

Blocking DNS Messages is Dangerous

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- ▶ Created in 2009, the ANSSI is the French national authority for the defense and the security of information systems
 - ▶ in French, ANSSI, Agence Nationale de la Sécurité des Systèmes d'Information
- ▶ Under the authority of the Prime Minister
- ▶ Main missions are:
 - ▶ prevention
 - ▶ defense of French information systems
- ▶ One of its priorities is **DDoS prevention and mitigation**

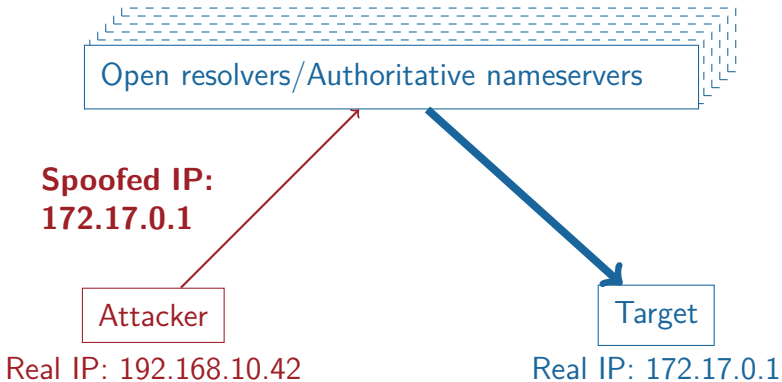
<http://www.ssi.gouv.fr/en>

State of the art regarding DNS-related DDoS



DNS reflection attacks

Threat: on IP networks, sender address **can be spoofed**





DNS amplification attacks

Principle:

- ▶ Based on reflection attacks
- ▶ **Increase** the attacker **throughput** by leveraging **non-malicious nameservers**
- ▶ DNS answer IP packets are often **40-50 times** the size of the associated query IP packets
- ▶ 2 Mbps (attacker) \Rightarrow 100 Mbps (target)



What can an operator do?

DNS messages can be filtered at different levels:

L3 Drop packets

L4-7 Drop DNS datagrams or queries

L7 Response Rate Limiting (RRL):

- ▶ Identical DNS answers detection
- ▶ Bind, NSD, Knot
- ▶ **Slips a truncated answer every X queries**
 - ▶ e.g. 2 Mbps (attacker) \Rightarrow up to 2 Mbps (target)

Can anti-DDoS technologies
be useful for cache poisoning attacks?



Cache poisoning attacks reminder

Principle:

- ▶ Insert forged data in cache

Example:

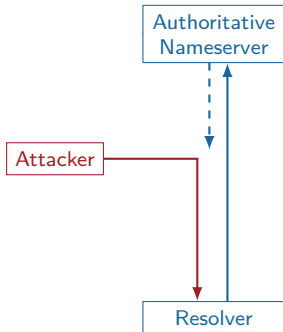
- ▶ 2008: Kaminsky attack

Current Fix:

- ▶ Source Port Randomization

Long Term Fix:

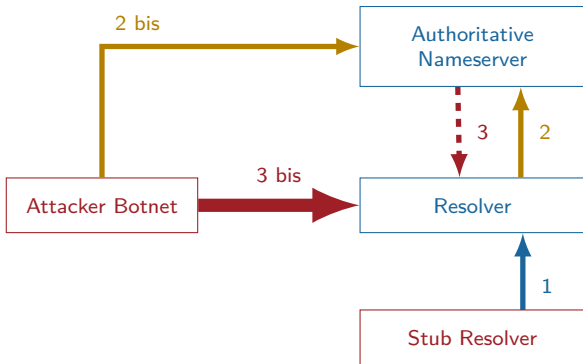
- ▶ DNSSEC
 - ▶ Requires large adoption





Exploiting anti-DDoS mechanisms

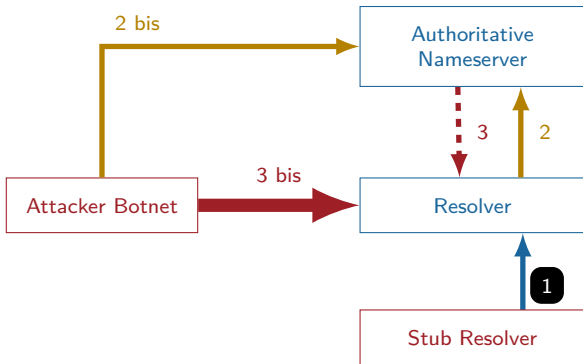
Our cache poisoning attack: Step by step





Exploiting anti-DDoS mechanisms

Our cache poisoning attack: Step by step

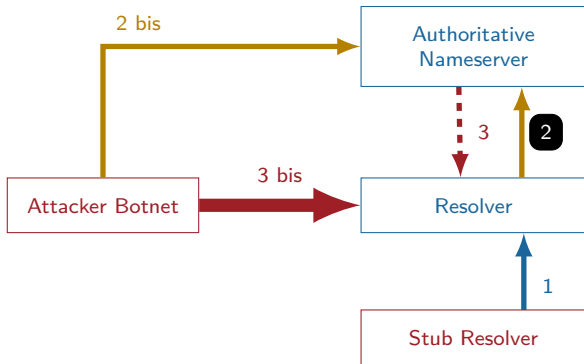


1: Send a query



Exploiting anti-DDoS mechanisms

Our cache poisoning attack: Step by step

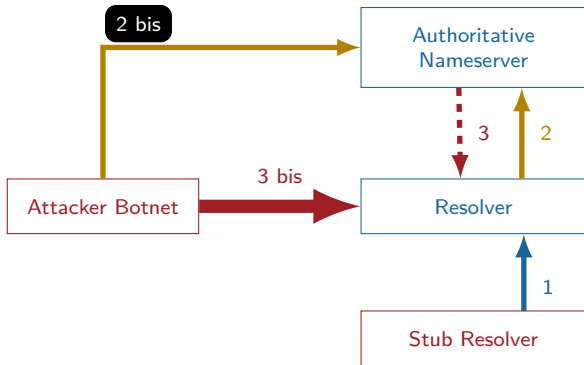


2: Perform the recursive resolution



Exploiting anti-DDoS mechanisms

Our cache poisoning attack: Step by step

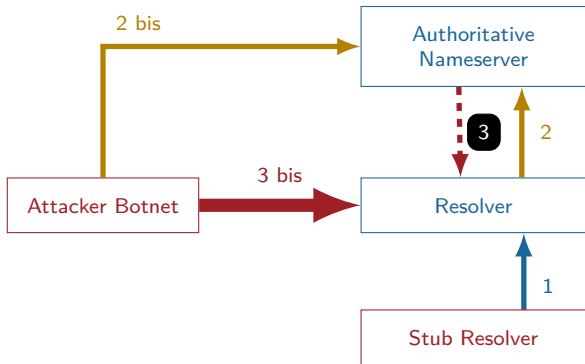


2 bis: Trigger anti-DDoS mechanism against the resolver



Exploiting anti-DDoS mechanisms

Our cache poisoning attack: Step by step

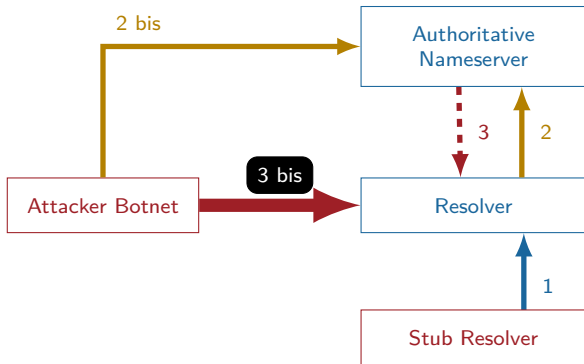


3: Either answer with a truncated answer or drop the query
Dropping answers lead to resolver timeouts and retries



Exploiting anti-DDoS mechanisms

Our cache poisoning attack: Step by step



3 bis: Send lots of Kaminsky-style answers to poison the cache

Experiments & results

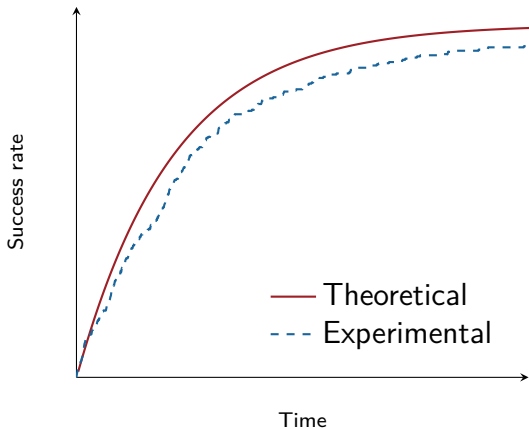


Attack setup

- ▶ A single authoritative nameserver
 - ▶ Realistic thanks to authoritative nameserver selection attacks (Shulman fragment attacks, SRTT tricks. . .)
- ▶ A single outbound IP on resolver
- ▶ 100 Mbps of spoofed traffic
 - ▶ would go unnoticed by most ISP
- ▶ RRL with `slip=2`



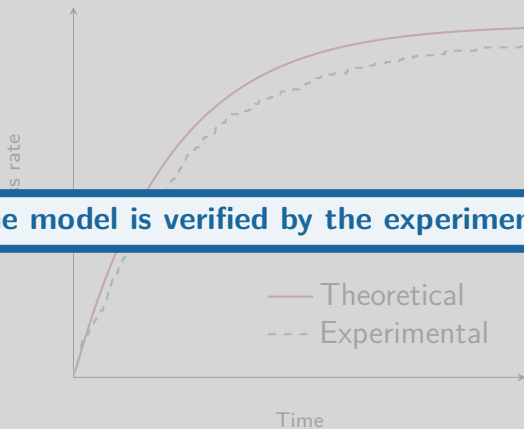
Validation of the theoretical model



We mathematically modeled the attack
Details available on demand



Validation of the theoretical model



We mathematically modeled the attack
Details available on demand



Results based on the model

Based on the model, real-world attacks can be successful with a probability P in less than the following time estimates:

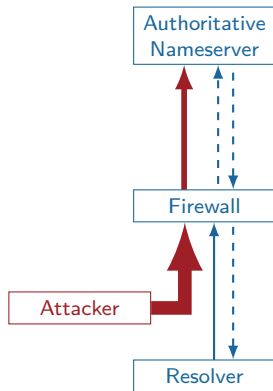
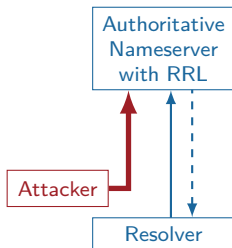
P : Probability of a successful cache poisoning attack

$P = 10\%$	\approx 1h 15min
$P = 50\%$	\approx 8h

Are firewalls doing any better?

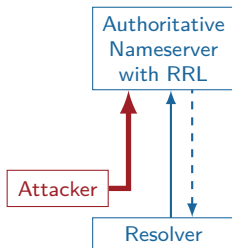


General-purpose firewalls

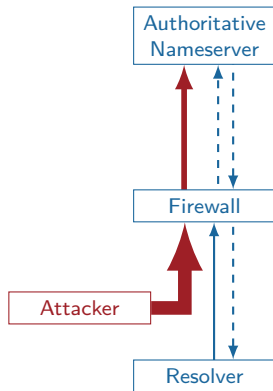




General-purpose firewalls



is equivalent to

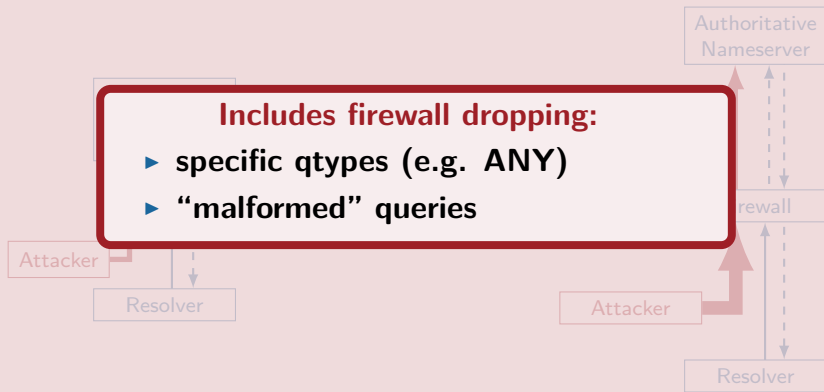




General-purpose firewalls

Includes firewall dropping:

- ▶ specific qtypes (e.g. ANY)
- ▶ “malformed” queries



ANSSI recommendations



Always answer queries

- ▶ **Never drop DNS queries when you can't tell which are legitimate**

Slip 1 is the only RRL safe configuration against our cache poisoning attack



Disclosure timeline

Timeline and feedbacks

Disclosure timeline:

- ▶ June: DNS Software Vendors, Packagers
- ▶ August: NIC and root operators
- ▶ May-August: CERTs

Security notifications:

- ▶ CVE-2013-5661 and CVE-2013-5752
- ▶ CERTA and NCSC advisory bulletin (September 9th, 2013)

All have confirmed the vulnerability

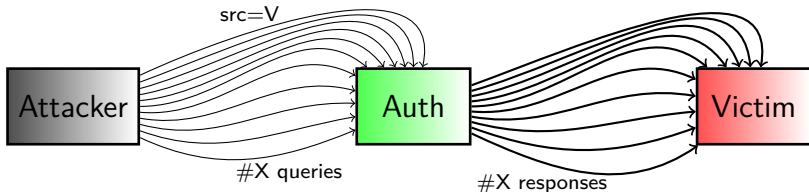
Some raised concerns

Is slip 1 dangerous?



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Concern 1: reflection attacks



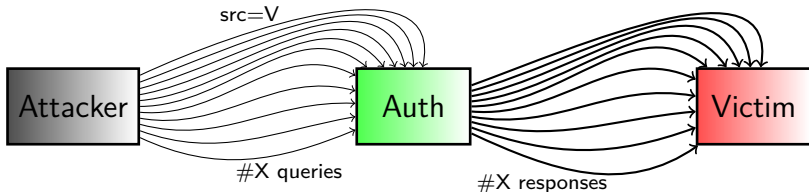
courtesy of  netnod

As slip 1 grants an even payback, is this configuration dangerous for PPS attacks?



Is slip 1 dangerous?

Concern 1: reflection attacks



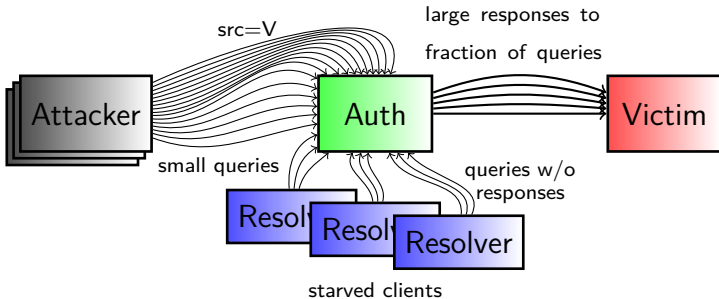
Facts:

- ▶ **Current** attacks are volumetric/bandwidth-related DDoS
- ▶ More susceptible protocols available for PPS attacks



Is slip 1 dangerous?

Concern 2: authoritative nameservers DDoS



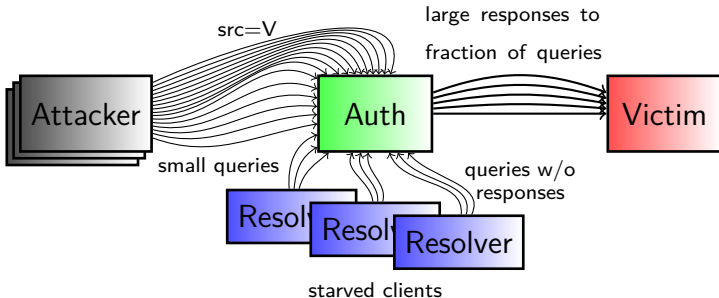
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Network DDoS on the authoritative nameservers
because of slip 1?



Is slip 1 dangerous?

Concern 2: authoritative nameservers DDoS



Facts:

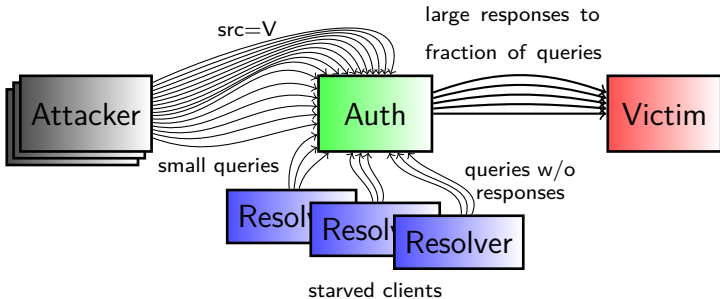
- ▶ Amplification factor: 1:1
- ▶ Operators have symmetric bandwidth

Investigation should be led if upload capacity is reached



Is slip 1 dangerous?

Concern 2: authoritative nameservers DDoS

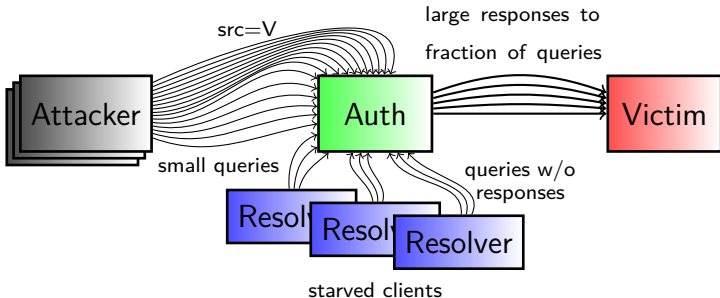


Computational DDoS on the authoritative nameservers because of slip 1?



Is slip 1 dangerous?

Concern 2: authoritative nameservers DDoS



Fact^a:

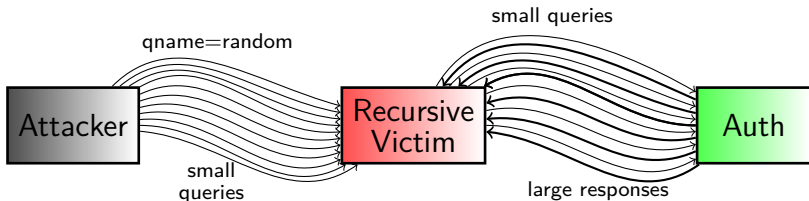
- ▶ Slip 1 **increases** CPU consumption by less than 5% depending on implementations

^atested on Xeon X5650 @2.67Ghz with 4000 qps



Is slip 1 dangerous?

Concern 3: recursive servers DDoS



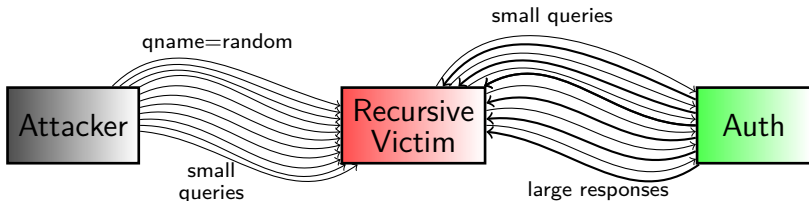
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Network DDoS on the resolver because of slip 1 on the authoritative nameserver?



Is slip 1 dangerous?

Concern 3: recursive servers DDoS



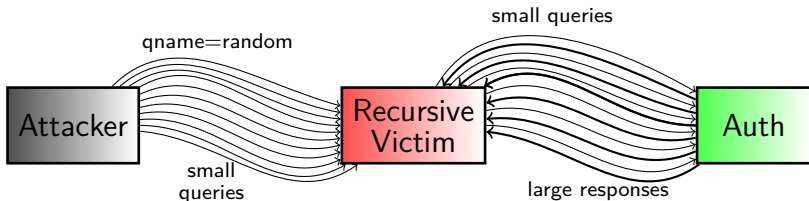
Fact:

- ▶ On average, the number of packets exchanged between a resolver and authoritative nameserver per query:
 - ▶ Slip 1: 9
 - ▶ Slip 2: 9.68



Is slip 1 dangerous?

Concern 3: recursive servers DDoS

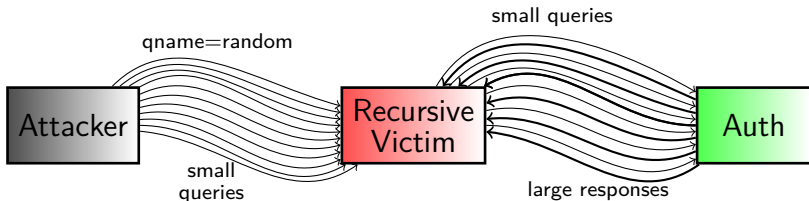


Computational DDoS on the resolver because of slip 1 on the authoritative nameserver?



Is slip 1 dangerous?

Concern 3: recursive servers DDoS



Fact^a:

- ▶ Slip 1 **decreases** CPU consumption by up to 20%, depending on implementations

^atested on Xeon X5650 @2.67Ghz with 4000 qps



Is slip 1 dangerous?

Summary

RRL with Slip 1:

- ▶ Is **worthless** for attackers performing volumetric or PPS DDoS attacks
- ▶ is **less** CPU consuming for flooded resolvers
- ▶ Is a **negligibly more** CPU consuming for authoritative nameservers

TL;DR summary: **Slip 1 is OK**



Conclusion

- ▶ Timeouts lead to more efficient cache poisoning attacks
- ▶ Always answering queries:
 - ▶ **Thwarts** our attack
 - ▶ Offers **no benefit** for attackers
- ▶ **RRL Slip=1 mitigates DDoS**
 - ▶ RRL Slip=2 is **overkill** for current DDoS attacks and is **vulnerable** to our cache poisoning attack
- ▶ Always answering is a temporary fix:
 - ▶ DNSSEC wake-up call?



Thank you for your attention

Any questions?



Packets count for DOS of recursive servers

$$E(PC) = \sum_{i=1}^n \left(1 - \frac{1}{s}\right)^{i-1} \left(1 + \frac{8}{s}\right)$$

with $E(PC)$ being the mean packet count,
n being the number of retries by the resolver
and s being the slip value