

# Cache Poisoning Protection Deployment Experience

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# Agenda

Recap from OARC 38 Presentation

Case Randomization Deployment

DNS Cookies Deployment

DNS Cookies Deployment on Name servers

DNS-over-TLS to Authoritative (ADoT)

Concluding remarks



# RECAP from OARC 38

- Cache poisoning is a risk for UDP queries
- Proposed mitigations reduce risk (port+query ID randomization, case randomization, DNS cookies)
- Most effective approach (DNS cookies) not deployed widely
- Additional mechanisms for protection exist
  - Nonce prepending (for delegation only zones - root and TLDs)
  - DNS-over-TLS

*(for details see [OARC 38 presentation](#))*



# RECAP: Google Public DNS Countermeasures

Resolvers replicated across metros with multiple servers in each metro.

Our countermeasures ([Security Benefits](#)):

- Randomize source ports, query ID, choice of name servers
- Prepending nonce label
- **Case Randomization (0x20)**
- **DNS Cookies**
- **DNS-over-TLS to Authoritative (ADoT)**



# Google Public DNS Deployment Updates



# Case Randomization: Deployment Experience

- Enabled in multiple metros (not all) around the world
  - Covers > 90% UDP traffic in each enabled metro
- Problem name servers added to actively maintained disable-list
  - 2000 name server IPs + a few subnets (total NS count: 1.5–2 million)
  - At least one large operator in the list

## Observed problems

- Response case mismatch
- Error responses to mixed case queries
- No response (timeout) to mixed case queries
- Case for PTR record type sometimes not preserved
- [NEW] Occasional response case mismatch - discovered during deployment
  - Only observed with higher QPS

(Deployment [announcement](#))



# Case Randomization: Failure Mitigations

- disable-list *will* miss some broken name servers
- Primary fallback: mismatched response results in retry over TCP
- Server regression could generate TCP flood
- Additional fallback for consistent failures with a name server (in progress)
  - Disable case randomization with confirmation from other signals.
- Case randomization is disabled for PTR record type

# DNS Cookies ([RFC 7873](#)): Deployment Experience

- Expanded manual configuration: primarily more TLDs
- Enabled In-line probing with production service: probe top ~400K IPs
- No probing based enablement for user queries yet
  - expected to cover < 12% of user queries
  - analyzing probe results to make a decision
- Probe results from LAX (% of nameservers)
  - Valid response with Server Cookie: 20.96%
  - Valid response with Client Cookie echo<sup>1</sup>: 1.32% [we consider as supported]
  - Valid response without Cookie: 75.81%
  - Failures: < 3%
  - Nameservers change from supported to unsupported

1. [RFC 7873 section 5.3](#) describes response processing. [BIND](#), [Knot](#) do not consider “client cookie echo” as indicating server support.





# DNS Cookies: Failure Mitigation

- Responses without valid cookies
  - attack or implementation issues? Latter seen, former hard to observe during testing
- Mitigation: Fall back to TCP
- Additional mitigation: Disable cookies if server completely drops support

# DNS Cookies Deployment for Name Servers

Small increase since Oct 2022

Support Level	Nameserver July 2022	Nameserver Feb 2023	Query July 2022	Query Feb 2023
Full: Server Cookies	40.4%	42.20%	2.0%	2.38%
Echo: Client Cookies	0.8%	0.76%	10.0%	9.24%

# DNS Cookies Deployment for Name Servers

Note: not specific to Google Public DNS

- Why is deployment among large operators low?
- Open-source name servers have compliant support
- RFC 7873 section 7 covers topic of incremental deployment
- Deployments using anycast IPs and server farms behind load-balancers
  - Need careful deployment to minimize resolvers seeing different behavior from same IP over a short period of time
- Avoid resolution failures during deployment
  - Clients dropping good responses without cookies should failover to other IPs for DNS zone
  - Client cookie echo could be an intermediate step?
- Experience from operators who have deployed or considering deploying DNS cookies?



# DNS-over-TLS (ADoT): Deployment Experience

- Unilateral probing for DoT on by default
- TLS 1.3 session resumption not supported
- ADoT in use for ~700 nameserver IPs for 4.5% of egress traffic
  - ADoT is down as percent of total name server queries since Oct 2022.
- For name servers supporting DoT and UDP
  - Success rate: DoT (99.8%) slightly better than UDP
  - Average Latency: DoT (85 ms) vs UDP (93 ms)
- Top authoritative servers by traffic
  - Facebook, CDN77, one.com, Wikimedia
- Issues experienced with TLS connection management



# ADoT: Operational Issues

- Servers closing TLS connections even if not idle
  - Closed after 10s in reaction to the next query (no response)
  - Unconditional close after 4s
  - Queries in flight over the connection fail
  - Requires repeating connection setup
- Google Public DNS: Mid-size operator connection count high for query volume
  - Google egress servers highly replicated per metro
  - Outbound load balancing results in many connections with low QPS per connection.
  - In progress: Optimizing outbound connection management for low volume servers.



# Concluding Remarks



# Google Public DNS Plans

- DNS Cookies
  - Enable based on probing if all misbehaviors can be mitigated sufficiently
  - Name servers: investigate safe rollout steps
  - Clarify behavior for client cookie echo response
  - Can we get significant name server traffic adoption?
    - Eliminates need for less elegant mechanisms
- ADoT scaling improvements
  - Optimize connection management (reduce count, resumption, metrics)
  - Share best practices?
- Case Randomization
  - Is it worth reviving [draft-vixie-dnsext-dns0x20](#)?



Thank you

