



MAY 11-12

BRIEFINGS

Phoenix Domain Attack: Vulnerable Links in Domain Name Delegation and Revocation

Xiang Li Tsinghua University

May 12, 2023

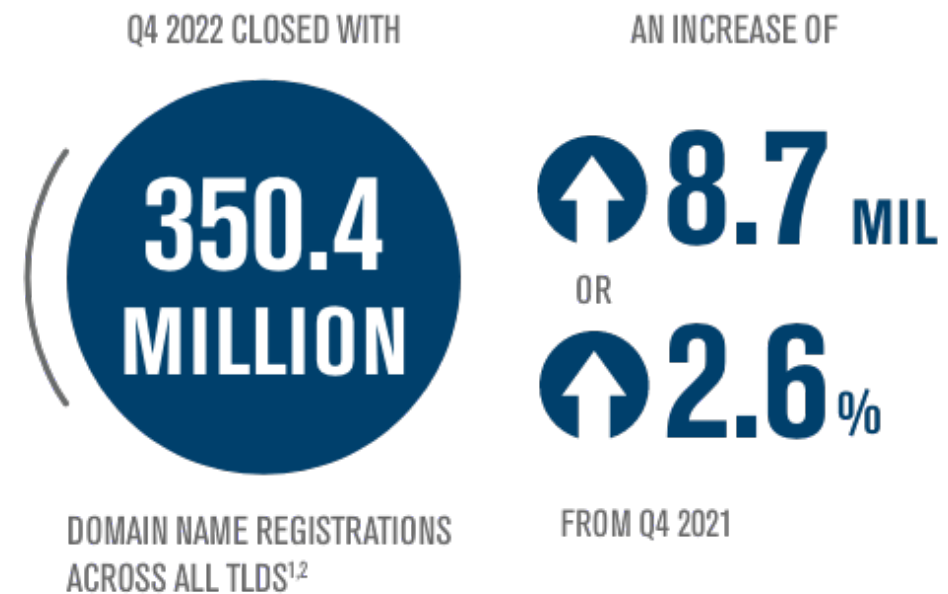
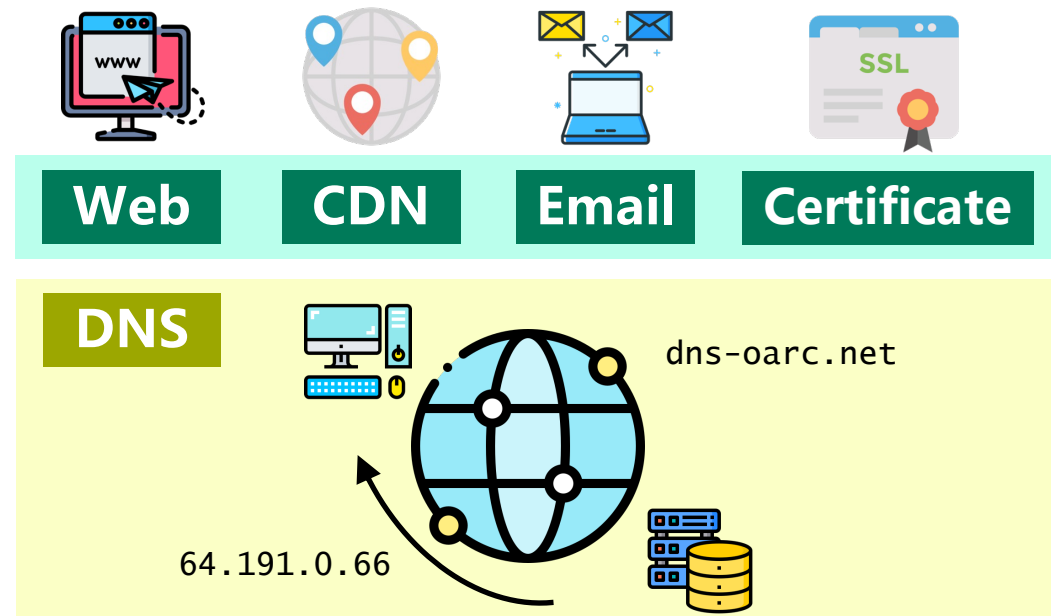
Exploitation Impact

Even a domain expired or was removed,

**Attackers could still use it for free
with the Phoenix Domain Attack.**

Domain Name

- **Domain name system (DNS)**
 - Entry point of many Internet activities
 - Security guarantee of multiple application services
 - Domain names are widely registered



Domain Name Abuse

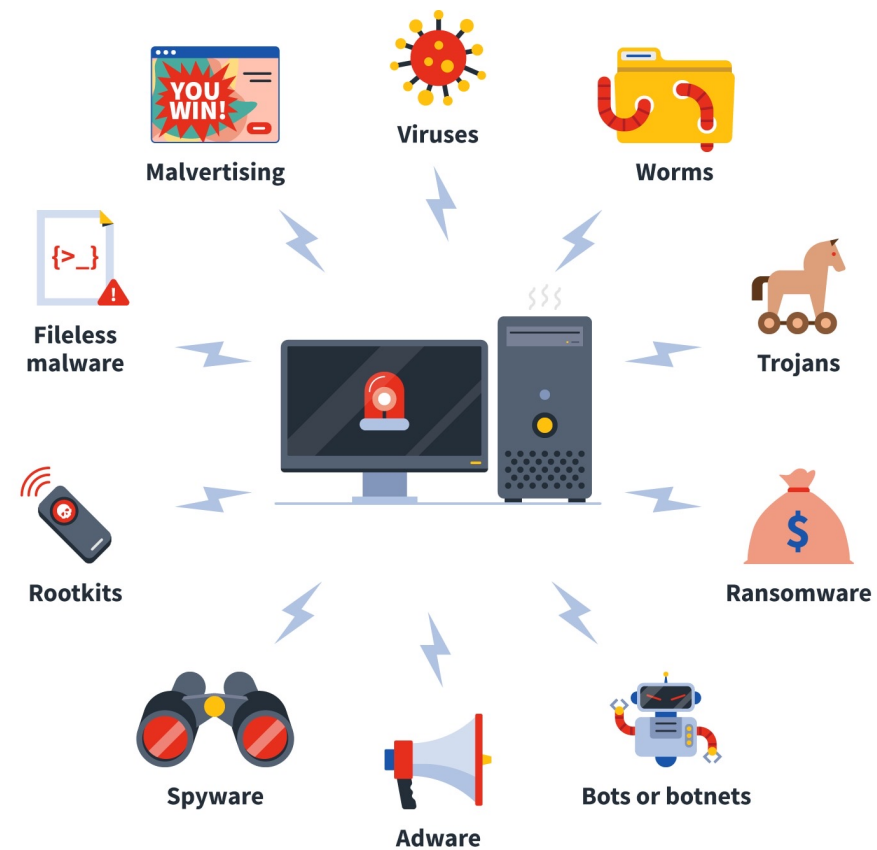
- Also abused by criminal activities
 - Botnet, phishing, malware distribution



bleepingcomputer.com



scmp.com



norton.com

Domain Name Abuse

- **Also abused by criminal activities**
 - Botnet, phishing, malware distribution
- **ICANN Domain abuse activity reporting (DAAR)**
 - In March 2023
 - Check 216,171,933 domain names within 1,154 gTLDs

**622,875 domains
showing security threats**

Domain Name Revocation

- **Fighting against malicious domain names**
- **Mechanism**
 - Domain name revocation
 - Operated by registries or registrars
 - Deleting or changing domain name registration (delegation)
- **Result**
 - Domains are no longer controlled by original registrants/attackers


Domain Name Revocation

➤ Domain name seizure activity

- Best security practice
- Widely adopted

Microsoft seizes Chinese dot-org to kill Nitol bot army

Takedown after infected new computers sold to victims

 [John Leyden](#)

Thu 13 Sep 2012 // 15:01 UTC

Microsoft has disrupted the emerging Nitol botnet - and more than 500 additional strains of malware - by taking control of a rogue dot-org website. The takedown is the latest in Microsoft's war against armies of hacker-controlled PCs.

theregister.com



intelligentciso.com



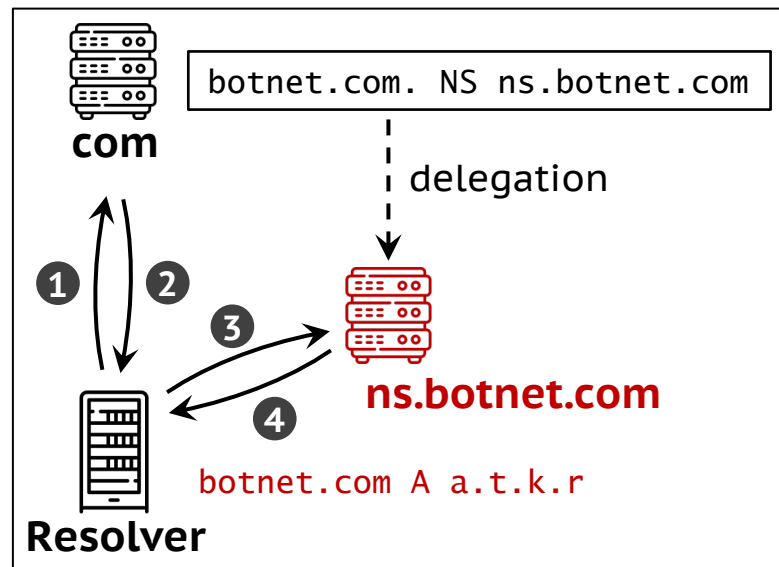
Question

How does domain name revocation work on domain name registration (delegation)?

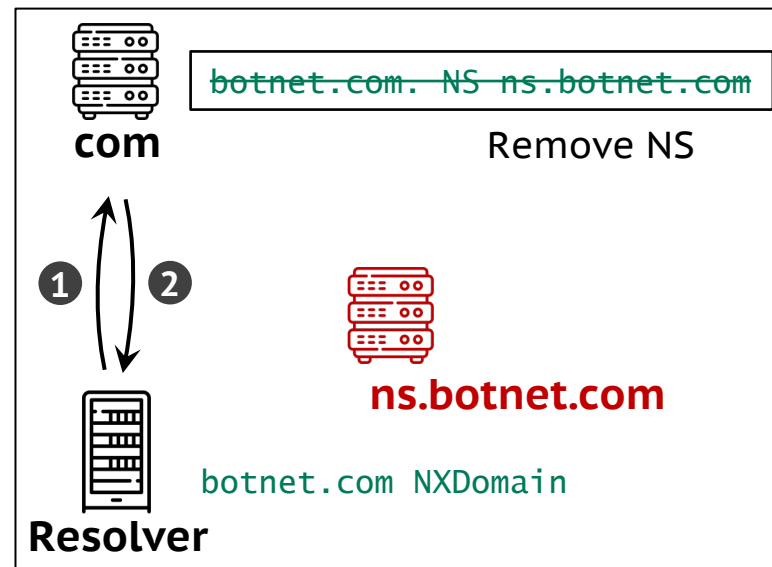
It is the reverse process of **delegation**.

Domain Name Revocation

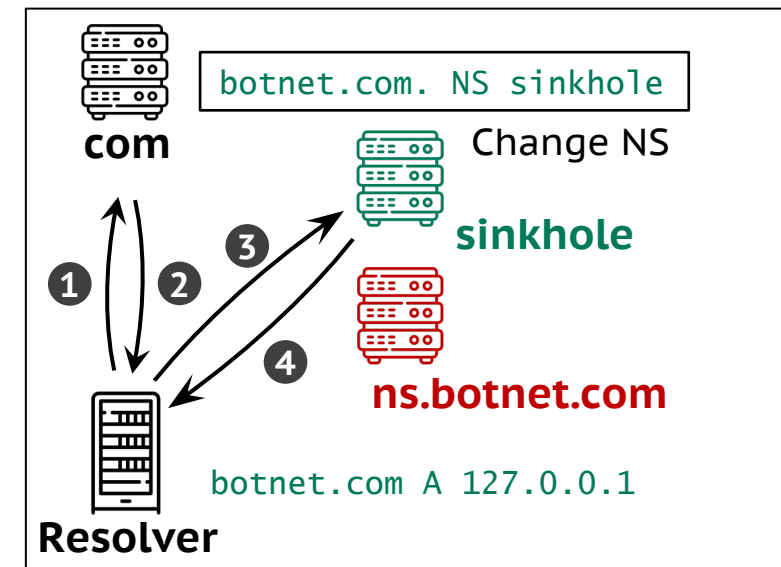
- Normal resolution
- Revocation
 - Domain delisting
 - Domain sinkholing



Normal resolution



Domain delisting



Domain sinkholing

Question

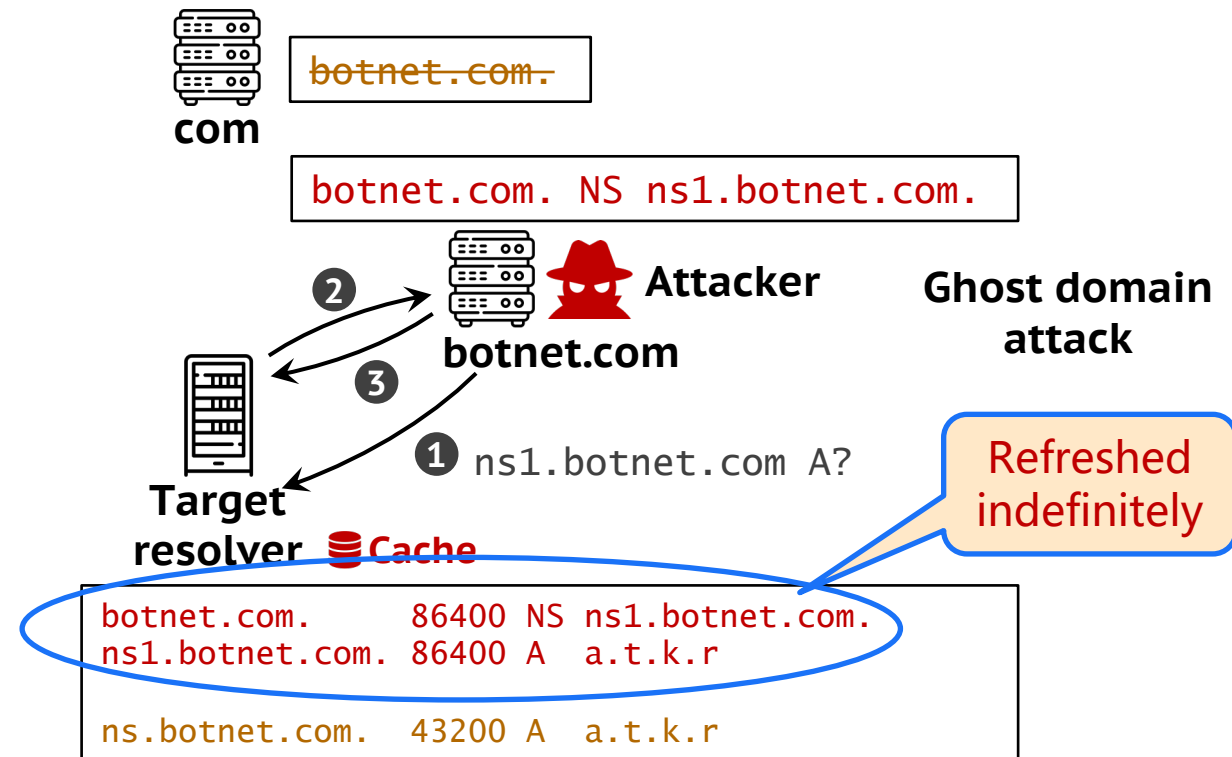
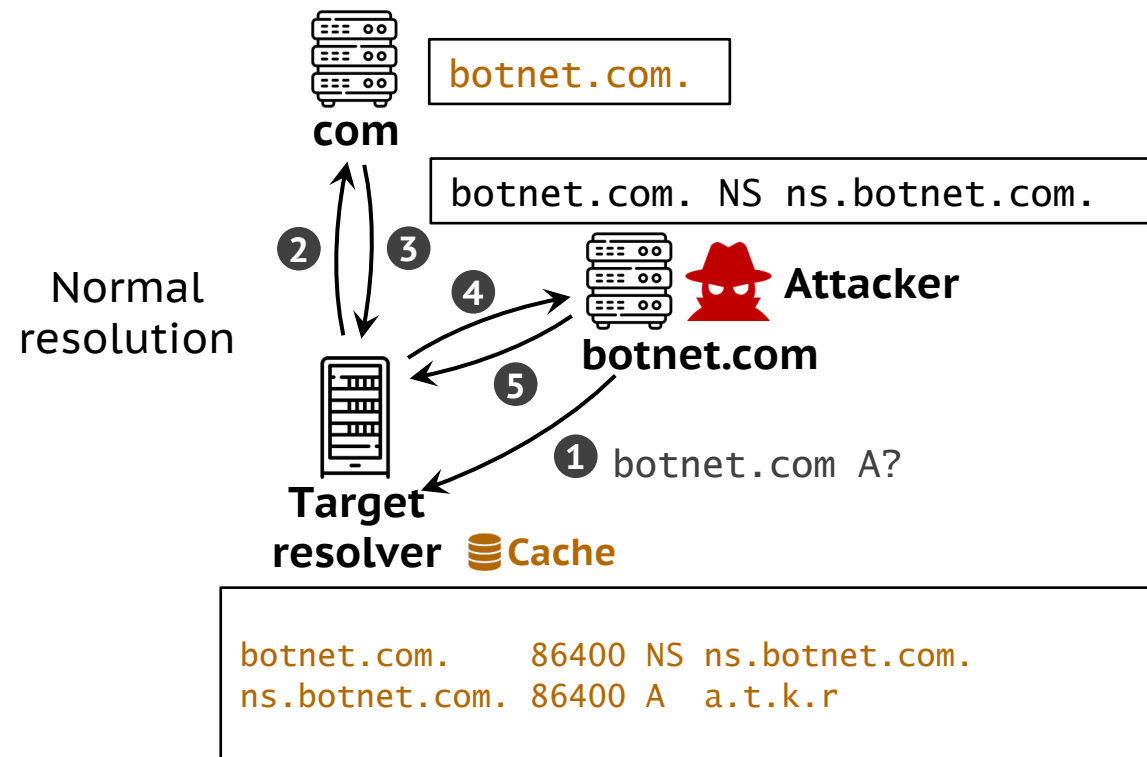
**Does domain name revocation
function as desired?**

No. **Ghost domain** broke this guarantee.

Ghost Domain

➤ Ghost domain attack

- Proposed in NDSS 2012 by our NISL lab
- Making revoked domain names still resolvable on resolvers





Takeaway

With ghost domain, even after revocation, malicious domains can still be resolvable.

Attackers can use it to evade **domain take-down** or **domain expiration**.

Ghost Domain

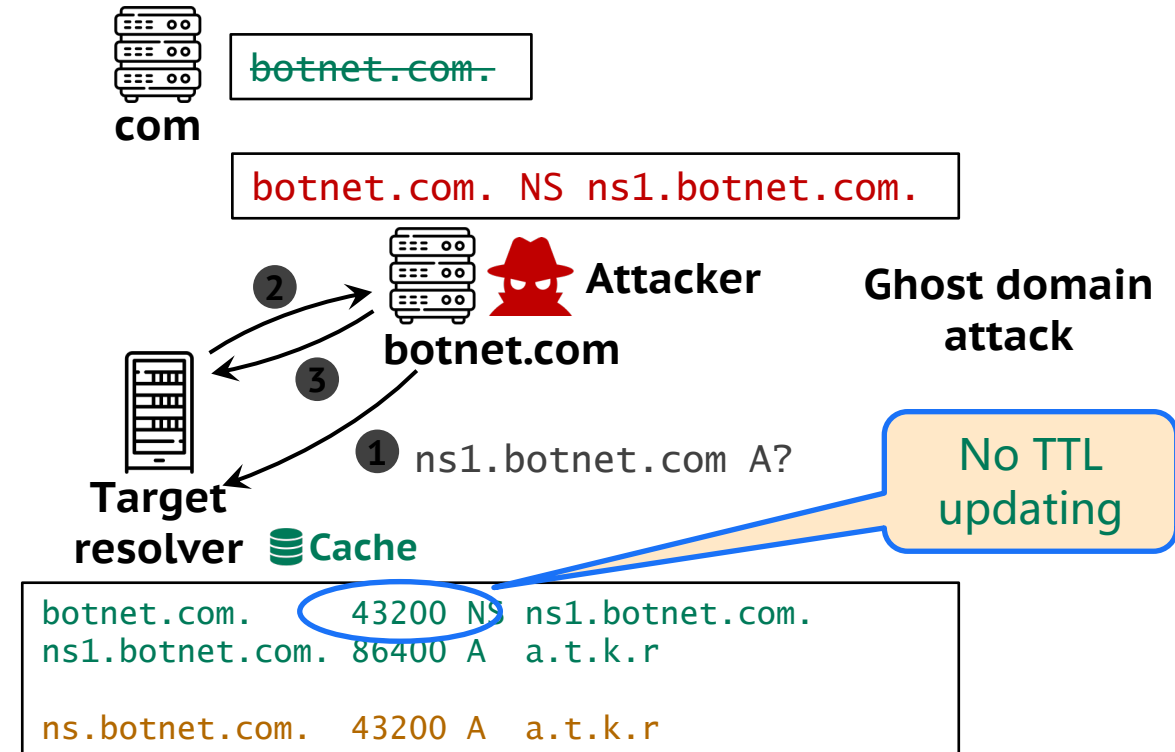
➤ Vulnerable software

- Not all software: BIND, PowerDNS, etc.

➤ Mitigation

- TTL field cannot be prolonged

DNS Vendor	Version	Vulnerable?
BIND	9.8.0-P4	Yes
DJB dnscache	1.05	Yes
Unbound	1.4.11	No
	1.4.7	Yes
PowerDNS	Recursor 3.3	Yes
MaraDNS	Deadwood-3.0.03	No
	Deadwood-2.3.05	No
Microsoft DNS	Windows Server 2008 R2	No
	Windows Server 2008	Yes



Question

10 years later, does domain name revocation work as desired after fixing ghost domain?

No. **Phoenix domain** still breaks this guarantee with a broader attack surface.

Phoenix Domain

➤ What is phoenix domain

- Proposed by our NISL lab too
- Published in NDSS 2023
- Also making revoked domain names still resolvable on resolvers
- Two new vulnerabilities in protocols or implementations
- Two variations (**T1** and **T2**)
- **Affecting all DNS implementations**



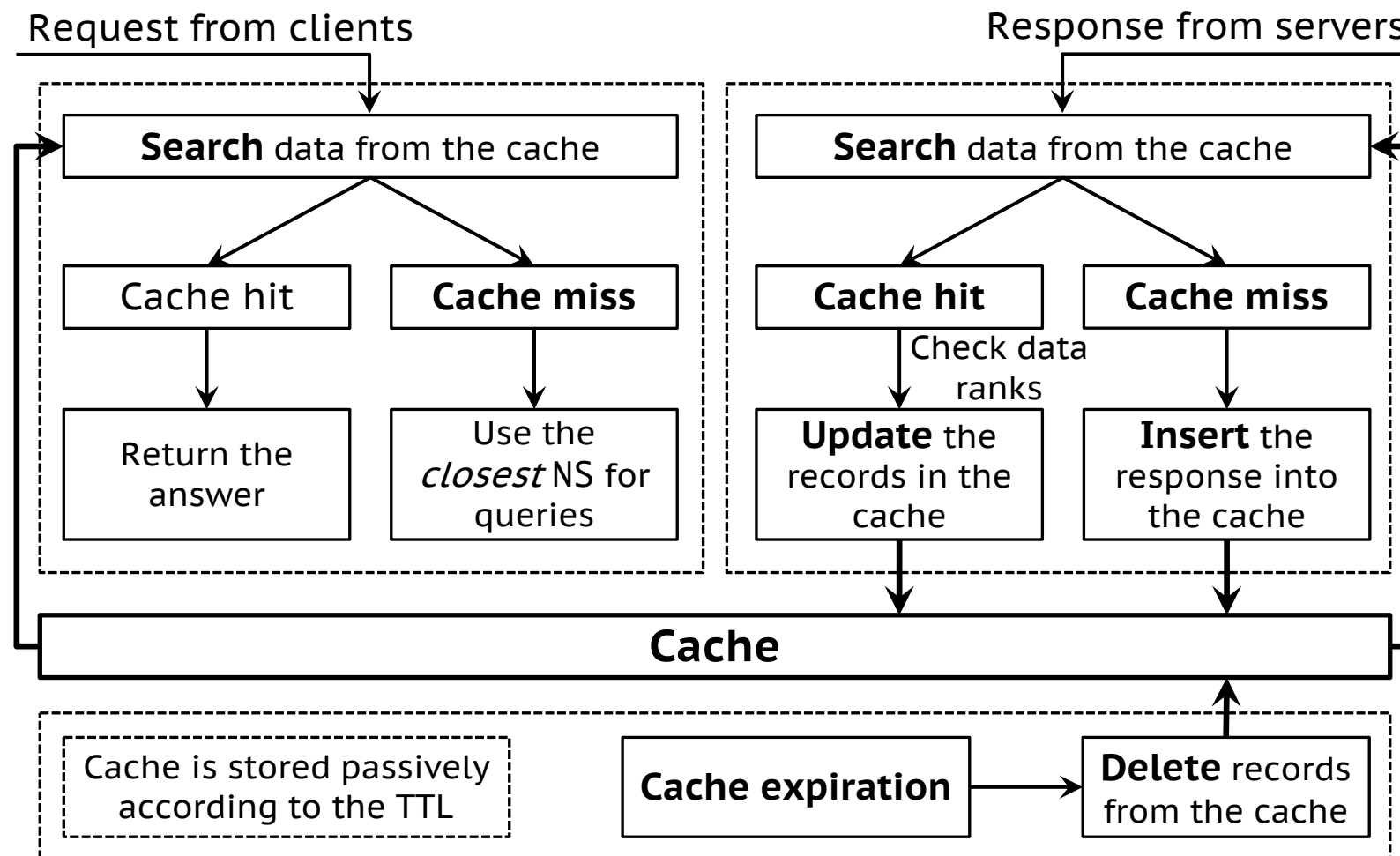
Question

**Why is domain name revocation
still vulnerable?**

We find that the entire attack surface
remains unclear now.

DNS Cache Operations

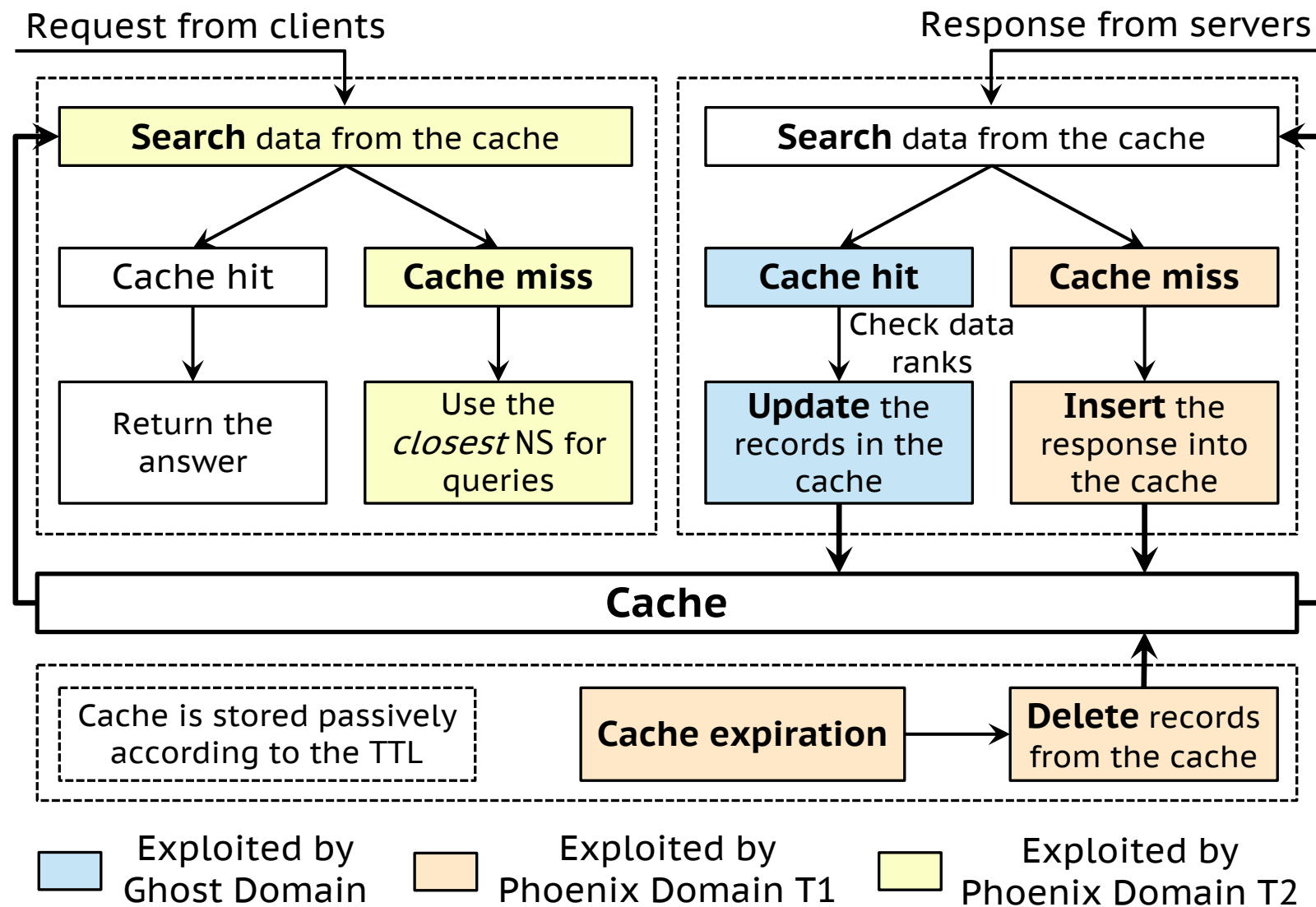
➤ Summary



DNS Cache Operations

➤ Summary

- Updating
- Insertion
- Searching





Question

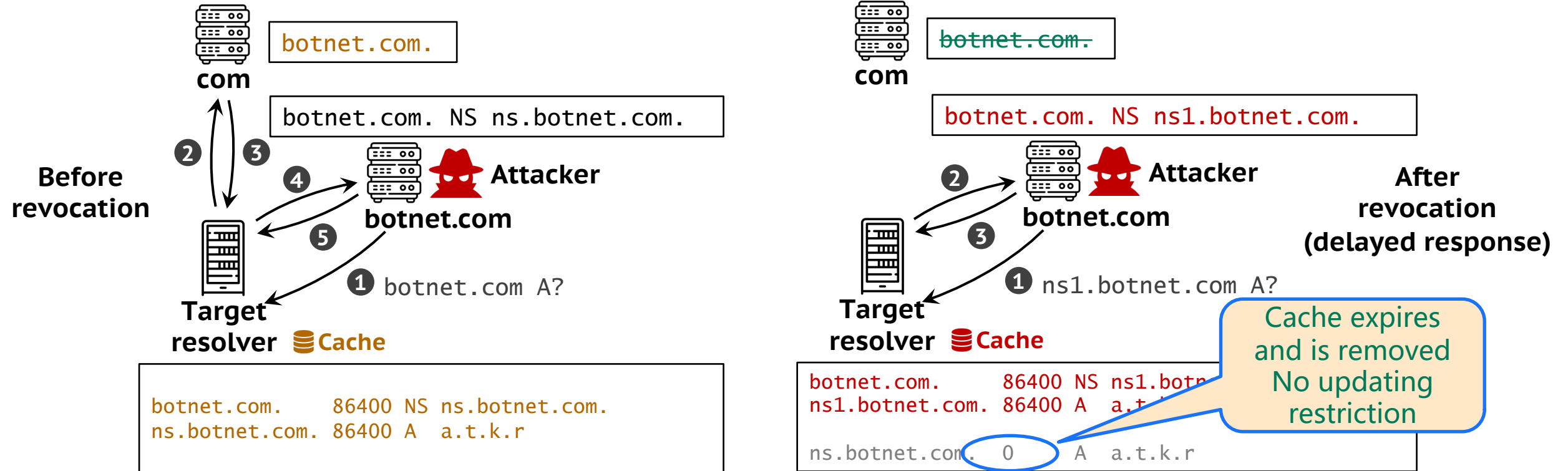
How does Phoenix Domain work?

Two variations, two ways.

Phoenix Domain T1

➤ T1 attack

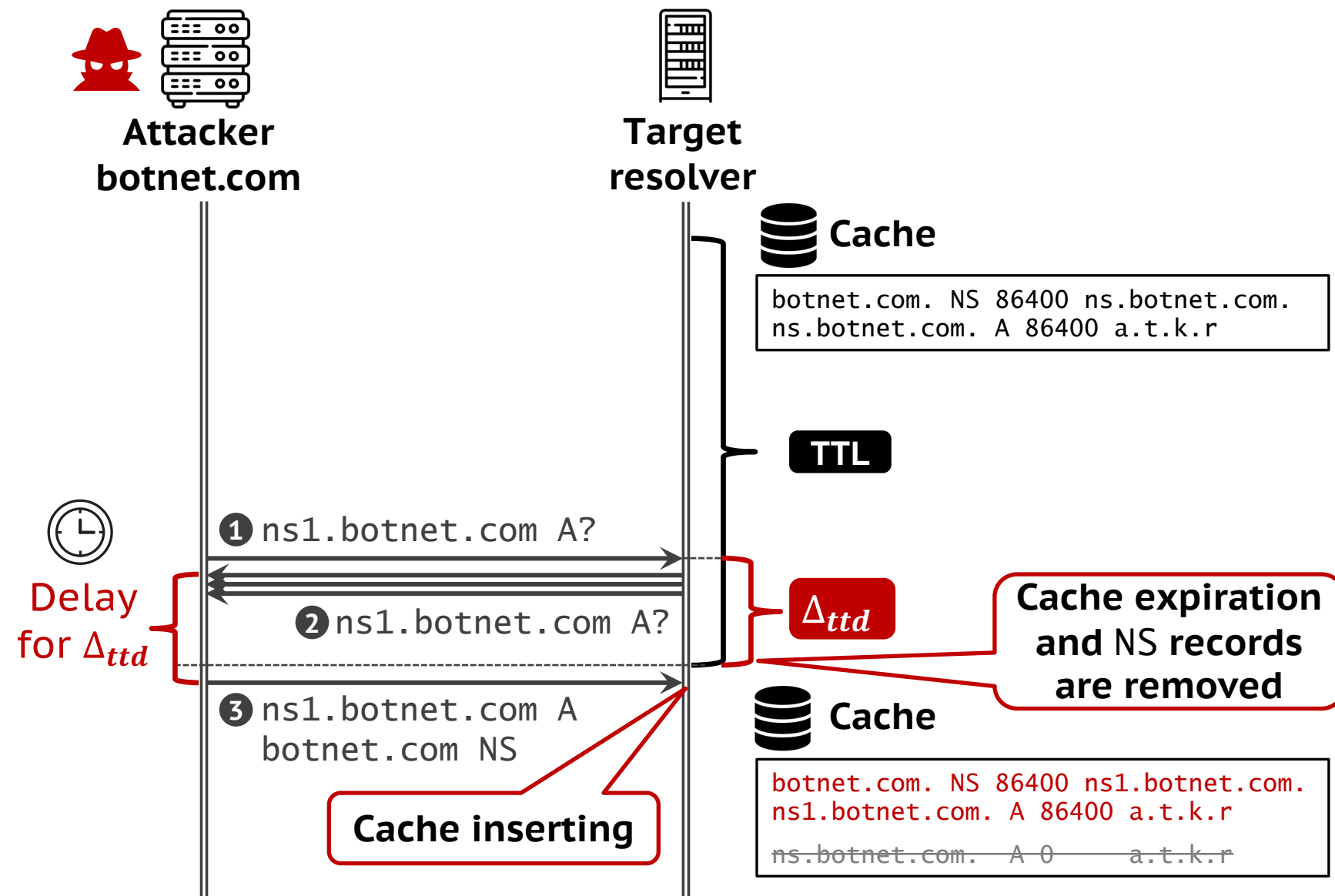
- Exploiting vulnerable cache insertion implementations
- Inserting new NS records **when the old is about to expire**



Phoenix Domain T1

➤ T1 attack

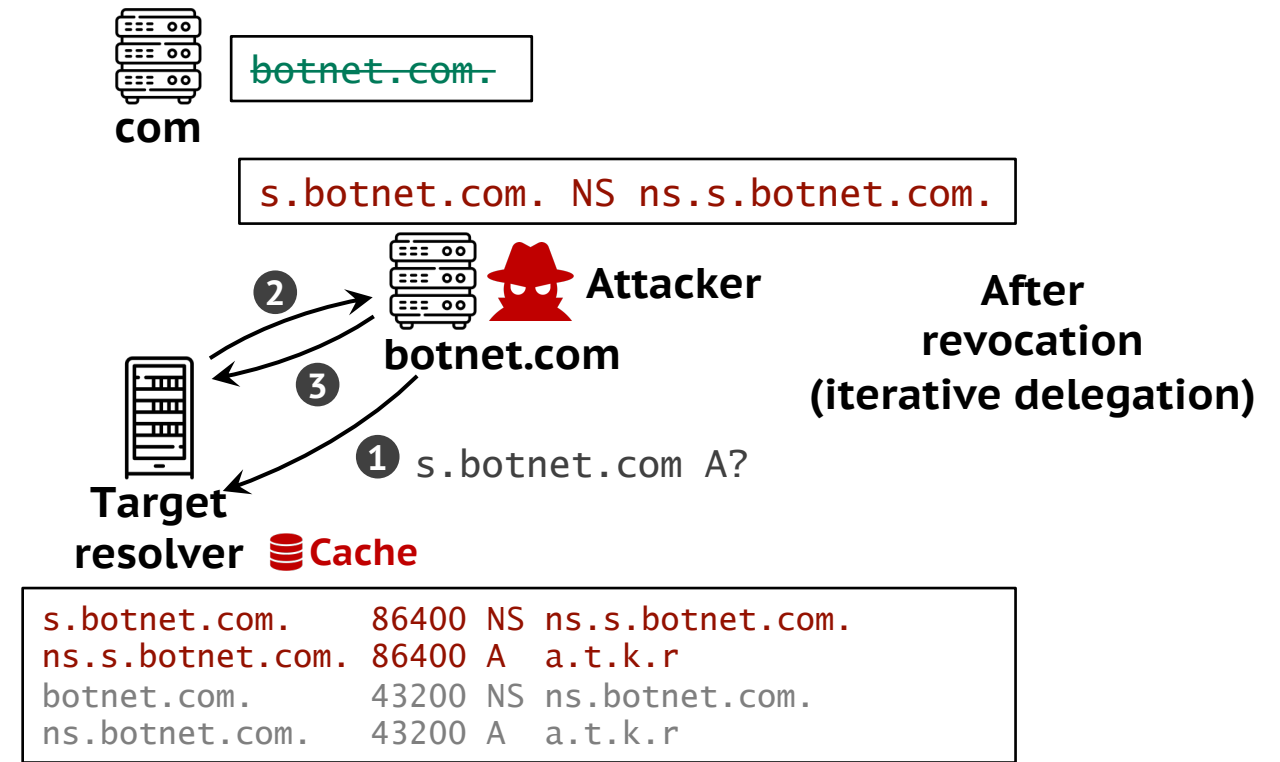
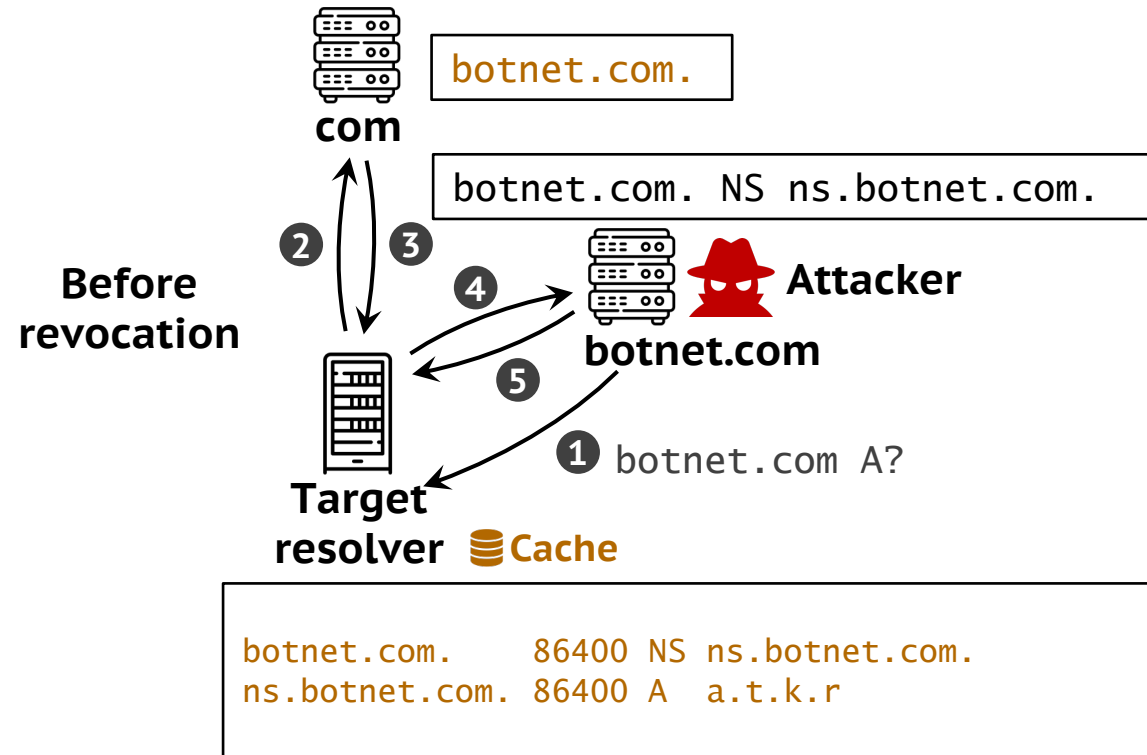
- Attack steps
- Cache expiration
- Cache deletion
- Cache insertion



Phoenix Domain T2

➤ T2 attack

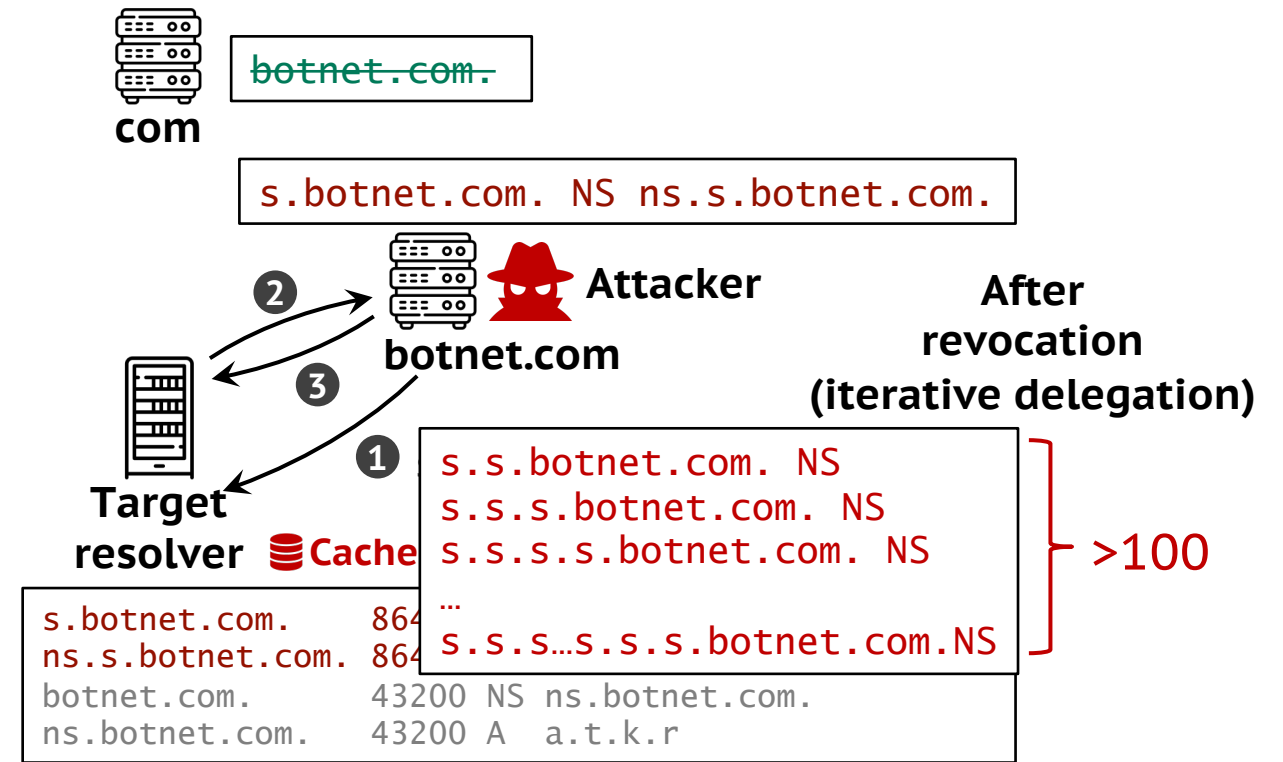
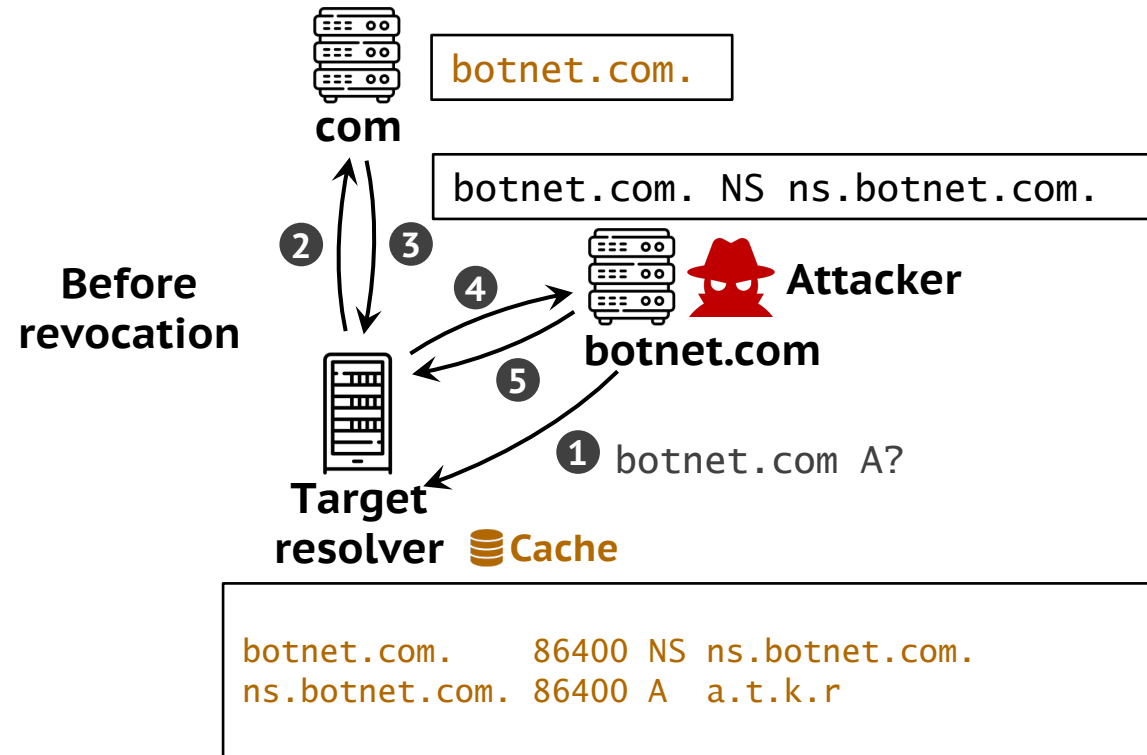
- Exploiting vulnerable cache searching operations
- Inserting new NS records of subdomains



Phoenix Domain T2

➤ T2 attack

- Exploiting vulnerable cache searching operations
- Inserting **new NS records of subdomains**



Vulnerable Software

➤ Phoenix domain T1

- BIND9, Knot, Unbound, and Technitium

➤ Phoenix domain T2

- All tested 8 software are vulnerable (7 confirmed, 9 CVEs)

BIND 9

**KNOT
RESOLVER**

unbound

POWERDNS

Microsoft
DNS

MaraDNS

Simple DNS Plus

Technitium DNS Server

CVE-2022-30250 CVE-2022-30251
CVE-2022-30252 CVE-2022-30254
CVE-2022-30256 CVE-2022-30257
CVE-2022-30258 CVE-2022-30698
CVE-2022-30699

Vulnerable Public Resolvers

- **Phoenix domain T1 and/or T2**
 - We test **41 public resolver vendors**
 - **All resolvers** are vulnerable to T1 and/or T2
 - Such as Google, Cloudflare, Akamai, AdGuard, etc. (15 confirmed)



Vulnerable Open Resolvers

➤ Recursive resolver list

- Through scanning, we collected 1.2M resolvers
- 210k recursive resolvers are selected

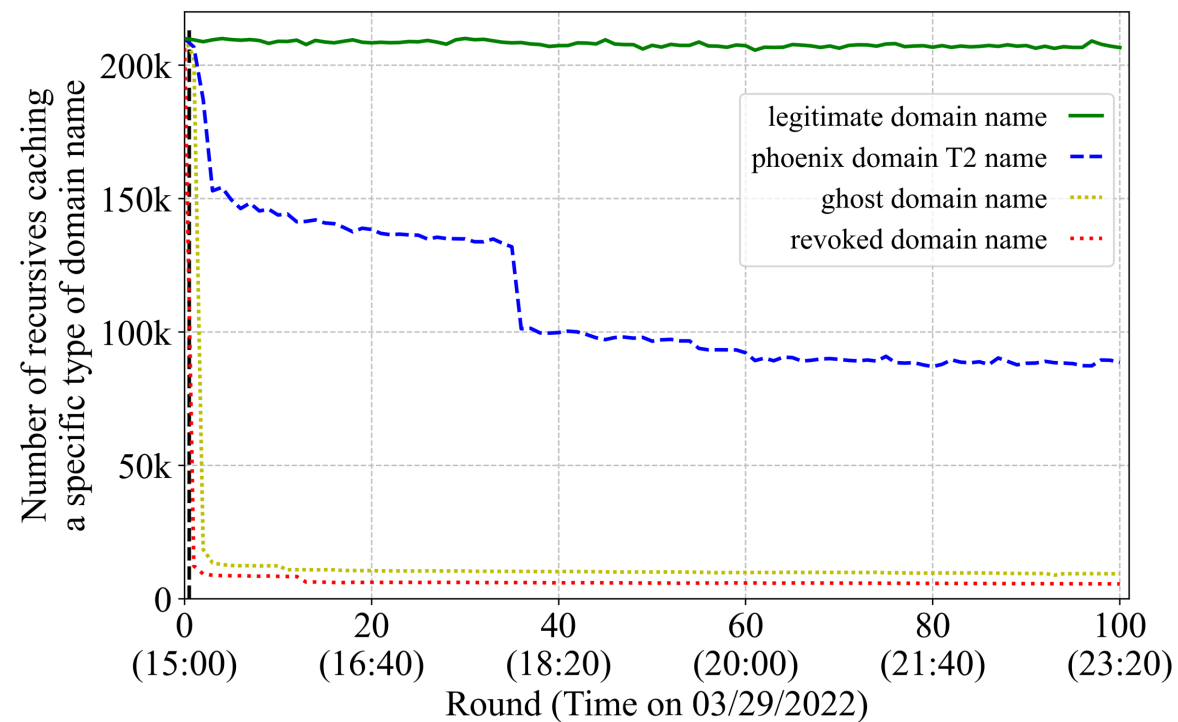


Region	Number	%	ASN	Number	%
USA	43,034	20.5%	4837	9,825	4.7%
China	25,152	12.0%	4134	5,988	2.9%
Russia	22,802	10.9%	3462	5,864	2.8%
Japan	13,421	6.4%	4713	5,134	2.4%
France	12,801	6.1%	8866	4,884	2.3%
Turkey	8,389	4.0%	9121	4,779	2.3%
Brazil	7,128	3.4%	16276	4,355	2.1%
Sweden	7,026	3.3%	209	3,937	1.9%
Taiwan	6,869	3.3%	3215	3,735	1.8%
Ukraine	6,572	3.1%	12389	3,485	1.7%
Total 218 regions			Total 11,274 ASes		

Experiments for T2

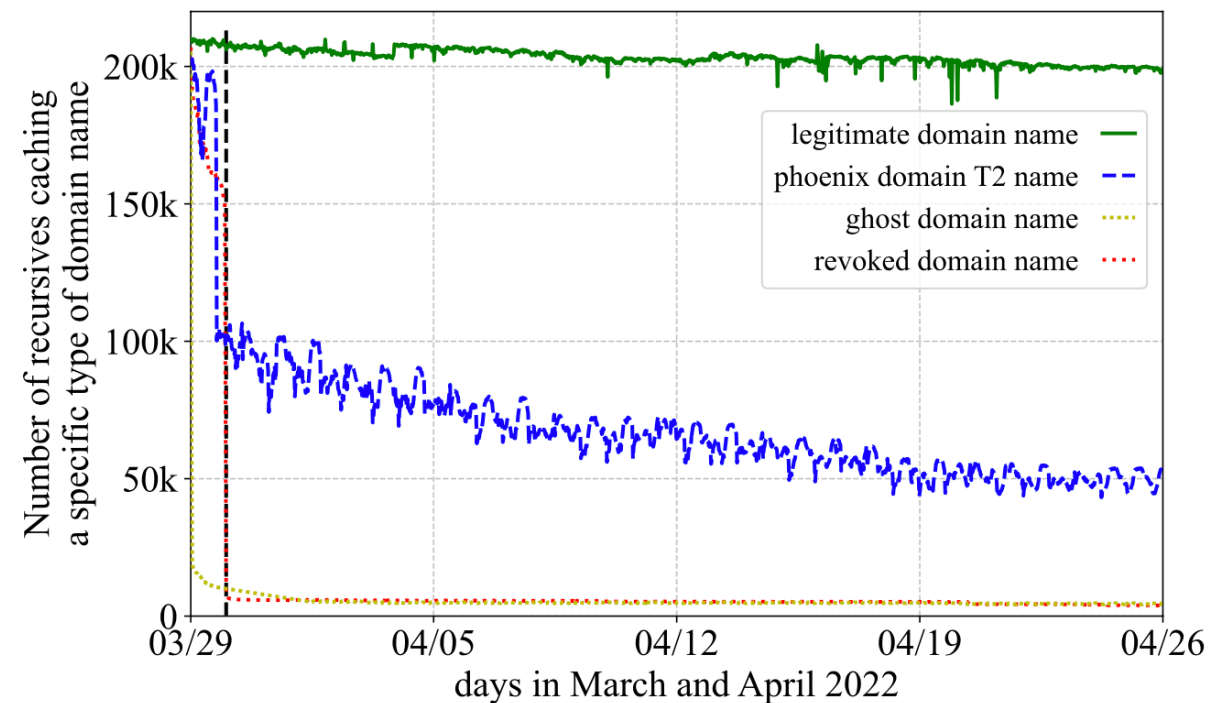
➤ Short-term experiments

- Check how many labels are supported
- **89%** are vulnerable
- After 100 rounds, **42%** are vulnerable



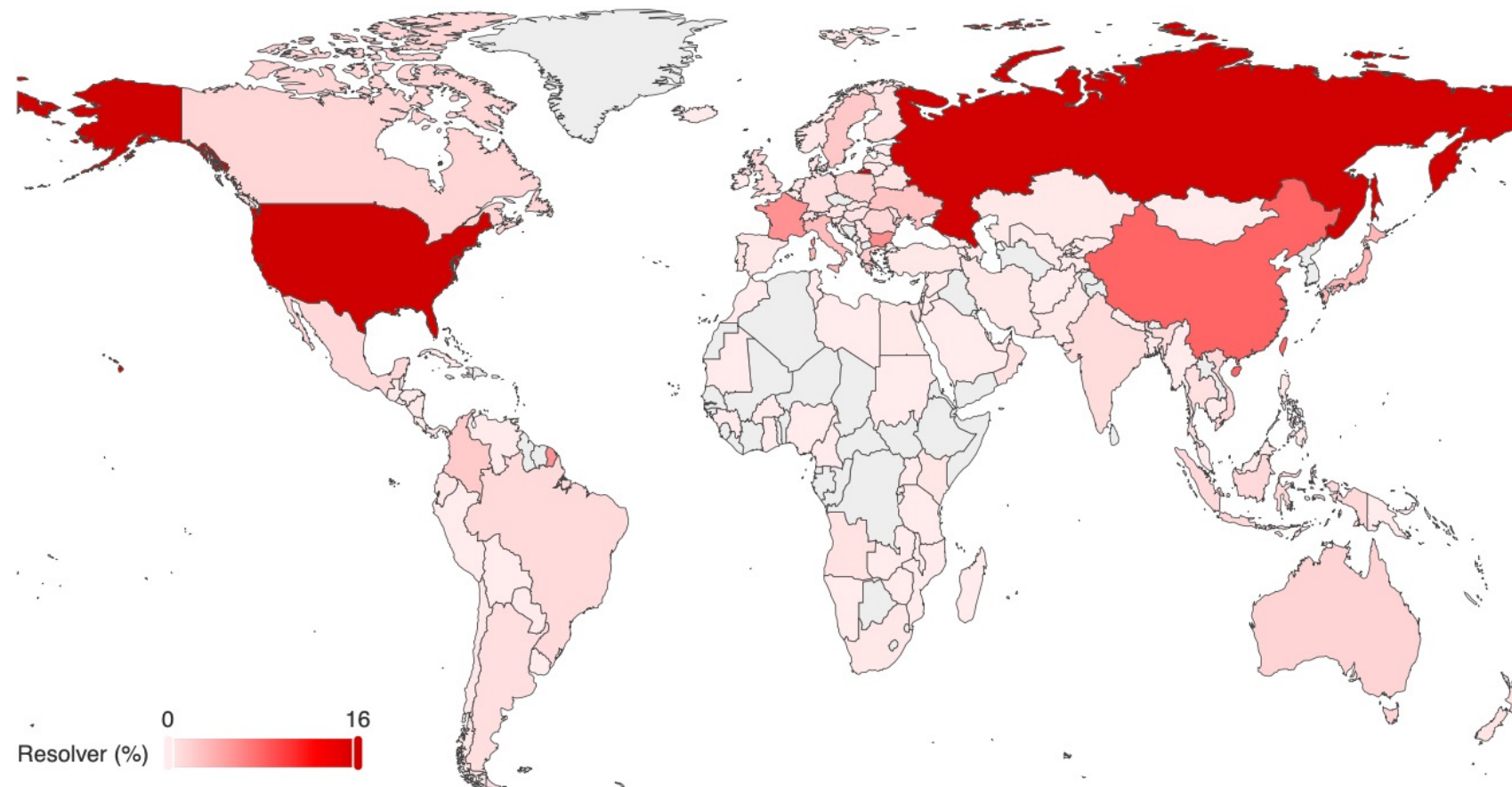
Experiments for T2

- Long-term experiments
 - Check how long phoenix domain can be alive
 - After **one week, 40%** are vulnerable
 - After **one month, 25%** are vulnerable



Experiments for T2

- **Geolocation of vulnerable resolvers**
 - USA, Russia, and China



Mitigation

- 6 approaches
- Discussing with RFC editors
- For example,
- **M1**: when NS RRs expire, querying upstream for NS
- **M2**: trust NS from the parent more than the child
- **M3**: use small TTL values

Delegation Revalidation by DNS Resolvers
draft-ietf-dnsop-ns-revalidation-03

Mitigation	T1	T2
<i>M1</i> : Re-validating delegation information	●	●
<i>M2</i> : Updating delegation data by parent-centric policies.	●	○
<i>M3</i> : Aligning the cache use-and-check operations	●	○
<i>M4</i> : Ignoring unsolicited DNS records	◐	◐
<i>M5</i> : Scrutinizing domain names with over many labels	○	◐
<i>M6</i> : Restricting the maximum cache TTL	○	◐

●: Fully valid. ◐: Partially valid. ○: Not valid.

Black Hat Sound Bytes

- **The DNS RFCs and specifications are not clear to provide a deterministic definition for each operation, hence leaving a large attack window for ambiguous implementations.**
 - We should check the RFC's essential specifications.
- **The DNS implementations are not consistent across software, even for identical client queries.**
 - This inconsistency is likely to conceal possible risks, which should be thoroughly researched and evaluated.
- **The original DNS mechanism is insufficient to defend against several types of attacks.**
 - To improve it, we should propose new patches or redesign some structures.

Question

Thanks for listening!
Any question?

Paper



Xiang Li, Tsinghua University
x-l19@mails.tsinghua.edu.cn



Tool

