Mitigating DNS DoS Attacks

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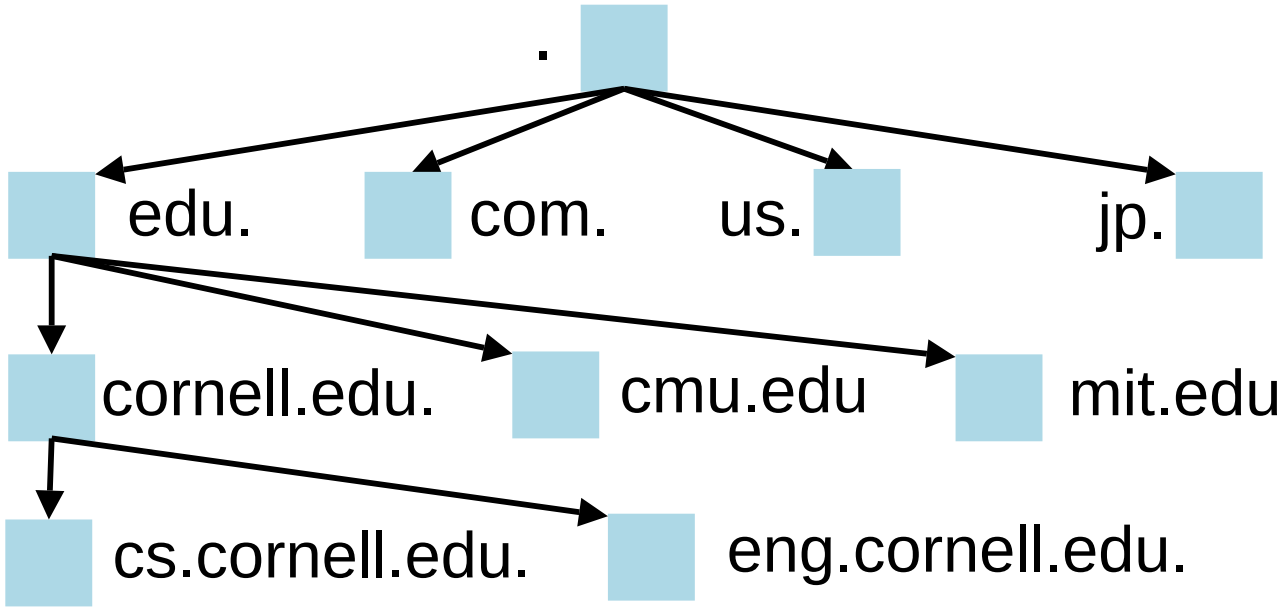
DoS attacks on DNS

Attack: Flood the nameservers of a DNS zone

Goal: Disrupt the resolution of

- The zone's resource records
- And the records for any of the sub-zones



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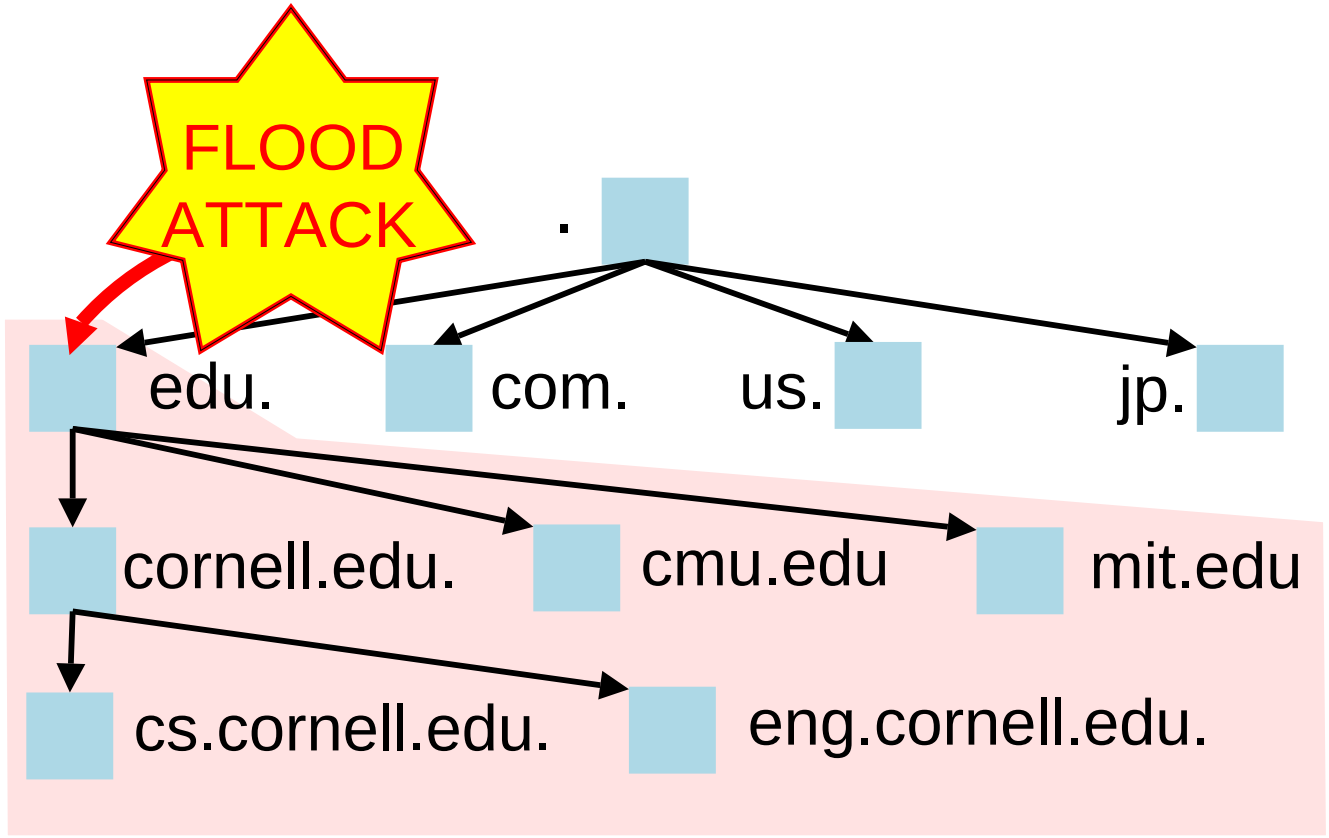

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Attacks aplenty (some successful, other not!)

- Microsoft attacked (2001)
- DNS Root Servers attacked (2002)
- SCO attacked (2003)
- Akamai attacked (2004)
- Root Servers, TLDs and UltraDNS (2006)
- Root Servers attacked (2007)

Networking community to the rescue

- Kangasharaju et. al. [INFOCOM'00]
- Cox et. al. [IPTPS'02]
- Theimer et. al [ICDCS'02]
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Decouple data distribution from authority hierarchy

Ensure **availability** of data distribution mechanism

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- Centralized approaches

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Decouple data distribution from authority hierarchy

Ensure **availability** of data distribution mechanism

- Centralized approaches
- Peer-to-peer approaches

A complementary tact to handle DoS attacks

Do away with the need for 100% availability

Clients are able to resolve a zone's records even when the zone's nameservers are not available

In this paper

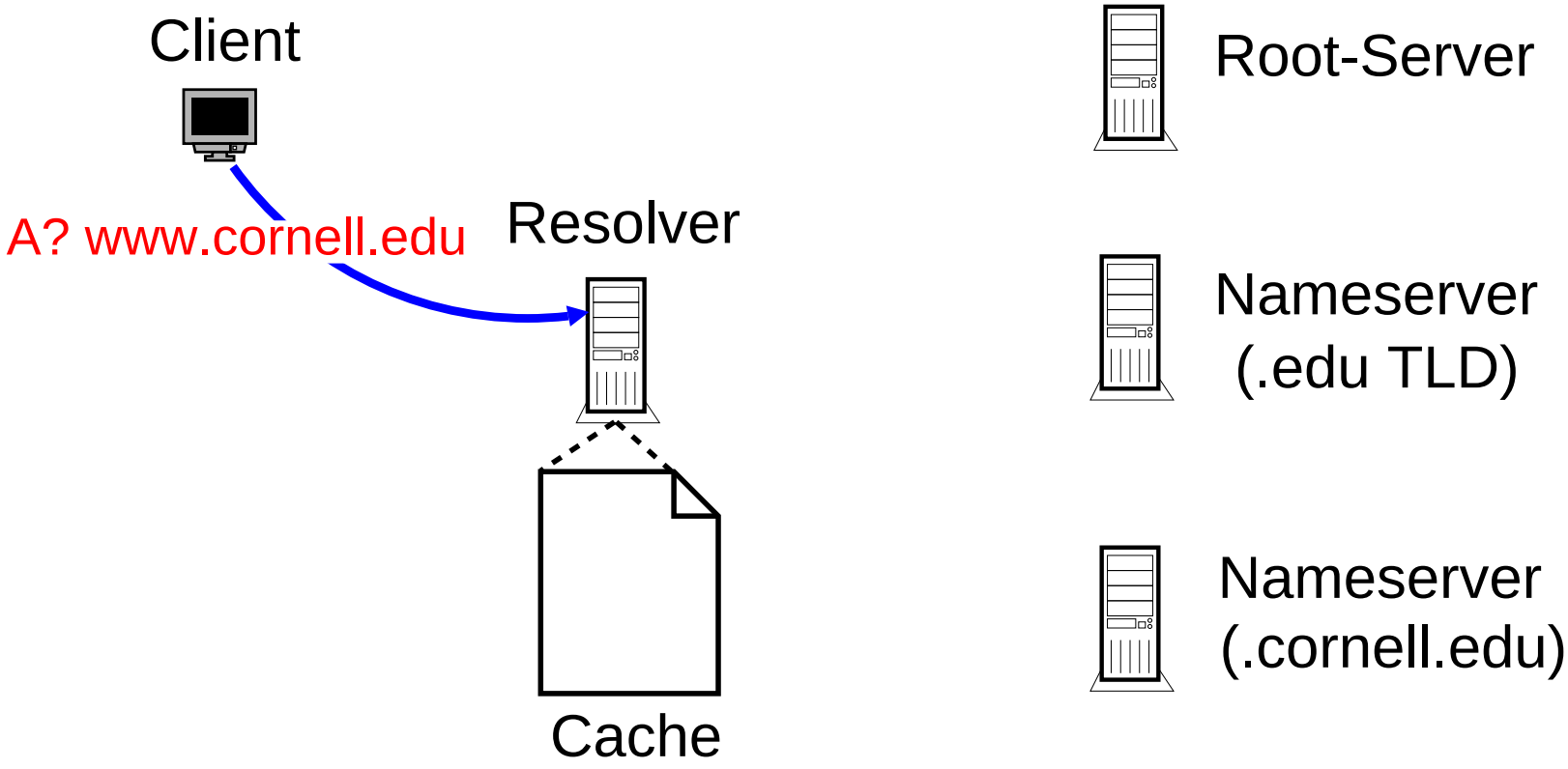
A minor modification in the caching behavior of DNS resolvers

- Reduces the need for nameserver availability in the **existing DNS framework**
- Mitigates the impact of DoS attacks on DNS

Talk Outline

- Introduction
- DNS Resolvers Today
- Proposed Modification
- Evaluation
- The Good
- The Bad and the Ugly

DNS Resolvers Today



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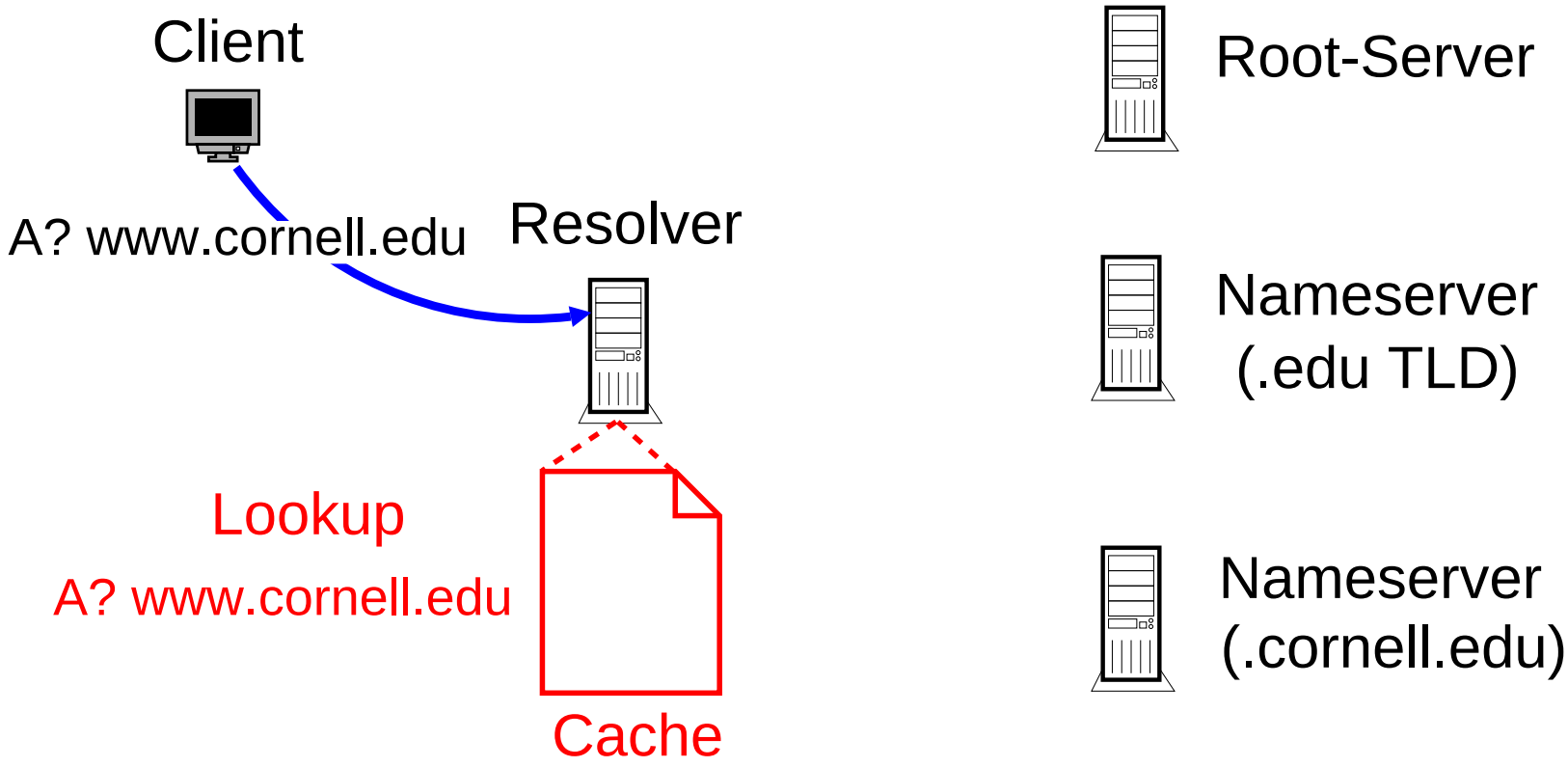

Resolution Process

1. Lookup the resolver cache
2. Traverse down the DNS hierarchy
3. Traversal fails $\Rightarrow$ Resolution fails

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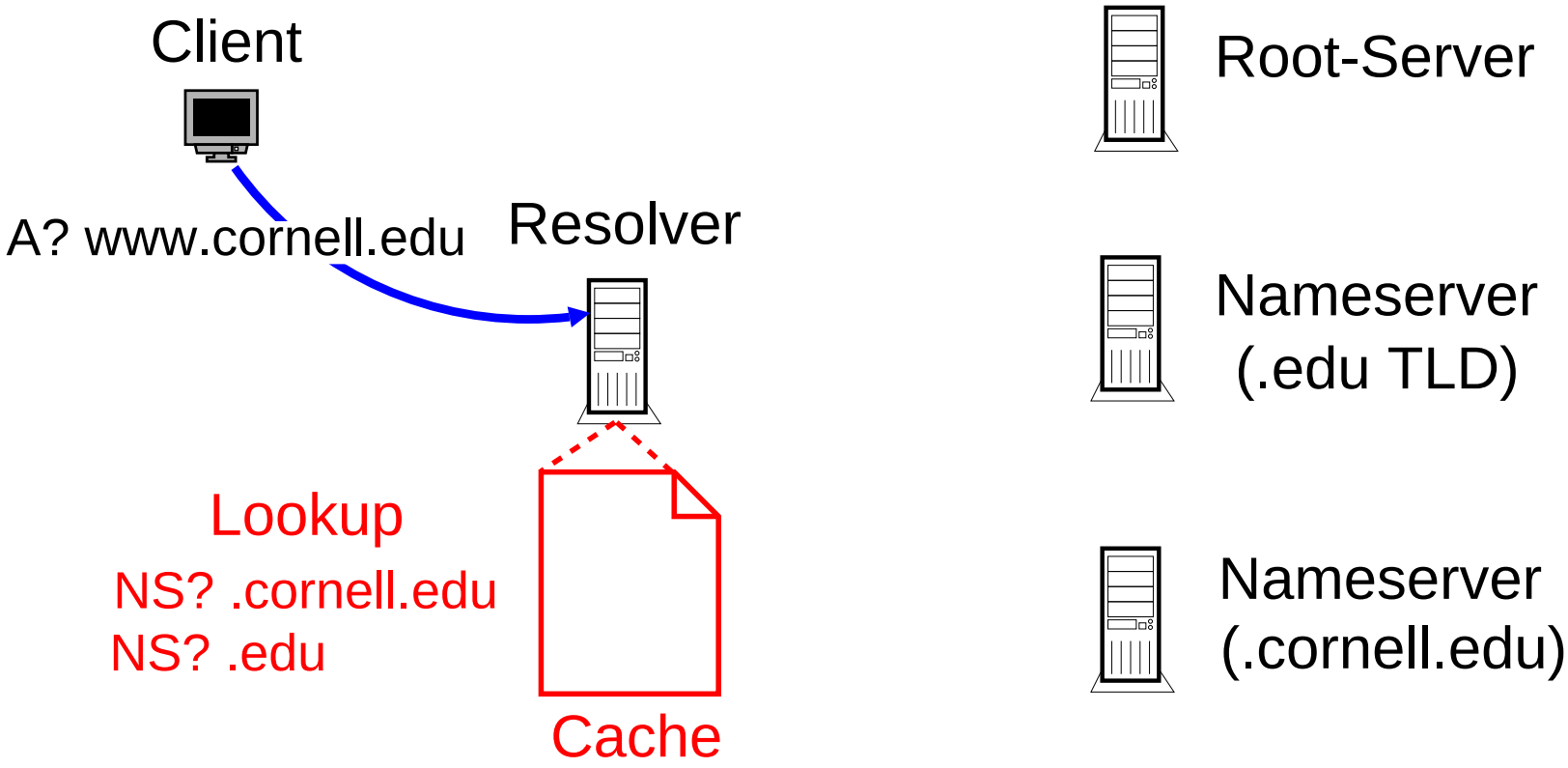

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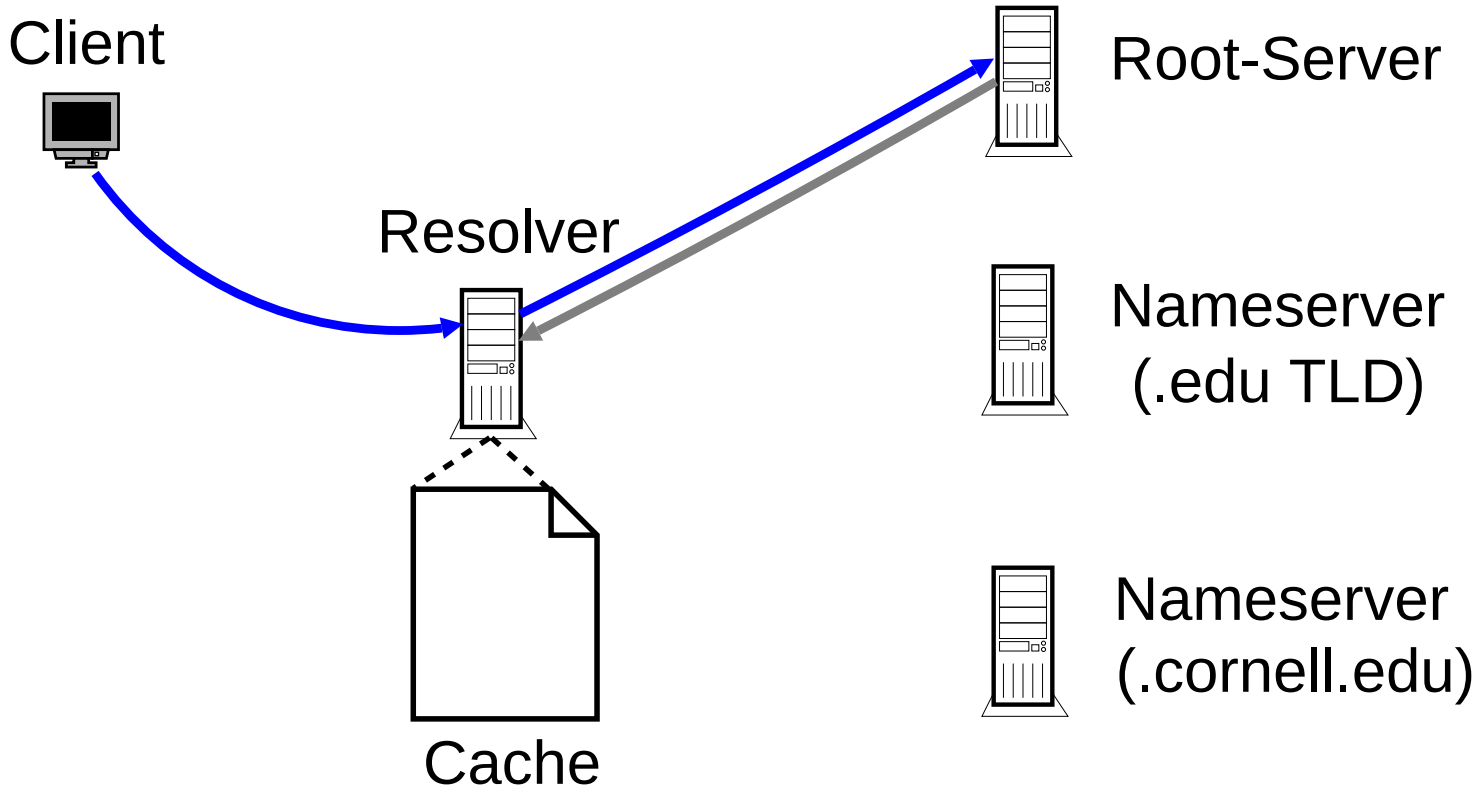

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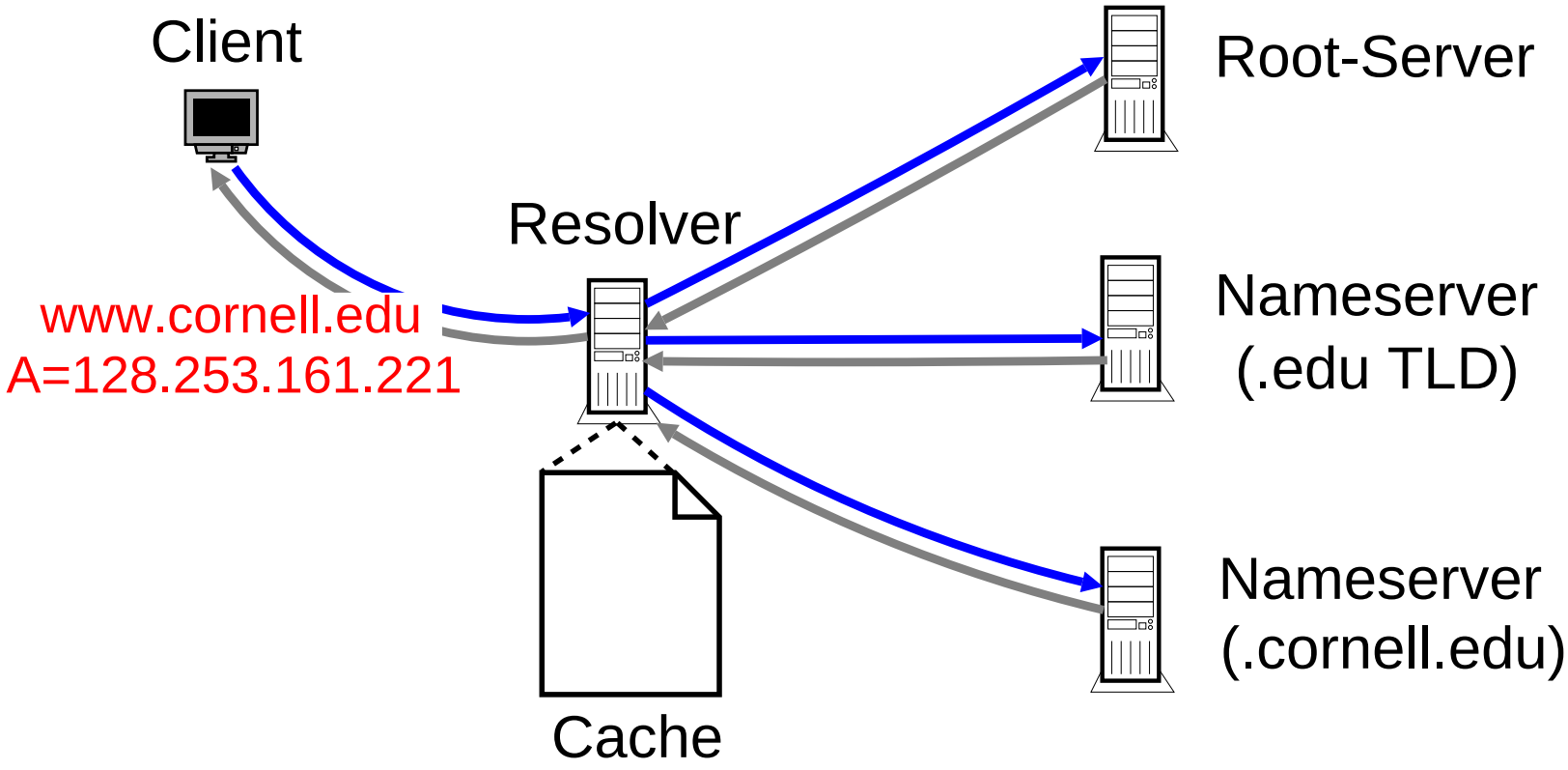

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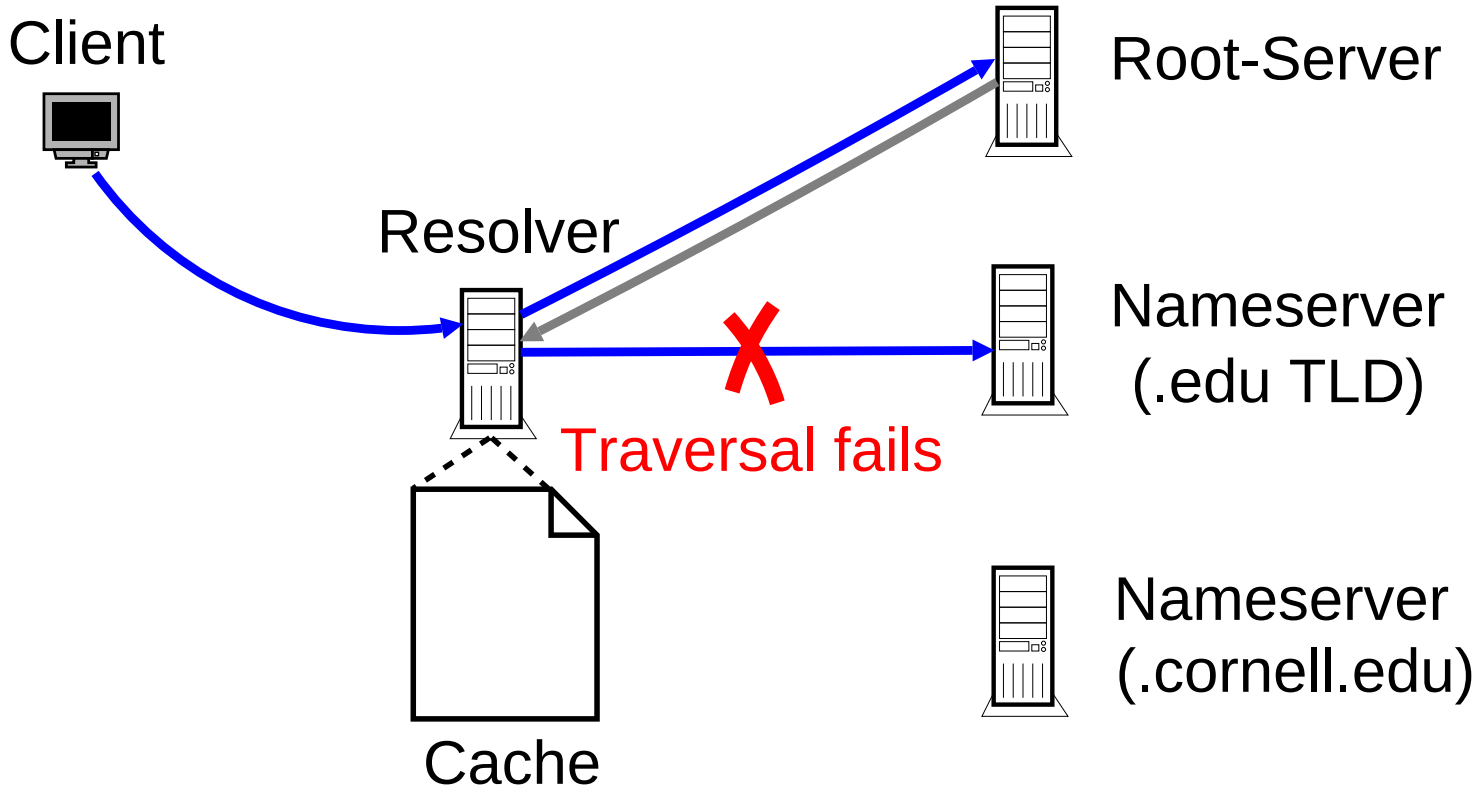

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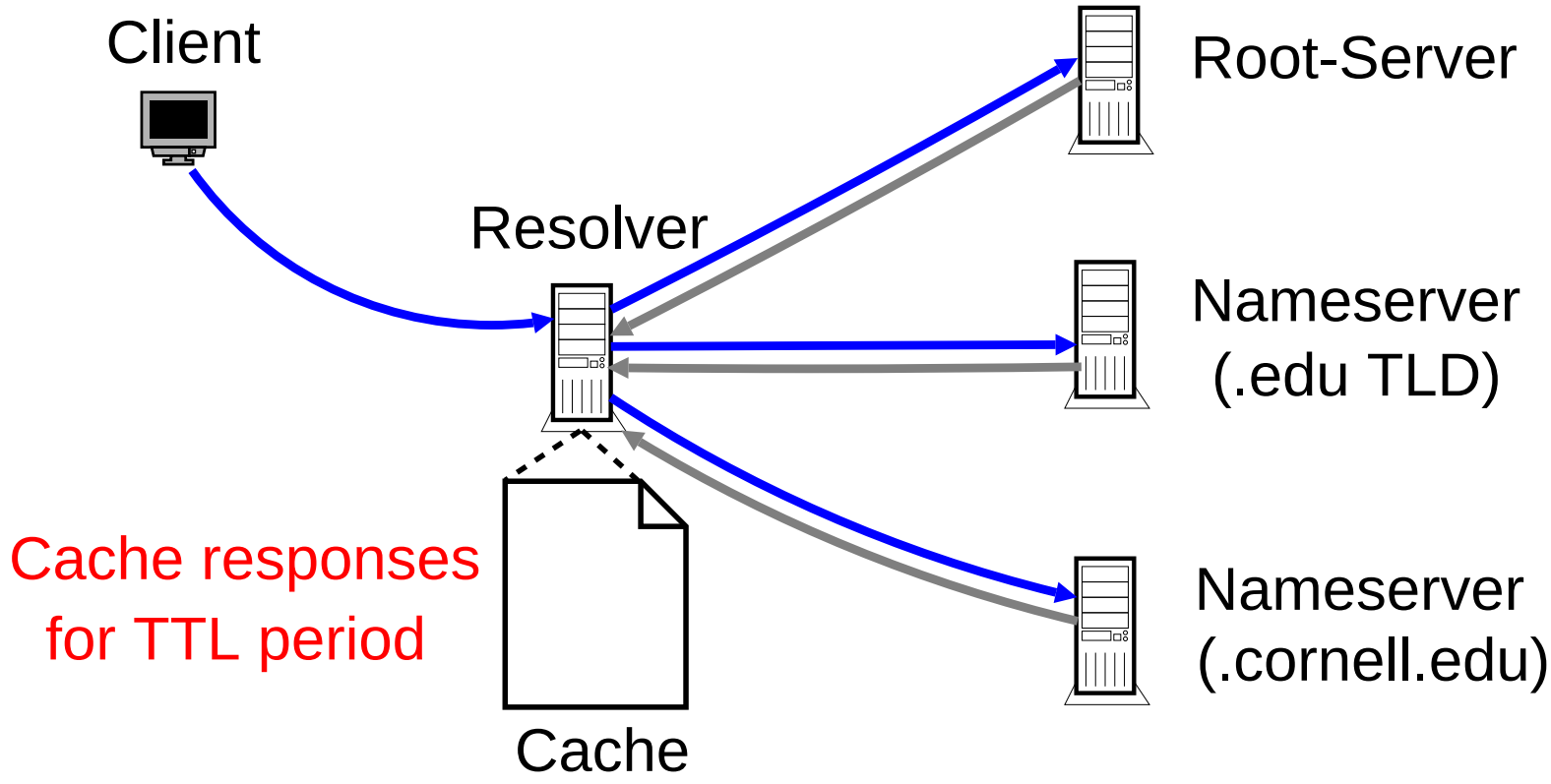
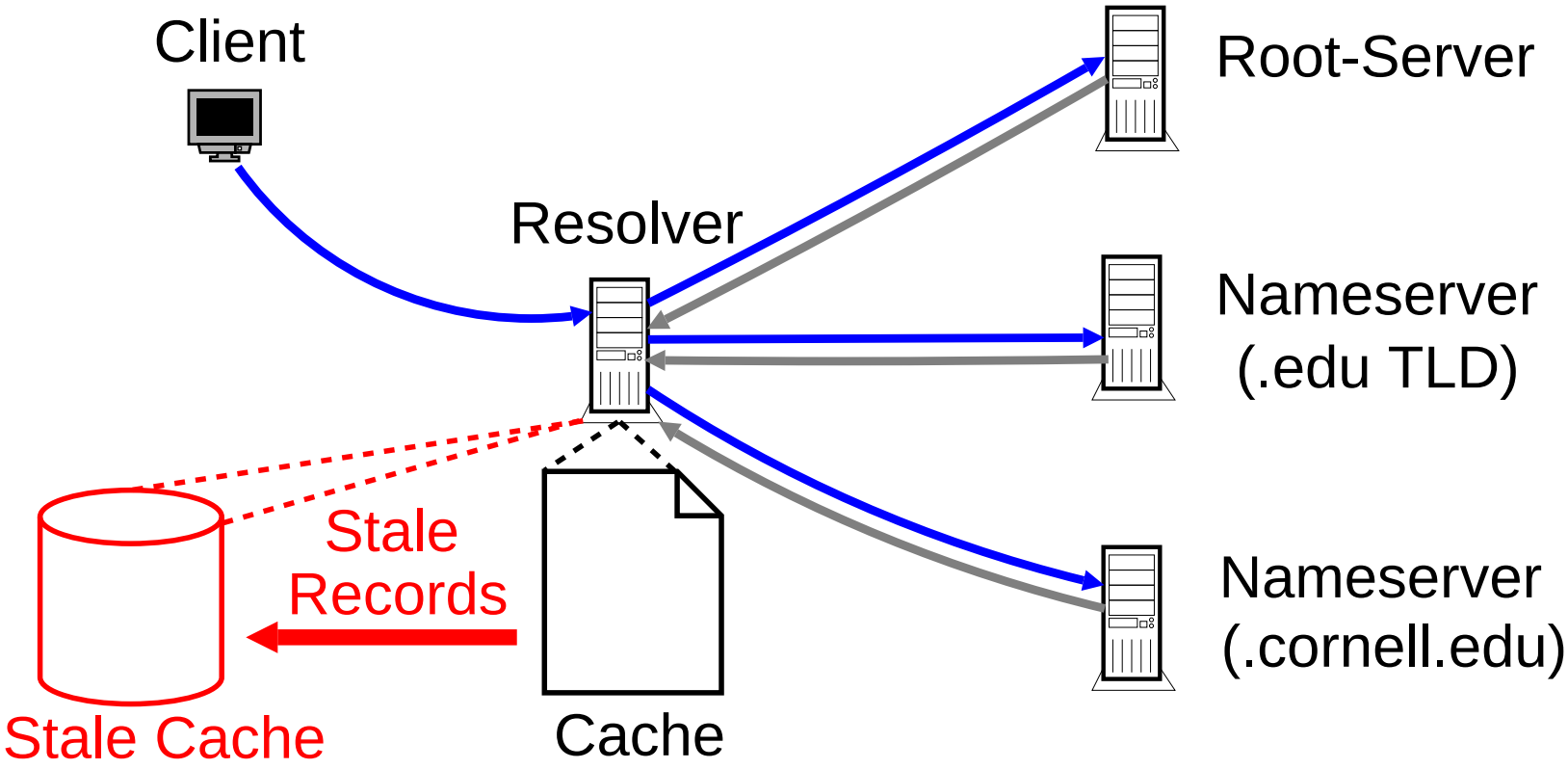


Resolver caching behavior

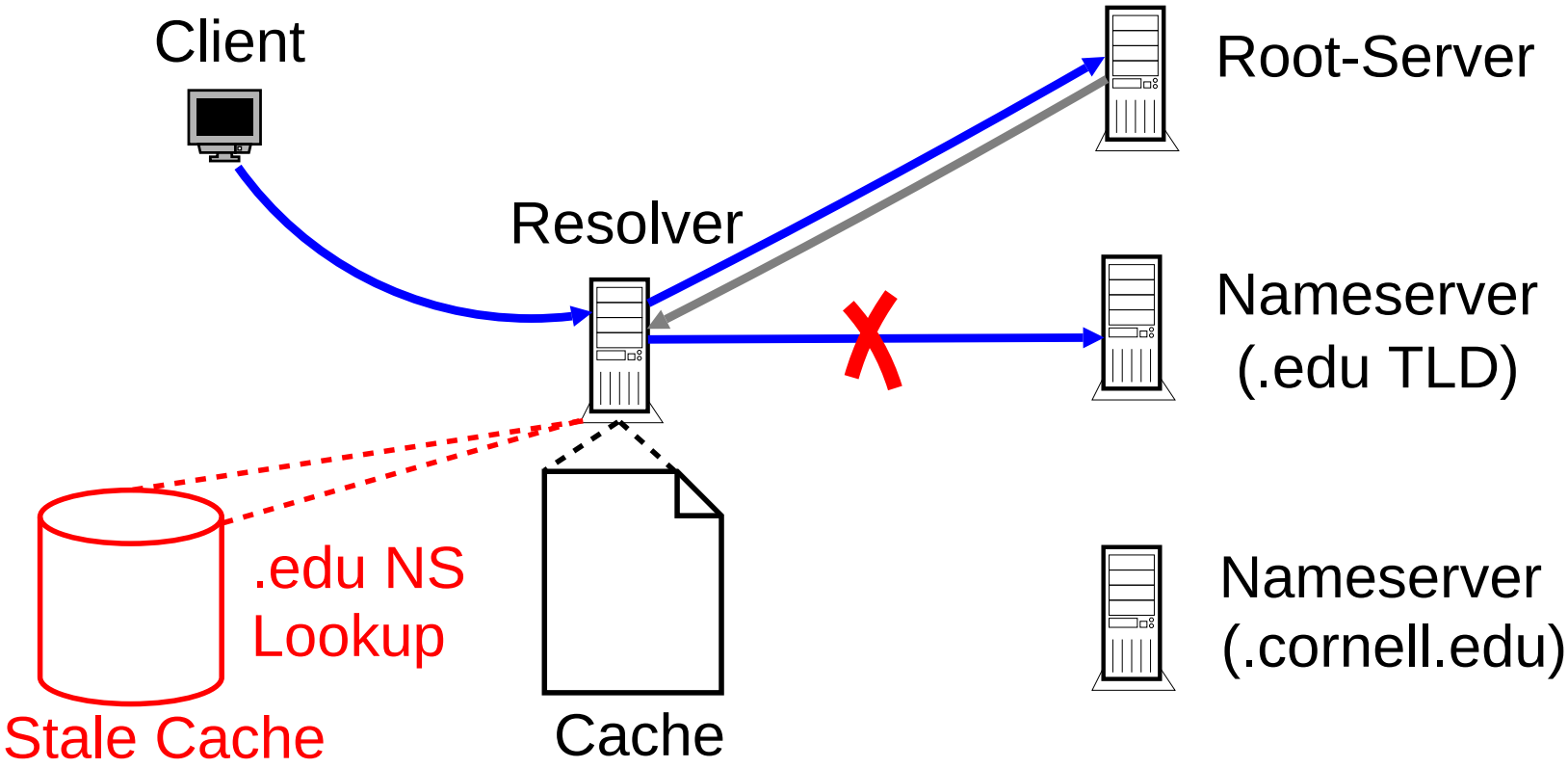
Cached records expunged after their TTL expires

Proposed Modification



Cached records expunged to a **Stale Cache**

Proposed Modification



Modified Resolution Process

1. Lookup the resolver cache
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3. Traversal fails $\Rightarrow$ Resolution can continue

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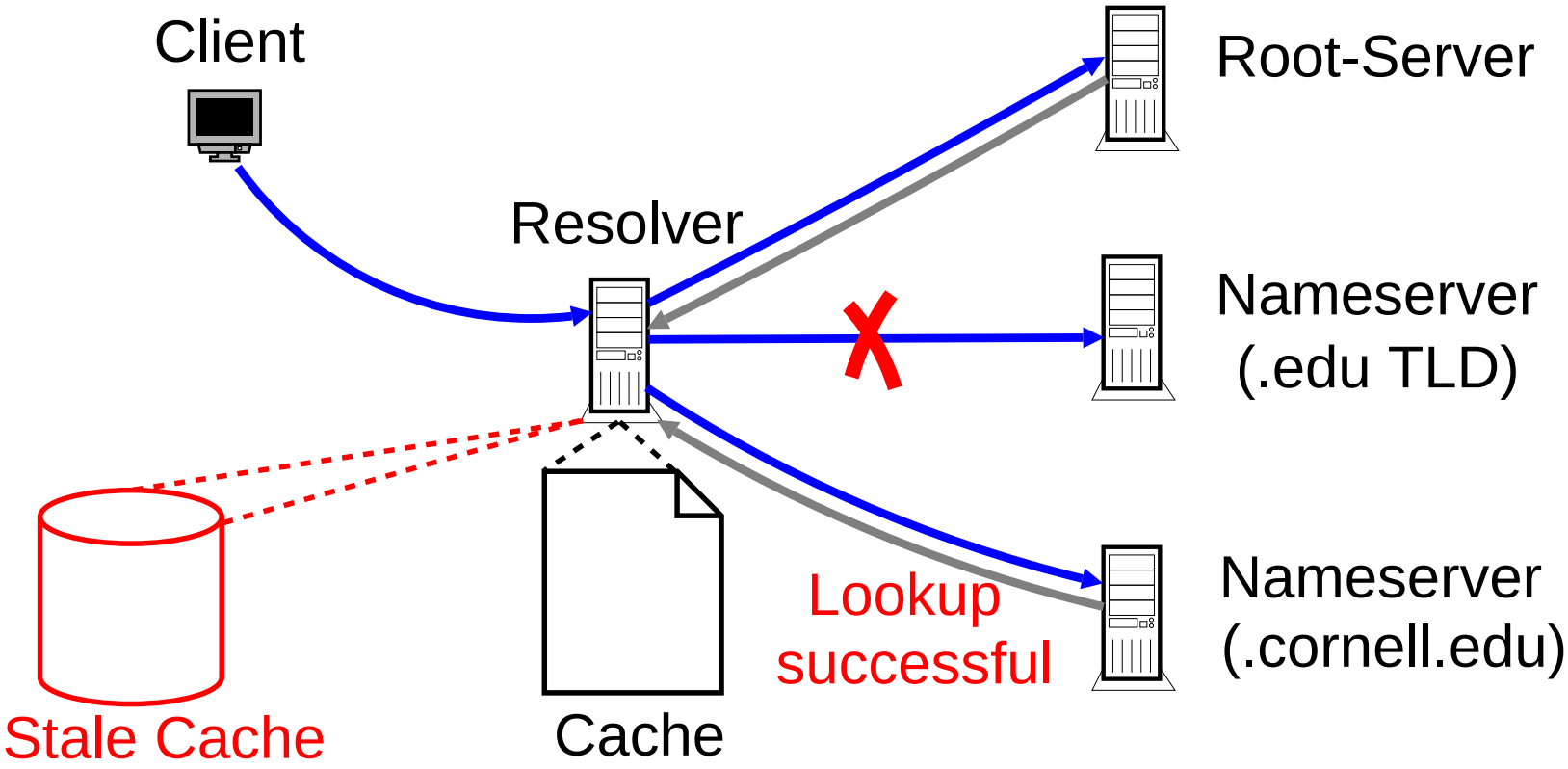

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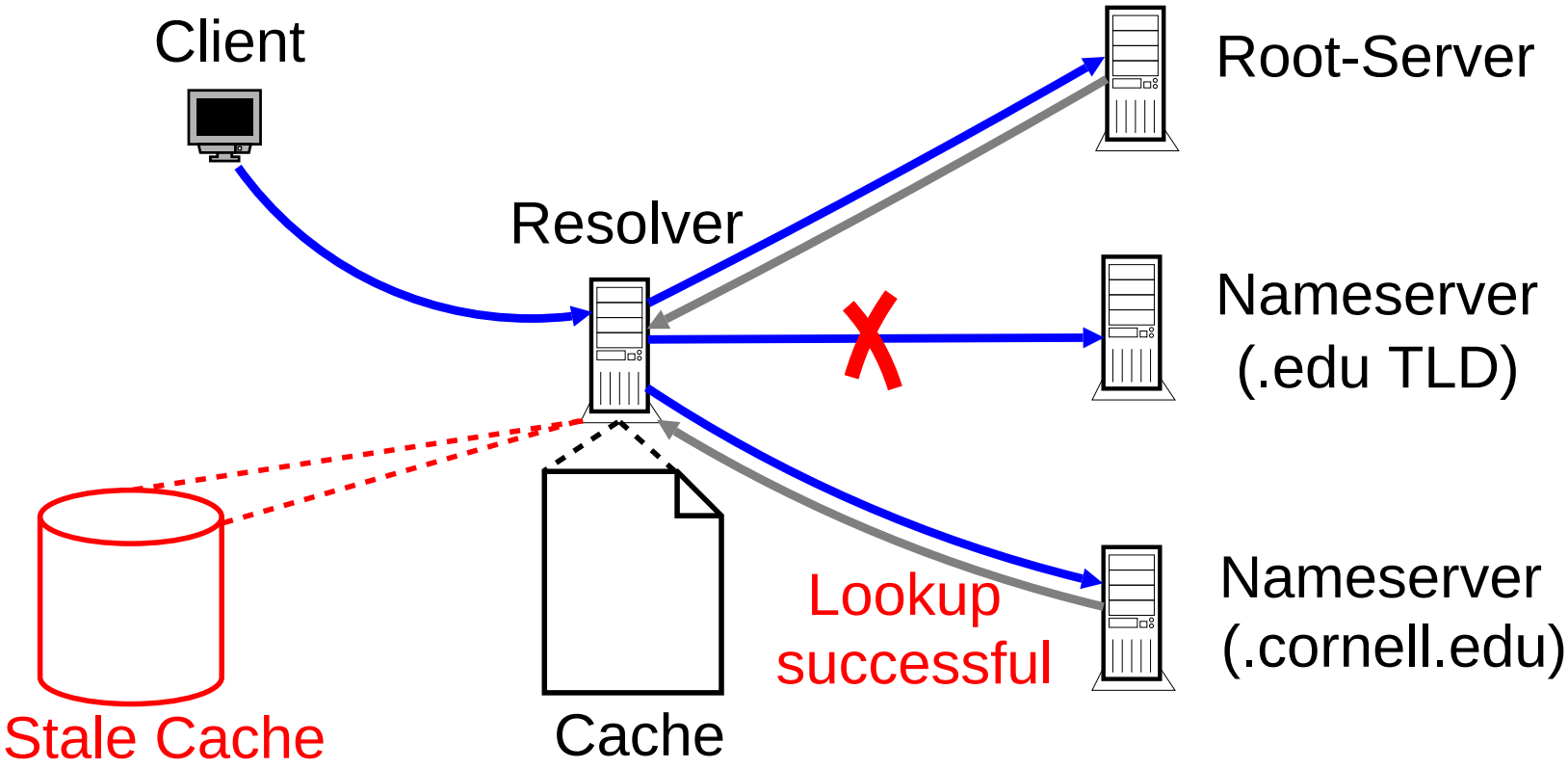

Stale records for a zone used **only** when the nameservers for the zone are unavailable

Stale Cache Details

Expunging records from the Stale Cache

Responses from nameservers used to clean up the stale cache

Stale Cache lookup time not critical

Lookups can be done while querying the nameservers

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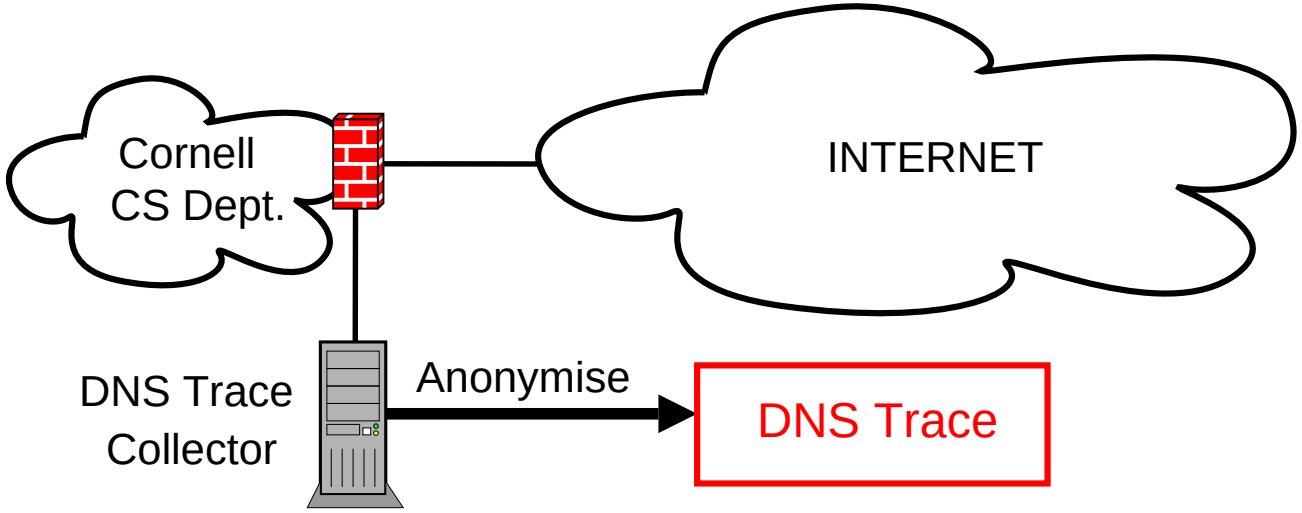
DNS Trace Collection



65-Day DNS Trace

- 138 million DNS packets
- 4.5 million unique DNS names

Trace collected at Border Router

- Network's resolvers could not answer the collected queries

Stale Cache Simulation

Simulation Variables

- Stale Cache Size
  - Number of days for which stale records are kept
  - Varied from 1 to 30 days
- Attack Duration
  - Varied from 3 to 24 hours

Is History Useful?

Attack: Entire DNS Fails

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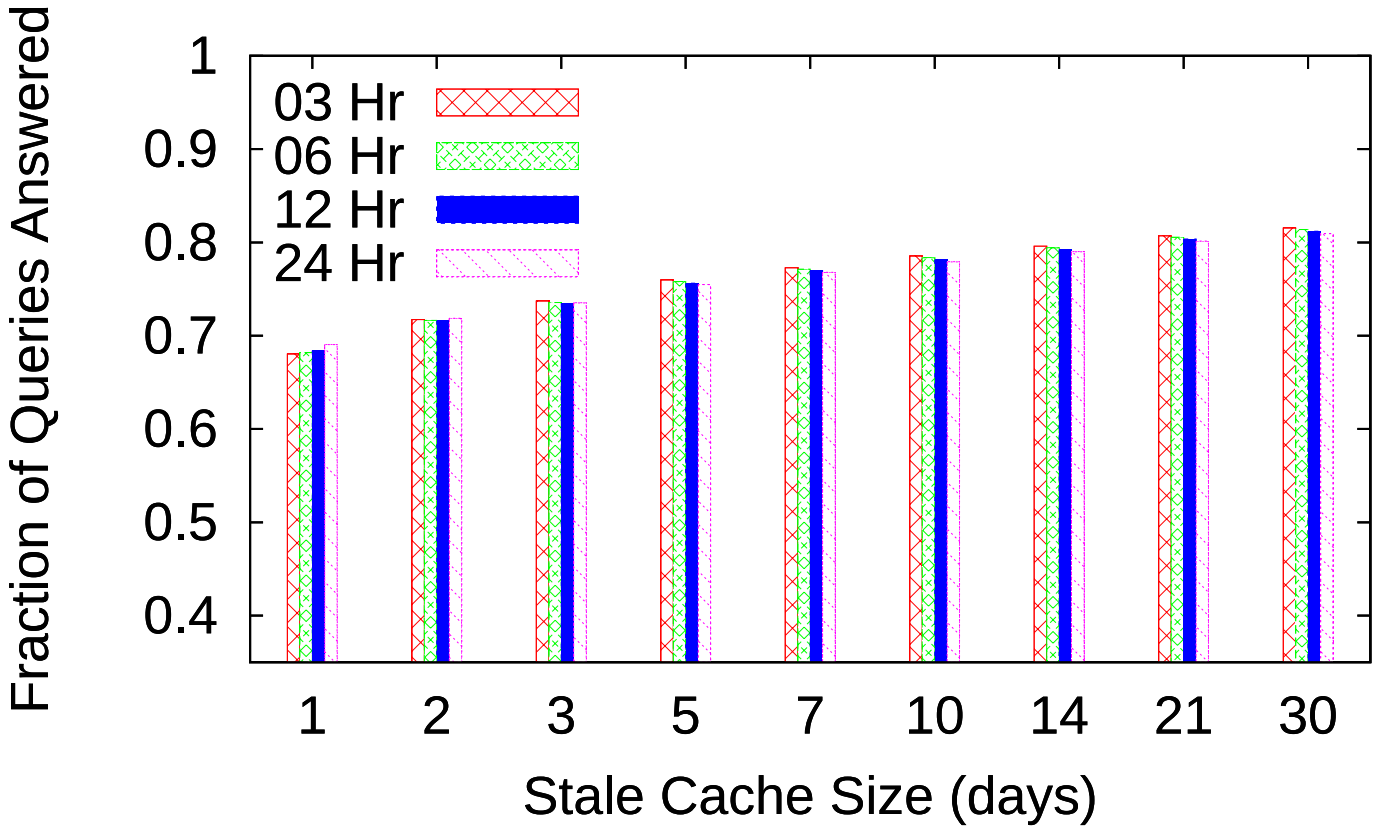

14-Day Stale Cache can answer ∼80% queries

Is History Useful?

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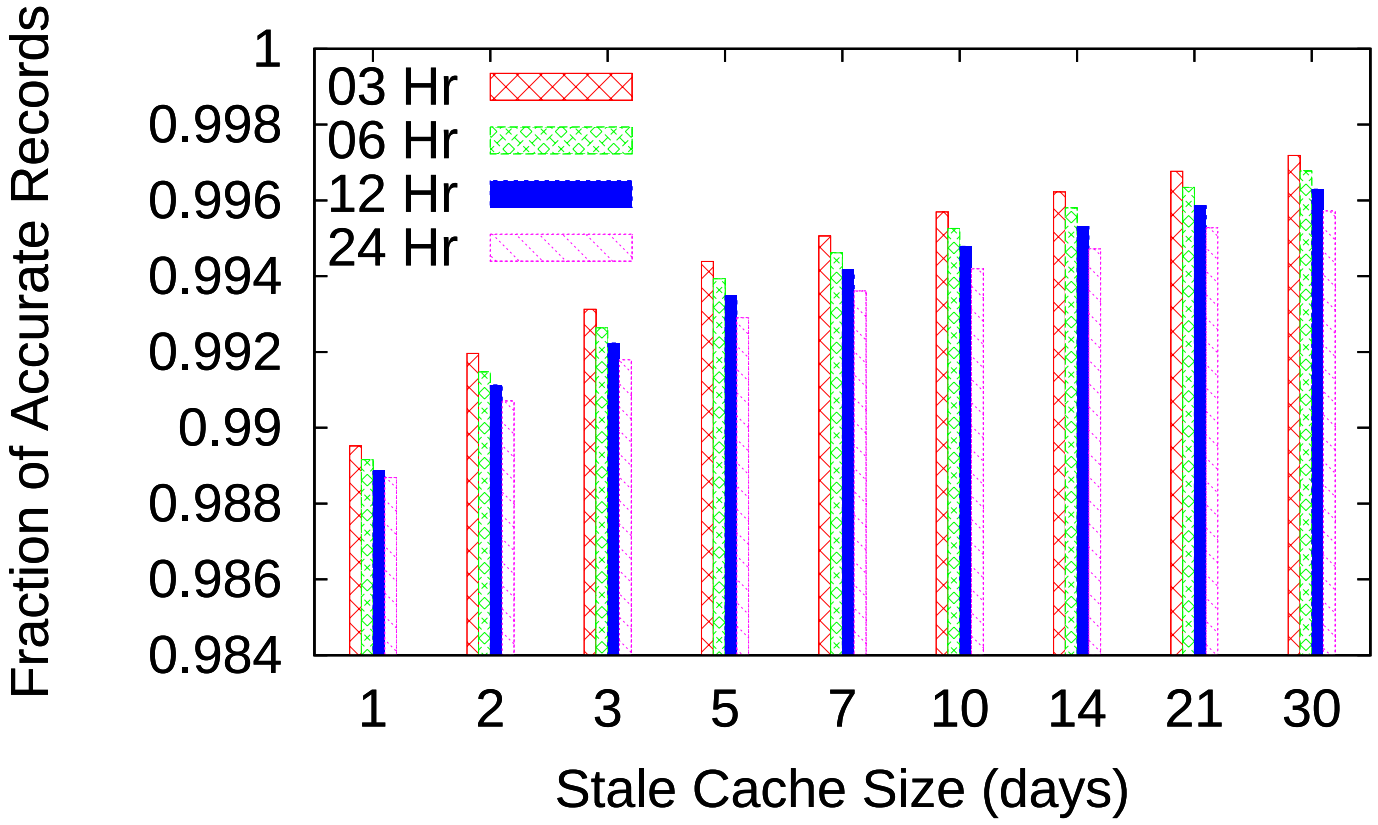

99.6% accurate answers with 14-Day Stale Cache

Other Attack Scenarios

Root-Servers Fail

- Queries for Top-level Domains (TLDs) not resolved
- Stale Cache can answer all such queries

TLD Nameservers Fail

- Queries for two-level names (eg, *a.com*) not resolved
- Stale Cache can answer $>$75% such queries
- Accuracy of answers is 99.4%

Memory Footprint

Depends on network

- Number of hosts
- Query-rate

For the collected trace

- 1300 hosts and $\approx$25 DNS pkts/sec
- Month-long Stale Cache = 313MB

Proposed Modification: Pros

Increased DNS Robustness

- Nameserver availability less crucial
- Mitigates the impact of DoS attacks

Simplicity

- Does not change the basic protocol operation
- Does not impose any load on DNS
- Does not impact the query resolution latency

Incremental Deployment

- Motivation for deployment

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Ballani					
Vixie					

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Possibility of obsolete information being used

Obselete zone records used by a resolver only if

- Zone's records have been updated since the last access by the resolver
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Restrict the Stale Cache size

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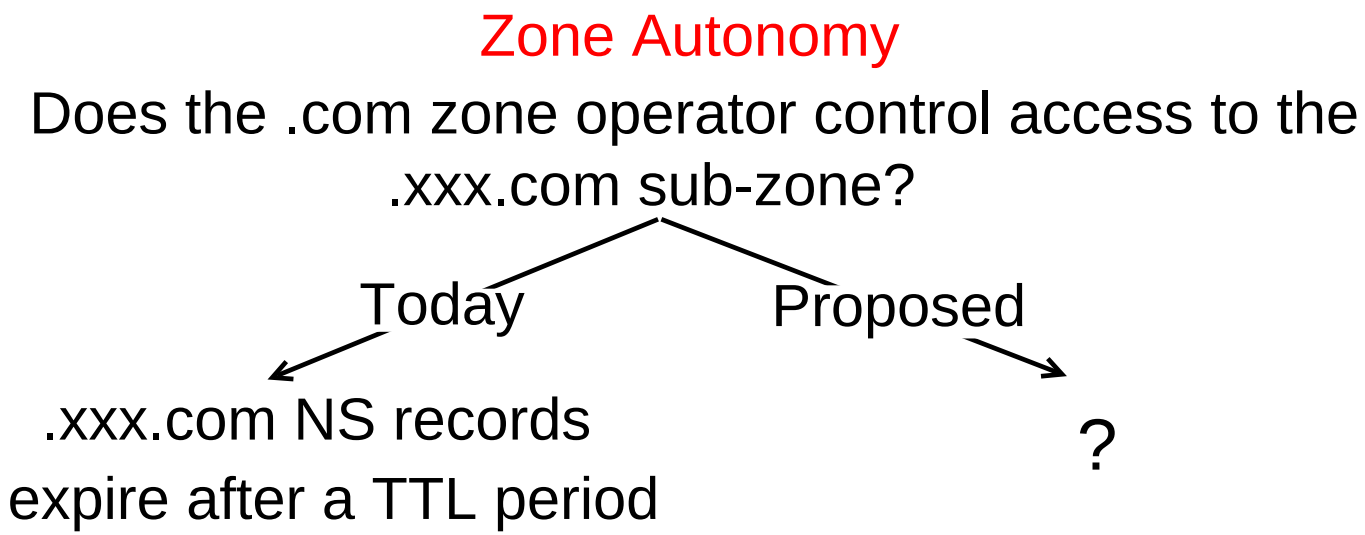

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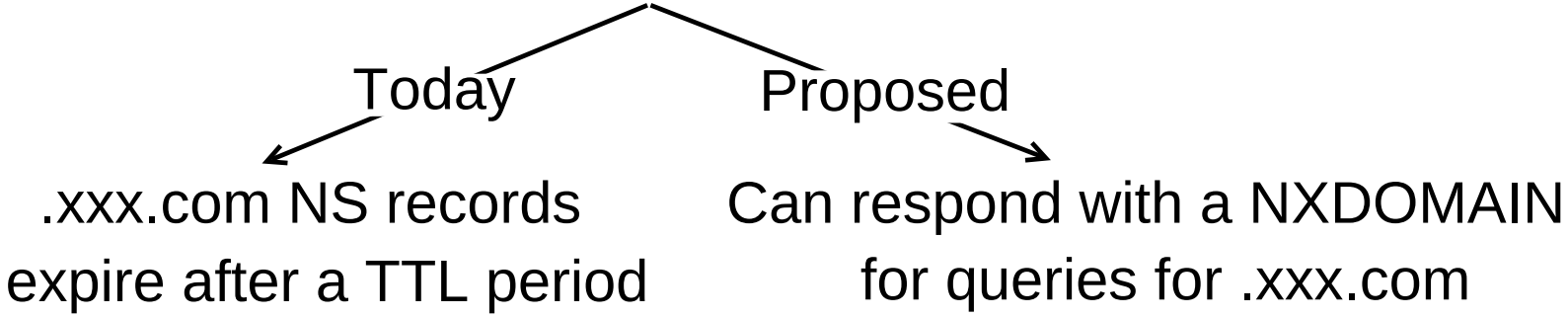
Zone Autonomy

Does the .com zone operator control access to the .xxx.com sub-zone?



Zone operators still control access to their sub-zones

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Attackers forcing the use of obsolete records for a zone by

- Waiting for the zone's records to be updated
- And then flooding the zone's nameservers

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Resolution latency in the face of attacks

- Resolver must query each nameserver of a zone before using the zone's records from the stale cache
- Given default resolver timeout configurations, this can lead to high resolution latencies

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Alleviative: Resolvers configured with aggressive retry and timeout values

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DNS servers can still be overwhelmed

- Unable to update the zone's records

Application servers can still be DoS'ed

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DNS servers can still be overwhelmed

- Unable to update the zone's records

Application servers can still be DoS'ed

- Do DNS servers and Application servers share the network bottleneck?

Summary

A minor modification in the caching behavior of DNS resolvers

- Reduces the need for nameserver availability in the **existing DNS framework**
- Mitigates the impact of DoS attacks on DNS

Stale Cache

- Modifies the DNS caching semantics
- **Does not impact** fundamental DNS characteristics

Thank You!