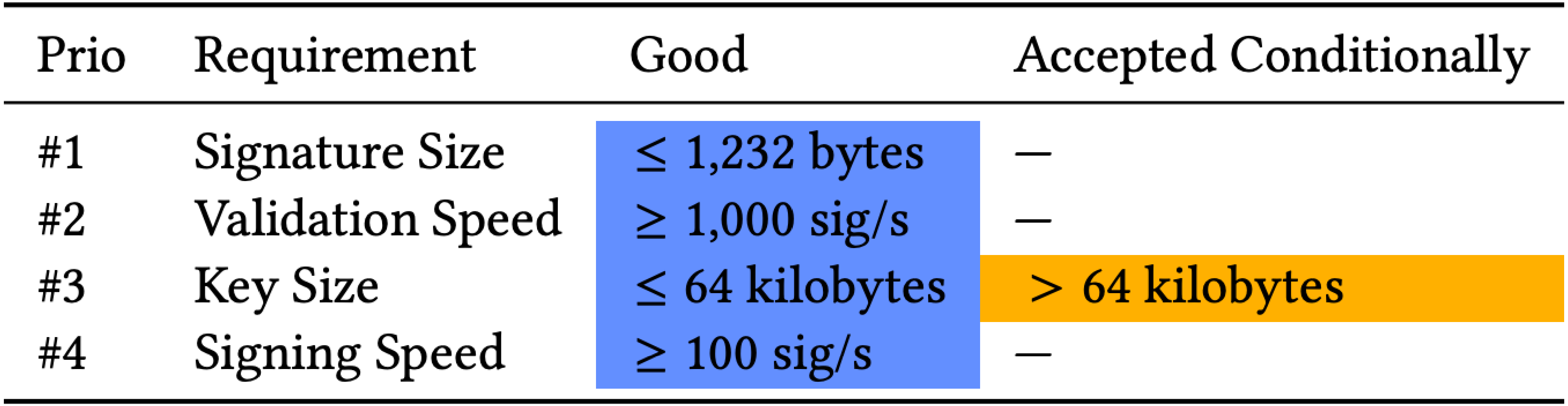
A testbed to evaluate post-quantum cryptography in DNSSEC

pq-dnssec side meeting at IETF 121

07 Nov 2024

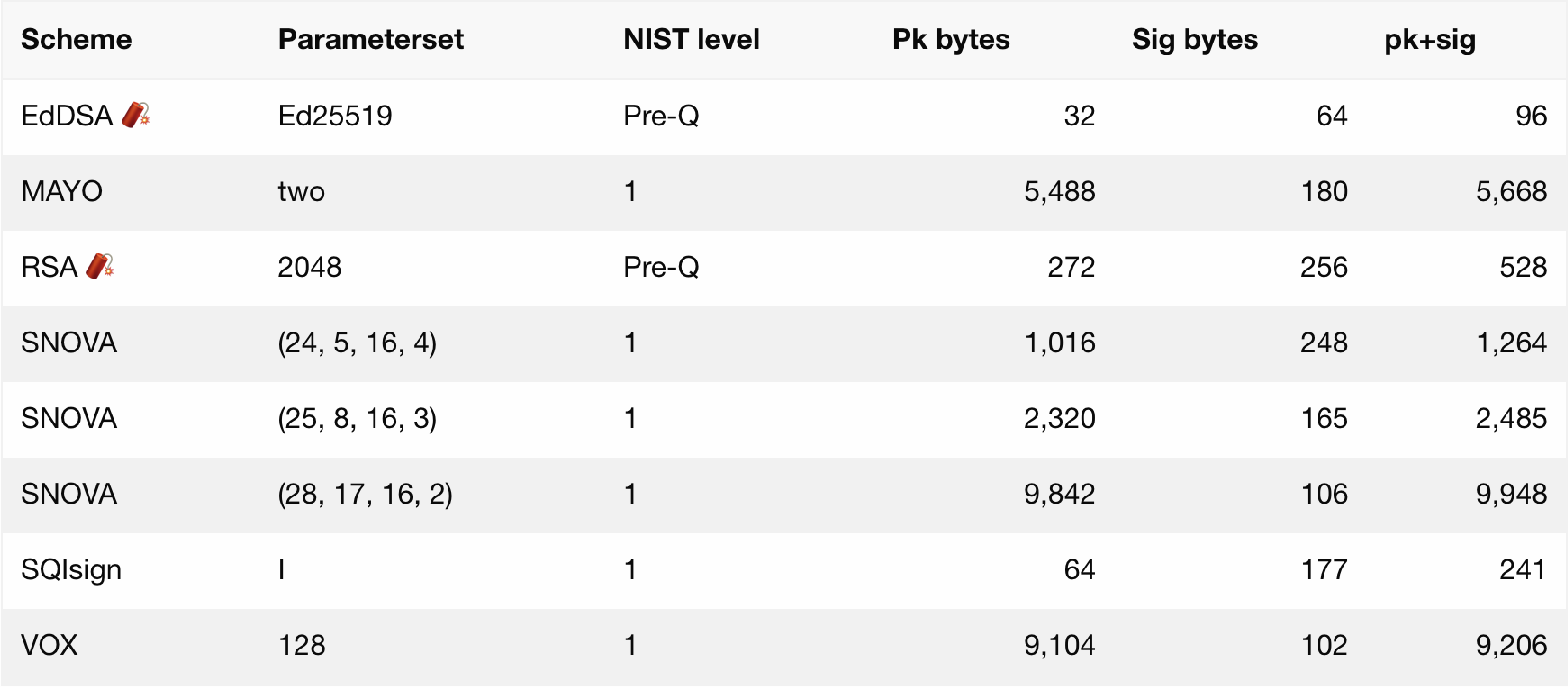
SIDN LABS



Prio	Requirement	Good	Accepted Conditionally
#1	Signature Size	≤ 1,232 bytes	—
#2	Validation Speed	≥ 1,000 sig/s	—
#3	Key Size	≤ 64 kilobytes	> 64 kilobytes
#4	Signing Speed	≥ 100 sig/s	—

Table 2: Requirements for quantum-safe algorithms.

M. Müller et al, “Retrofitting Post-Quantum Cryptography in Internet Protocols:
A Case Study of DNSSEC”, ACM SIGCOMM Computer Communication Review, vol. 50, no. 4, 2020.



Scheme	Parameterset	NIST level	Pk bytes	Sig bytes	pk+sig
EdDSA 🧨	Ed25519	Pre-Q	32	64	96
MAYO	two	1	5,488	180	5,668
RSA 🧨	2048	Pre-Q	272	256	528
SNOVA	(24, 5, 16, 4)	1	1,016	248	1,264
SNOVA	(25, 8, 16, 3)	1	2,320	165	2,485
SNOVA	(28, 17, 16, 2)	1	9,842	106	9,948
SQIsign	I	1	64	177	241
VOX	128	1	9,104	102	9,206

https://pqshield.github.io/nist-sigs-zoo

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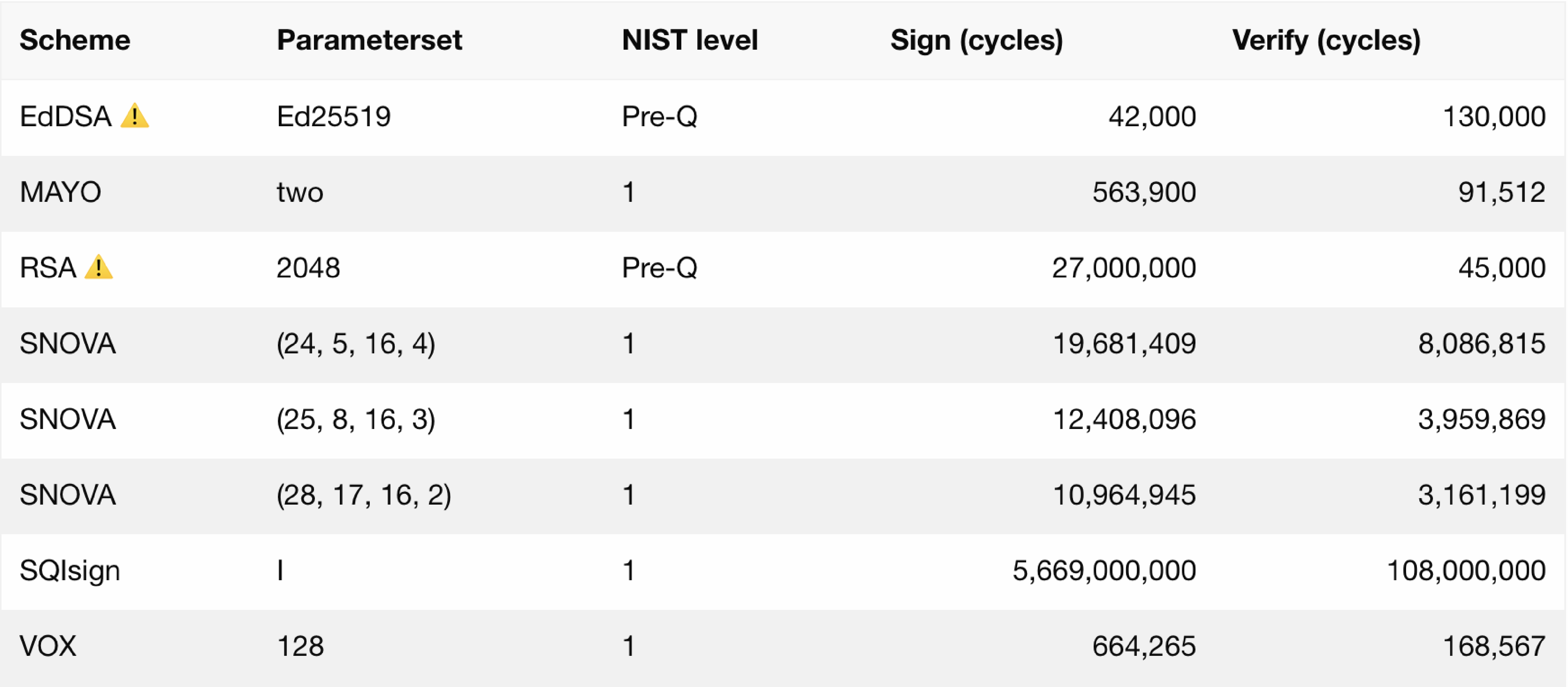


Scheme	Parameterset	NIST level	Sign (cycles)	Verify (cycles)
EdDSA ⚠	Ed25519	Pre-Q	42,000	130,000
MAYO	two	1	563,900	91,512
RSA ⚠	2048	Pre-Q	27,000,000	45,000
SNOVA	(24, 5, 16, 4)	1	19,681,409	8,086,815
SNOVA	(25, 8, 16, 3)	1	12,408,096	3,959,869
SNOVA	(28, 17, 16, 2)	1	10,964,945	3,161,199
SQIsign	I	1	5,669,000,000	108,000,000
VOX	128	1	664,265	168,567

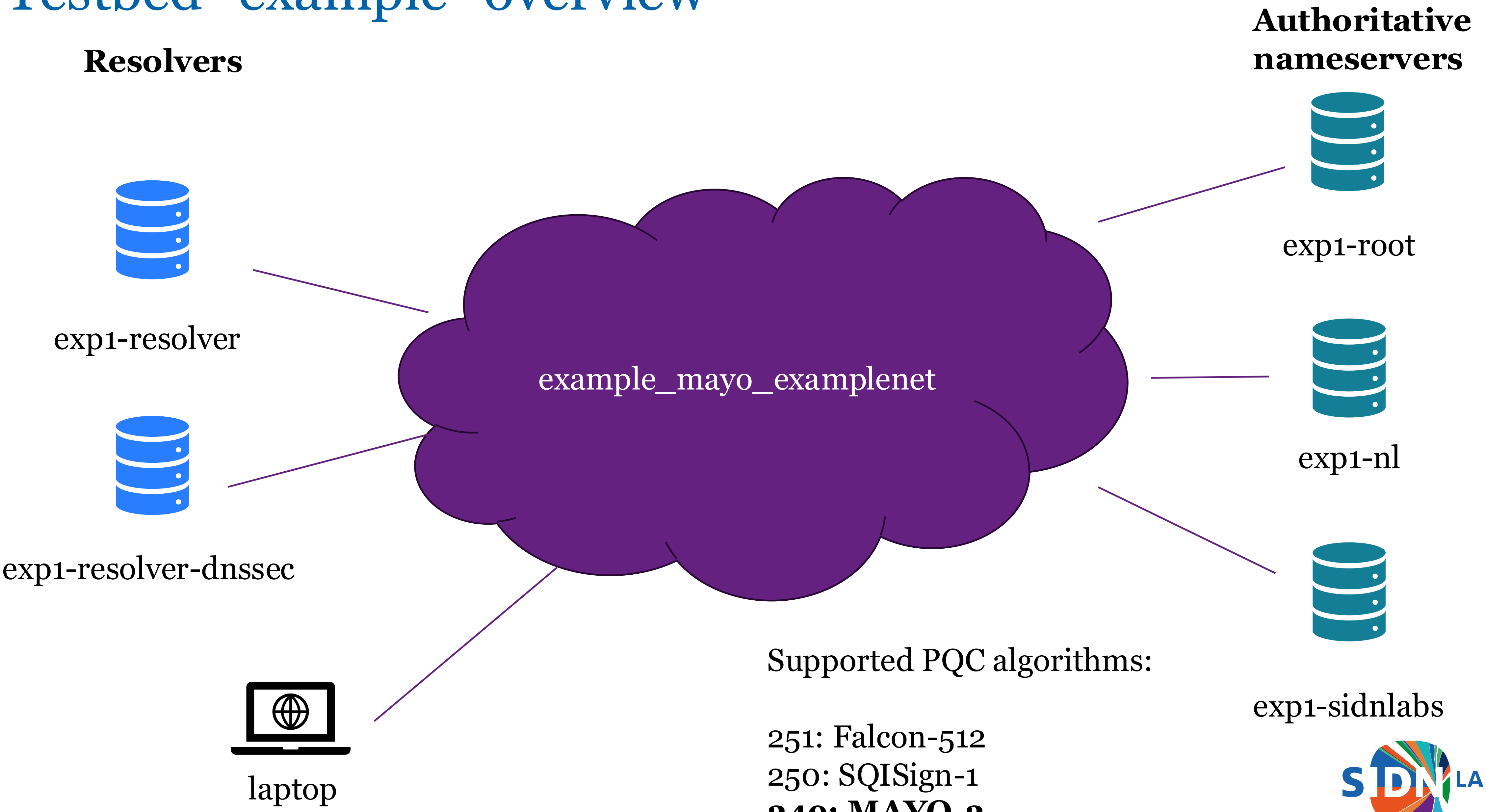
https://pqshield.github.io/nist-sigs-zoo

PATAD testbed is available

- Prebuilt docker images plus testbed using docker–compose
  - Specify your own topology.
  - Run your own experiments.

- Currently supported software:
  - PowerDNS with algorithms:
    - SQIsign-I
    - MAYO-2
    - Falcon-512

Testbed "example" overview



Resolvers

exp1-resolver

exp1-resolver-dnssec

laptop

example_mayo_examplenet

Authoritative nameservers

exp1-root

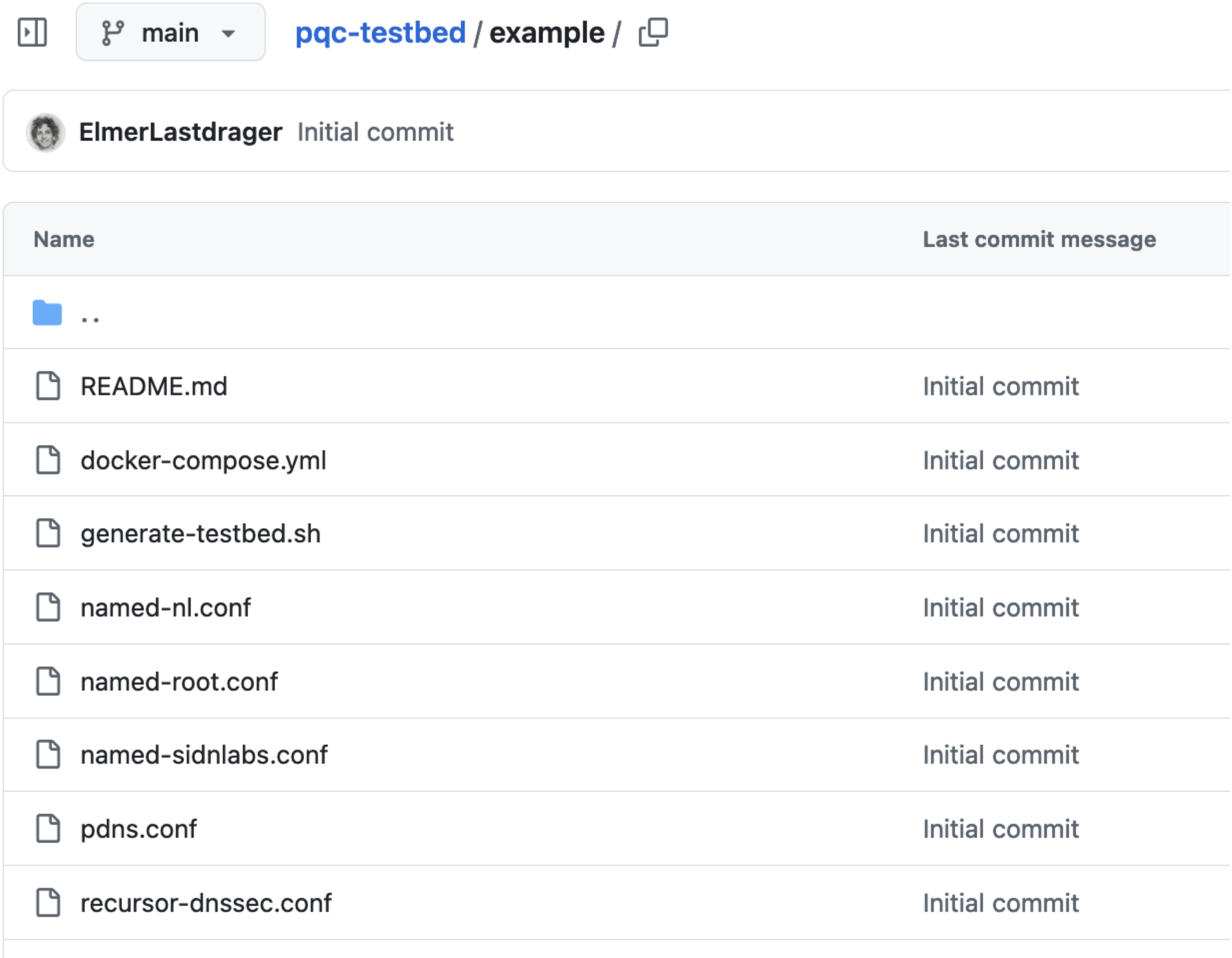
exp1-nl

exp1-sidnlabs

Supported PQC algorithms:

251: Falcon-512
250: SQISign-1
249: MAYO-2

Configuring the testbed



main ▾ pqc-testbed / example /

ElmerLastdrager Initial commit

Name	Last commit message
..	
README.md	Initial commit
docker-compose.yml	Initial commit
generate-testbed.sh	Initial commit
named-nl.conf	Initial commit
named-root.conf	Initial commit
named-sidnlabs.conf	Initial commit
pdns.conf	Initial commit
recursor-dnssec.conf	Initial commit

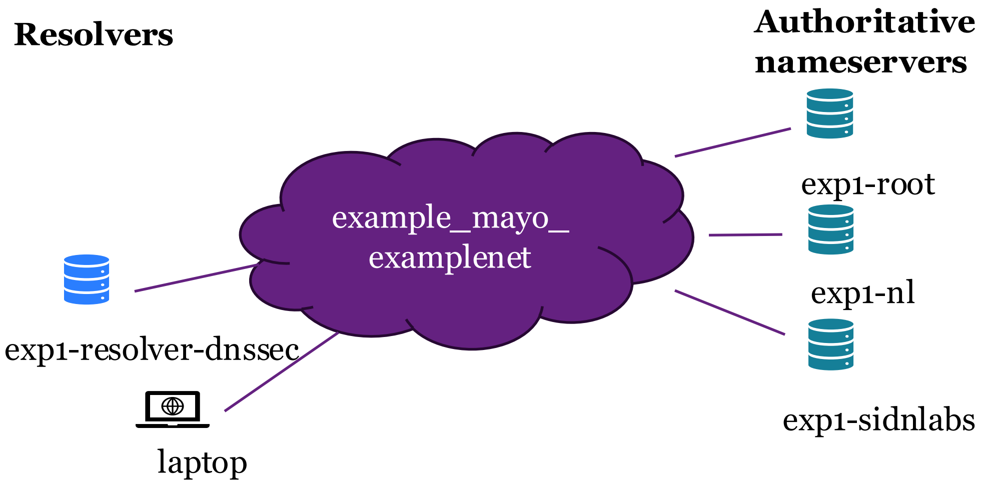
Starting the testbed

```
patad$ ./generate-testbed
setting up dnssec on root server
Jul 31 12:26:17 [bindbackend] Done parsing domains, 0 rejected, 1 new, 0 removed
pub: [omitted] 1
Added a KSK with algorithm = 250, active=0
Jul 31 12:26:19 [bindbackend] Done parsing domains, 0 rejected, 1 new, 0 removed
pub: [omitted] 2
Added a ZSK with algorithm = 250, active=0
exporting trust anchor
setting up trust between root and nl
Jul 31 12:26:21 [bindbackend] Done parsing domains, 0 rejected, 1 new, 0 removed
pub: [omitted] 1
Added a ZSK with algorithm = 249, active=1
Jul 31 12:26:21 [bindbackend] Done parsing domains, 0 rejected, 1 new, 0 removed
nl. IN DS 16434 249 2 [omitted] ; ( SHA256 digest )
nl. IN DS 16434 249 4 [omitted] ; ( SHA-384 digest )
.:         parsed into memory at 2024-07-31 12:26:21 +0000
setting up trust between nl and sidnlabs
Jul 31 12:26:21 [bindbackend] Done parsing domains, 0 rejected, 1 new, 0 removed
pub: [omitted] 1
Added a ZSK with algorithm = 251, active=1
Jul 31 12:26:22 [bindbackend] Done parsing domains, 0 rejected, 1 new, 0 removed
sidnlabs.nl. IN DS 11468 251 2 [omitted] ; ( SHA256 digest )
sidnlabs.nl. IN DS 11468 251 4 [omitted] ; ( SHA-384 digest )
nl:        parsed into memory at 2024-07-31 12:26:22 +0000
Forcing root to sign all records
 ... waiting for nameserver
Finished signing root
Forcing sidnlabs.nl to sign all records
Finished signing sidnlabs.nl
```

AXFR to force sign the zone

Verifying the status of the testbed

```
patad$ podman ps --format="{{.Names}} {{.State}} \t {{.Ports}}"

v2_database_1 running
v2_apiserver_1 running                127.0.0.1:8000->80/tcp
example_exp1-root_1 running           0.0.0.0:5302->53/tcp, 0.0.0.0:5302->53/udp
example_exp1-nl_1 running             0.0.0.0:5303->53/tcp, 0.0.0.0:5303->53/udp
example_exp1-sidnlabs_1 running       0.0.0.0:5304->53/tcp, 0.0.0.0:5304->53/udp
example_exp1-resolver-dnssec_1 running 0.0.0.0:5311->53/tcp, 0.0.0.0:5311->53/udp
```



Querying the root authoritative

```
patad$ dig . NS -p 5302 @::1

; <<>> DiG 9.18.27 <<>> . NS -p 5302 @::1
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 60209
;; flags: qr aa rd; QUERY: 1, ANSWER: 2, AUTHORITY: 0, ADDITIONAL: 5

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: do; udp: 1232

;; QUESTION SECTION:
;.                               IN NS

;; ANSWER SECTION:
.                                3600 IN    NS s.root-servers.net.
.                                3600 IN    RRSIG NS 250 0 3600 (
                                            20240808000000 20240718000000 15317 .
                                            [omitted] )

;; ADDITIONAL SECTION:
s.root-servers.net.   3600 IN    AAAA fc01::2
s.root-servers.net.   3600 IN    RRSIG AAAA 250 3 3600 (
                                            20240808000000 20240718000000 15317 .
                                            [omitted] )

;; Query time: 3 msec
;; SERVER: ::1#5302(::1) (UDP)
;; WHEN: Wed Jul 31 14:27:08 CEST 2024
;; MSG SIZE  rcvd: 726
```

AA bit set

250 = SQISign-I

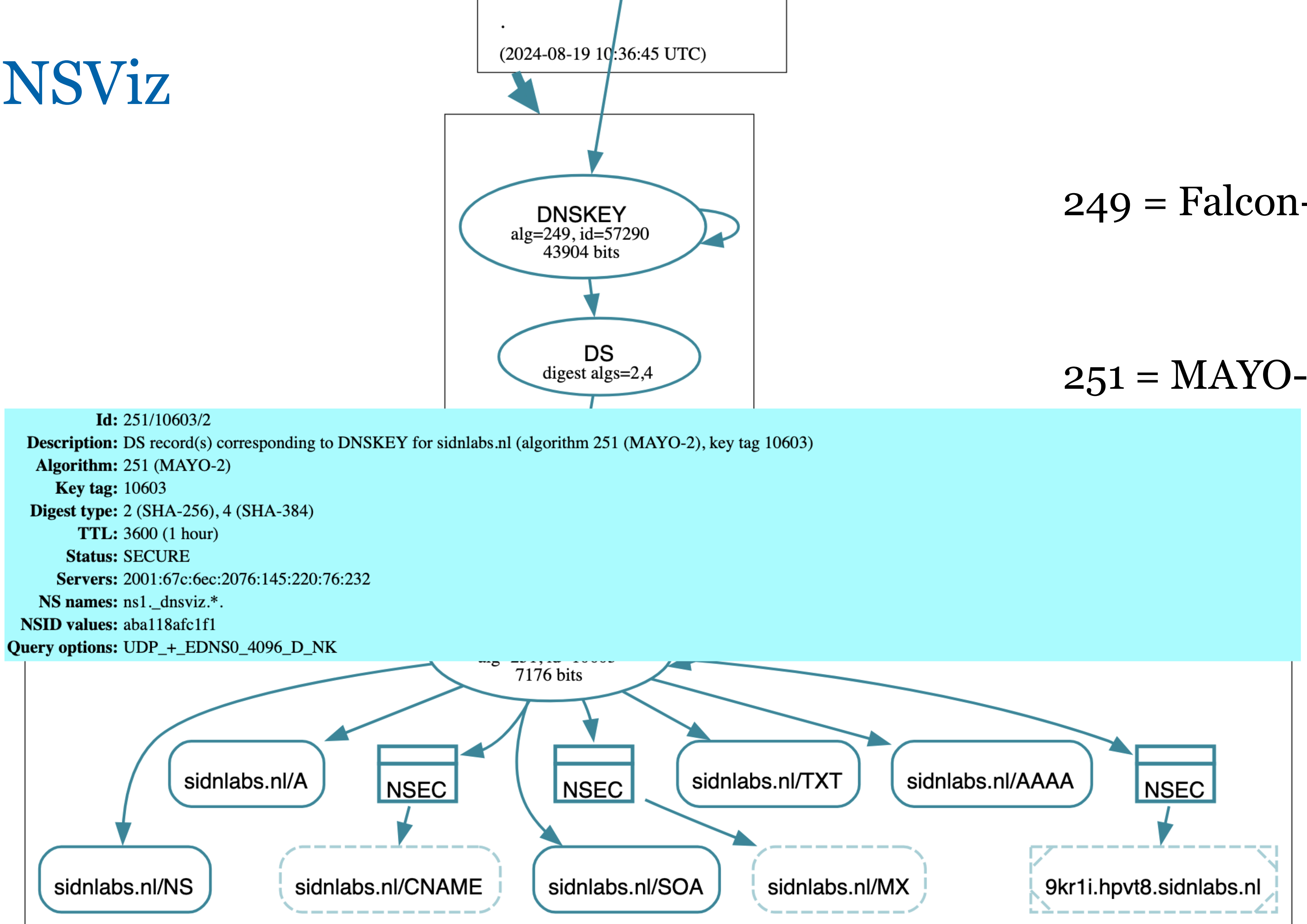
Querying the resolver

```
patad$ dig sidnlabs.nl txt -p 5311 @::1

; <<>> DiG 9.18.27 <<>> sidnlabs.nl txt -p 5311 @::1
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 31760
;; flags: qr rd ra ad; QUERY: 1, ANSWER: 2, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: do; udp: 512

;; QUESTION SECTION:
;sidnlabs.nl.                     IN TXT

;; ANSWER SECTION:
sidnlabs.nl.                      3600 IN     TXT "This is the sidnlabs.nl zone"
sidnlabs.nl.                      3600 IN     RRSIG TXT 251 2 3600 (
                                              20240808000000 20240718000000 11468 sidnlabs.nl.
                                              [omitted] )

;; Query time: 57 msec
;; SERVER: ::1#5311(::1) (UDP)
;; WHEN: Wed Jul 31 14:27:19 CEST 2024
;; MSG SIZE  rcvd: 783

patad$
```

AD bit set

251 = MAYO-2

DNSViz



Id: 251/10603/2
Description: DS record(s) corresponding to DNSKEY for sidnlabs.nl (algorithm 251 (MAYO-2), key tag 10603)
Algorithm: 251 (MAYO-2)
Key tag: 10603
Digest type: 2 (SHA-256), 4 (SHA-384)
TTL: 3600 (1 hour)
Status: SECURE
Servers: 2001:67c:6ec:2076:145:220:76:232
NS names: ns1._dnsviz.*.
NSID values: aba118afc1f1
Query options: UDP_+_EDNS0_4096_D_NK

249 = Falcon-512

251 = MAYO-2

Running PQC testbed yourself

https://patad.sidnlabs.nl

https://github.com/SIDN/pqc-testbed

PowerDNS with PQC patches:

https://github.com/SIDN/pdns/tree/master-pqc-20240606

Next steps for us

Research paper under submission.

Work together with SURF (Dutch NREN) to measure impact on DNSSEC signing and resolvers: validation timings, response times, packet sizes.

Implement/investigate other Round 2 candidate algorithms:

- SQIsign variant SQIsign2D-West
- SNOVA (24, 5, 4), UOV (Ip-pkc)

Look further at Merkle-Trees/MTL based solutions.

Questions for the group:

- **Should we as a group ask cryptographers to develop parameter sets that give more properties that are more suitable for DNSSEC?**
- What are our constraints regarding cryptographic strengths?
- How long do we need to keep zones signed with a particular key secure?

- **Can we somehow pinpoint a moment when quantum computers become a threat to DNS security?**

We are open for collaboration,
let’s discuss.

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