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assisted by LaQuSo Laboratory for Quality Software

DNS(SEC) client analysis

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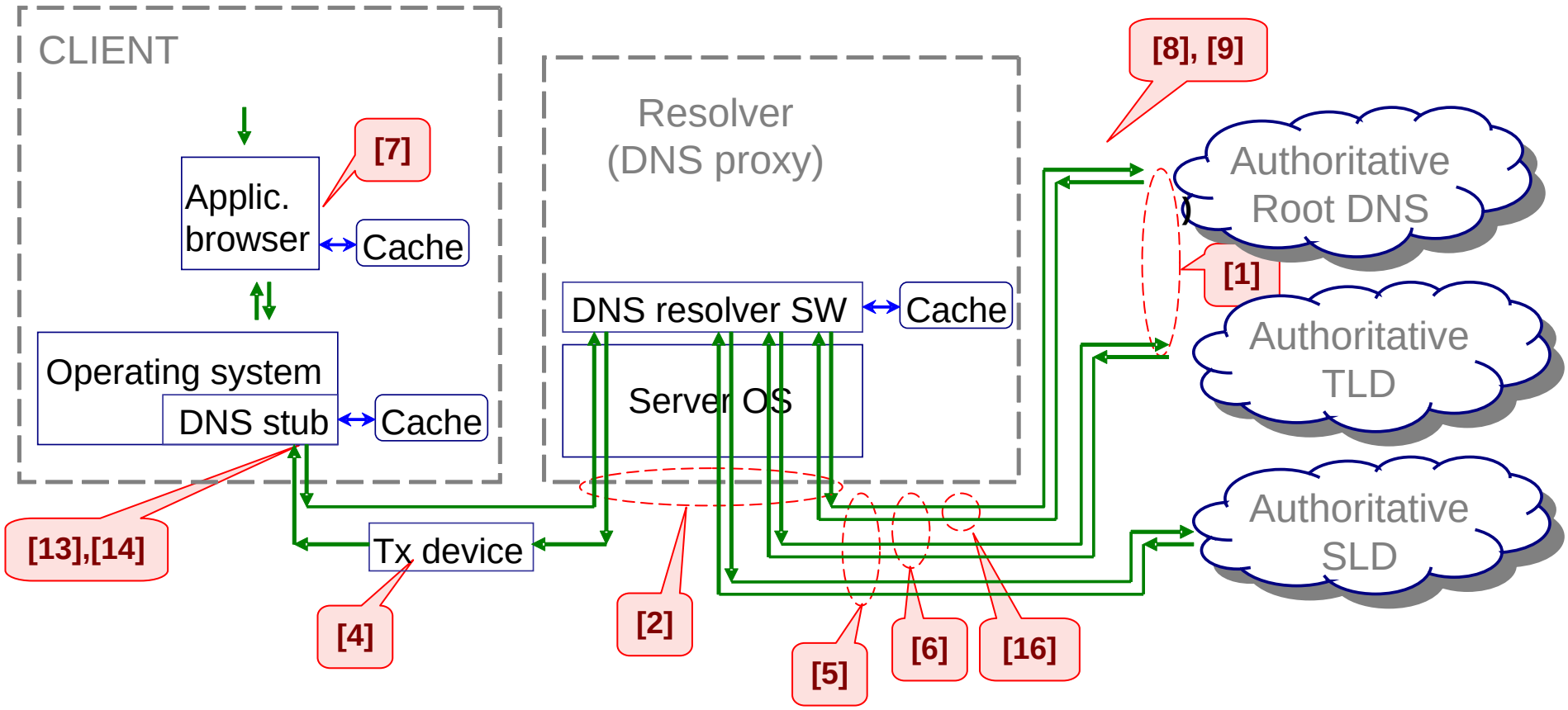
DNS-OARC, San Francisco, March 2011

‘Overview’ DNS traffic analysis



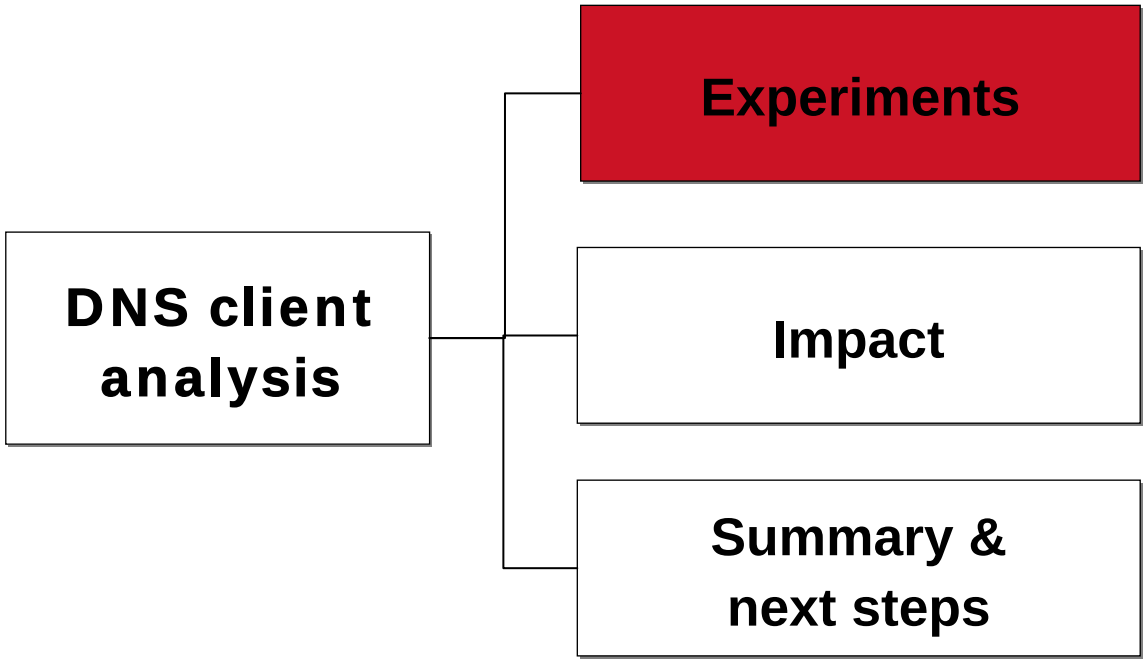
- Focus of DNS analysis has been on resolver and authoritative ⇔ bulk data analysis

Key question:

- How will DNSSEC change the behavior of DNS client querying?

  More specific …

- How do DNS stub resolvers react to response types such as ServFail, responses > 512 Bytes, …?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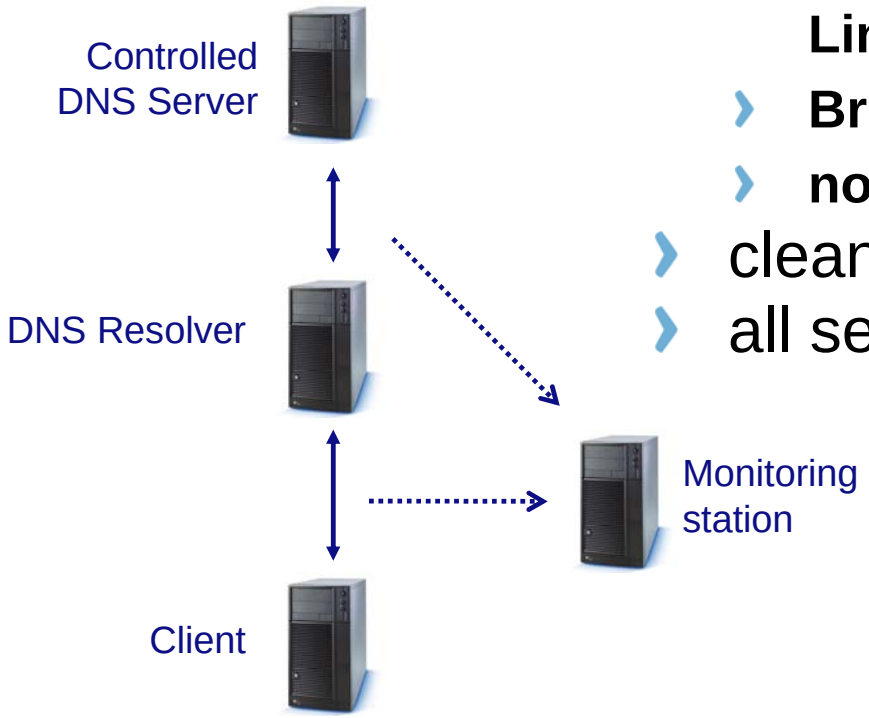
Experimental set-up



- Configure OS / browser on client machine
  - **OS: Windows XP, Windows 7, Ubuntu Linux, Mac OSX**
  - **Browsers: IE, Firefox, Chrome, Safari**
  - **not all combi's, but quite some …**
- clean OS image
- all settings left on defaults

Test execution

- Execute test run
  - query each URLs with predefined response (ldns tool)
    - **Valid, Valid (>512 Bytes), NXdomain, Partial, ServFail, No reply, Truncated, Recursion refused**
  - query via ping (=> OS only) and via browser (=> browser & OS)
  - repeat query once to check impact of caching

➢ Observe the number of repeated queries and delays

Example of DNS client behaviour: Linux-Ubuntu /w Firefox

```
15:26:38.694678 IP 10.0.3.2.56600 > 10.0.2.1.53: 7000+ AAAA? servfail.dnslab.nl. (36)
15:26:38.704409 IP 10.0.2.1.53 > 10.0.3.2.56600: 7000 ServFail 0/0/0 (36)
15:26:38.704779 IP 10.0.3.2.46832 > 10.0.2.1.53: 7000+ AAAA? servfail.dnslab.nl. (36)
15:26:38.711533 IP 10.0.2.1.53 > 10.0.3.2.46832: 7000 ServFail 0/0/0 (36)
15:26:38.712139 IP 10.0.3.2.34859 > 10.0.2.1.53: 751+ AAAA? servfail.dnslab.nl. (36)
15:26:38.720254 IP 10.0.2.1.53 > 10.0.3.2.34859: 751 ServFail 0/0/0 (36)
15:26:38.722147 IP 10.0.3.2.60413 > 10.0.2.1.53: 751+ AAAA? servfail.dnslab.nl. (36)
15:26:38.732281 IP 10.0.2.1.53 > 10.0.3.2.60413: 751 ServFail 0/0/0 (36)
15:26:38.732819 IP 10.0.3.2.53267 > 10.0.2.1.53: 62476+ A? servfail.dnslab.nl. (36)
15:26:38.741631 IP 10.0.2.1.53 > 10.0.3.2.53267: 62476 ServFail 0/0/0 (36)
15:26:38.742221 IP 10.0.3.2.55543 > 10.0.2.1.53: 62476+ A? servfail.dnslab.nl. (36)
15:26:38.750843 IP 10.0.2.1.53 > 10.0.3.2.55543: 62476 ServFail 0/0/0 (36)
15:26:38.750843 IP 10.0.3.2.55146 > 10.0.2.1.53: 40336+ A? servfail.dnslab.nl. (36)
15:26:38.757800 IP 10.0.2.1.53 > 10.0.3.2.55146: 40336 ServFail 0/0/0 (36)
15:26:38.758084 IP 10.0.3.2.55095 > 10.0.2.1.53: 40336+ A? servfail.dnslab.nl. (36)
15:26:38.768255 IP 10.0.2.1.53 > 10.0.3.2.55095: 40336 ServFail 0/0/0 (36)
15:26:38.769784 IP 10.0.3.2.33077 > 10.0.2.1.53: 38673+ AAAA? servfail.dnslab.nl. (36)
15:26:38.776757 IP 10.0.2.1.53 > 10.0.3.2.33077: 38673 ServFail 0/0/0 (36)
15:26:38.776971 IP 10.0.3.2.52085 > 10.0.2.1.53: 38673+ AAAA? servfail.dnslab.nl. (36)
15:26:38.787268 IP 10.0.2.1.53 > 10.0.3.2.52085: 38673 ServFail 0/0/0 (36)
15:26:38.787583 IP 10.0.3.2.60192 > 10.0.2.1.53: 55536+ AAAA? servfail.dnslab.nl. (36)
15:26:38.797645 IP 10.0.2.1.53 > 10.0.3.2.60192: 55536 ServFail 0/0/0 (36)
15:26:38.797985 IP 10.0.3.2.46728 > 10.0.2.1.53: 55536+ AAAA? servfail.dnslab.nl. (36)
15:26:38.803552 IP 10.0.2.1.53 > 10.0.3.2.46728: 55536 ServFail 0/0/0 (36)
15:26:38.803796 IP 10.0.3.2.60114 > 10.0.2.1.53: 40195+ A? servfail.dnslab.nl. (36)
15:26:38.810014 IP 10.0.2.1.53 > 10.0.3.2.60114: 40195 ServFail 0/0/0 (36)
15:26:38.810456 IP 10.0.3.2.35270 > 10.0.2.1.53: 40195+ A? servfail.dnslab.nl. (36)
15:26:38.823206 IP 10.0.2.1.53 > 10.0.3.2.35270: 40195 ServFail 0/0/0 (36)
15:26:38.823551 IP 10.0.3.2.57144 > 10.0.2.1.53: 50408+ A? servfail.dnslab.nl. (36)
15:26:38.829749 IP 10.0.2.1.53 > 10.0.3.2.57144: 50408 ServFail 0/0/0 (36)
15:26:38.829961 IP 10.0.3.2.35860 > 10.0.2.1.53: 50408+ A? servfail.dnslab.nl. (36)
15:26:38.836833 IP 10.0.2.1.53 > 10.0.3.2.35860: 50408 ServFail 0/0/0 (36)
```

↔ example: servfail response

3 immediate retries in case of servfail response

and IPv4?

OS sends servfail to FireFox; Firefox makes OS retry

16 queries in 0.14 seconds

Browser & OS DNS query amplification

Response type	Firefox	Linux	Total
Valid	x1	x1	x1
NXdomain / Partial	x2	x2	x4
ServFail / No response / Refused	x2	x4	x8
Truncated	x1	1+TCP	1+TCP

Response type	Safari	Mac OSX	Total
Valid	x1	x1	x1
NXdomain / Partial	x1	x2	x2
ServFail / No response / Refused	x1	x4	x4
Truncated	x1	1+TCP	1+TCP

- **DNS query count in case of:**
  - **single authoritative NS; in case of primary and secondary => 2x**
  - **only IPv4; in case of IPv4 and IPv6 => 2x**

Browser & OS DNS query amplification

Response type	IE	Windows XP	Total
Valid / NXdomain	x1	x1	x1
Partial / ServFail / Refused	x1	x1	x1
No response	x1	x5	x5
Truncated	x1	1+TCP	1+TCP

Response type	Chrome	Windows XP	Total
Valid / NXdomain	x1	x1	x1
Partial / ServFail / Refused	x1	x1	x1
No response	x1	x5	x5
Truncated	x1	1+TCP	1+TCP

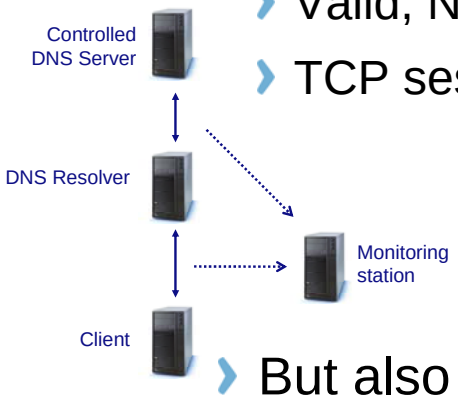
- **In fact, same behaviour for IE, Chrome, Firefox, Safari on Windows XP or Windows 7**

Other sources of aggressive DNS clients (not investigated)

- Greedy – synchronisation apps: bonjour, facebook apps, …
  - may generate continuous stream of DNS requests
- Browser pre-fetching
  - Firefox by default queries “anticipated next URLs” for a page
  - Chrome pre-fetches stored, successfully retrieved URLs, when started
- Ubuntu Linux: by default no DNS caching

Impact of the caching resolver

- Some damping of aggressive client behaviour by (BIND9) resolver
  - In case of no-response the resolver retries (7 retries, with exponential timer back-off), while holding back client side retries
  - Valid, NXdomain and truncated responses are cached
  - TCP session for truncated responses is handled by resolver



- But also some amplification / modification by the resolver
  - Resolver ‘double checks’ ServFail responses
  - Unvalidatable response is returned as ServFail to client by non-DNSSEC enabled resolver
  - Also: partial, recursion refused and timeout are fed back as ServFail

Causes of aggressive DNS client behavior?

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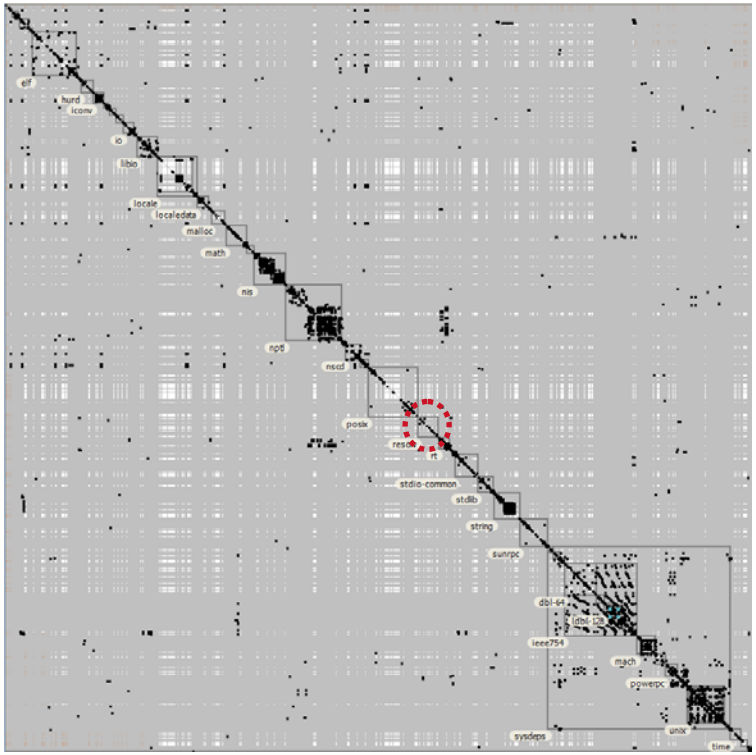
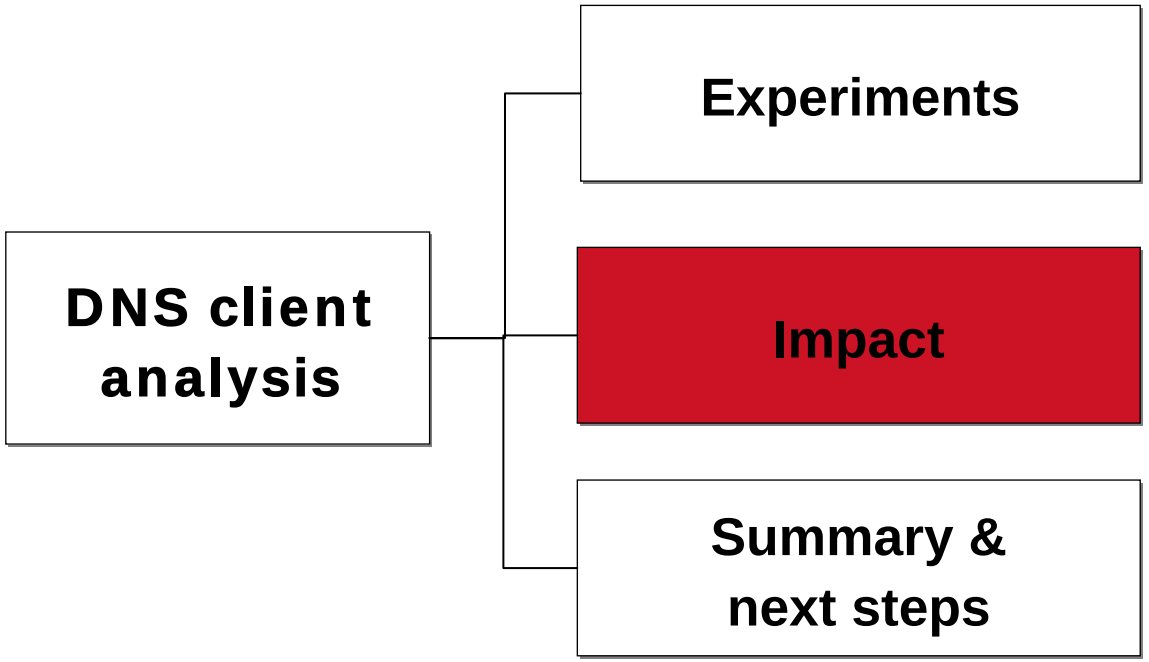
- GNU Library C ('glibc') DNS service
  - static code analysis:
    - overall glibc no ordinary characteristics found
  - dynamic code analysis of DNS part:
    - 'responsible' code part is pinpointed
    - code part is complex ⇔ improvement not found yet



- Ok, before we drill down to the cause … what's the impact?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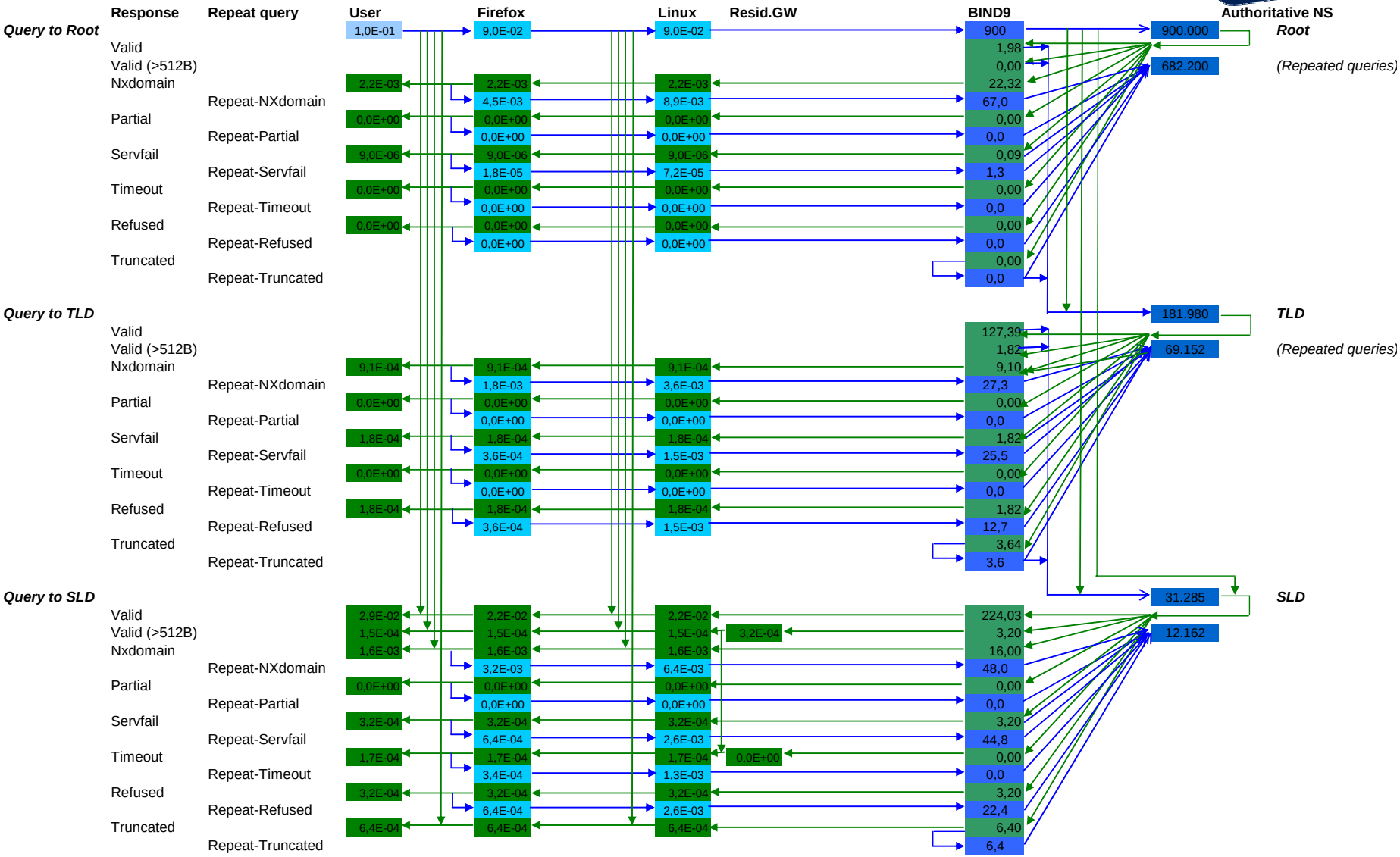
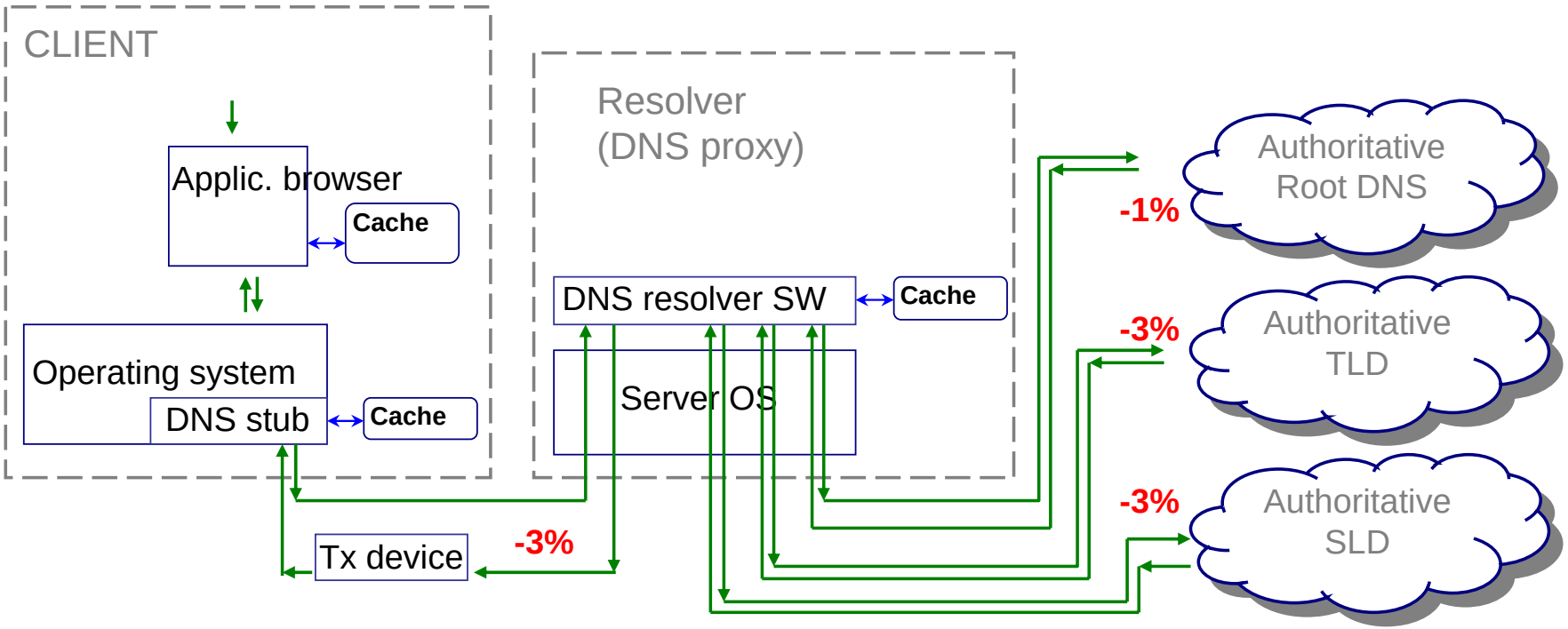
Impact model (“*perfect behavior*”)

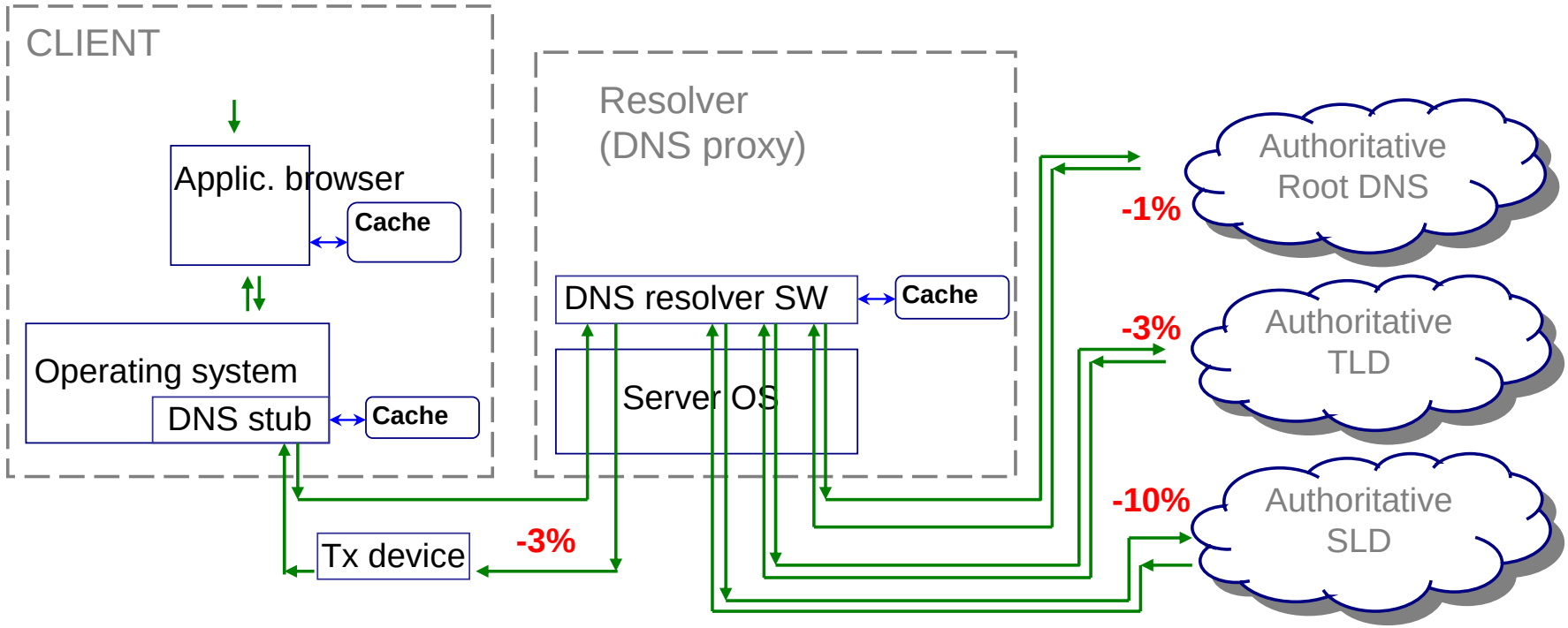


Impact on average DNS traffic volume



- **Predicted query load reduction as result of modifying aggressive Linux/Mac behavior is small**
  - penetration of Linux / Mac OSX relatively low
  - behavior occurs in case of ‘exceptions’ (ServFail, NXdomain, …)

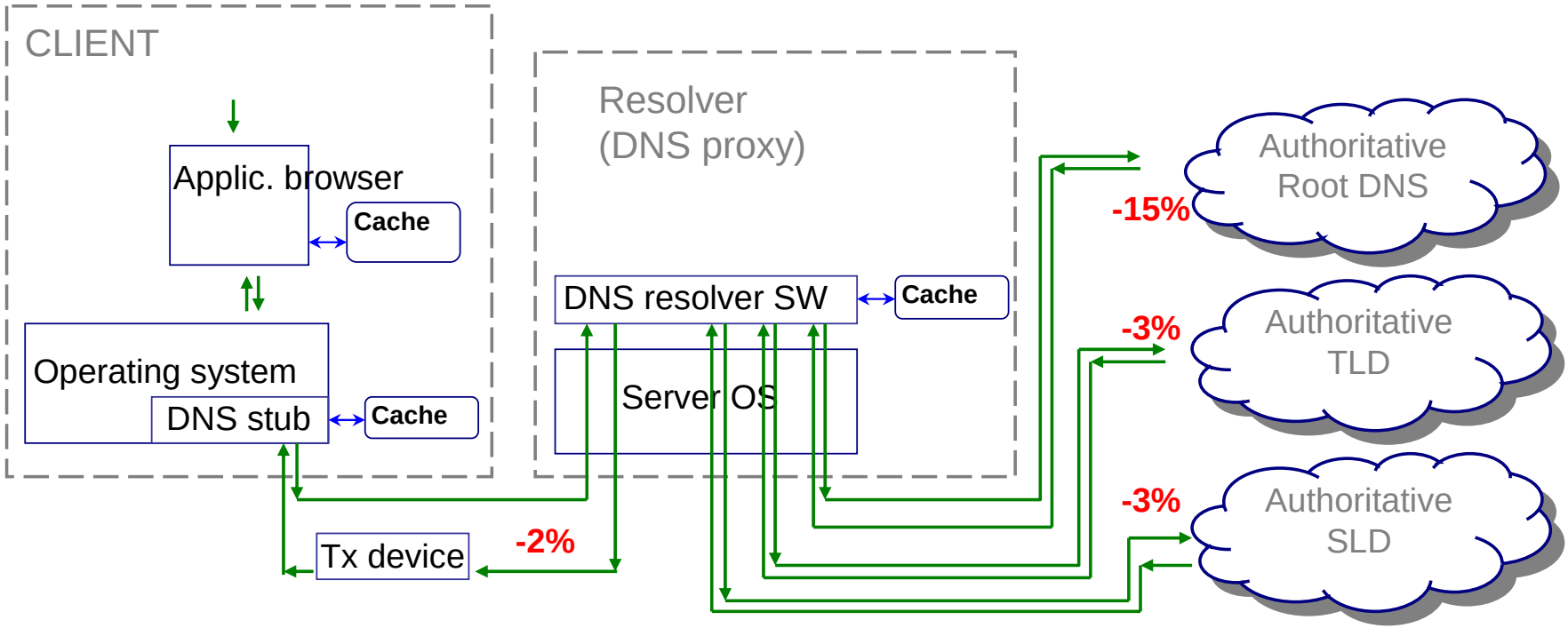
Impact outlook
- scenario: 10% DNSSEC validation error for SLD



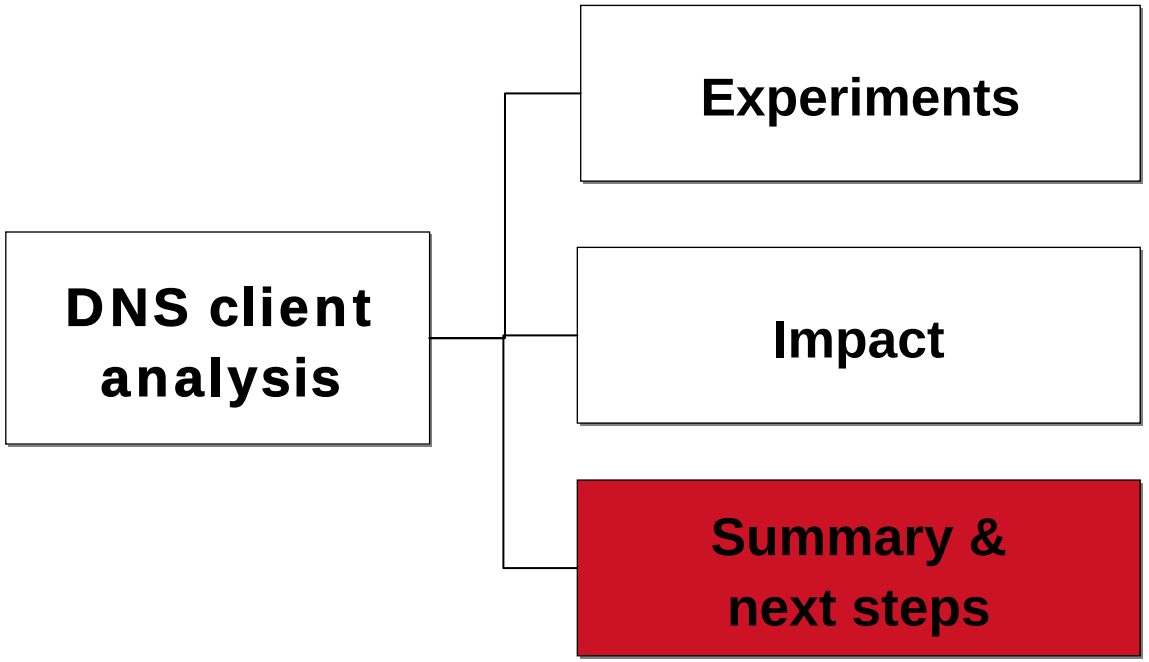
- DNSSEC configuration errors at a domain will attract more traffic, due to observed behavior

Impact outlook

- scenario: NXdomain caching disabled at resolver



- Some amplification of bogus traffic to the Root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Summary

- Linux and Mac clients display aggressive DNS behavior, in case of non-valid responses
  - Resolvers partly damp aggressive behavior, but also amplify it
- Impact of client behavior on *average* DNS traffic is relatively low
  - because fraction of Mac / Linux traffic is relatively low and
  - behavior occurs in particular for minority of DNS responses
- Although, for some particular cases the behavior amplifies traffic volume and rate

Next steps

- Share experiences with other experts
- Contribute to improving DNS function in the glibc(?)
  - alternative for pinpointed code part causing the amplification
- Further quantitative scenario impact analysis
  - further verification with ISP (SURFnet), SIDN data
  - compare to greedy apps behavior
- Is mobile internet different from other ISP traffic?
  - ABI Research: “in 2015 62% of mobile device will be Linux-based” …