ImpersoNATION: The adoption of anti spoofing DNS records in U.S. Government domains

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Overview

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Introduction

- DNS is most commonly used to map from a domain name to an IP address
  - There are also other security specific uses too:
    - DNS Security (DNSSEC)
    - Domain Keys Identified Mail (DKIM)
    - Sender Policy Framework (SPF)
    - Certification Authority Authorization (CAA)
    - Domain-based Message Authentication, Reporting & Conformance (DMARC)
- These security related records help provide authenticity to prevent forgery or impersonation.
- The goal of this research is to determine the adoption and validity of CAA, SPF, and DMARC records in U.S. Government domains across all government types.

Motivation

- According to the United States Census Bureau, there are over 90,075 governments in the United States
  - Includes governments such as townships, cities, counties, and school districts.
- These governments provide crucial services like voting information, taxes, utilities, and public notices.
- Cybersecurity is paramount to state and local governments effort to maintain the trust of their citizens.

Certification Authority Authorization (CAA)

- Certification Authority Authorization (CAA) records is a DNS record indicated which Certification Authority (CA) can issue a certificate for a given domain. Specified in RFC 6844
  - Prevents all CAs from issuing certificates on the domain's behalf
- Direct result of CAs mis-issuing certificates
- All CAs must check to ensure it's on the domains list before it gives a certificate

Ex: “issue "letsencrypt.org"”
Ex: “issuewild "sectigo.com"”

Sender Policy Framework (SPF)

- Sender Policy Framework (SPF) allows website operators to specify which mail servers can send email on their behalf. Specified in RFC 7208
  - A whitelist for mail servers
- SPF records are published as a TXT record on the base of the domain.

Ex: “`v=spf1 ip4:134.48.6.21 include:mu.edu -all`”

Domain-based Message Authentication, Reporting & Conformance (DMARC)

- Domain-based Message Authentication, Reporting and Conformance (DMARC) informs receiving mail servers actions if the email message does not pass SPF. Specified in RFC 7489
- Published as a TXT record under the `_dmarc` subdomain (ex. `_dmarc.example.com`)

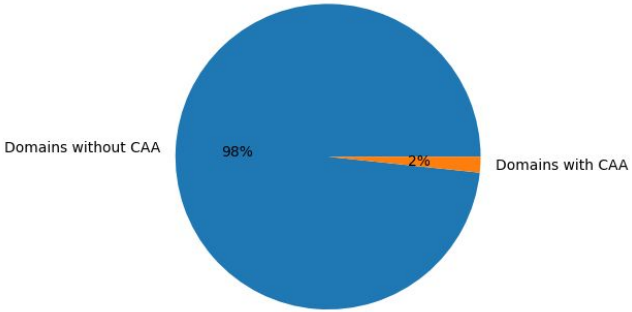
Ex: “`v=DMARC1 p="reject" ruf="mailto:admin@mu.edu”`”

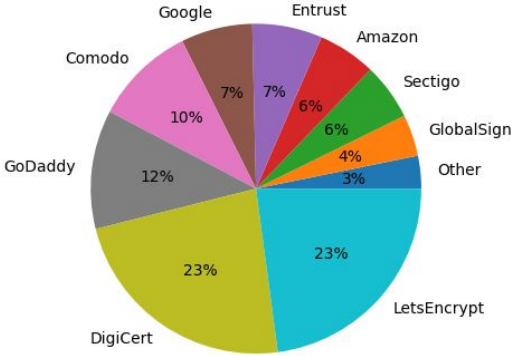
Experiment

- I’ve used the union between the DotGov data set (published by CISA) and the Govt-URL dataset (published by GSA).
  - In total this gives us 17,763 domains across all government types in the U.S.
- Created a scanner and parser to validate each record in accordance to its RFC
- Conducted the first scan across all domains using Google’s Public DNS on January 28th
  - Took a little over 24 hours to complete

Results (CAA)

- Only 2% of scanned government domains have an CAA record





Results (SPF)

- 78% of scanned government domains have an CAA record

Government Type	Adoption Rate
Local	75.70%
County	76.23%
State	45.87%
Federal	70.48%
Native Sovereign Nations	72.88%

Government Type	Error Rate
Local	8.97%
County	8.39%
State	9.25%
Federal	2.44%
Native Sovereign Nations	10.14%

Results (SPF)

Error	Number of domains
More than 10 DNS lookups	508
Use of deprecated PTR mechanism	249
Unresolvable domain in record	239
Unknown mechanism	170
Mechanism after `all`	104

Results (DMARC)

- 23% of scanned government domains implement DMARC.
- *More to come…*

Future Work

- **Three weeks from now**: Run February monthly scan, remove domains that no longer exist, create visualization for CAA, SPF, and DMARC adoption by state.
- **Six weeks from now**: Run March monthly scan, create graphs to determine adoption trends over the previous three months, begin writing paper, and look into possibly notifying domain owners.
- **Eight weeks from now**: Run April monthly scan, finish writing paper.