Forwarding-Loop Attacks in Content Delivery Networks

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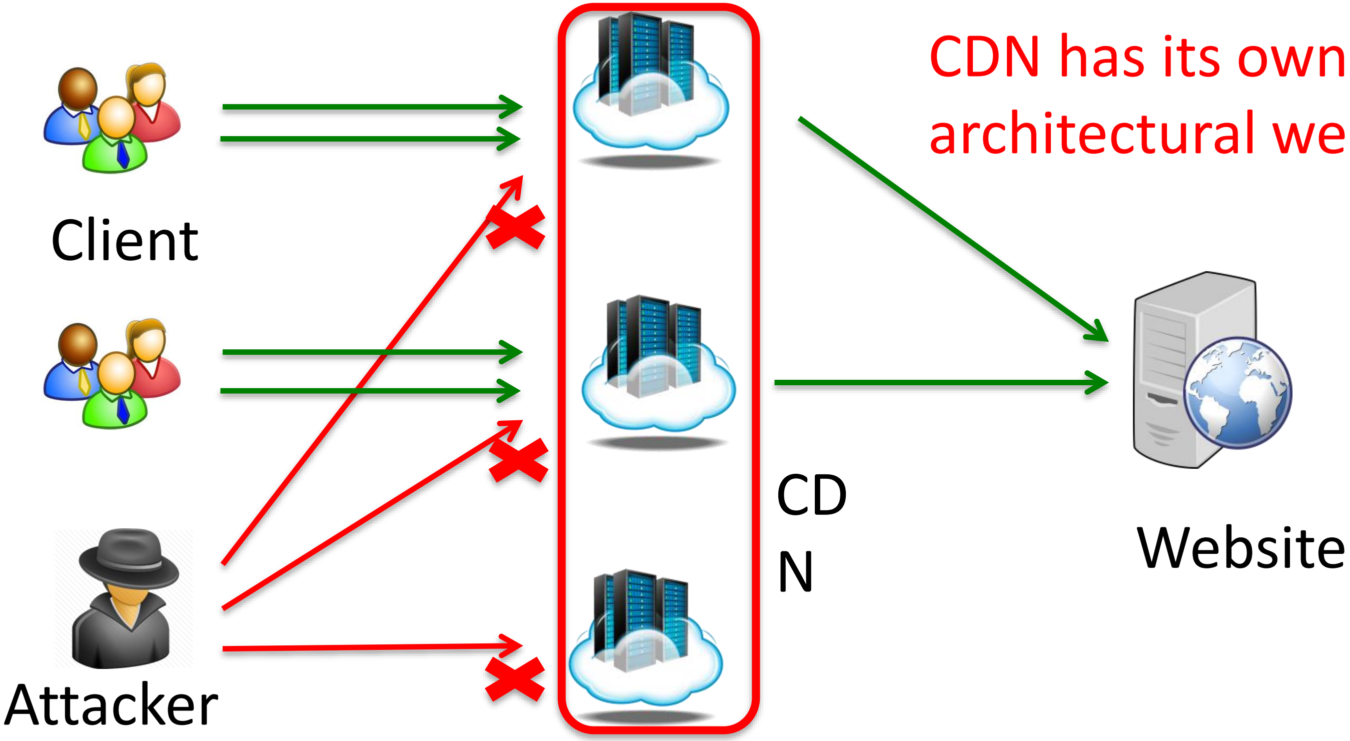
Content Delivery Networks

- CDN is now an important Internet infrastructure, it is a popular solutions for:
  - Performance, Security(WAF), Availability(anti-DDoS)

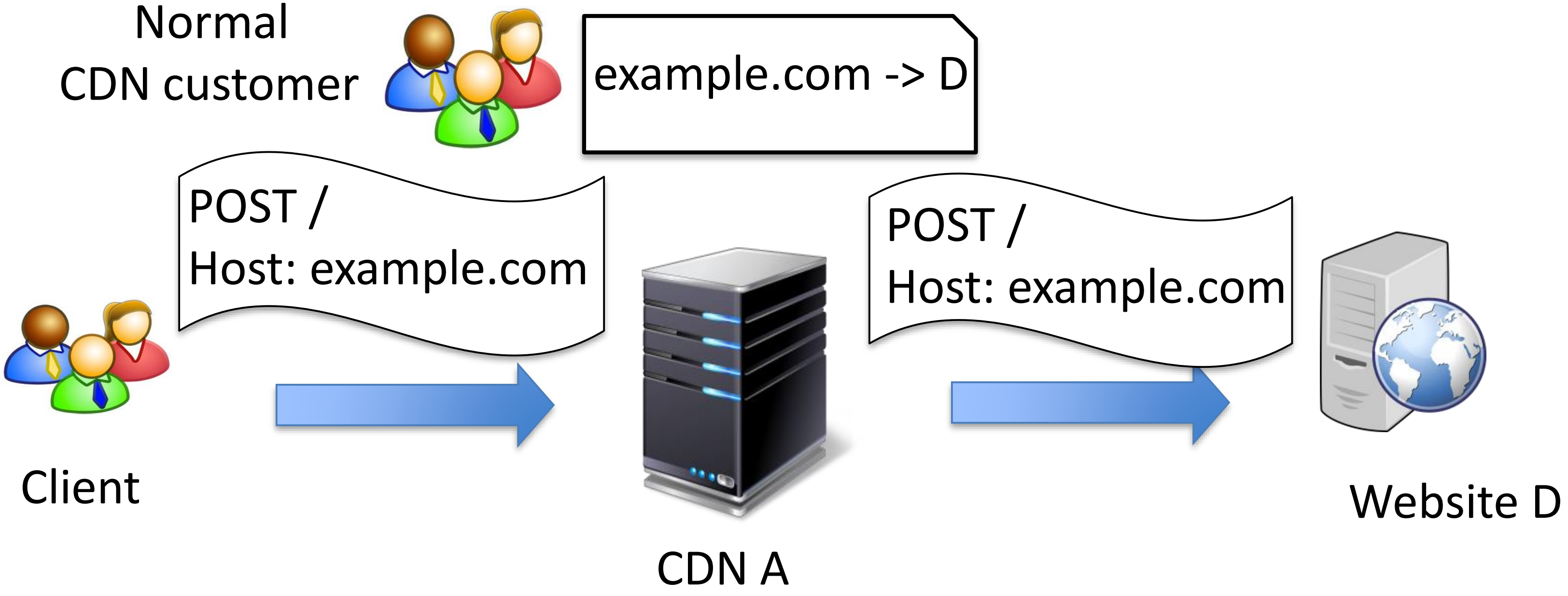


CDN has its own architectural weaknesses

Our work

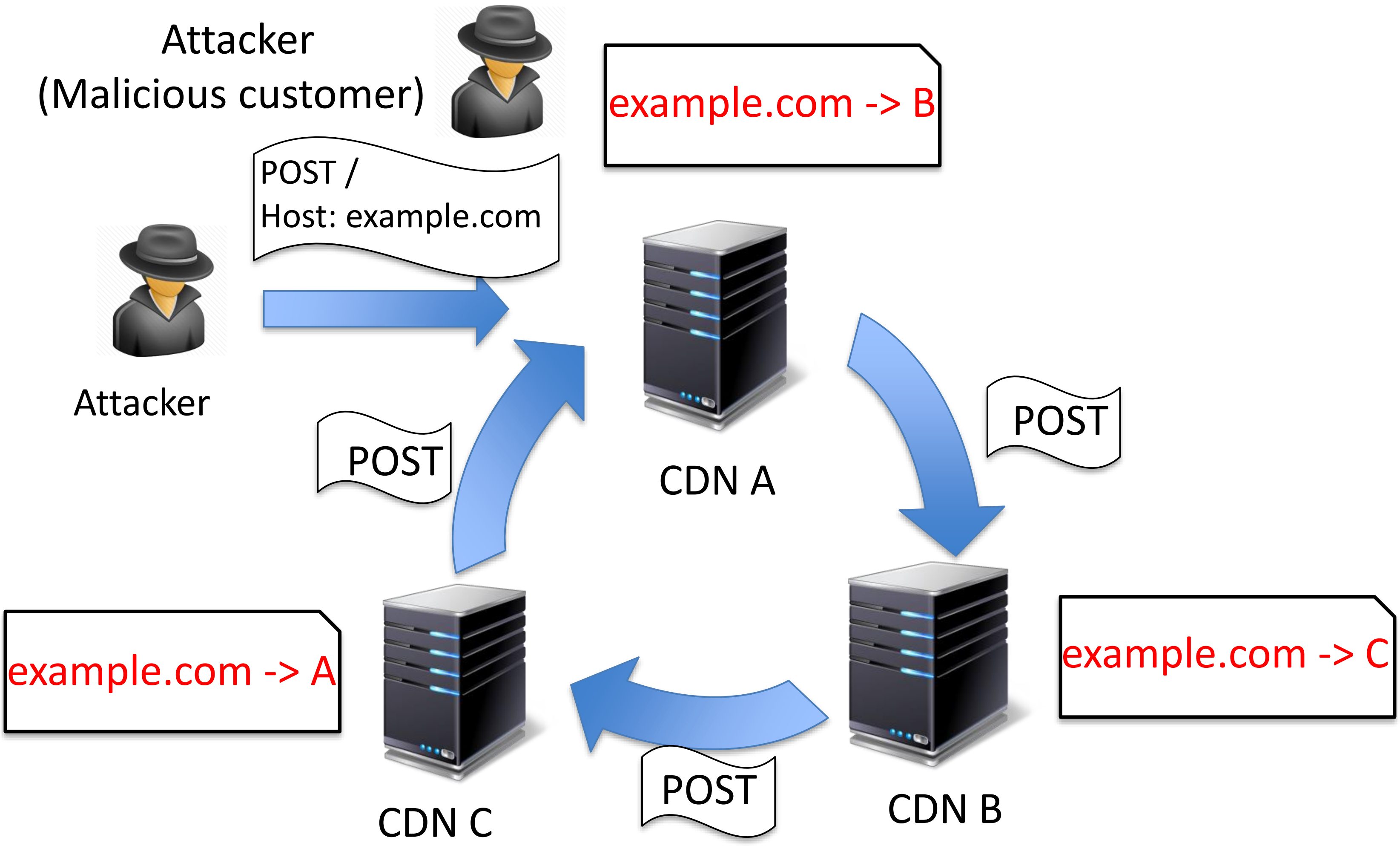
- We present “forwarding loop” attacks that threaten CDN availability.
- We measured 16 popular CDNs and find all of them are vulnerable to such attacks.
- Vendors have acknowledged the problem and are actively addressing it.

The normal forwarding process of CDNs



Customer controls forwarding rules of CDNs

Conceptual view of a forwarding-loop attack



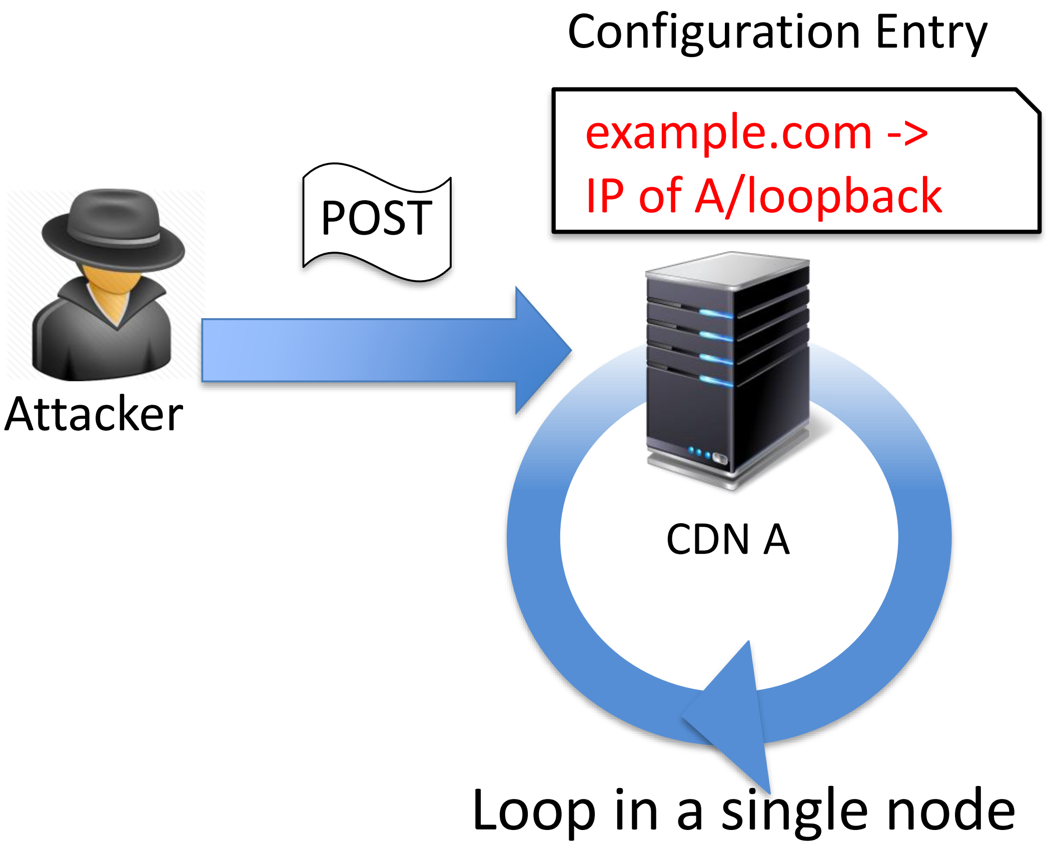
- Malicious customers can manipulate forwarding rules to create loop
- Amplification -> consume resource -> potentially DoS

Practicality of forwarding-loop attacks

- Cost
  - All 16 CDNs provide free or free-trial account
- Anonymity
  - 11/16 CDNs only require an email address
- Some CDNs agreed this attack is severe

- Next we describe 3 types of looping attacks, and 3 factors for enhancing the loop
  - Self loop, intra-CDN, Inter-CDN
  - Abort-forwarding, Streaming, gzip bomb

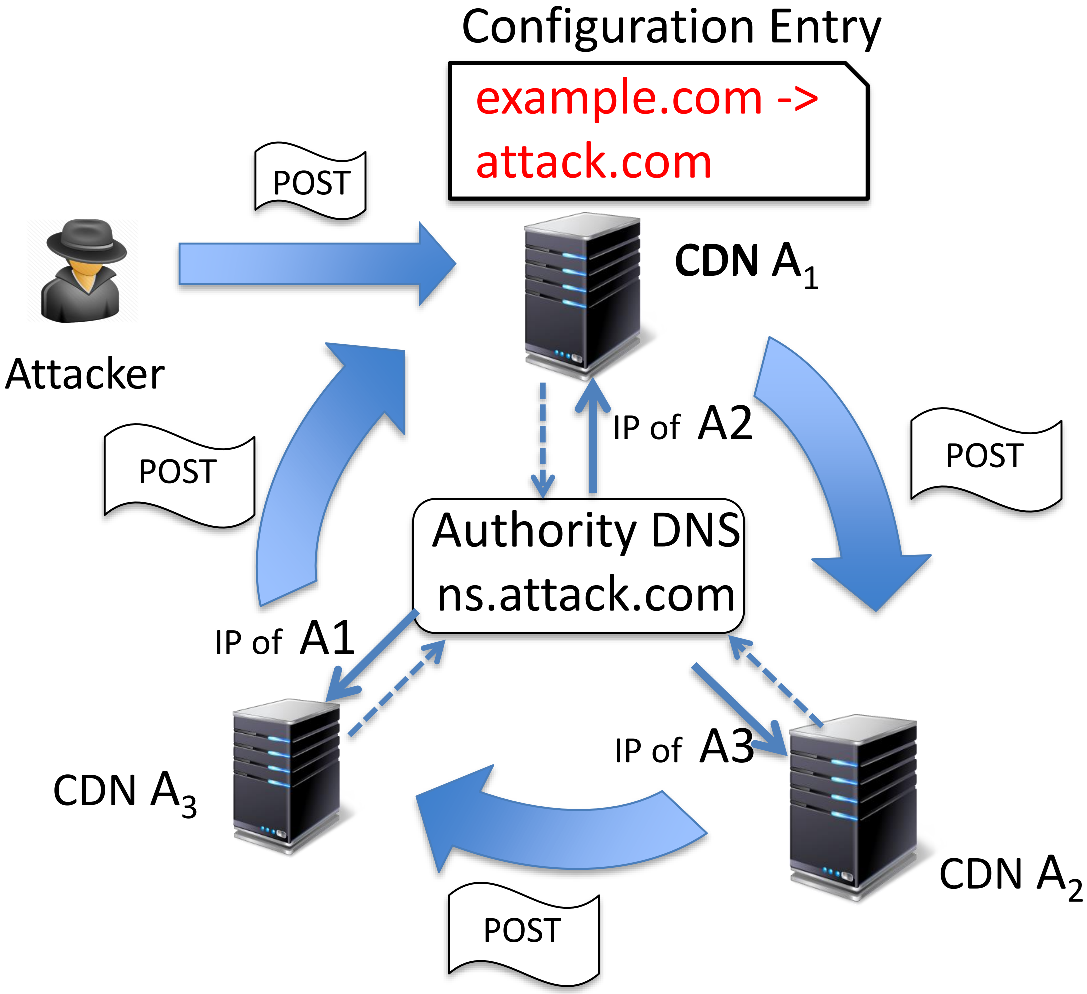
Self loop



Affected vendors(1/16):

- Azure(China)

Intra-CDN loop

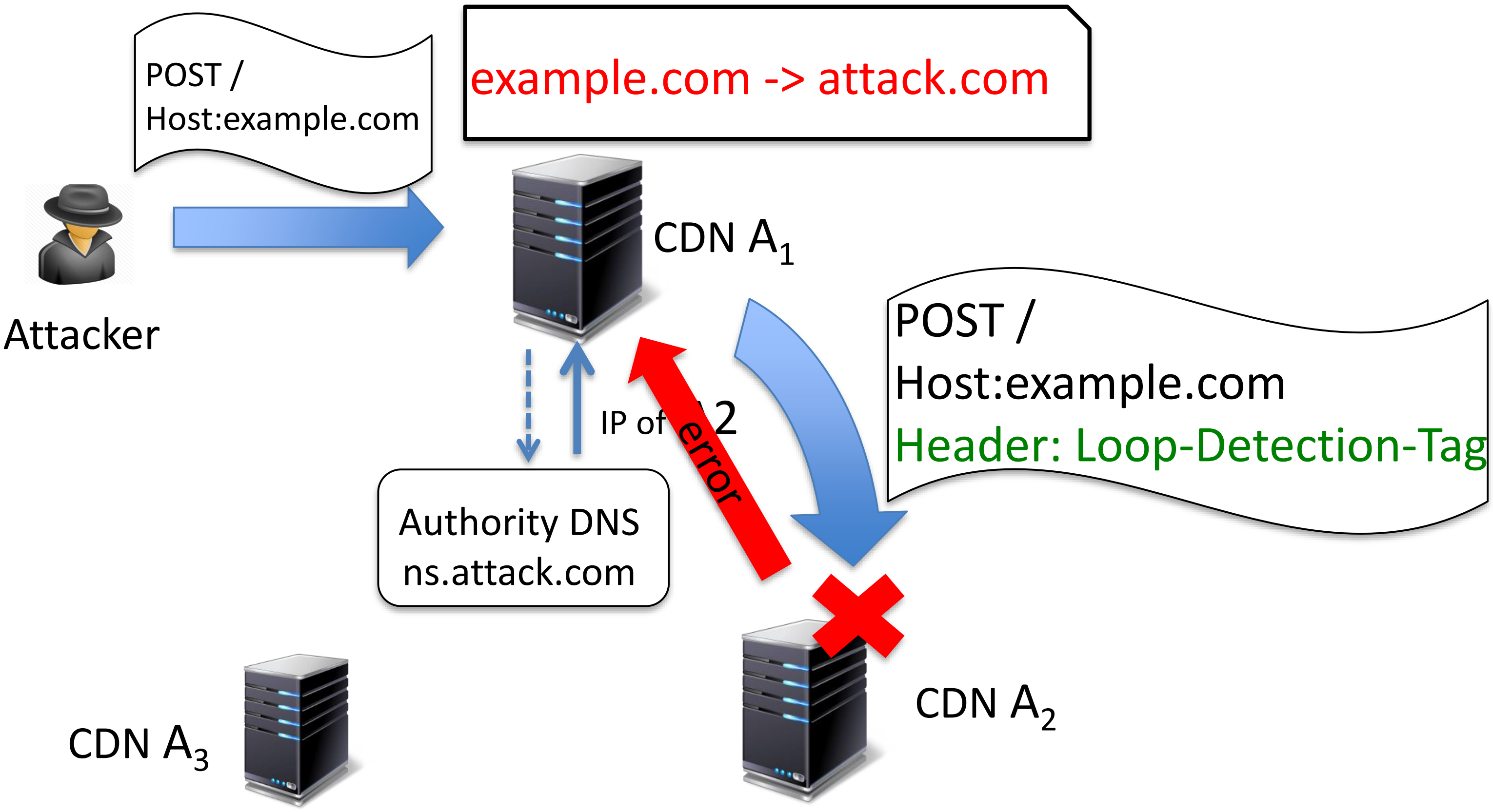


Affected vendors(7/16):

- Azure(China)
- CDN77
- CDNlion
- CDN.net
- CDNsun
- KeyCDN
- MaxCDN

Loop among multiple nodes within one CDN

Loop Detection by CDNs



Current Defenses	Use headers to tag processed requests

Loop-Detection Headers are different

CDN Provider	Loop Detection Header	CDN Provider	Loop Detection Header
Akamai	Akamai-Origin-Hop	**CloudFlare**	X-Forwarded-For CF-Connecting-IP
Alibaba	Via	**CloudFront**	Via
Azure(China)		**Fastly**	Fastly-FF
Baidu	X-Forwarded-For CF-Connecting-IP	**Incapsula**	Incap-Proxy-ID
CDN77		**KeyCDN**	
CDNlion		**Level3**	Via
CDN.net		**MaxCDN**	
CDNsun		**Tencent**	X-Daa-Tunnel

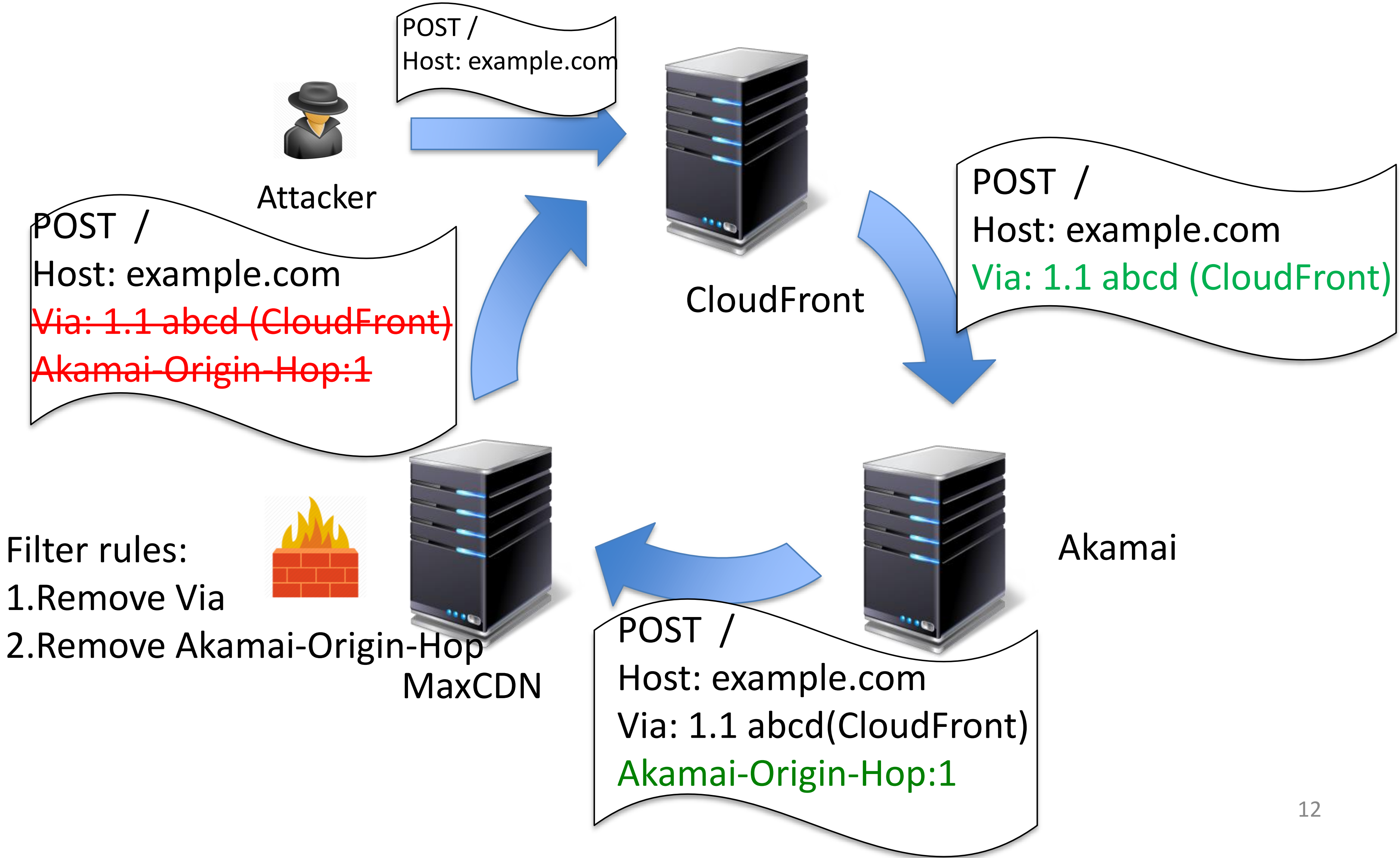
RFC 7230 recommends to use Via header for loop detection

Bypassing CDN defenses

- Chain loop-aware CDNs to other CDNs that can be abused to *disrupt* loop-detection headers
- Abusive features provided by CDNs:

CDN Provider	Reset	Filter
CDN77	Via	
CDNlion	Via	
CDN.net	Via	
CDNsun	Via	
Fastly		No-self-defined
MaxCDN		Any

Inter-CDN loops:



POST /
Host: example.com

POST /
Host: example.com
Via: 1.1 abcd (CloudFront)

POST /
Host: example.com
Via: 1.1 abcd(CloudFront)
Akamai-Origin-Hop:1

POST /
Host: example.com
~~Via: 1.1 abcd (CloudFront)~~
~~Akamai-Origin-Hop:1~~

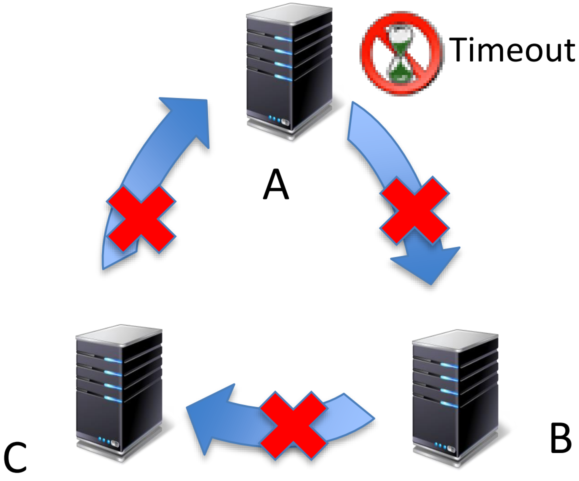
Filter rules:
1.Remove Via
2.Remove Akamai-Origin-Hop

Can a loop last indefinitely ?

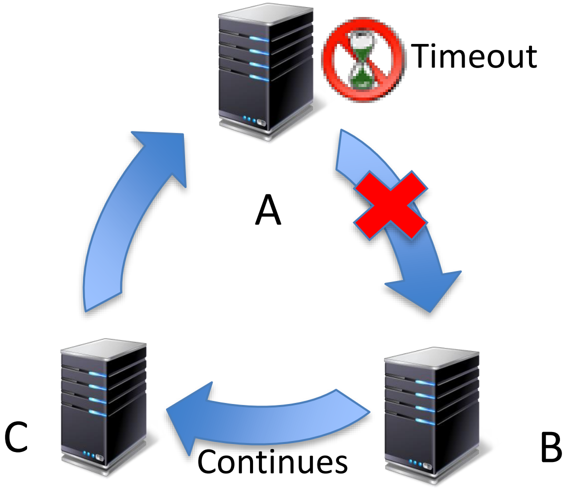
- Limitation on header size might terminates a loop
  - All CDNs limit header size;
  - some CDNs increase header size when forwarding a request;
  - Filtering and reset behaviors can bypass such limitation
- Timeout might also terminate a loop
  - A careful attacking plan can avoid this effect.

Handling timeout

Factors	Attacker countermeasure
Timeout	Add a no-abort-forwarding node(7/16)



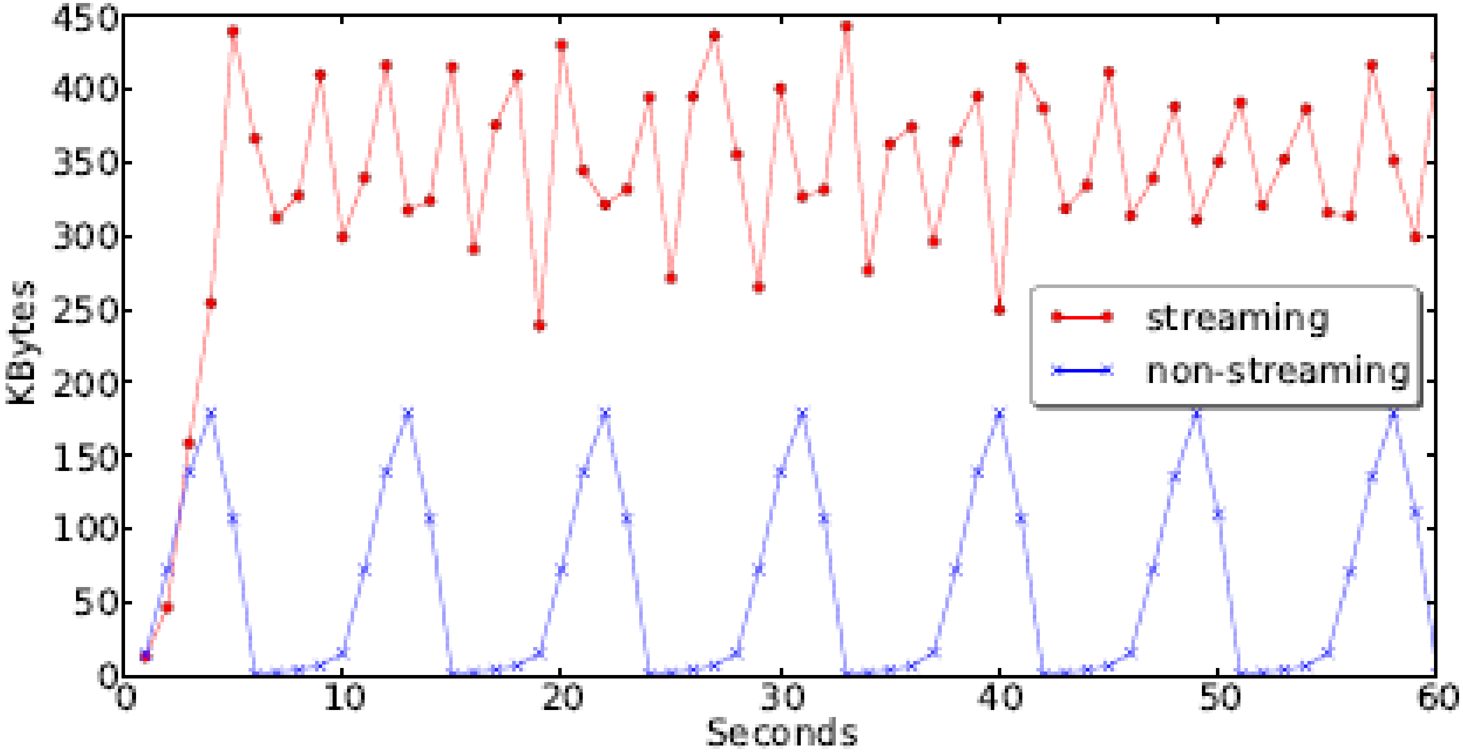
Abort-forwarding



No-abort-forwarding

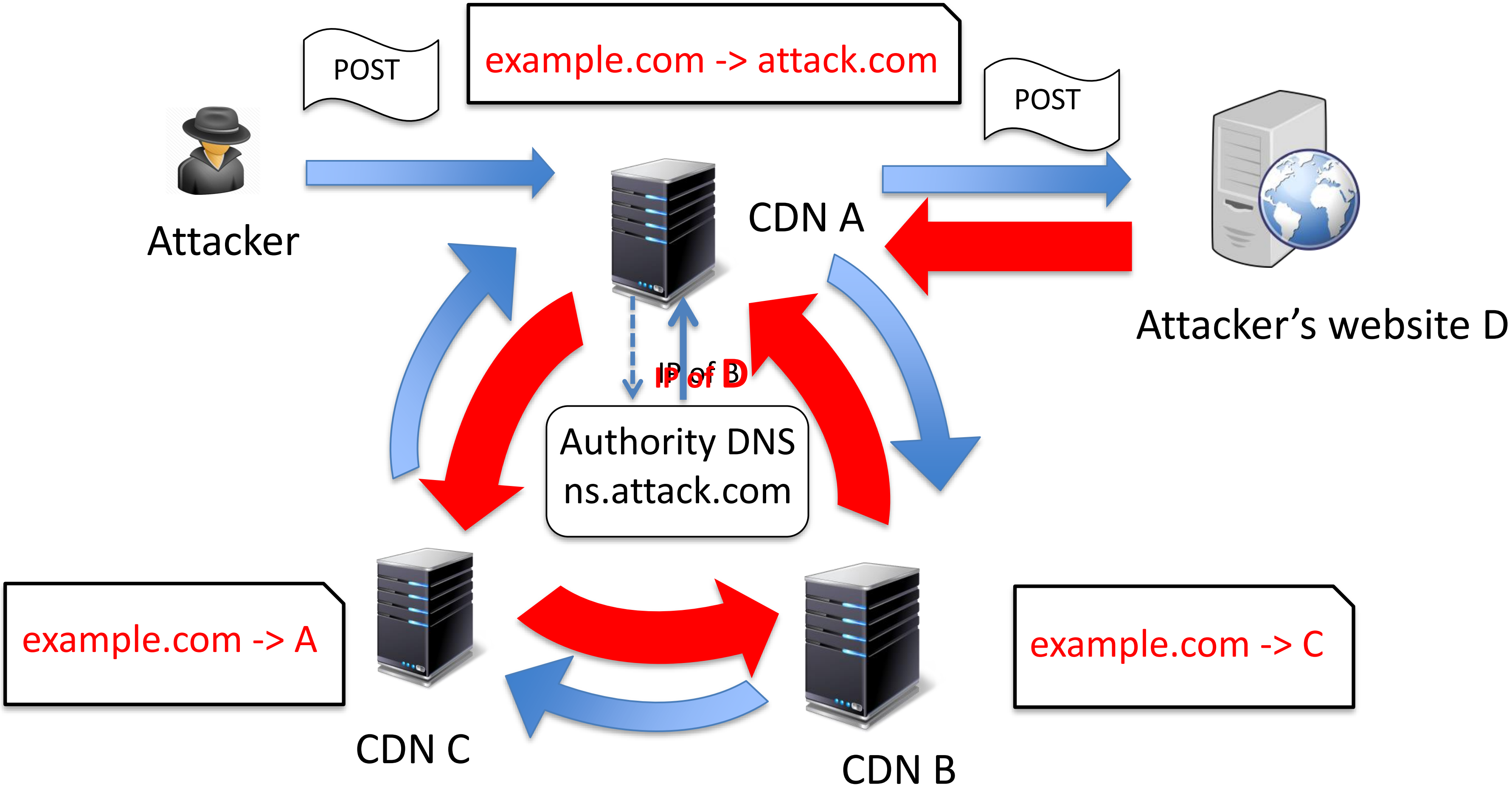
- Experiment
  - A request loops for 5+ hours among CloudFlare, MaxCDN, CDN77 and our control node

How to enlarge attacking traffic?



- Streaming loop
  - faster speed -> overlap -> higher traffic
  - All nodes need to support streaming
  - 7/16 CDNs support request streaming, all CDNs support response streaming

“Dam Flooding” attack: streaming loop with response



POST

example.com -> attack.com

POST

Attacker

CDN A

Attacker’s website D

IP of B

IP of D

Authority DNS
ns.attack.com

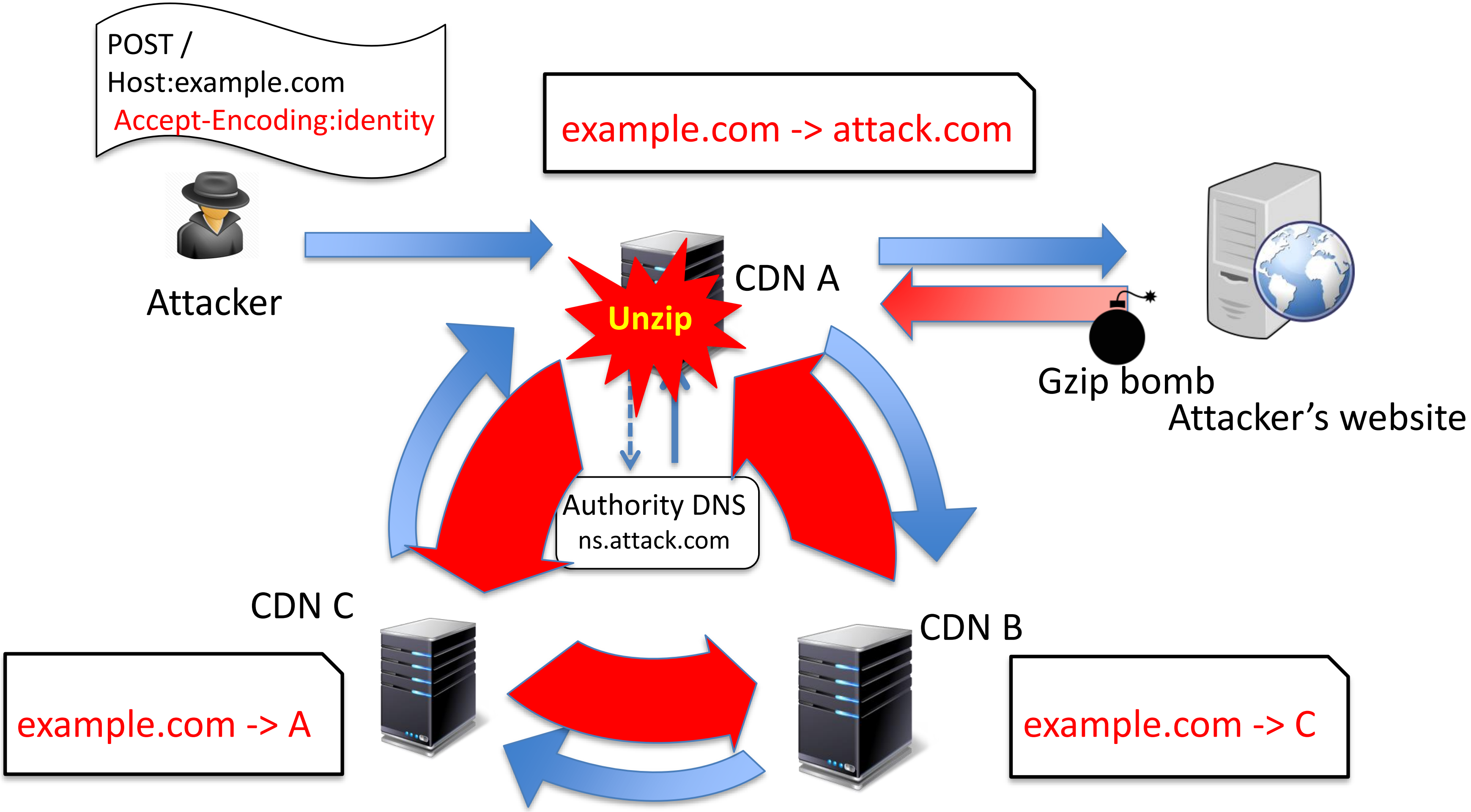
example.com -> A

example.com -> C

CDN C

CDN B

Enhance streaming loop with gzip bomb



```
POST /
Host:example.com
Accept-Encoding:identity
```

- 3 CDNs can be used to uncompress gzip bombs
- Total Amplification Factor = Loop Amplification * Gzip Bomb Amplification(~ 1000)

Defenses

- Unifying and standardizing a loop-detection header,
  - **`Via`** as recommended by RFC
- Interim defenses, independently
  - Obfuscating self-defined loop-detection headers
  - Monitoring and rate-limiting
  - Constraint on forwarding destination

CDN Vendor Feedback

- CDNs are actively addressing it
  - CloudFlare and Baidu implemented **`Via`** header
  - CDN77 and CDNsun will change to not reset **`Via`**
  - Verizon (Edgecast) agreed the problem is serious
  - Tencent evaluates as high risk
  - Fastly actively discussed defenses with us
  - Alibaba are intreseted in interim defenses

Summary

- A variety of implementation issues make forwarding loops a potentially severe attack vector
- A case that highlights the danger of allowing cross-organization, user-controlled (untrusted) policies without centralized administration
- How to enforce standard compliance, especially when global coordination is needed

Acknowledgement

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Thank you!