Blocking DNS Messages is Dangerous

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ANSSI

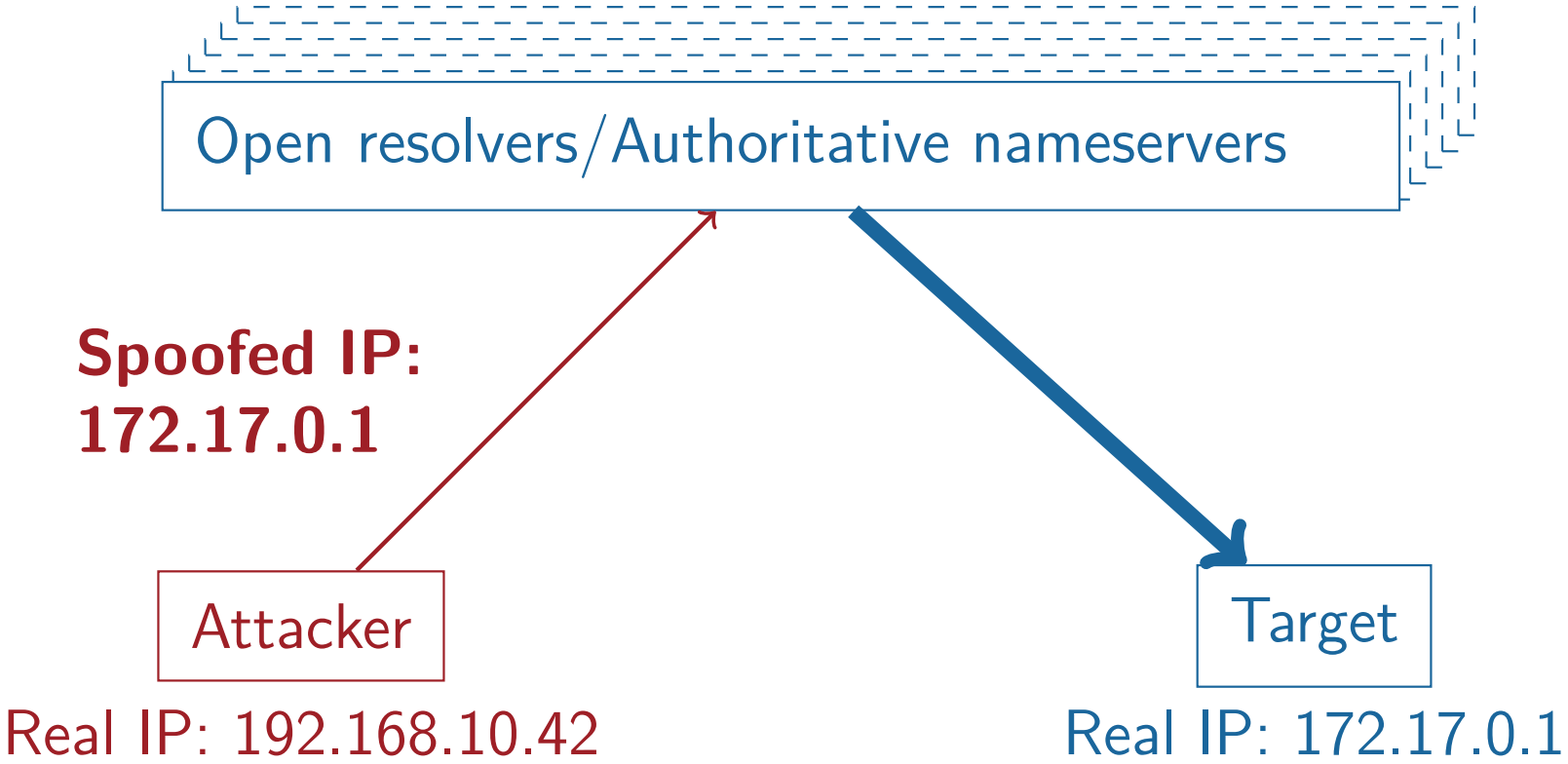
- Created in 2009, the ANSSI is the French national authority for the defense and the security of information systems
  - in French, ANSSI, Agence Nationale de la Sécurité des Systèmes d'Information
- Under the authority of the Prime Minister
- Main missions are:
  - prevention
  - defense of French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

Amplifications attacks countermeasures

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:

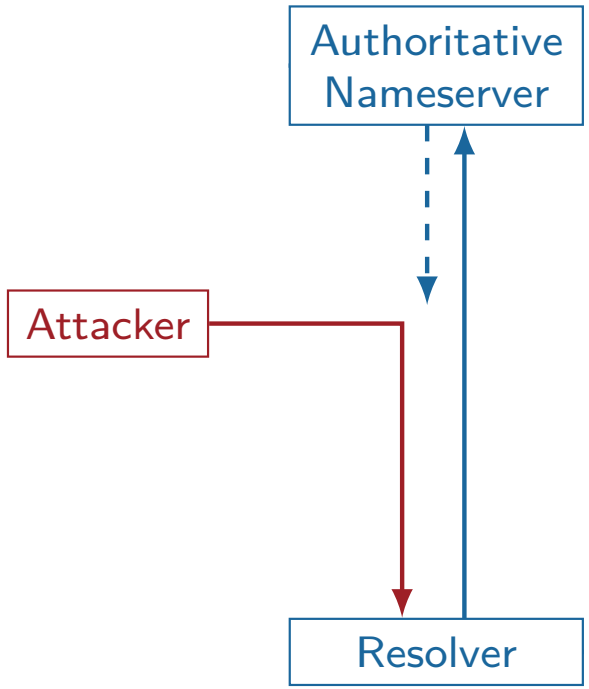
- 2008: Kaminsky attack

Current Fix:

- Source Port Randomization

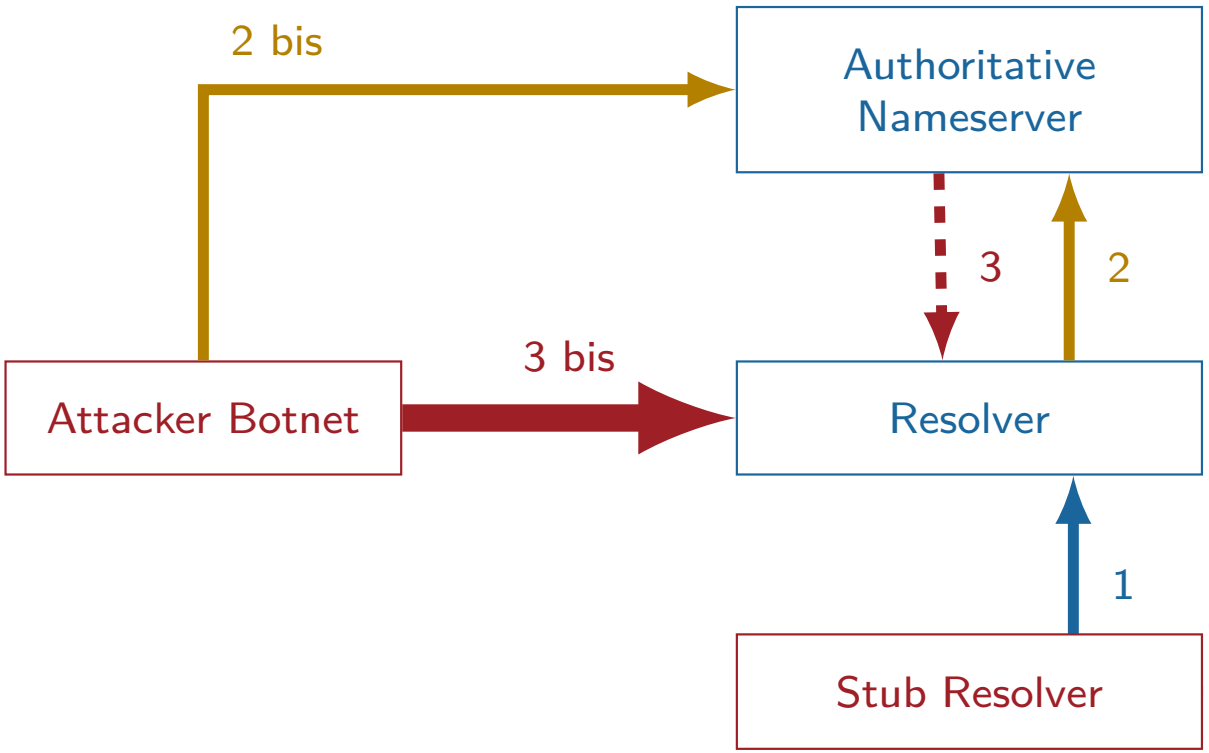
Long Term Fix:

- DNSSEC
  - Requires large adoption



Exploiting anti-DDoS mechanisms

Our cache poisoning attack: Step by step



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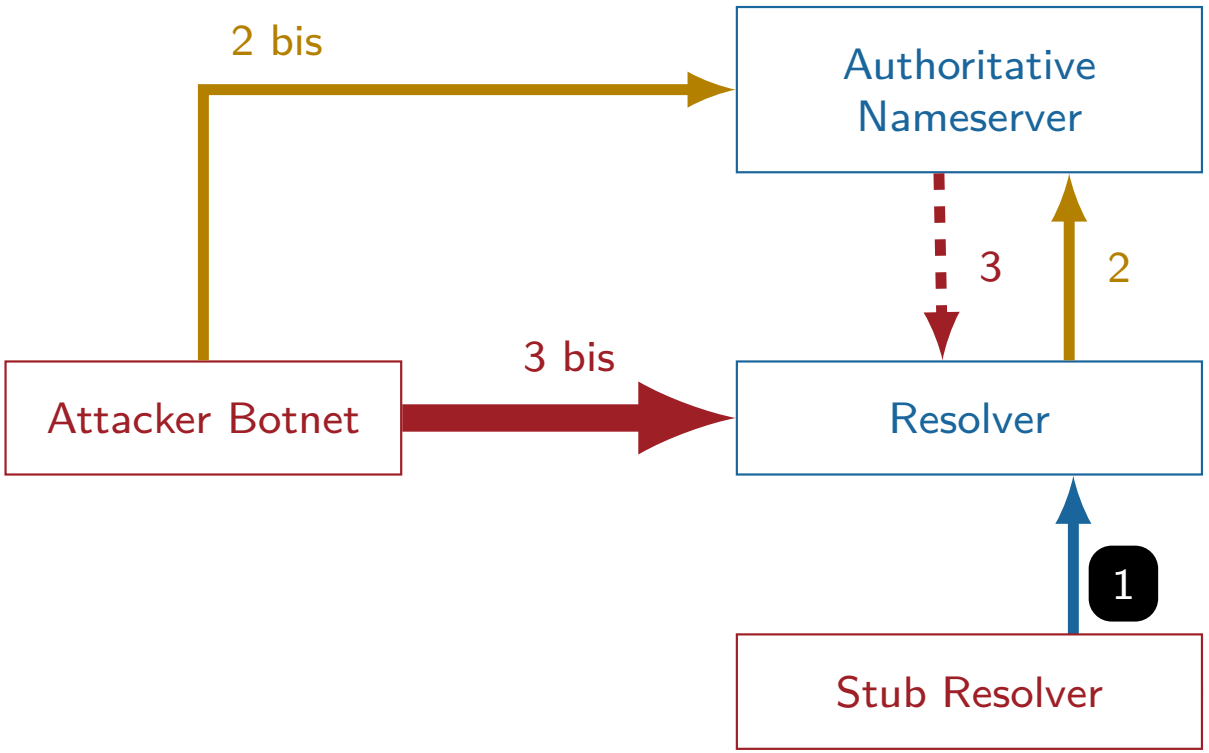

1: Send a query

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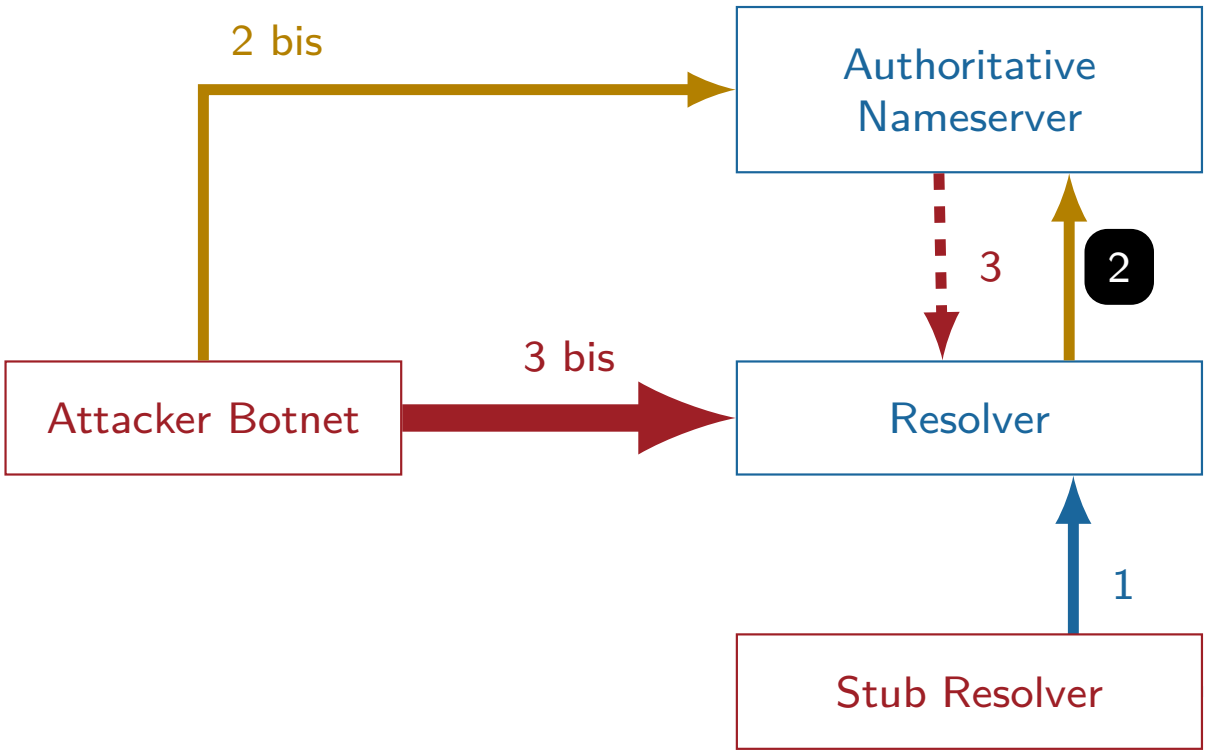

2: Perform the recursive resolution

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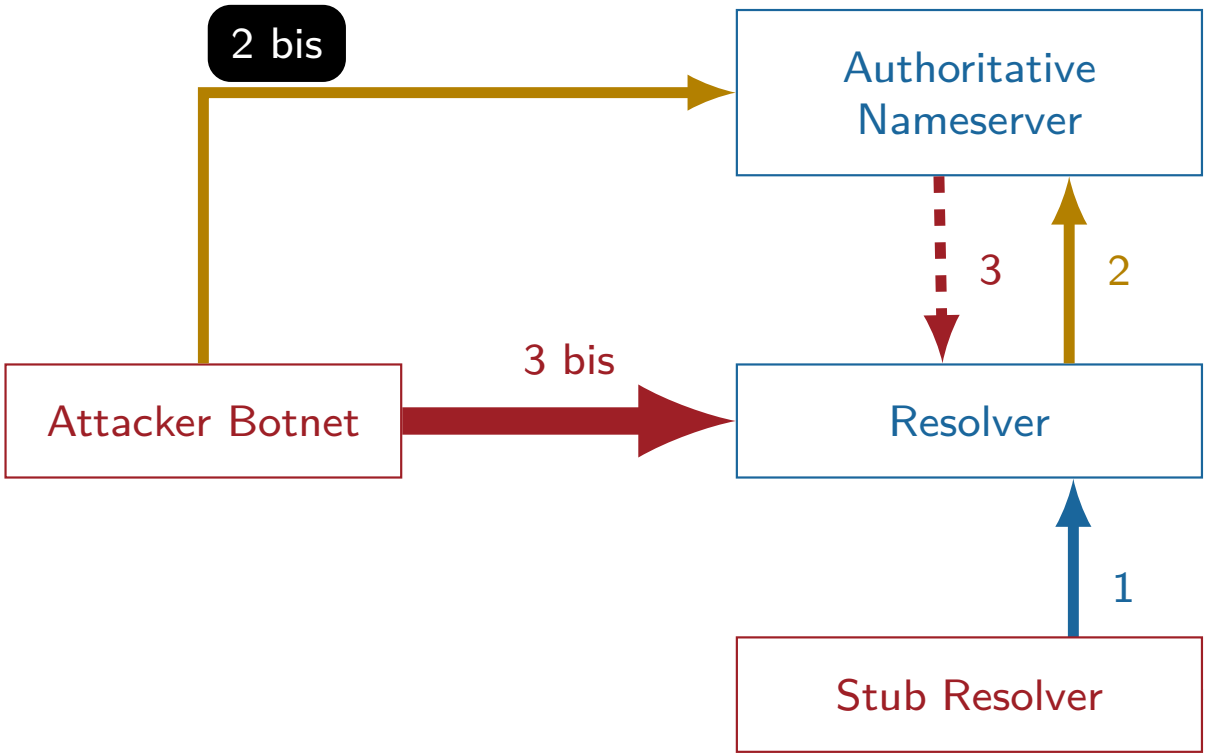

2 bis: Trigger anti-DDoS mechanism against the resolver

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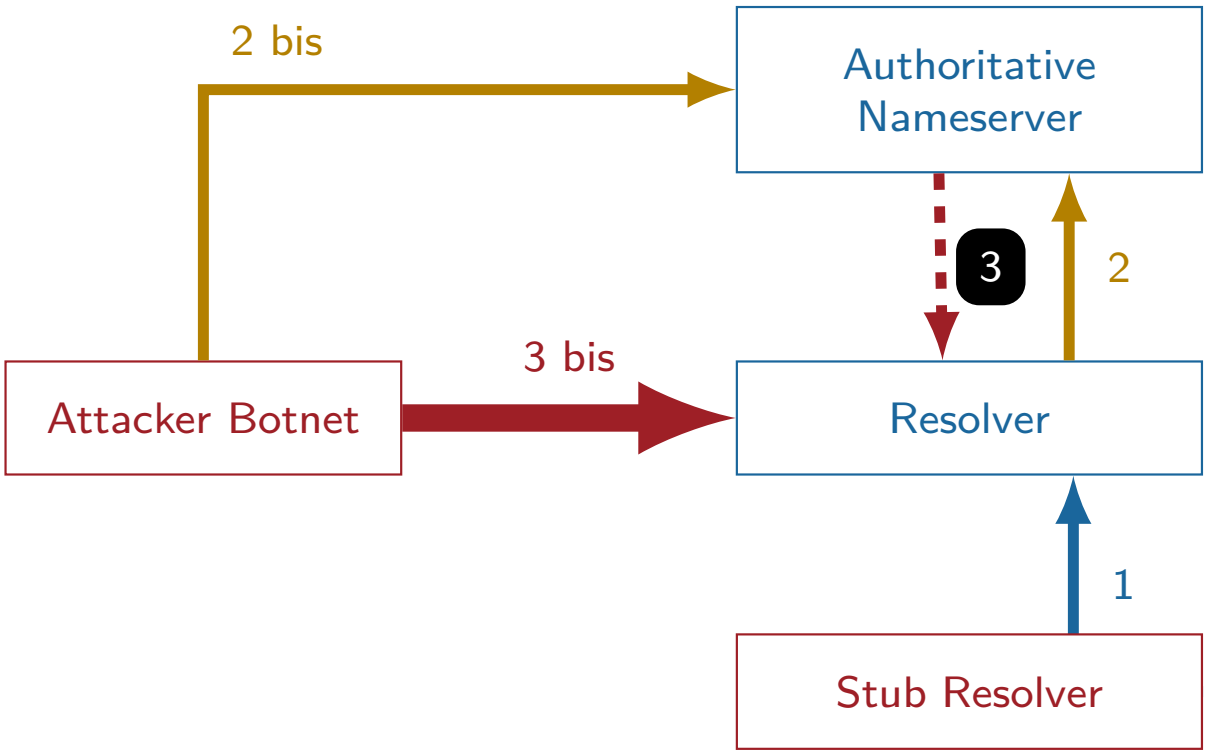

3: Either answer with a truncated answer or drop the query

Dropping answers lead to resolver timeouts and retries

Exploiting anti-DDoS mechanisms

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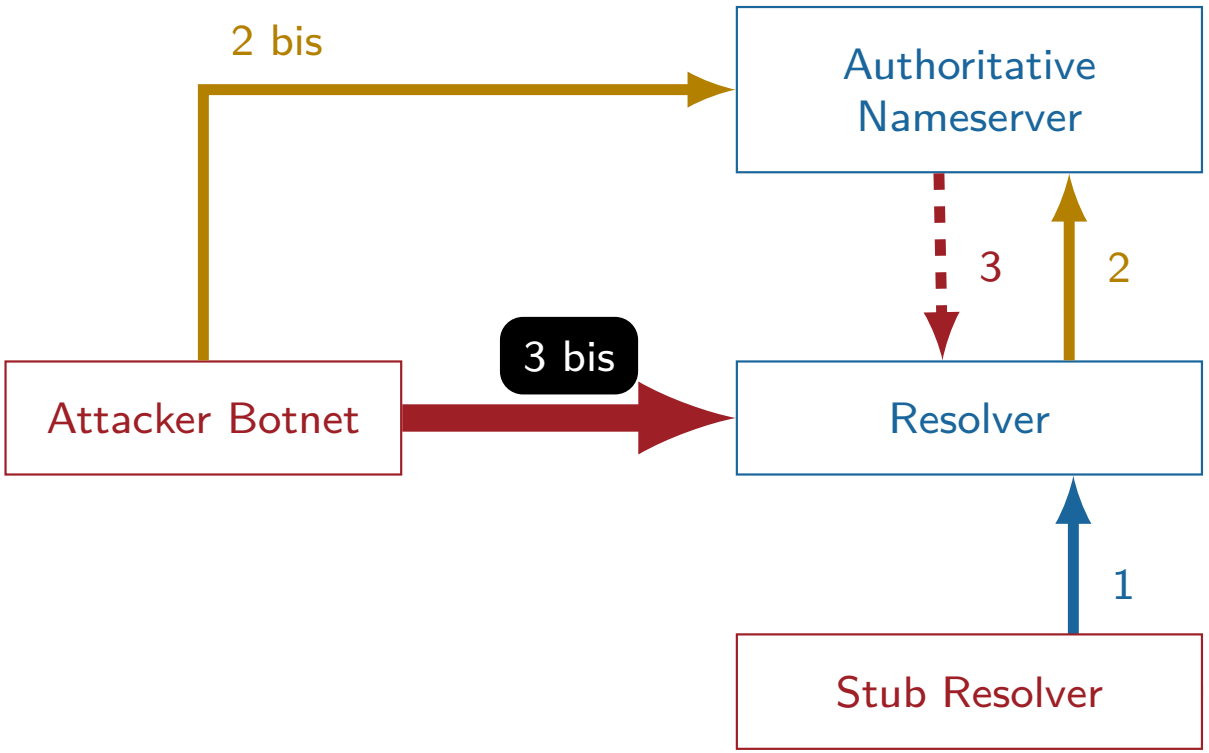


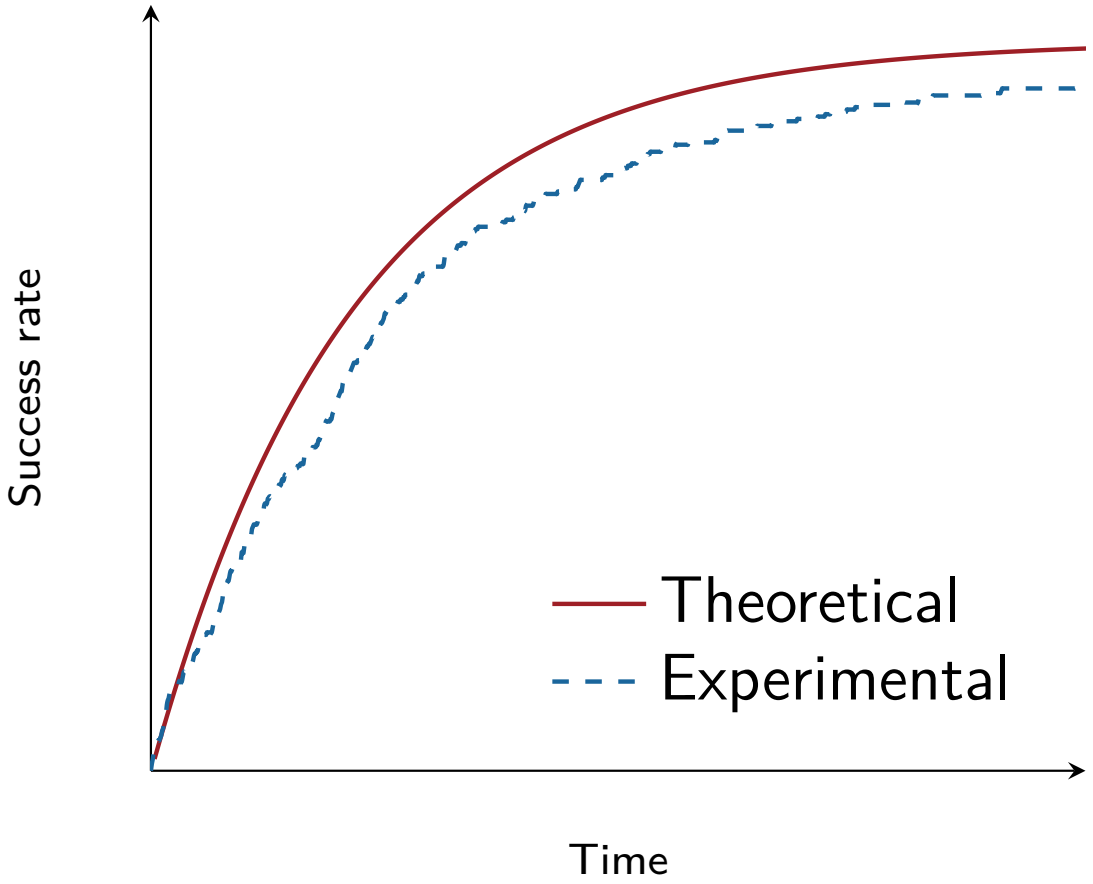
3 bis: Send lots of Kaminsky-style answers to poison the cache

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

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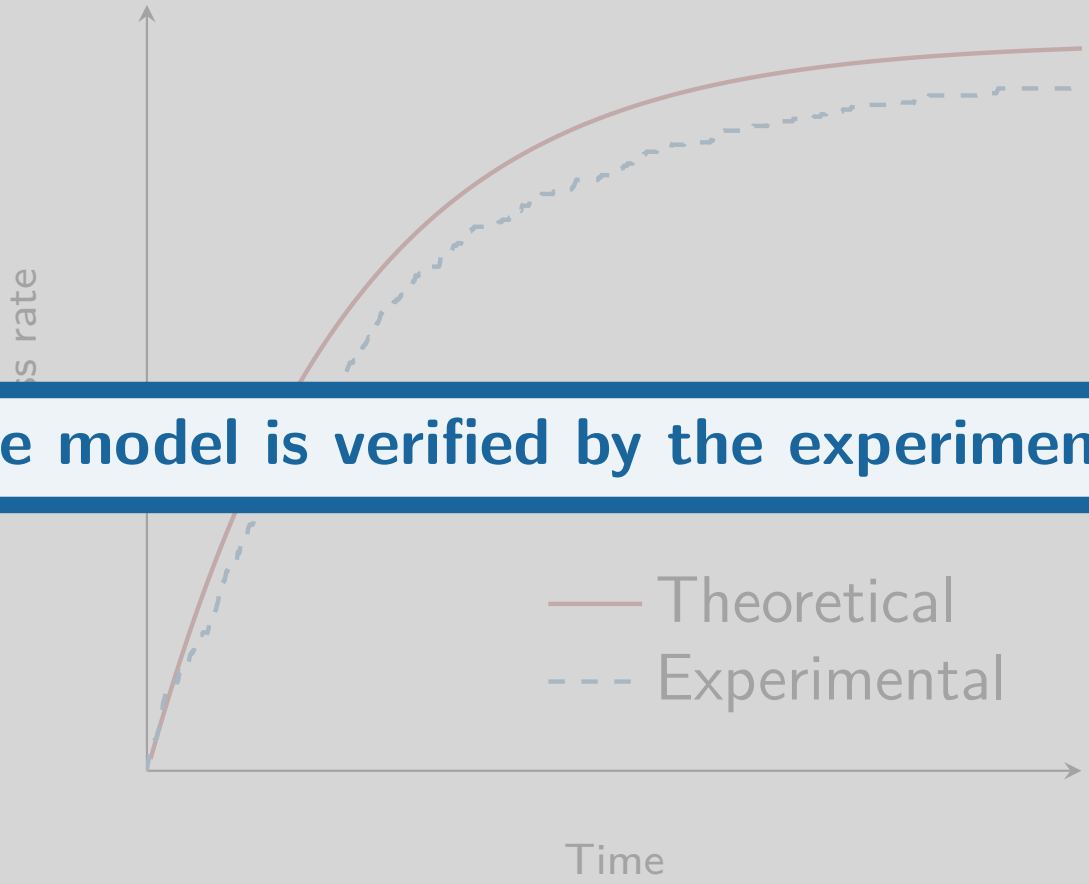


The model is verified by the experiments

We mathematically modeled the attack

Details available on demand

Results based on the model

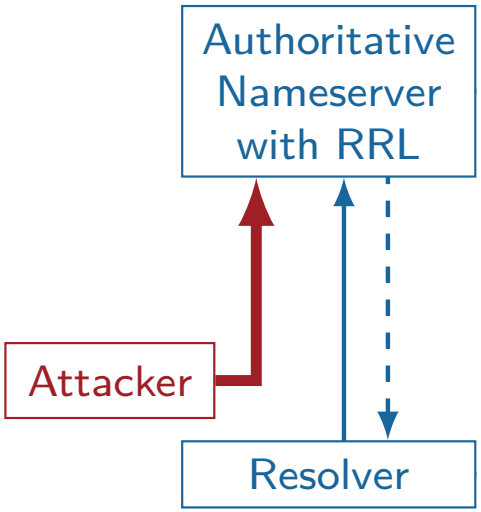
Based on the model, real-world attacks can be successful with a probability P in less than the following time estimates:

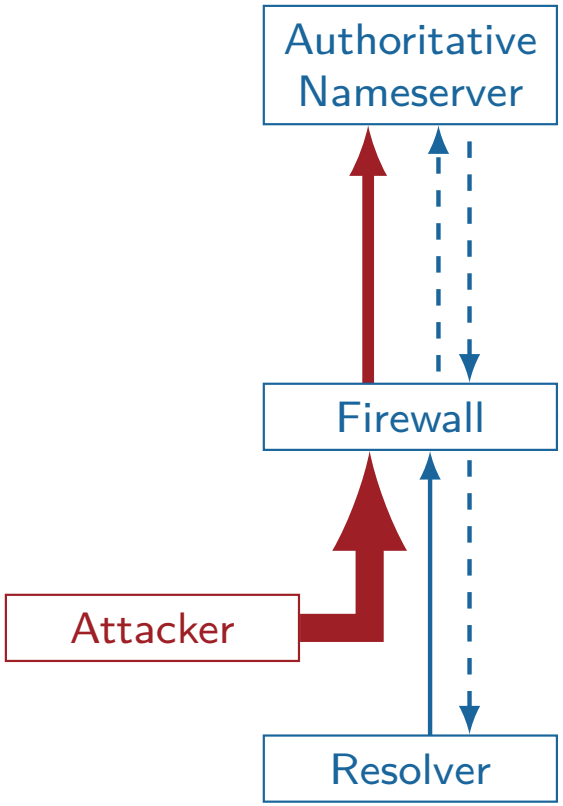
P: Probability of a successful cache poisoning attack

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

Are firewalls doing any better?

General-purpose firewalls





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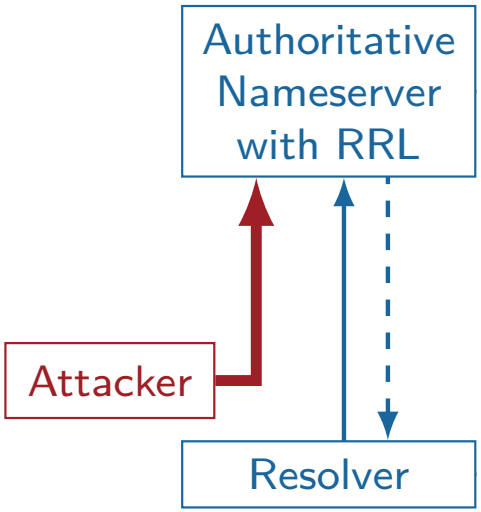
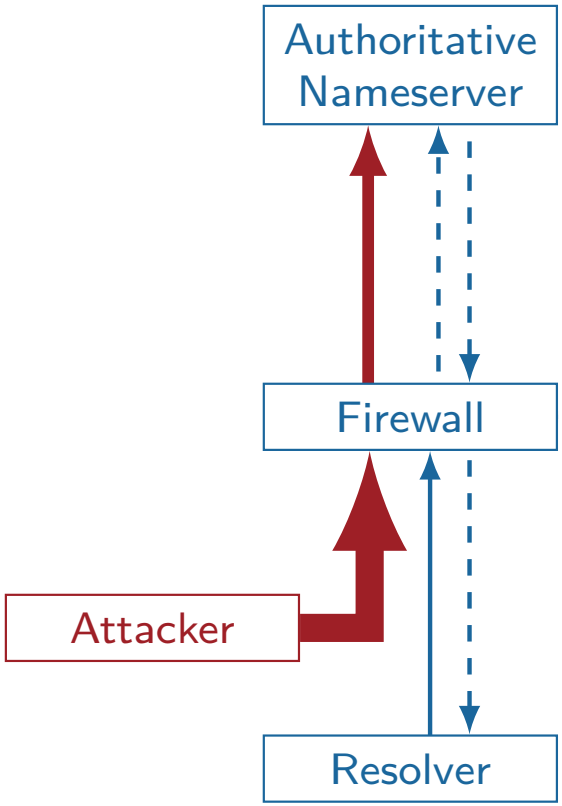


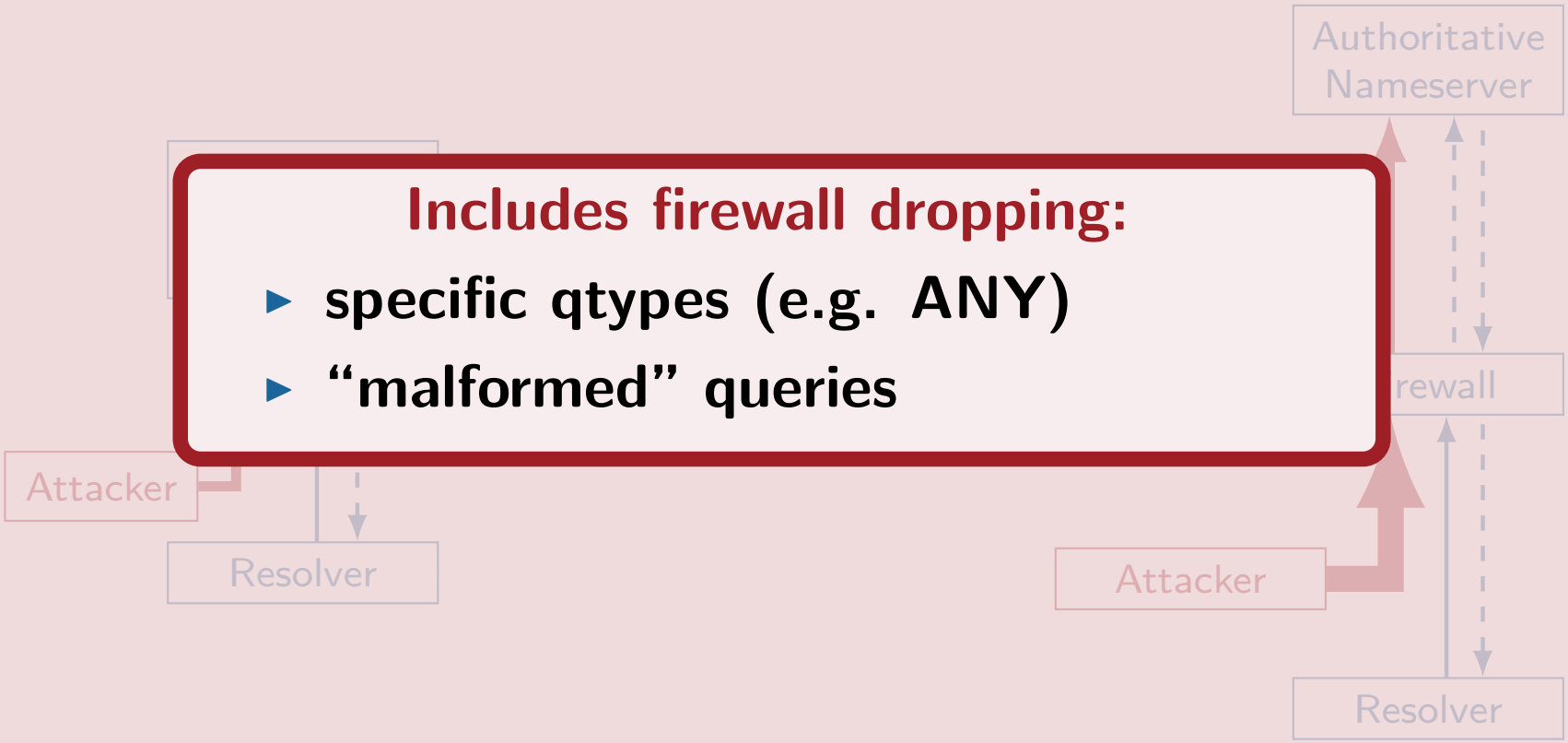
is equivalent to



General-purpose firewalls

Includes firewall dropping:

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



ANSSI recommendations

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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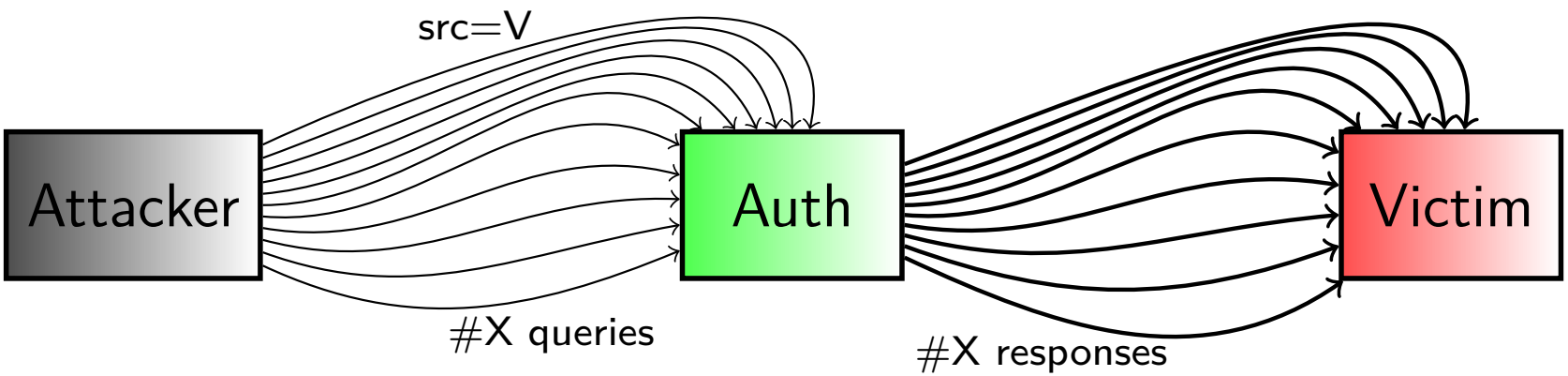
Concern 1: reflection attacks

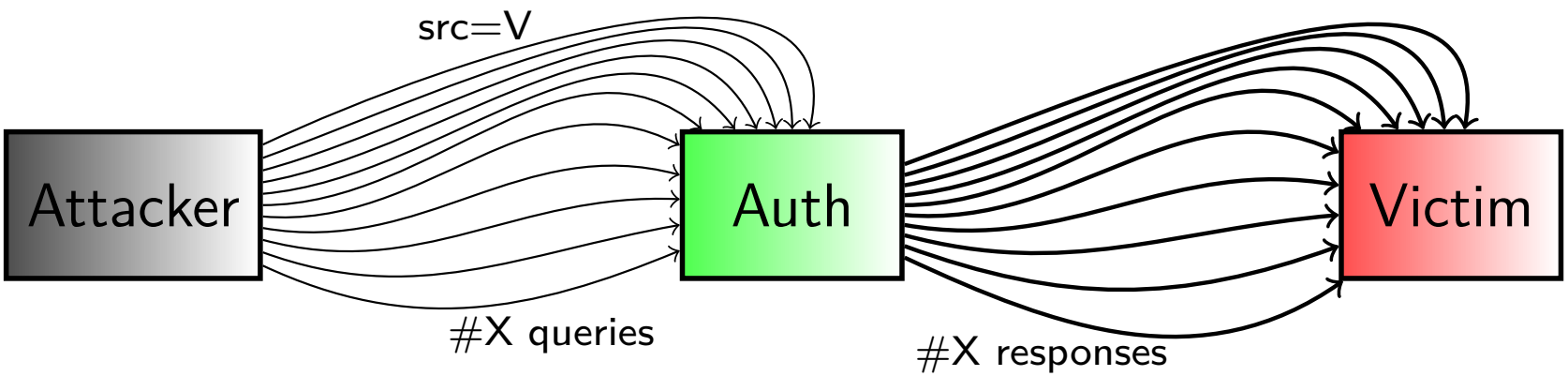


courtesy of netnod

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

Is slip 1 dangerous?

Concern 1: reflection attacks

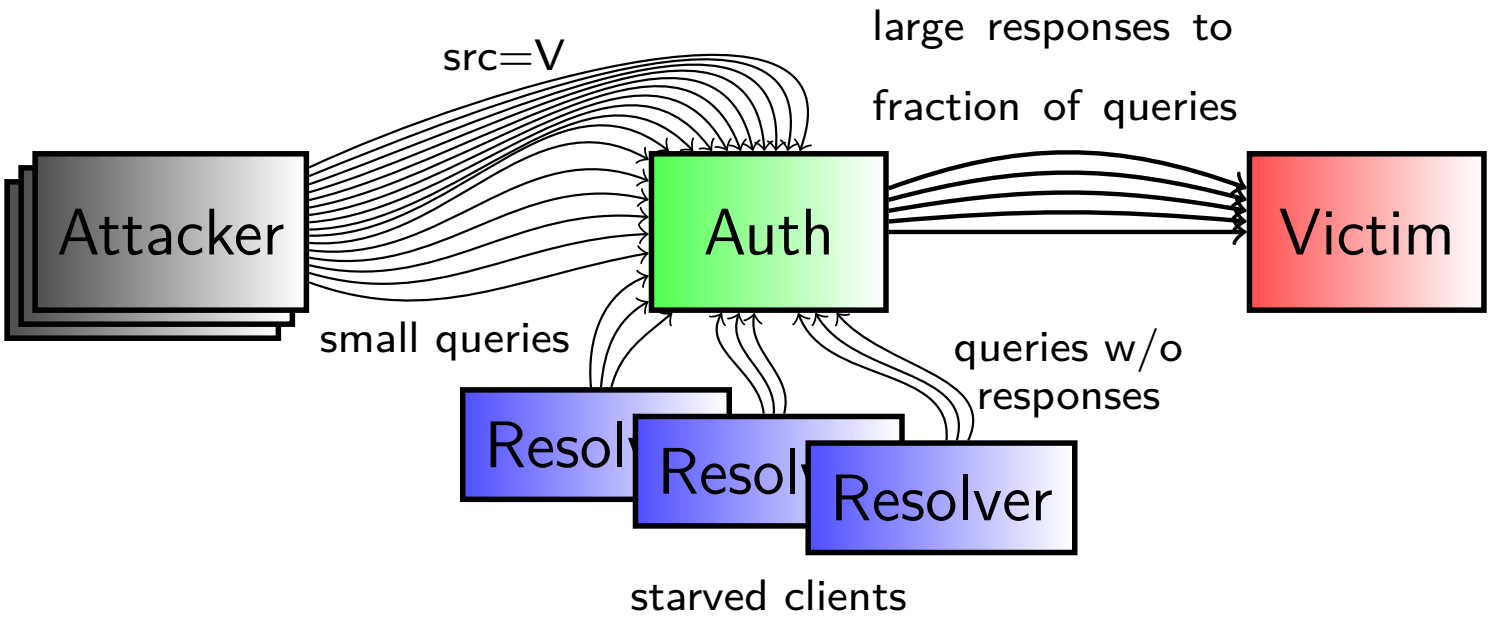


Facts:

- **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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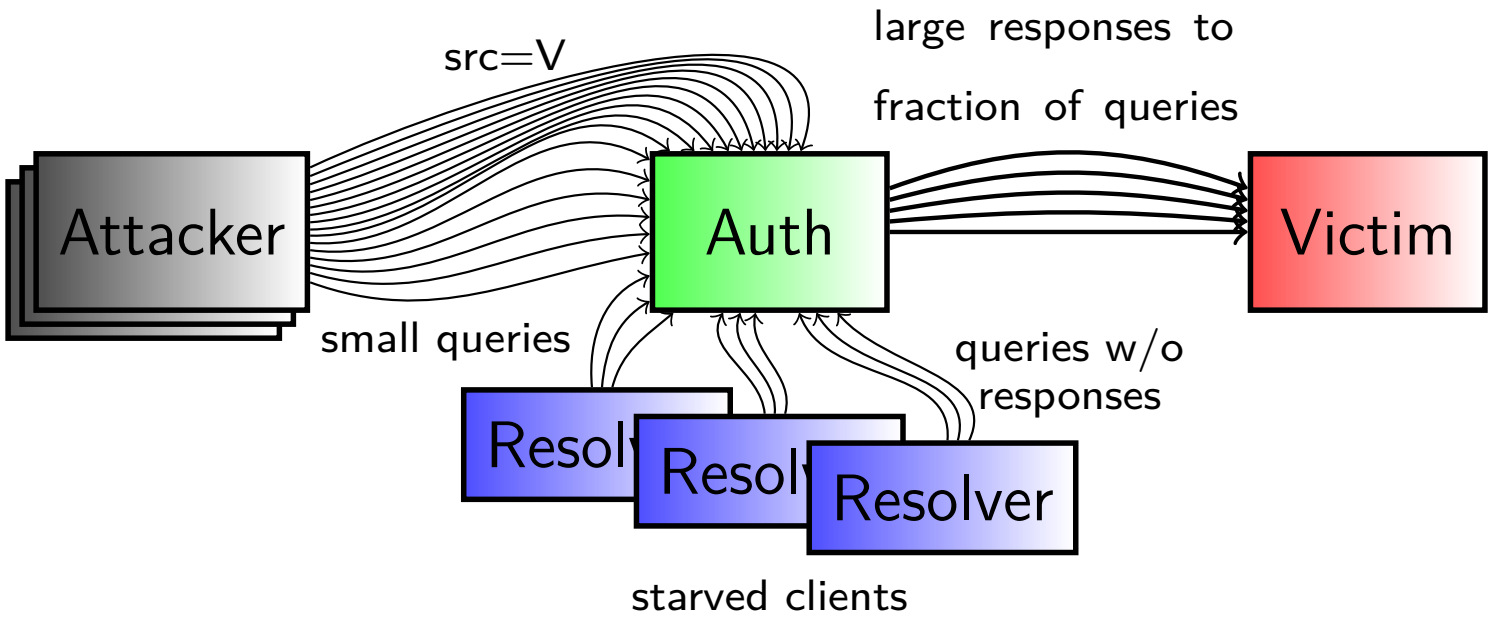
Network DDoS on the authoritative nameservers because of slip 1?

Is slip 1 dangerous?

Concern 2: authoritative nameservers DDoS



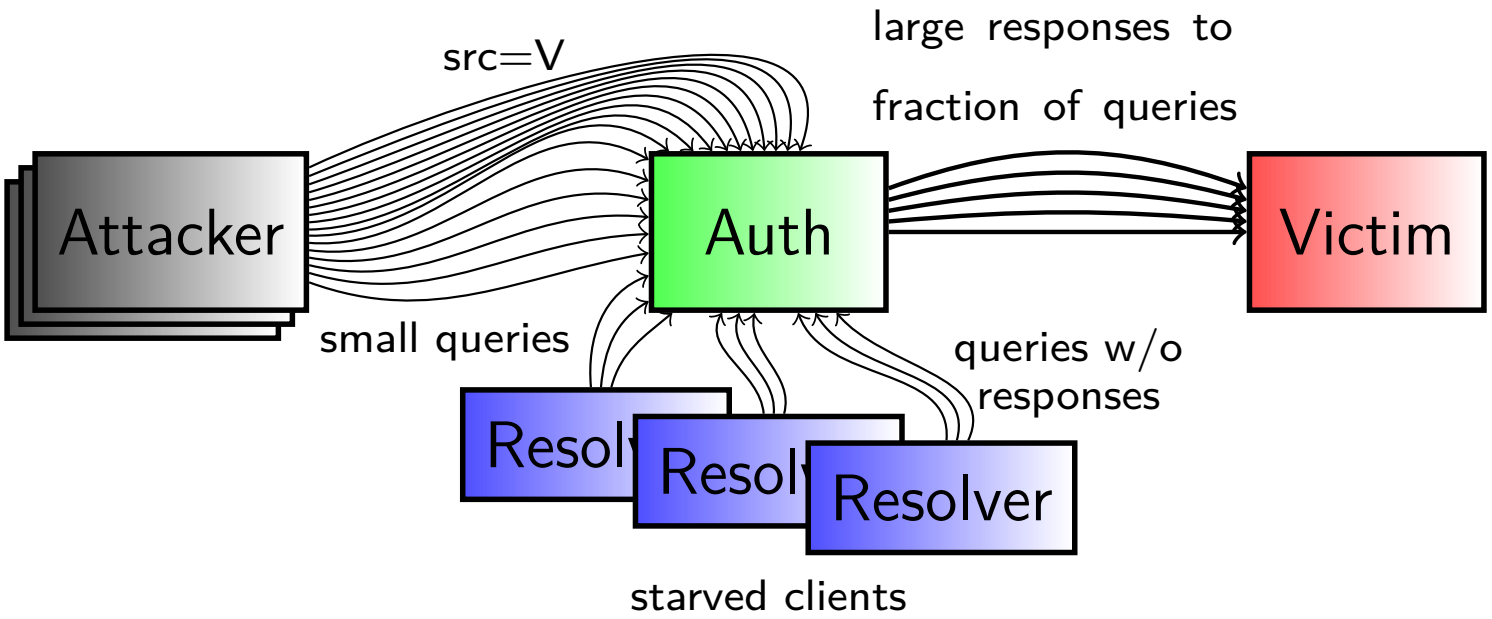
Facts:

- 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?

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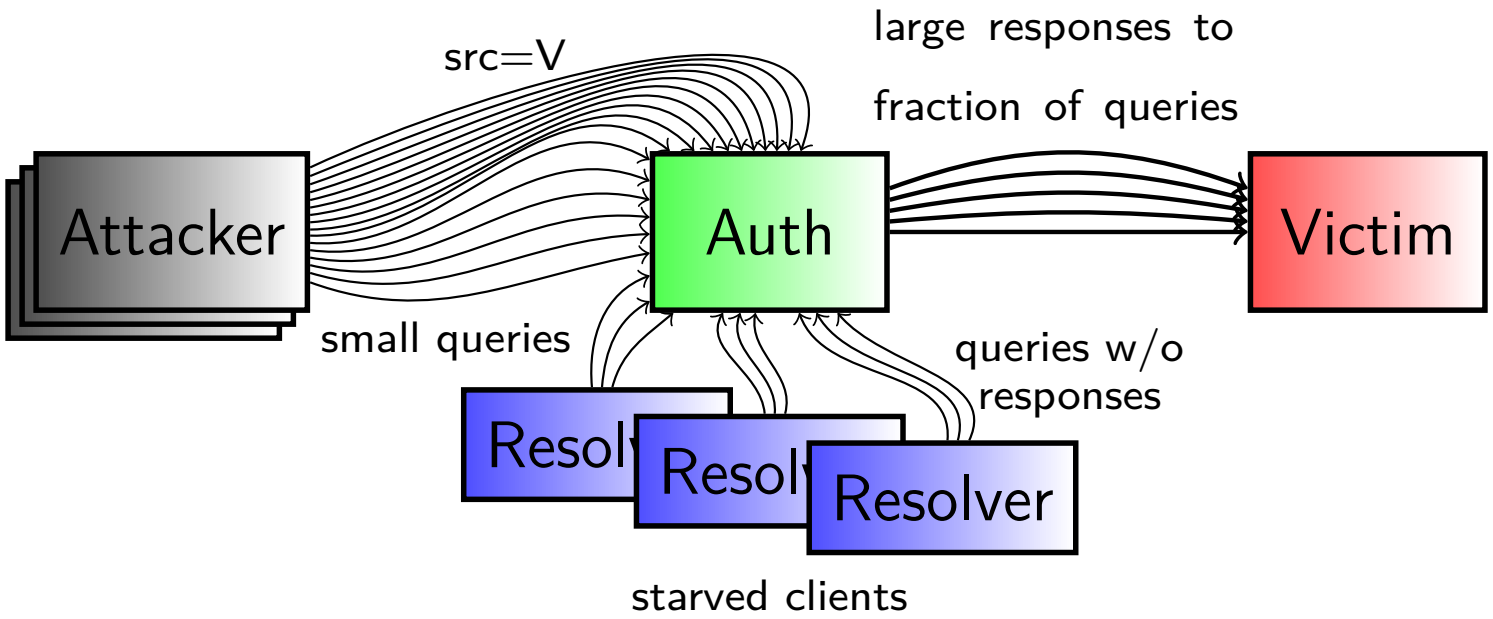


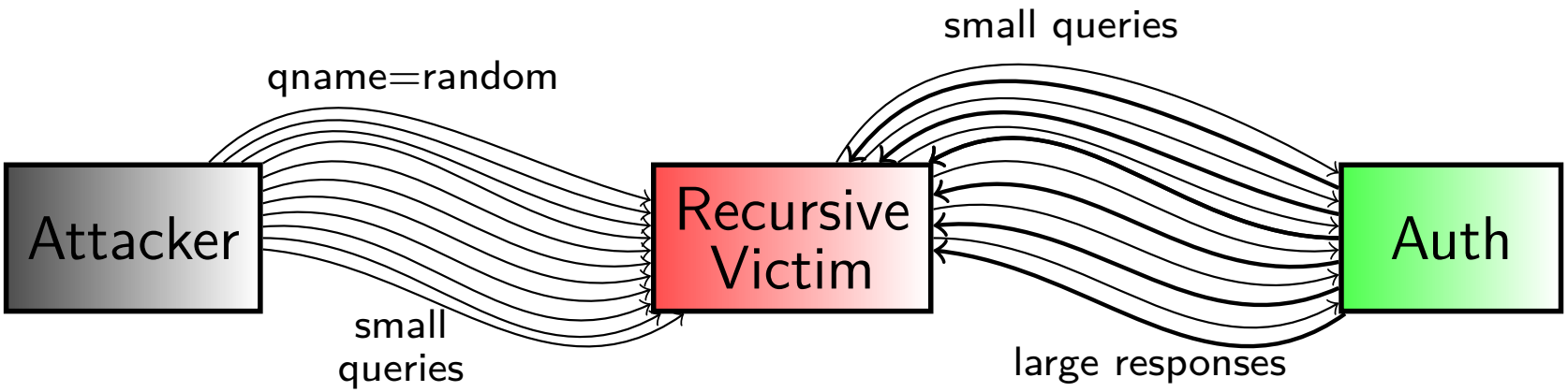
Fact[a]:

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

[a] tested on Xeon X5650 @2.67Ghz with 4000 qps

Is slip 1 dangerous?

Concern 3: recursive servers DDoS



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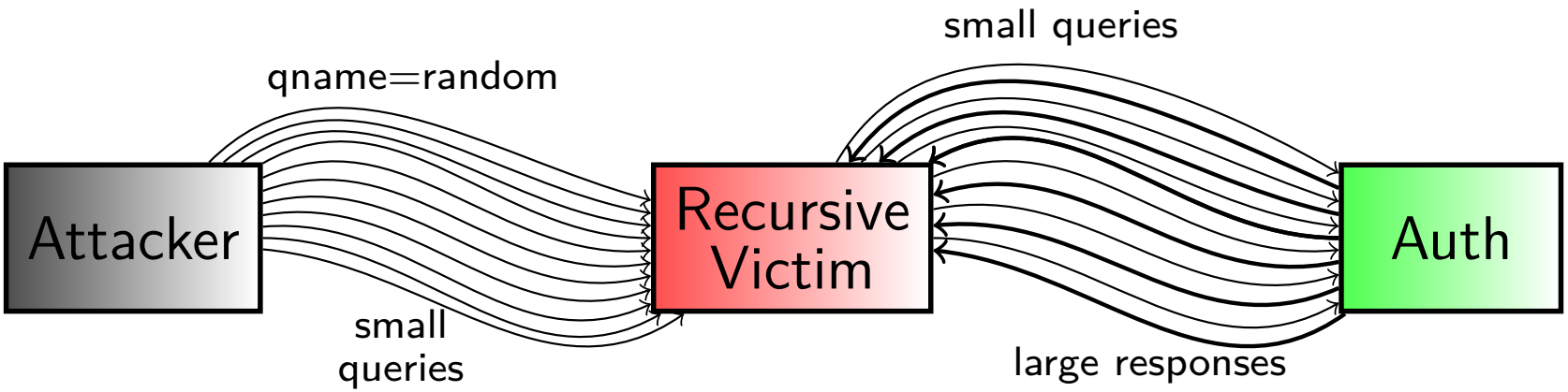
Network DDoS on the resolver because of slip 1 on the authoritative nameserver?

Is slip 1 dangerous?

Concern 3: recursive servers DDoS

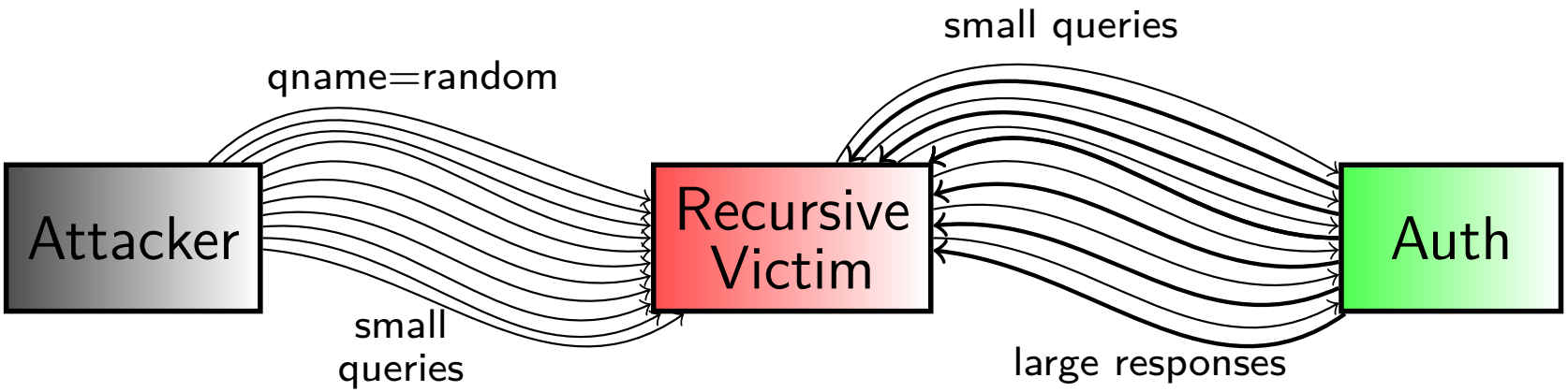


Fact:

- 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



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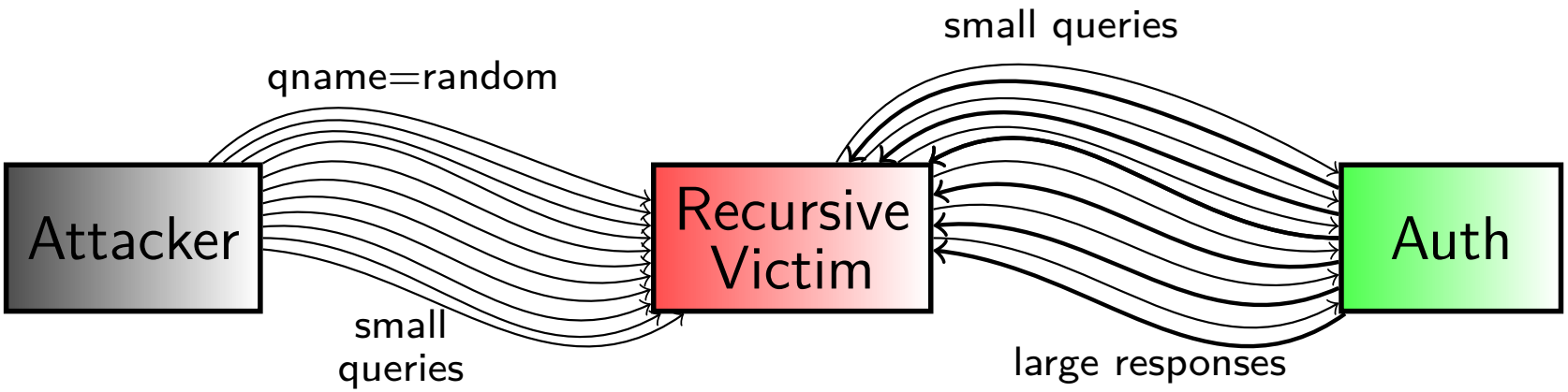

Fact[a]:

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

[a] tested on Xeon X5650 @2.67Ghz with 4000 qps

Is slip 1 dangerous?

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