# DNS Security

- The Domain Name Service (DNS) translates human-readable names to IP addresses
  - E.g., thesiger.cs.ucla.edu translates to 131.179.192.144
  - DNS also provides other similar services
- It wasn't designed with security in mind

# DNS Threats

- Threats to name lookup secrecy
  - Definition of DNS system says this data isn’t secret
- Threats to DNS information integrity
  - Very important, since everything trusts that this translation is correct
- Threats to DNS availability
  - Potential to disrupt Internet service

# What Could Really Go Wrong?

- DNS lookups could be faked
  - Meaning packets go to the wrong place
- The DNS service could be subject to a DoS attack
  - Or could be used to amplify one
- Attackers could "bug" a DNS server to learn what users are looking up

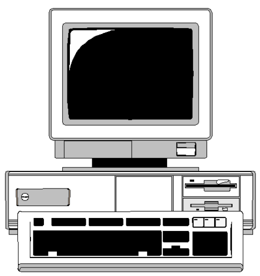
# Where Does the Threat Occur?

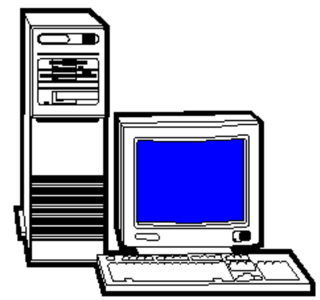
- Unlike routing, threat can occur in several places
  - At DNS servers
  - But also at DNS clients
    - Which is almost everyone
- Core problem is that DNS responses aren't authenticated

# The DNS Lookup Process

```
lookup thesiger.cs.ucla.edu
```

```
answer  131.179.191.144
```





```
ping thesiger.cs.ucla.edu
```

Should result in a ping packet being sent to 131.179.191.144

If the answer is wrong, in standard DNS the client is screwed

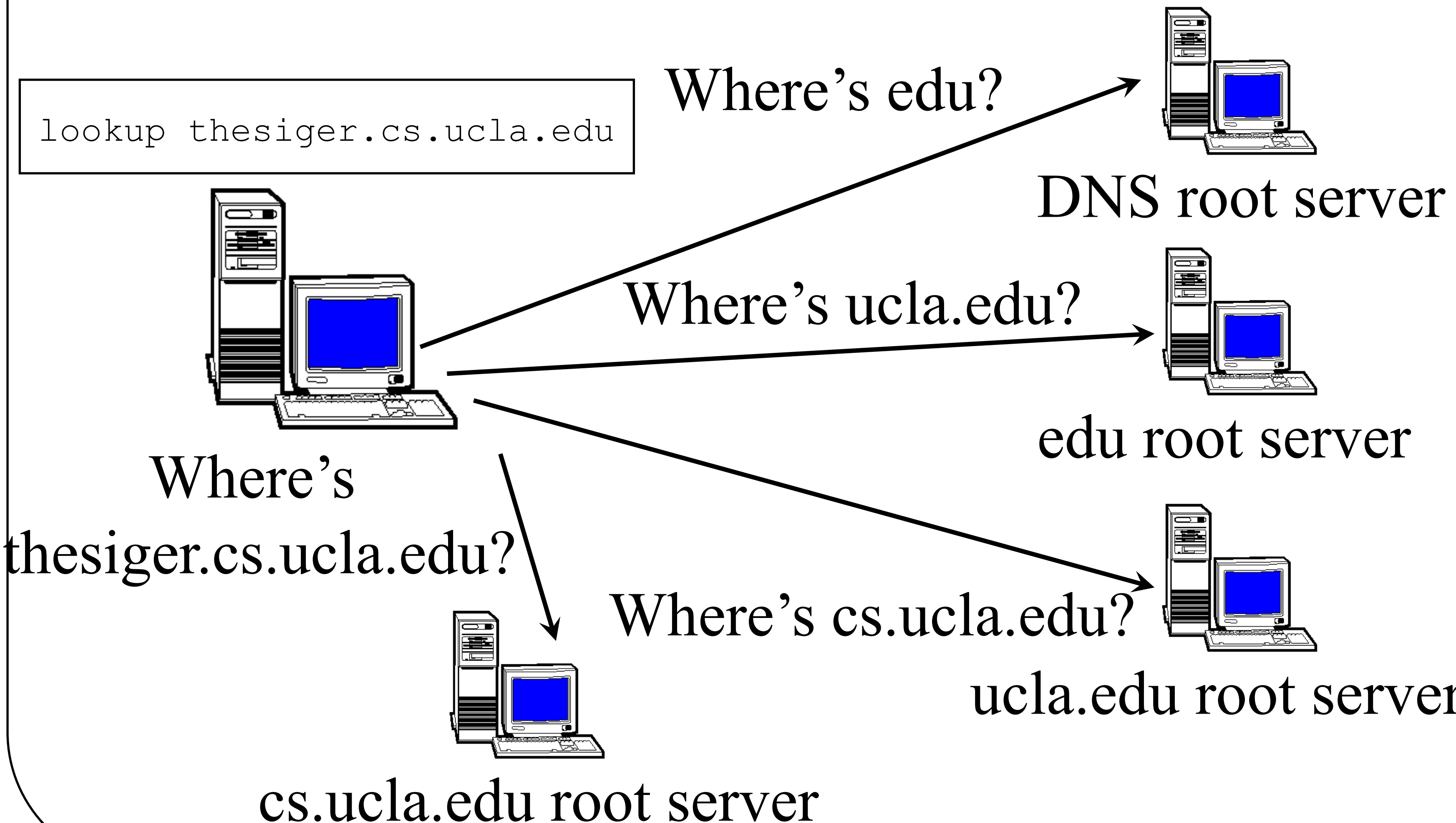
# How Did the DNS Server Perform the Lookup?

- Leaving aside details, it has a table of translations between names and addresses
- It looked up thesiger.cs.ucla.edu in the table
- And replied with whatever the address was

# Where Did That Table Come From?

- Ultimately, the table entries are created by those owning the domains
  - On a good day . . .
- And stored at servers that are authoritative for that domain
- In this case, the UCLA Computer Science Department DNS server ultimately stored it
- Other servers use a hierarchical lookup method to find the translation when needed

# Doing Hierarchical Translation



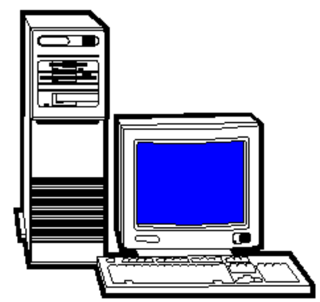
# Where Can This Go Wrong?

- Someone can spoof the answer from a DNS server
  - Relatively easy, since UDP is used
- One of the DNS servers can lie
- Someone can corrupt the database of one of the DNS servers

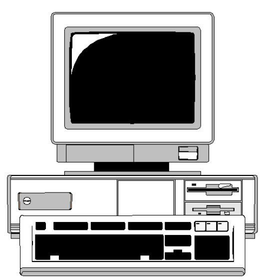
# The Spoofing Problem

`lookup thesiger.cs.ucla.edu`

`answer  131.179.191.144`



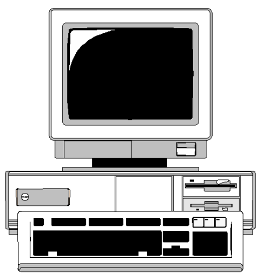
Unfortunately, most DNS stub resolvers will take the first answer



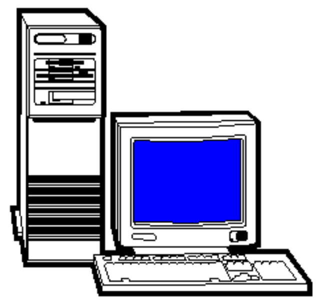
`answer  97.22.101.53`

# DNS Servers Lying

lookup thesiger.cs.ucla.edu



answer 97.22.101.53

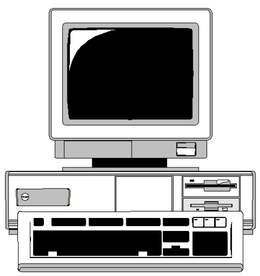


| | |
|---|---|
| . . . | . . . |
| . . . | . . . |
| . . . | . . . |
| . . . | . . . |
| . . . | . . . |
| thesiger.cs.ucla.edu | 131.178.192.144 |
| . . . | . . . |
| . . . | . . . |
| . . . | . . . |
| . . . | . . . |
| . . . | . . . |

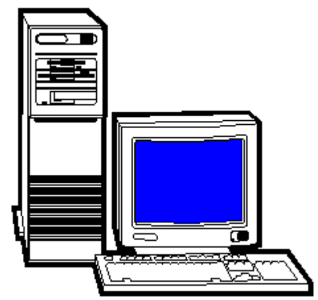
That wasn't very nice of him!

# DNS Database Corruption

lookup thesiger.cs.ucla.edu



answer 97.22.101.53



| | |
|---|---|
| . . . | . . . |
| . . . | . . . |
| . . . | . . . |
| . . . | . . . |
| . . . | . . . |
| thesiger.cs.ucla.edu | 97.22.101.53 |
| . . . | . . . |
| . . . | . . . |
| . . . | . . . |
| . . . | . . . |
| . . . | . . . |

# The DNSSEC Solution

- Sign the translations
- Who does the signing?
  - The server doing the response?
  - Or the server that “owns” the namespace in question?
- DNSSEC uses the latter solution

# Implications of the DNSSEC Solution

- DNS databases must store signatures of resource records
- There must be a way of checking the signatures
- The protocol must allow signatures to be returned

# Checking the Signature

- Basically, use certificates to validate public keys for namespaces
- Who signs the certificates?
  - The entity controlling the higher level namespace
- This implies a hierarchical solution

# The DNSSEC Signing Hierarchy

- In principle, ICANN signs for itself and for top level domains (TLDs)
  - Like .com, .edu, country codes, etc.
- Each TLD signs for domains under it
- Those domains sign for domains below them
- And so on down

# An Example

- Who signs the translation for thesiger.cs.ucla.edu to 131.179.192.144?
- The UCLA CS DNS server
- How does someone know that's the right server to sign?
- Because the UCLA server says so
  - Securely, with signatures
- The edu server verifies the UCLA server's signature
- Ultimately, hierarchical signatures leading up to ICANN's attestation of who controls the edu namespace
- Where do you keep that information?
  - In DNS databases

# Using DNSSEC

- To be really secure, you must check signatures yourself
- Next best is to have a really trusted authority check the signatures
  - And to have secure, authenticated communications between trusted authority and you

# A Major Issue

- When you look up something like cs.ucla.edu, you get back a signed record
- What if you look up a name that doesn't exist?
- How can you get a signed record for every possible non-existent name?

# The DNSSEC Solution

- Names are alphabetically orderable
- Between any two names that exist, there are a bunch of names that don't
- Sign the whole range of non-existent names
- If someone looks one up, give them the range signature

# For Example,

| | | |
|---|---|---|
| lasr.cs.ucla.edu | 131.179.192.136 | |
| pelican.cs.ucla.edu / last.cs.ucla.edu | 131.179.128.17 / NOT ASSIGNED | |
| toucan.cs.ucla.edu / pdu.cs.ucla.edu | 131.179.128.16 | |
| pelican.cs.ucla.edu | 131.179.128.17 | |
| toucan.cs.ucla.edu | 131.179.128.16 | |

You get authoritative information that the name isn't assigned

Foils spoofing attacks

```
> host last.cs.ucla.edu
```

# Status of DNSSEC

- Working implementations available
- In use in some places
- Heavily promoted
  - First by DARPA
  - Now by DHS
- Beginning to get out there

# Status of DNSSEC Deployment

- ICANN has signed the root
  - .com, .gov, .edu, .org, .net all signed at top level
  - Not everyone below has signed, though
- Many “islands” of DNSSEC signatures
  - Signing for themselves and those below them
  - In most cases, just for themselves
- Utility depends on end machines checking signatures

# Using DNSSEC

- Actually installing and using DNSSEC not quite as easy as it sounds
- Lots of complexities down in the weeds
- Particularly hard for domains with lots of churn in their namespace
  - Every new name requires big changes to what gets signed

# Other DNS Solutions

- Encrypt communications with DNS servers
  - Prevents DNS cache poisoning
  - But assumes that DNS server already has right record
- Ask multiple servers
  - Majority rules or require consensus

# Conclusion

- Correct Internet behavior depends on a few key technologies
  - Especially routing and DNS
- Initial (still popular) implementations of those technologies are not secure
- Work is ongoing on improving their security