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# Why DNS Security and Privacy is important


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# How the DNS works

- The DNS was designed in 1983 and was designed to be a scalable distributed system, operated on a hierarchical basis
- It has proved to be a successful and essential Internet service, but was designed in an era where the Internet was comprised of a relatively small group of users and systems
- Host computers use a DNS resolver to query DNS servers to discover the IP address(es) associated with a domain name
- DNS resolvers traditionally provided by ISPs, although increasingly by third-parties (Google, Cloudflare, Quad9, Dyn et. al.)
- Responses are cached for a specified time period (the Time-to-Live or TTL) so the DNS does not have to be queried again.

# DNS Limitations

First result received by a DNS resolver is treated as the correct answer

The DNS is reliant on a host trusting that a response to a DNS query is correct

- Can be spoofed (cache poisoning) where incorrect/corrupt DNS data is introduced into DNS resolver,
- OR Man-in-the-Middle attack (e.g. compromised access router) directing DNS queries to a name server that returns forged responses
- Incorrect IP addresses result in traffic being diverted to another computer (e.g. that of an attacker)

DNS queries are not encrypted ← more on this later

# How does DNSSEC help?

## DNSSEC = “DNS Security Extensions”

- Defined in RFCs 4033, 4034, 4035 with Operational Practices in RFC 4641
- Set of extensions to DNS that allow resolvers to authenticate the origin of data in the DNS (i.e. has not been modified in transit)
- Also provides authenticated denial-of-existence of DNS records
- DNSSEC introduces new DNS records:

  RRSIG – a signature (‘hash’) of a set of DNS records (e.g. ‘www.isoc.org’, ‘mail.isoc.org’)

  NSEC3 – used by resolvers to verify the non-existence of a record

  DNSKEY – a public key that a resolver can use to validate RRSIG, authenticated by chain-of-trust

  DS – holds the name of a delegated zone (e.g. ‘isoc.org’), referencing the hash of a DNSKEY record

# How does DNSSEC help?

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- Set of extensions to DNS that allow resolvers to authenticate the origin of data in the DNS
- Authenticates that responses not modified in transit + provides denial-of-existence of DNS records

DNSSEC works by digitally-signing DNS records using public key cryptography

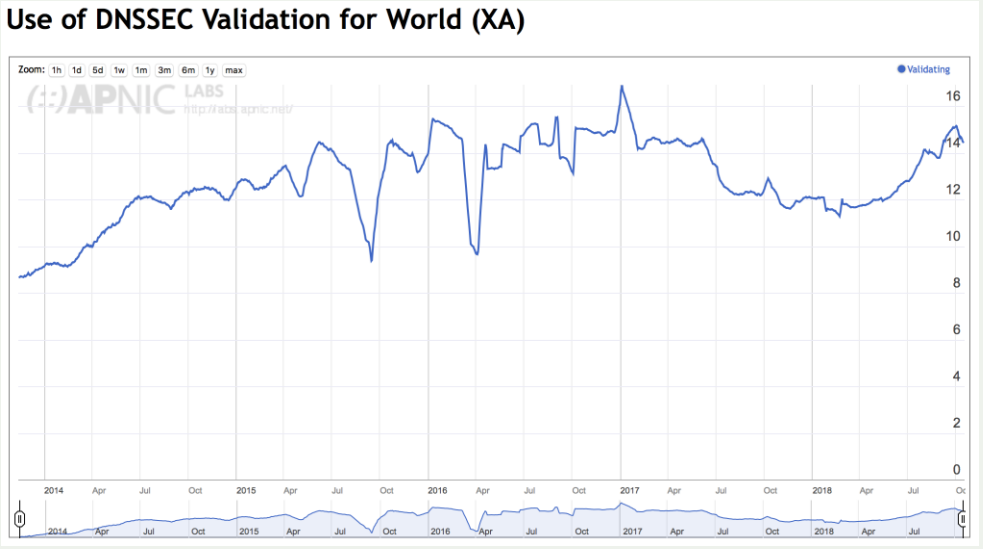
- Records can be authenticated via a chain-of-trust, starting with set of verified public keys for DNS root zone which is the trusted third party
- Domain owners sign their DNS zones with their own private keys, with authenticity of these keys established by the parent zone signing a hash of these keys, and so on up to the root zone in the hierarchy
- This is why it’s important for TLDs to sign their zones, otherwise the chain-of-trust breaks!

Ensures information entered into DNS by the domain name holder is the same information received by the end user.

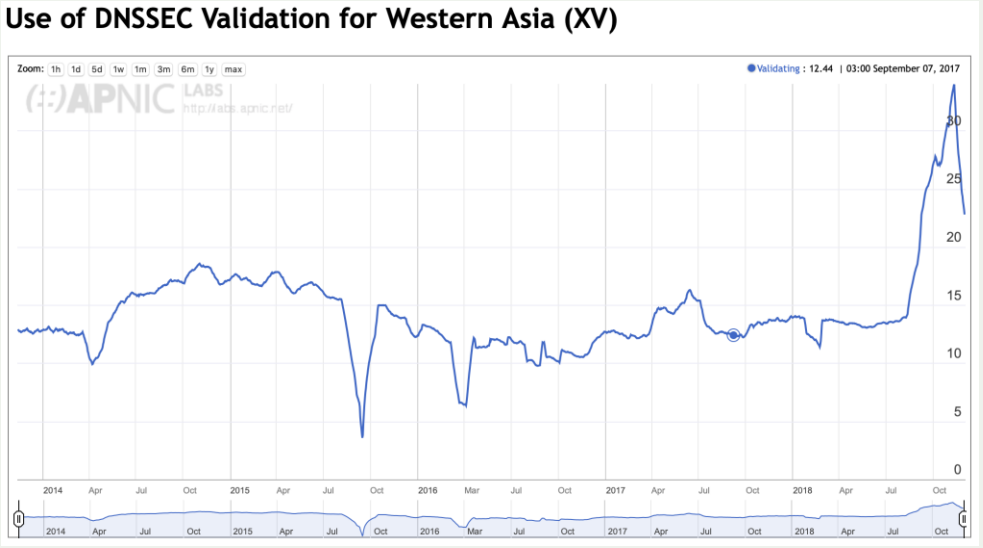
# DNSSEC Validation – Current State

- About 12% of all global DNS queries validated
- ~18% of Middle East DNS queries validated
- ~7% of North African DNS queries validated

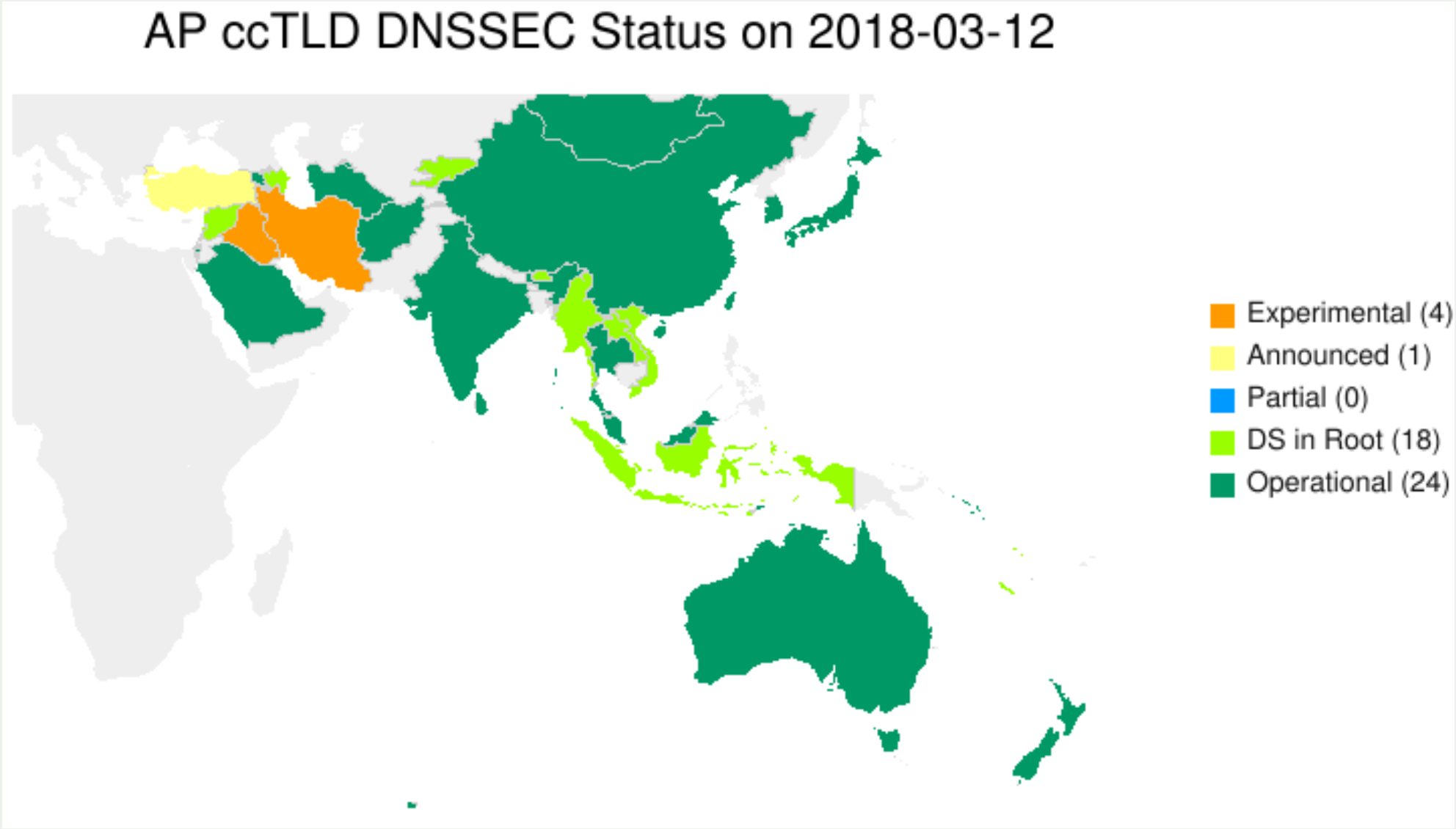
| | |
|---|---|
| Yemen (.ye) | 45.1% |
| Saudi Arabia (.sa) | 32.1% |
| Iraq (.iq) | 30.6% |
| Bahrain (.bh) | 23.2% |
| Palestine (.ps) | 22.5% |



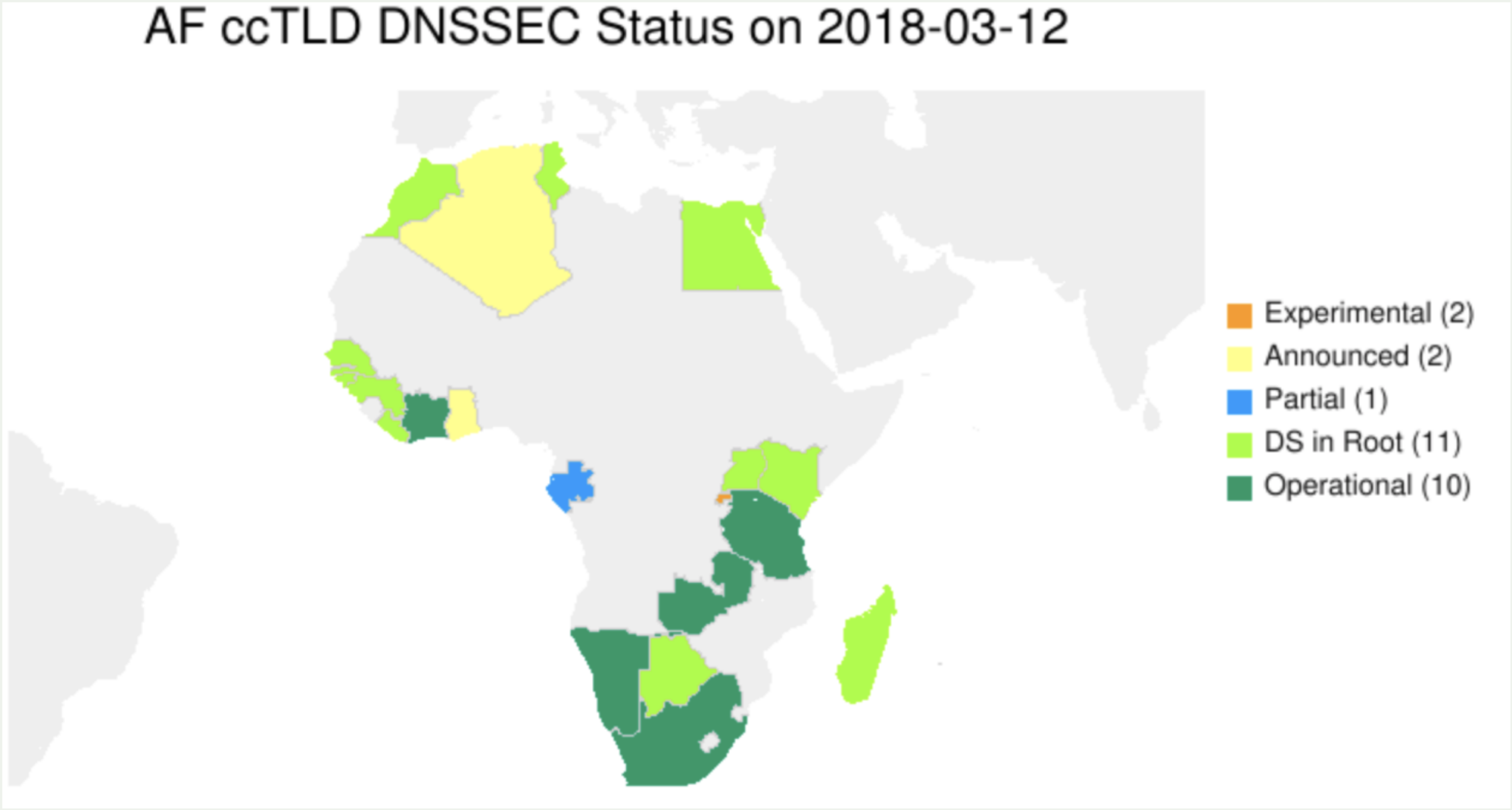

http://stats.labs.apnic.net/dnssec



# DNSSEC Deployment by ccTLD (Asia)



# DNSSEC Deployment by ccTLD (Africa)



# Why do I need DNSSEC if I already have a TLS/SSL certificate?

A TLS (formerly SSL) X.509 certificate serves two functions:

- Authenticates the identity of domain name holder
- Used to encrypt web connections using HTTPS, but can also be used for e-mail, instant messaging, streaming, VoIP and other applications

However…

- Third-party CAs are (currently) needed to validate domain holders
- Root certificate trust established through distribution of root certificates in operating systems or browsers (most commonl;y Microsoft, Apple and Mozilla certification programmes)
- Inherent weakness is that CAs are able to issue certificates for any name or organisation
- CAs have issued incorrect certificates in the past, and risk increases as number of CAs increases
- Not ideal for automated systems such as e-mail servers

# What DNSSEC does not do!

Does not ensure the correctness of DNS records – only that they haven’t been modified without the owner’s consent

Does not protect against threats against hosts (e.g. DDoS attacks, buffer overruns in code)

Does not keep DNS records private – either on the servers or ‘on the wire’

- The IETF has developed mechanisms to provide confidentiality to DNS transactions through the DNS PRIVate Exchange (DPRIVE) Working Group
- Aim is to encrypt queries and responses to/from DNS servers to prevent pervasive monitoring

# DNS Privacy

Most activities on the Internet start with a DNS query – translate human readable names to IP addresses

The DNS is a globally distributed system crossing international boundaries and using servers in many countries to provide resilience.

DNS queries are (by default) sent in clear text using UDP or TCP which allows passive eavesdropping (some VPNs also leak DNS queries)

DNS queries reveal what sites an individual (or host) is communicating with

Some ISPs log DNS queries to their resolvers and share this information with third-parties in ways not known or obvious to end users.

Some ISPs embed also user information (e.g. MAC address) within DNS queries to their resolvers that allows fingerprinting of individual users

**Whilst the data in the DNS is public, individual transactions made by an end user should not be public**

# DNS Privacy: The Solutions

The IETF DNS PRIVate Exchange (DPRIVE) Working Group has recently developed mechanisms to encrypt queries and responses to/from DNS resolvers and provide confidentiality to DNS transactions

- DNS-over-TLS (DoT) RFC 7858
- DNS-over-DTLS RFC 8094 ← currently no implementations
- DNS-over-HTTPS (DoH) awaiting RFC publication

# DNS Privacy: Implementations

## Public Resolvers

— Quad9 (9.9.9.9 and 2620:fe::fe), DoT

— Cloudflare (1.1.1.1, 1.0.0.1, 2606:4700:4700::1111 and 2606:4700:4700::1001), DoT & DoH

— CleanBrowing (various), DoT & DoH

## Clients

— Stubby 1.3+, DoT

— Unbound, 1.6.7+, DoT

— Knot resolver 2.0+, DoT

— Mozilla Firefox 62+, DoH

— Android 9 Pie, DoT

# DNS Privacy: Caveats

Resolvers and clients need to be upgraded to support DoT and DoH

Currently limited support for DoT and DoH in operating systems

DoT and DoH only encrypt DNS communications between client (stub-resolver) and recursive resolver, not between recursive resolver and authoritative DNS servers

Resolver provider has potential to monitor and log transactions, so needs to be trusted

DoT and DoH does not ensure the integrity of information returned from an authoritative server, so DNSSEC should also be used to cryptographically assert DNS entries are correct.

**BUT… important components in improving the security and confidentiality of the DNS**

# DNS Flag Day

Important to be aware of...

- DNSSEC and other extended features of the DNS require EDNS0 (Extension Mechanisms for DNS – RFC 6891)
- Properly implemented name servers should either reply with an EDNS0 compliant response, or provide a regular DNS response if they don't understand.
- Workarounds had to incorporated to allow resolvers to retry if name servers don't respond correctly, but these cause unnecessary retries, delays, and prevent the newer features of the DNS being used.
- The vendors of the most commonly used DNS software (BIND, Ubound, PowerDNS and Knot) will remove these workarounds as of 1 February 2019
- Consequence is that hostnames served by broken DNS implementations will no longer be resolved

Please check if your domain is affected! https://dnsflagday.net

# References

Internet Society Deploy360 https://www.isoc.org/deploy360/

DNSSEC Deployment Maps
https://www.isoc.org/deploy360/dnssec/maps/

APNIC Labs DNSSEC Measurements https://stats.labs.apnic.net/dnssec/

DNS Privacy Project https://dnsprivacy.org/

Let’s Encrypt https://www.letsencrypt.com/

# Thank you.

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