONCEPTS

• **Networks** → **Public Internet**; **Security protocols**; **Network measurement**; • **Security and privacy** → *Security protocols*.

**ACM Reference Format:**
Marcin Nawrocki, Maynard Koch, Thomas C. Schmidt, and Matthias Wählisch. 2021. Transparent Forwarders: An Unnoticed Component of the Open DNS Infrastructure. In *The 17th International Conference on emerging Networking EXperiments and Technologies (CoNEXT '21), December 7–10, 2021, Virtual Event, Germany.* ACM, New York, NY, USA, 9 pages. https://doi.org/10.1145/3485983.3494872


## 1 INTRODUCTION

The open DNS infrastructure (ODNS) [37] comprises all components that publicly resolve DNS queries on behalf of DNS clients



*CoNEXT '21, December 7–10, 2021, Virtual Event, Germany*



ACM ISBN 978-1-4503-9098-9/21/12…$15.00
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**Table 1: Comparison of known open DNS components.**

| | 2014 | 2020 | 2021 | | | |
|---|---|---|---|---|---|---|
| | [26] | [1] | [8] | [39] | [38] | This Work |
| # Rec. Resolvers | n/a | 20K | 50K | n/a | n/a | 32K (2%) |
| Forwarders | | | | | | |
| # Recursive | n/a | 1.4M | 1.7M | n/a | n/a | 1.5M (72%) |
| # Transparent | 0.6M (2%) | n/a | n/a | n/a | n/a | 0.6M (26%) |
| All ODNSes | 25.6M | 1.42M | 1.75M | 1.8M | 1.6M | 2.125M |

located in a remote network. This "openness" makes the ODNS system a popular target for attackers, who are in search for amplifiers of DNS requests, for periodic DNS scan campaigns, which try to expose the attack surface, and for researchers, who want to learn more about DNS behavior.

Originally observed in 2013 [31], *transparent* DNS forwarders have not been analyzed in detail since then, but fell off the radar in favor of *recursive* forwarders and resolvers. This raises concerns for two reasons. First, the relative amount of transparent forwarders increased from 2.2% in 2014 to 26% in 2021 (see Table 1). Second, as part of the ODNS, they interact with unsolicited, potentially malicious requests.

In this paper, we systematically analyze transparent forwarders. Our main contributions read as follows:

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ica
(4) We
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plor
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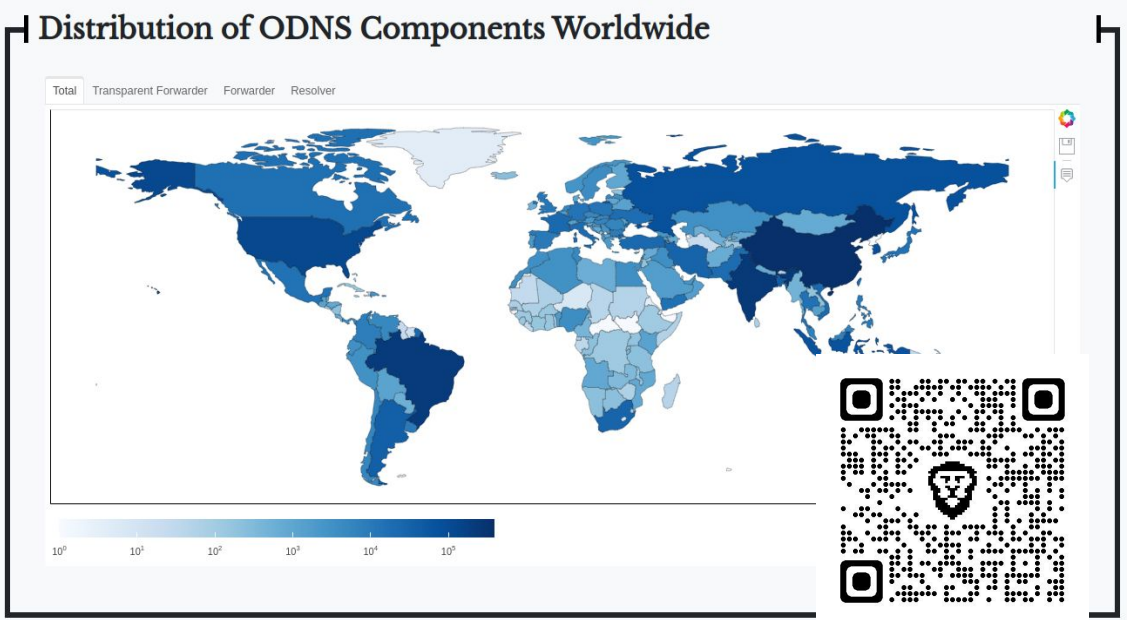
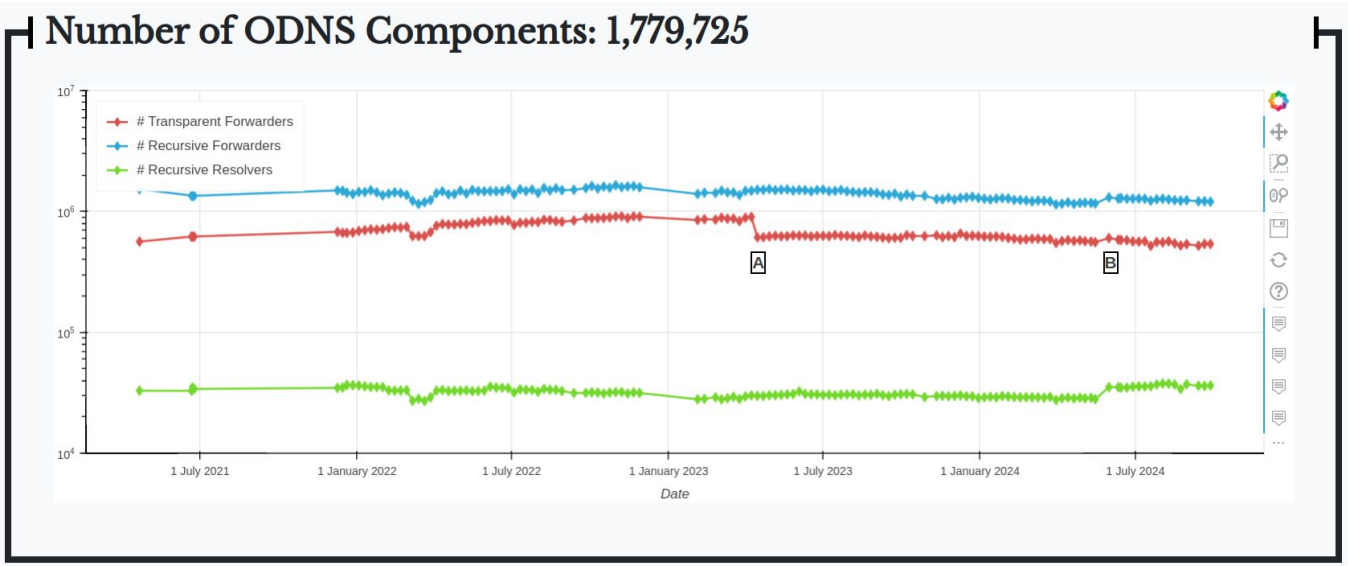
https://doi.org/10.1145/3485983.3494872

Weekly scan results and Open DNS classification:
odns.secnow.net



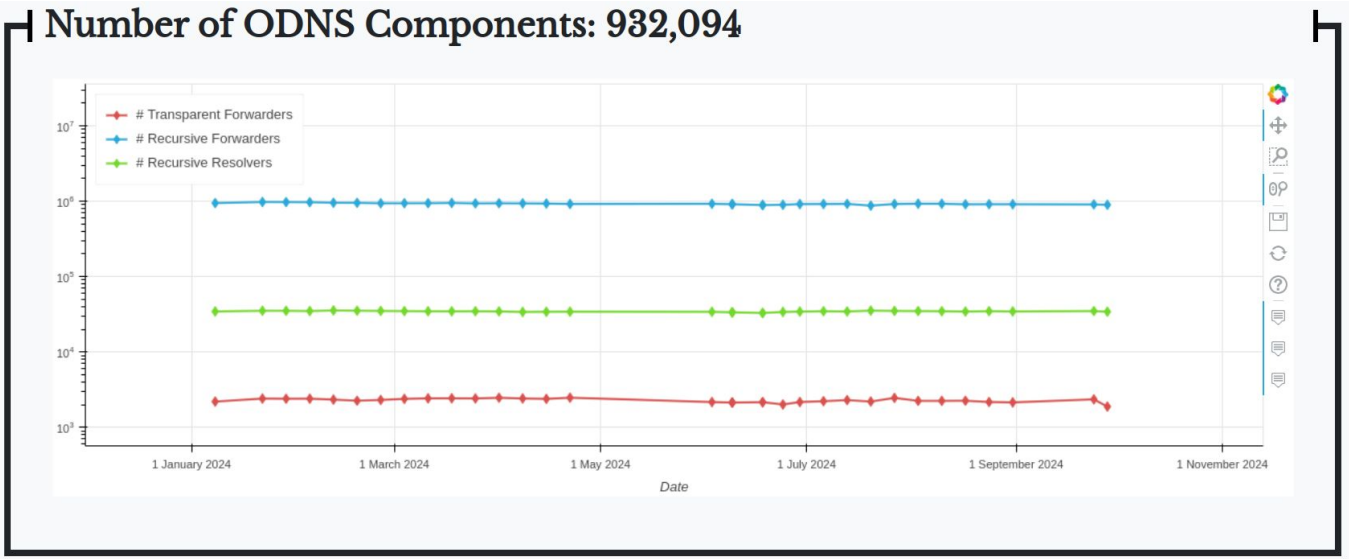
# Backup

# DNS over UDP




1. There is a slight decreasing trend for transp. and rec. forwarders
2. We were able to reduce the amount of transparent forwarders by approx. 250K (event **A**)
   a. How? We got in contact with a telecom. company that was responsible for more than 250K transp. fwd.
   b. They updated their packet filter rules.

# DNS over TCP

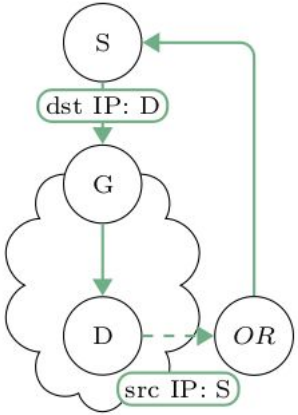



1. Transparent forwarders are rarely deployed over DoTCP
2. Connection-oriented nature of TCP reduces the threat potential significantly

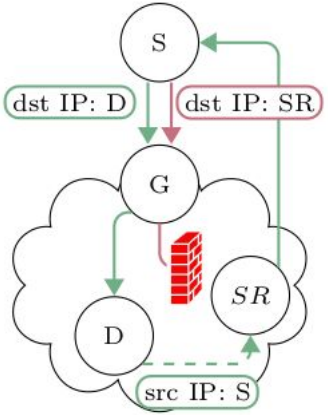
# You ship transparent forwarders?

Please, talk to us. We would like to understand your implementations better.

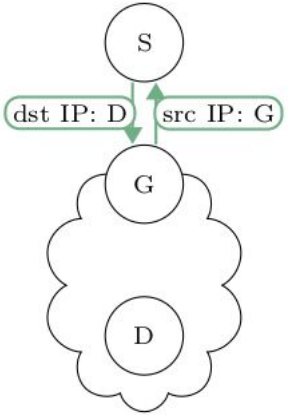
We have identified **MikroTik** and **Cisco** devices that are misconfigured by default.



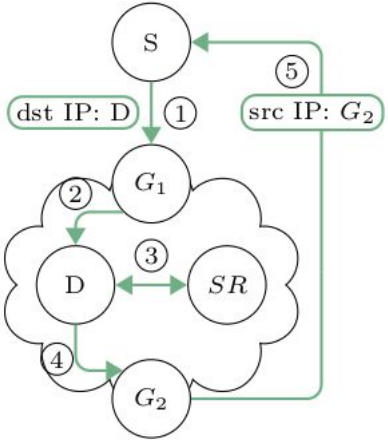

(a) D = Transp. Fwd.; D uses open resolver




(b) D = Transp. Fwd.; D uses shielded resolver




(c) DNS query gets intercepted by G




(d) NAT configuration at $G_2$ rewrites source IP address

S Scanner G Gateway *OR* Open Rec. Resolver *SR* Shielded Resolver D Queried Device

DNS Transaction Transp. Forwarding Firewall

# Regarding CPE devices that act as transparent forwarders
[https://seclists.org/nanog/2013/Aug/132]

(1) Some CPE devices provide DNS resolution by just **forwarding** DNS requests to a predefined resolver, i.e., they do not implement a full resolver.
(2) CPE devices usually implement NAT, i.e., at the **LAN interface**, they rewrite the source IP address and forward the incoming packet. This includes DNS requests.
(3) CPE devices do not rewrite source IP addresses of incoming packets from a **WAN interface**.
(4) Combining (1), (2), (3) means that (faulty) implementations also forward DNS requests received from the WAN interface without rewriting the source IP address.

**Understanding which type of CPE devices are affected will help to approach vendors and fix this bug.**