DNS Security

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Wildcards -- ERRATA (RFC4592)

- Generating responses for missing data
  - Left most label must be a “*” (and only a “*”)
  - Matches any label that doesn’t already exist
    - Including sub-labels under it
  - Causes a nameserver to **synthesize and answer**
  - **Please read RFC4592**! Good examples therein.
- Example records:

```
*.example.com.       3600 IN MX  10 mail.example.com
host1.example.com.   3600 IN A   192.0.2.1
```

- Reponses:

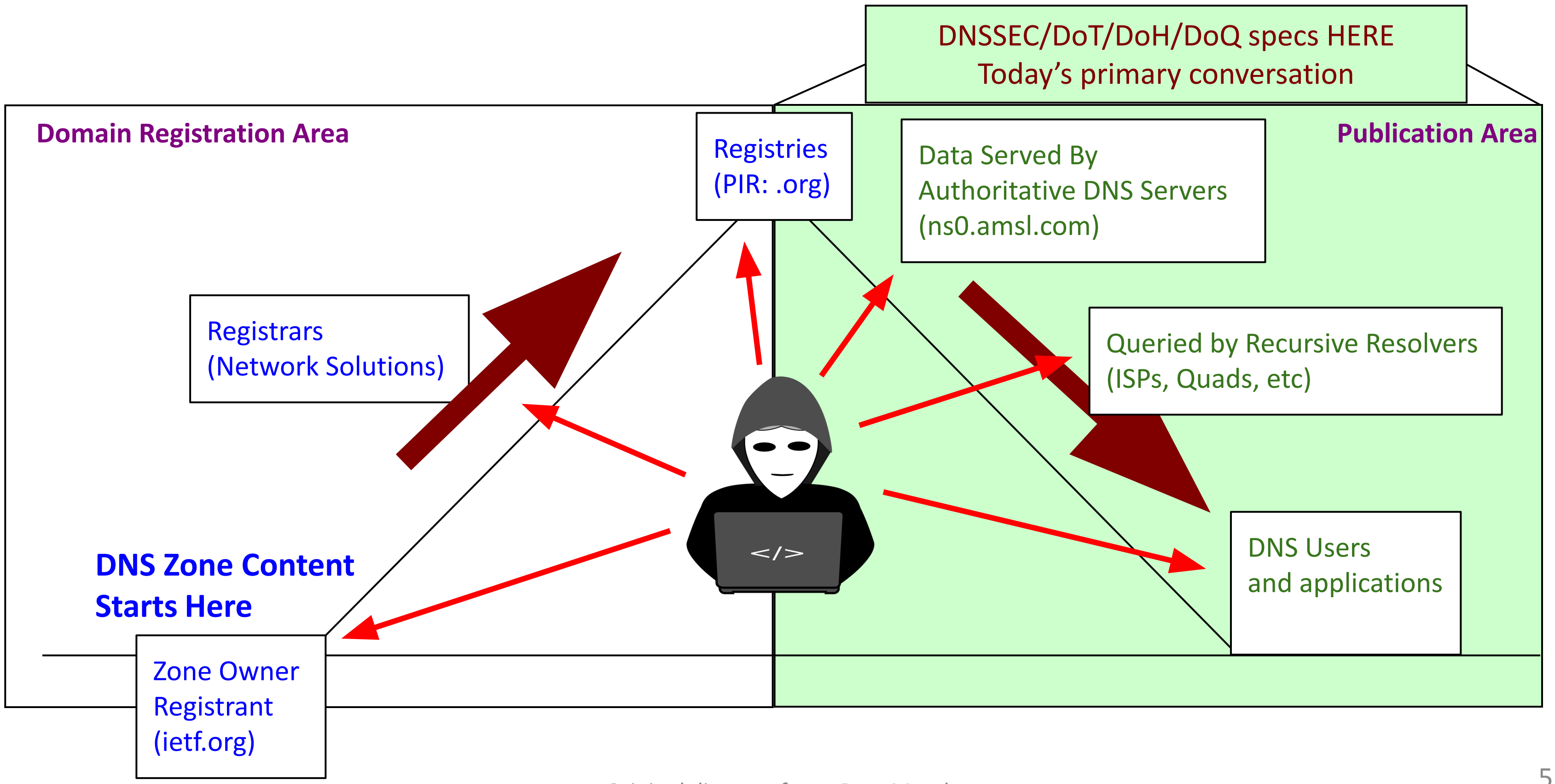
```
host1.example.com/MX    DOESN’T MATCH (returns NOERROR)
host2.example.com/MX    MATCHES
host1.example.com/A     DOESN’T MATCH (returns 192.0.2.1)
host2.example.com/A     DOESN’T MATCH (returns NOERROR)
```

DNS Security

DNS Attack Surfaces

Like every other early protocol,
DNS started out insecure

DNS Publication Architecture



Original diagram from: Russ Mundy

Sources of DNS Insecurity: Registration

Question: How do you get bad data into the DNS itself?
Answer: Insert it during publication side

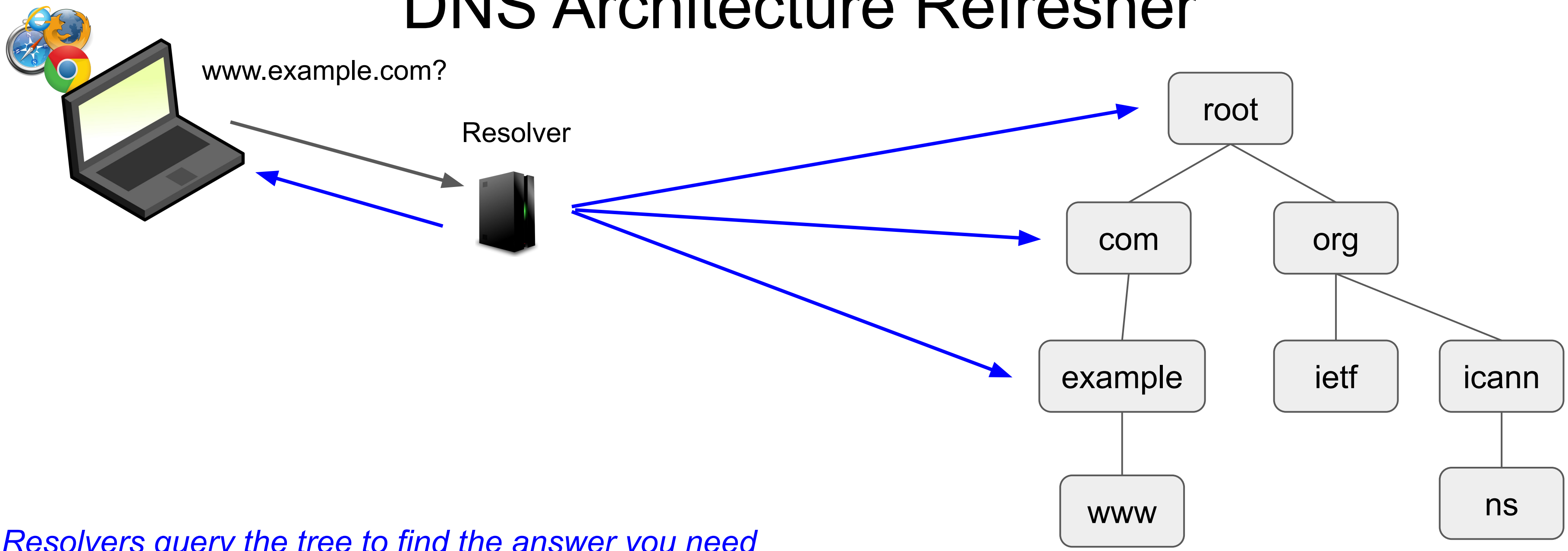
Example methods of attack:

1. Social engineering at the publishing side
   a. Registry attacks
   b. Registrar attacks
2. Attack the zone source itself
   a. Security protocols won’t help you if your source data isn’t stored securely!

Sources of DNS Insecurity: Publication / Consumption

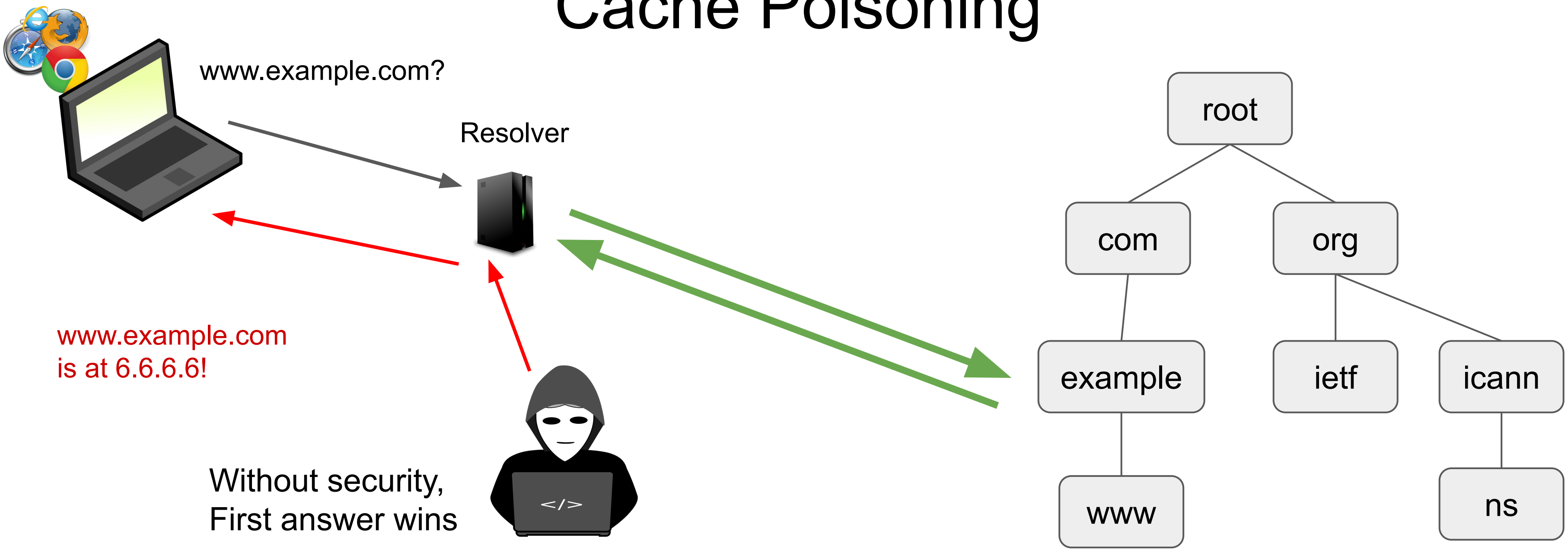
1. Protocol attacks
    a. Cache Poisoning
2. DDoS attacks: target and participant
    a. Resource consumption
    b. Reflection
    c. Loops
3. Privacy
    a. Queries are seen by both resolvers and authoritative servers
4. DNS abuse and deception
    a. One-off names/typos/bits and (ietf -> ieetf, itf, ietff, ietforg)
    b. Internationalization and other font issues (IETF -> 1ETF)

DNS Architecture Refresher



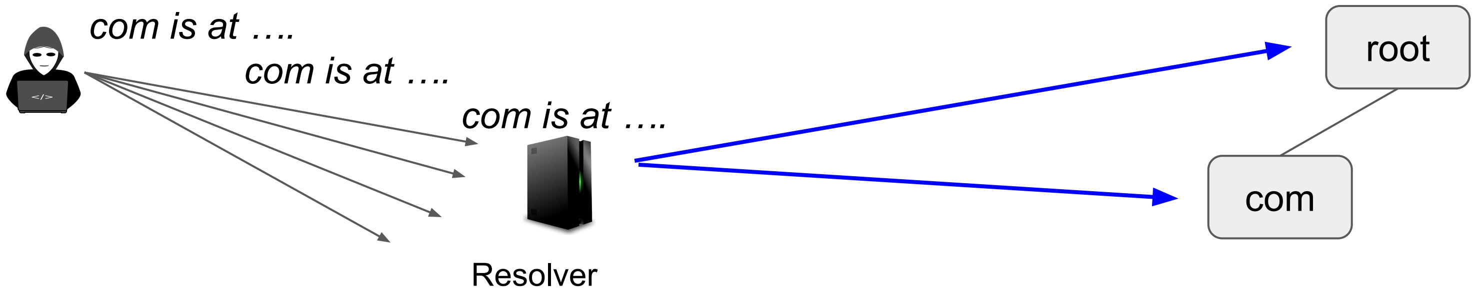
Resolvers query the tree to find the answer you need

Cache Poisoning



Early and Easiest Cache Poisoning **Attacks**

- Extra data in the additional section was considered authentic
  - I know you asked for www.example.com,
  - but did you know www.ietf.org is at 6.6.6.6?
    - It is! And you should trust me!
- Protocol attacks
  - Just **flood the DNS resolver** with response packets and hope they accept them
  - Possibly **guessing IP/protocol values** (name, source address, DNS ID field)
  - Answer is cached for **TTL chosen by the attacker**

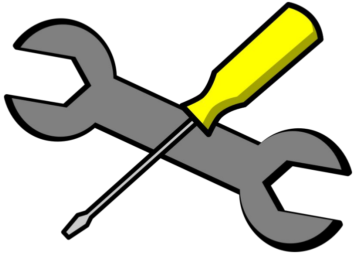


Early and easiest methods to **combat cache poisoning**

- Ignore non-authoratative answers
  - Only accept answers to questions you asked
  - Exception: parents can supply “glue” address records for in-zone child NS servers
- Resolvers must check that:
  - The IP source and UDP port is correct (handled by the UDP stack)
  - The DNS ID field is correct
- Senders must make it harder for attackers to guess these
  - Randomize the source port number
  - Randomize the ID field

32 bits of randomness

- Note that this
  - Isn’t cryptographically strong
  - Doesn’t work at all for on-path attackers that can see and copy the requests



But can we fix it?

Yes we can!

Data protection mechanisms

Object security

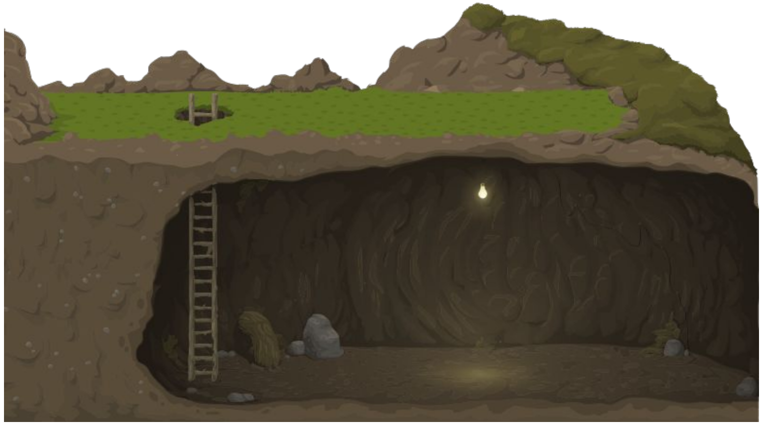
Path security

Object Security -- DNSSEC

- Adds cryptographic signatures on records
- Signed at or near the data's origin
- Verifiable in the middle
- Verifiable at the end
- Only provides integrity protection -- no privacy protection

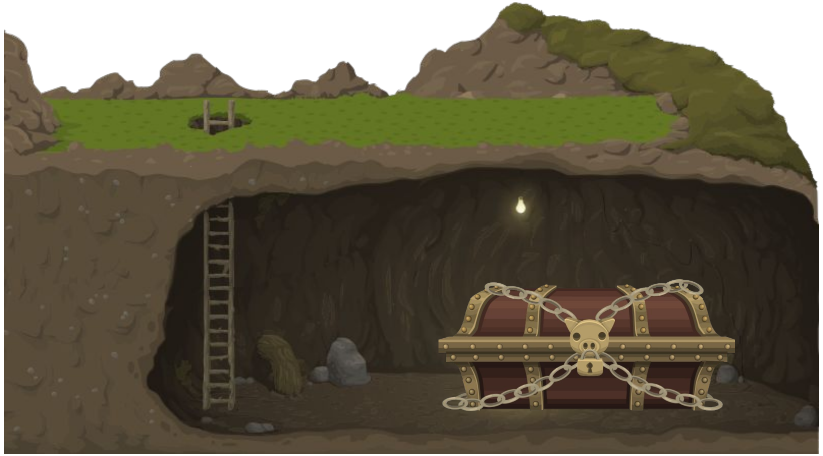
Path Security -- DOT, DOH, DOQ, ...

- Tunnel's answers securely between two points
- Provides integrity protection and Encryption
  - But, offers point-to-point protection only
  - Verifies **who you got it from**, but **not what it is**



Object ~~vs~~ and Path Security Compatibility

They have very different <u>complementary</u> properties



DNS Security Technologies

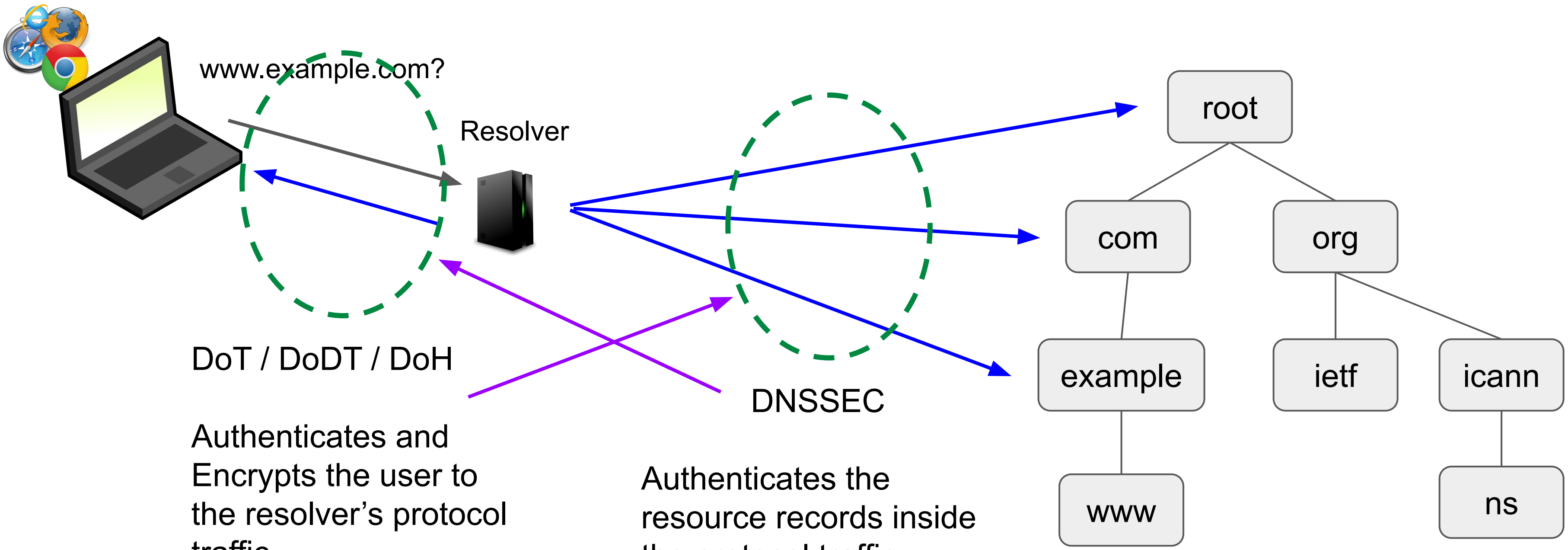
Object security (integrity, but no encryption)

- DNSSEC DNS records signed by their authoritative source RFC4033+

Path security (point-to-point integrity, and provides encryption)

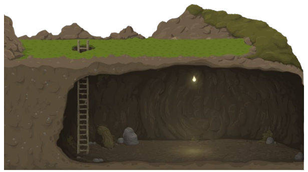
- DoT DNS over TLS RFC7858
- DoDT DNS over DTLS RFC8094
- DoH DNS over HTTPS RFC8484
- ODoH Oblivious DoH DNSOP
- TSIG DNS over DNS with shared keys RFC8945
- DNS Curve: point-to-point encryption and authentication with elliptic curve

Security Protection Areas



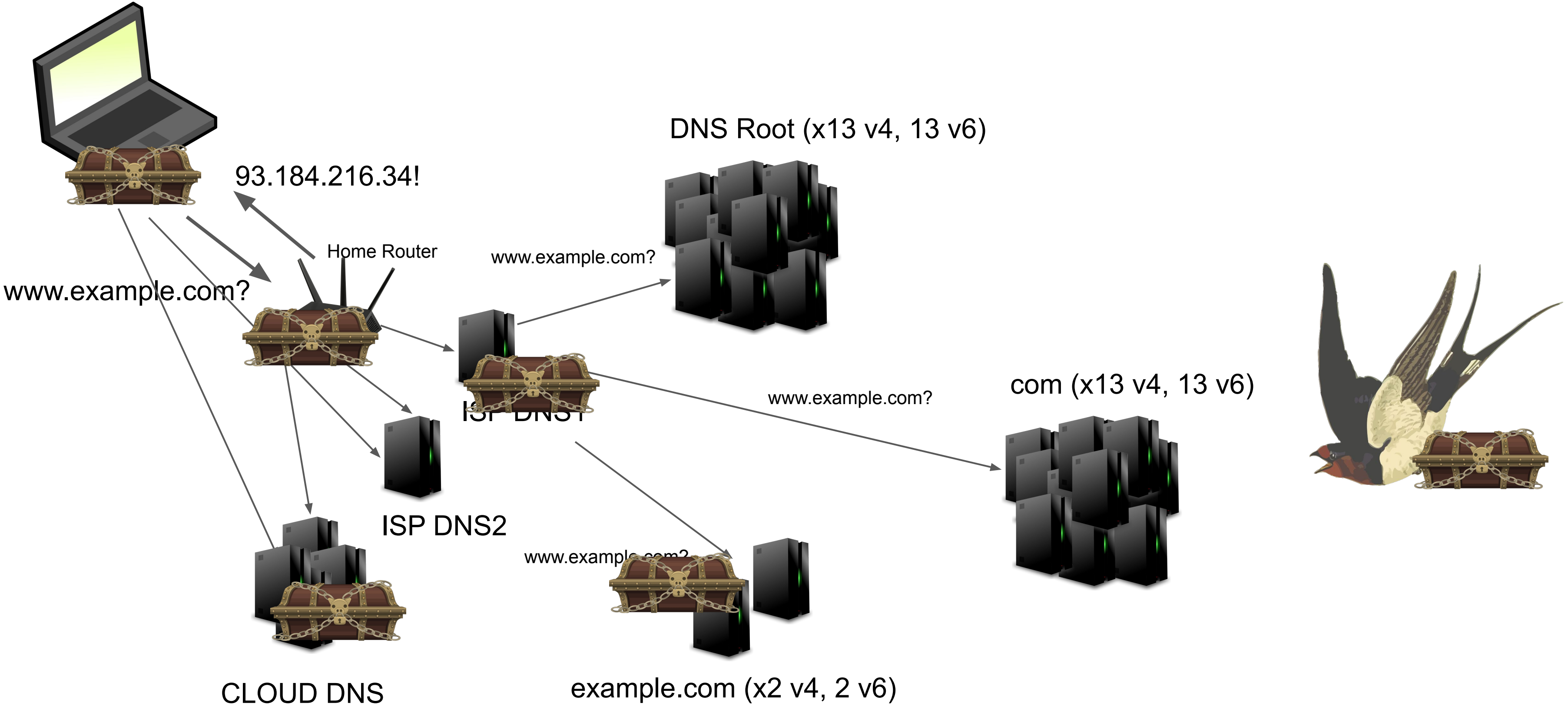
Authenticates and Encrypts the user to the resolver's protocol traffic

Authenticates the resource records inside the protocol traffic

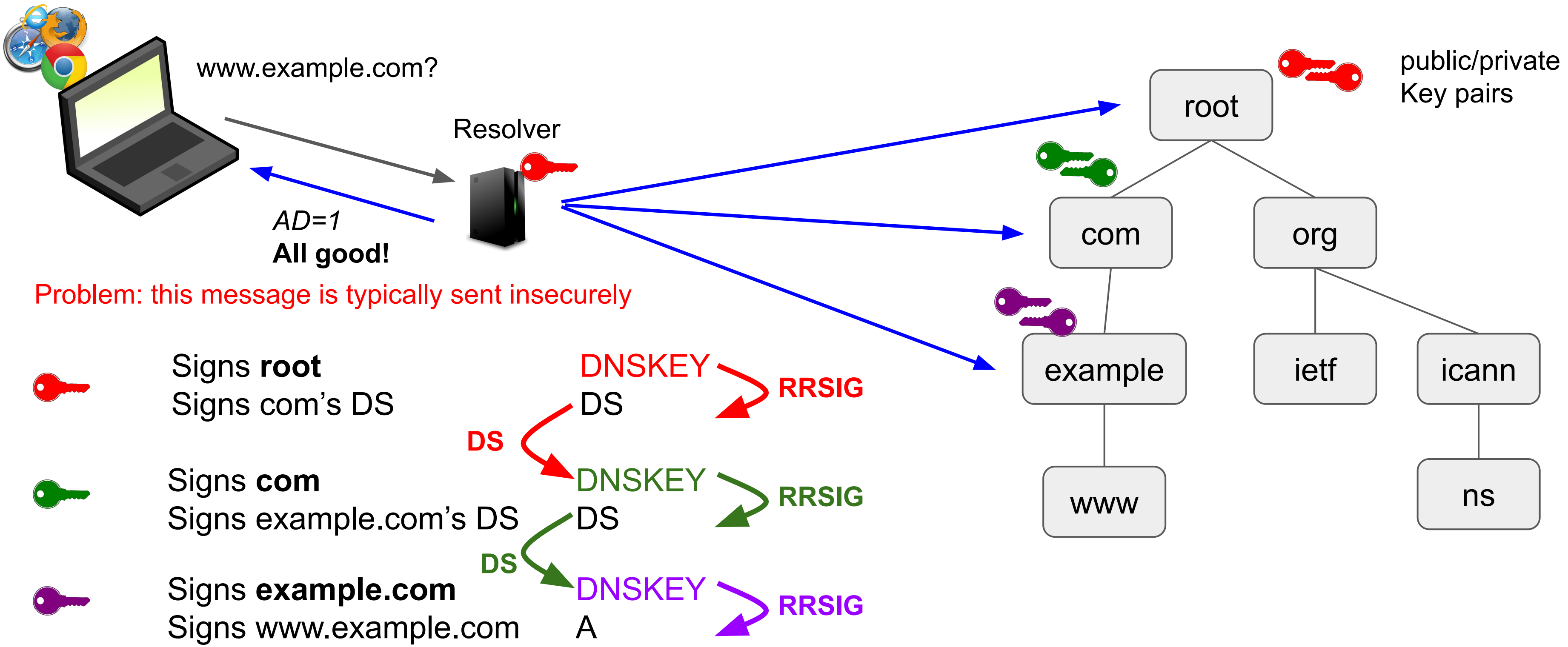


Can be used in both places, but typically isn't

DNSSEC secures records no matter where they are



DNSSEC - hierarchical object signing security



Path vs Object Differences

Object security *(DNSSEC)*

- Pro: Ensures end-to-end integrity is available everywhere
- Con: **Doesn’t provide privacy protection**
- Pro: Distributed trust model with minimal configuration (typically 1 archor)
- Con: Typically not deployed all the way to the user (“the last mile”)

Path security *(DoT, DOH, …)*

- Pro: Provides privacy protection and point-to-point integrity protection
- Con: Doesn’t verify data actually came from the origin (trust everyone?)
- Con: For true security, **requires that every link be protected & trusted**
- Pro: Solves the last mile problem

Path and Object security

Stronger together:

- Object security protects the data
- Object security ties the date to its source
- Path security fixes the last mile problem
- Path security provides encryption
  - Protects clients from on-path eavesdropping

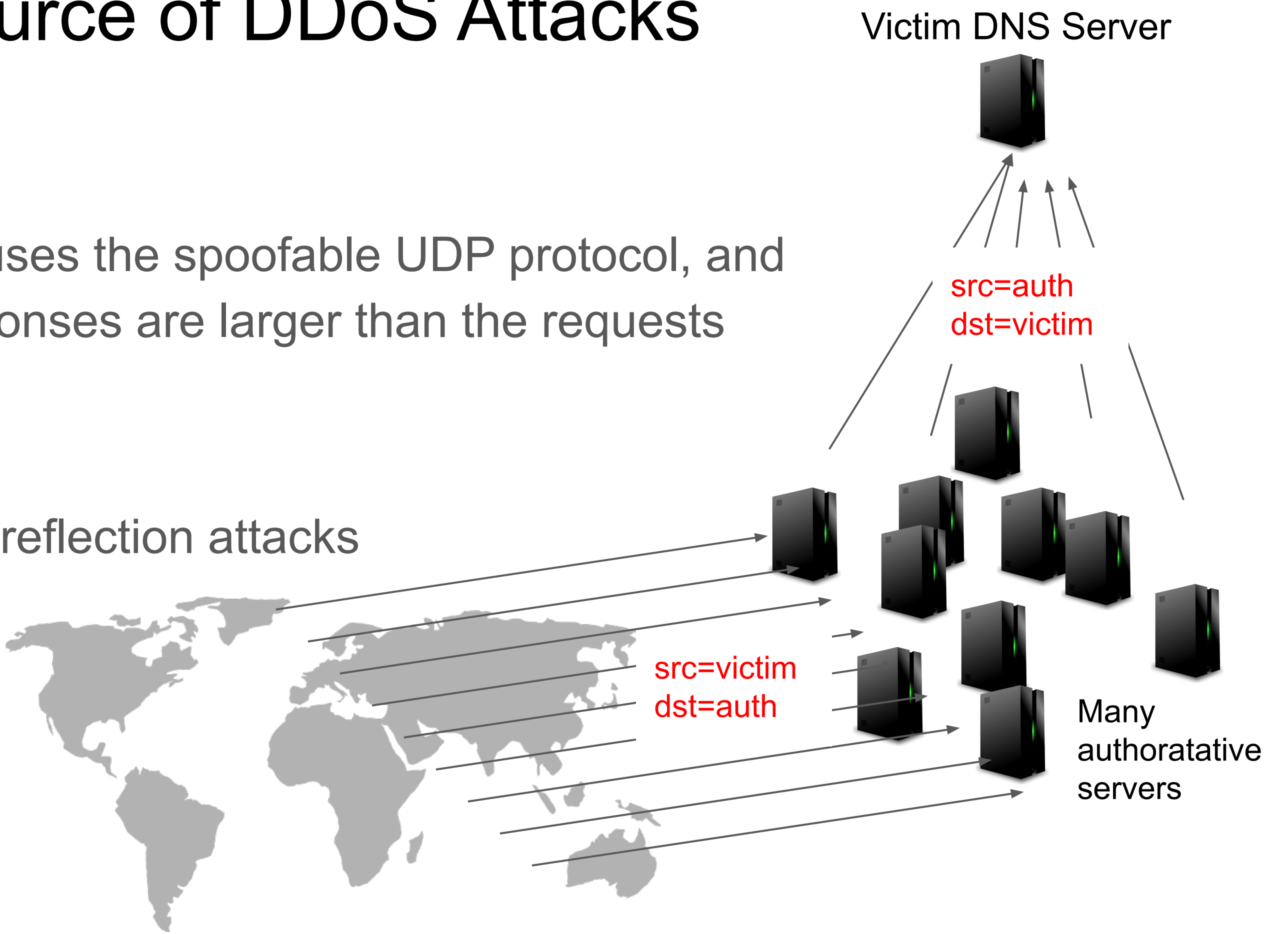
DNS as a source of DDoS Attacks

Because:

- DNS primarily uses the spoofable UDP protocol, and
- Most DNS responses are larger than the requests

Leads to:

- DNS is used in reflection attacks



DNS as a DDoS Target

Because:

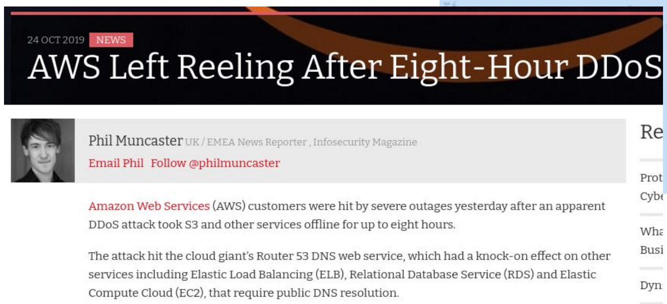
- Nearly all Internet communication starts with DNS lookups

Leads to:

- DNS itself is often a DDoS target

The New York Times

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



24 OCT 2019 NEWS

AWS Left Reeling After Eight-Hour DDoS

Phil Muncaster UK / EMEA News Reporter , Infosecurity Magazine

Email Phil Follow @philmuncaster

Amazon Web Services (AWS) customers were hit by severe outages yesterday after an apparent DDoS attack took S3 and other services offline for up to eight hours.

The attack hit the cloud giant's Router 53 DNS web service, which had a knock-on effect on other services including Elastic Load Balancing (ELB), Relational Database Service (RDS) and Elastic Compute Cloud (EC2), that require public DNS resolution.

To battle aggressive clients: deploy RRL

Dear client: Why do you ask so many questions?

Solution: Deploy **Response Rate Limiting (RRL)**

- I’ve answered you N times already in the last M minutes
- As punishment:
  - I’m setting the Truncated Bit
  - Please come back using TCP please (RFC7766)
  - … or implement DNS cookies (RFC7873)

Helps prevent overwhelming spoofed UDP requests

Note: Not-standardized, but widely implemented and deployed

To battle DNS outages: Optimize your caches

These all provide some resilience against network issues and DDoS attacks:

Serve Stale RFC8767

TL;DR: If you can't get a new answer, it's ok to use an old one

Running a copy of the root on your local resolver RFC8806, 

NSEC Aggressive Caching RFC8198

TL;DR: Don't ask questions you know there isn't an answer for

Reduces traffic loads to authoritative servers

Additional Security Topics Not Covered

- It’s possible to have multiple trust anchors
- NSEC3
- Bootstrapping security using DNSSEC signed public keys
  - DANE, PGP, SSHFP, ...
- Infrastructure interdependency concerns
- Deployment levels
- Algorithm strengths and rollovers
- Replay attacks and solutions
- QName Minimization
- Query loops
- Unauthorized authoritative servers
- DNS intercepting middle-boxes
- White-lies & black-lies
- Minimal signing
- Many new things in WG states