



# Extended DNS Errors: Unlocking the Full Potential of DNS Troubleshooting

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# RCODEs

RCODE	Name	RCODE	Name	RCODE	Name
0	NoError	9	NotAuth	19	BADMODE
1	FormErr	9	NotAuth	20	BADNAME
2	ServFail	10	NotZone	21	BADALG
3	NXDomain	11	DSOTYPENI	22	BADTRUNC
4	NotImp	12-15	Unassigned	23	BADCOOKIE
5	Refused	16	BADVERS	24-3840	Unassigned
6	YXDomain	16	BADSIG	3841-4095	Reserved for Private Use
7	YXRRSet	17	BADKEY	4096-65534	Unassigned
8	NXRRSet	18	BADTIME	65535	Reserved, can be allocated by Standards Action

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**Solution:  
Extended DNS Errors**

# RFC 8914

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Status: Proposed Standard  
 More info: [Datatracker](#) | [IPR](#) | [Info page](#)

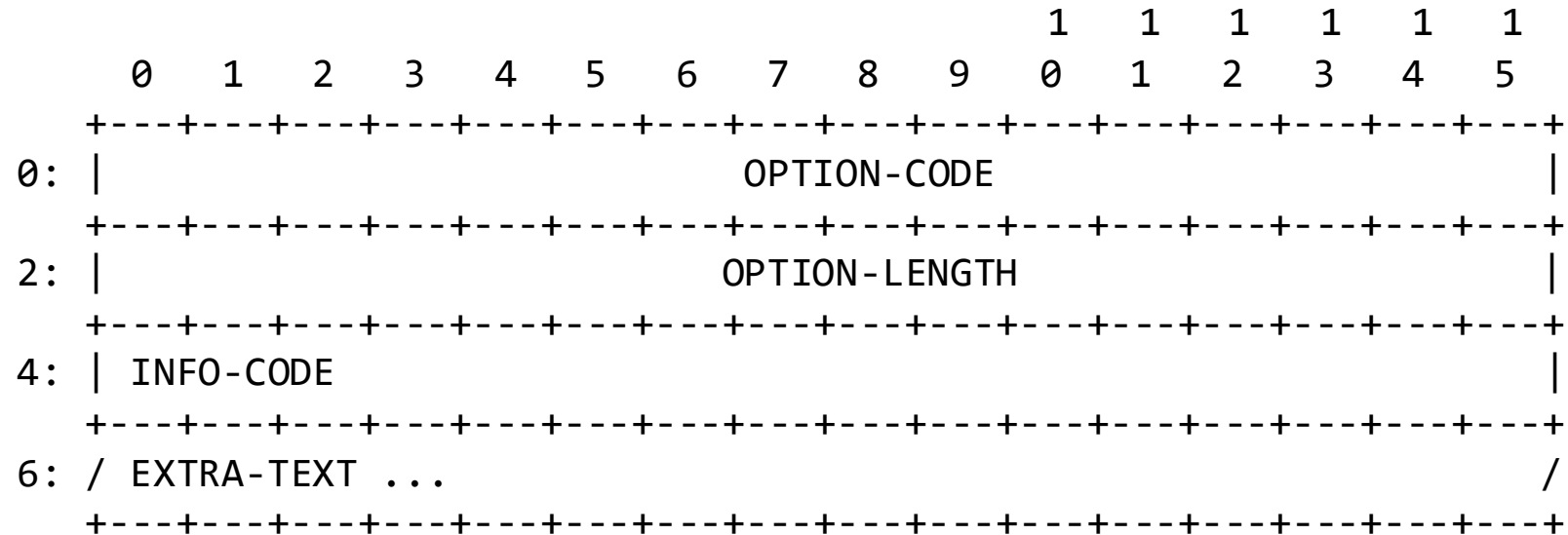
Stream: Internet Engineering Task Force (IETF)  
 RFC: [8914](#)  
 Category: Standards Track  
 Published: October 2020  
 ISSN: 2070-1721  
 Authors: W. Kumari   E. Hunt   R. Arends   W. Hardaker   D. Lawrence  
           *Google*        *ISC*            *ICANN*        *USC/ISI*        *Salesforce*

## RFC 8914 Extended DNS Errors

Source: <https://www.rfc-editor.org/rfc/rfc8914.html>

# RFC 8914: Format

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Source: <https://www.rfc-editor.org/rfc/rfc8914.html>



# Before: SERVFAIL

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```
$ dig rrsig-exp-all.extended-dns-errors.com

; <<>> DiG 9.18.28-1~deb12u2-Debian <<>> @64.6.64.6 rrsig-exp-all.extended-dns-errors.com
; (1 server found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: SERVFAIL, id: 4244
;; flags: qr rd ra; QUERY: 1, ANSWER: 0, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
;; QUESTION SECTION:
;rrsig-exp-all.extended-dns-errors.com. IN A
```

# After: SERVFAIL + EDE 7

```
$ dig rrsig-exp-all.extended-dns-errors.com
; <<>> DiG 9.18.28-1~deb12u2-Debian <<>> @1.1.1.1 rrsig-exp-all.extended-dns-errors.com
; (1 server found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: SERVFAIL, id: 37882
;; flags: qr rd ra; QUERY: 1, ANSWER: 0, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 1232
; EDE: 7 (Signature Expired): (for DNSKEY rrsig-exp-all.extended-dns-errors.com., id = 11245: RRSIG
rrsig-exp-all.extended-dns-errors.com., expiration = 1728310744)
;; QUESTION SECTION:
;rrsig-exp-all.extended-dns-errors.com. IN A
```

# Extended DNS Error Codes

Code	Purpose	Code	Purpose	Code	Purpose
0	Other Error	11	No Zone Key Bit Set	22	No Reachable Authority
1	Unsupported DNSKEY Algorithm	12	NSEC Missing	23	Network Error
2	Unsupported DS Digest Type	13	Cached Error	24	Invalid Data
3	Stale Answer	14	Not Ready	25	Signature Expired before Valid
4	Forged Answer	15	Blocked	26	Too Early
5	DNSSEC Indeterminate	16	Censored	27	Unsupported NSEC3 Iterations Value
6	DNSSEC Bogus	17	Filtered	28	Unable to conform to policy
7	Signature Expired	18	Prohibited	29	Synthesized
8	Signature Not Yet Valid	19	Stale NXDomain Answer	30	Invalid Query Type
9	DNSKEY Missing	20	Not Authoritative	31-49151	Unassigned
10	RRSIGs Missing	21	Not Supported	49152-65535	Reserved for Private Use

# DNS Resolver Recommendations

## RIPE-823

Publication date: 01 May 2024

State: Published

### Author

Shane Kerr

### Working Group

[DNS Resolver Best Common Practice Task Force](#)

### File(s)


 [PDF \(415.4 KB\)](#)

## Extended DNS Errors

**Extended DNS errors should be enabled.**

For: All DNS resolver operators.

DNS traditionally provides very broad error reporting, SERVFAIL being the most common. This makes diagnosing and fixing problems difficult. Extended DNS errors provide extra information about failures, for example expired DNSSEC signatures. They also allow resolver operators to report administrative reasons for DNS failures, such as blocks due to legal requirements.

[RFC8914](#)  defines extended DNS errors.

Source: <https://www.ripe.net/publications/docs/ripe-823/>

**Is the RFC-8914 implemented in software and public resolvers?**

# Tested Systems

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## Software:

- BIND 9.19.23
- Unbound 1.20.0
- PowerDNS Recursor 5.0.4
- Knot Resolver 5.7.3

## Public resolvers:

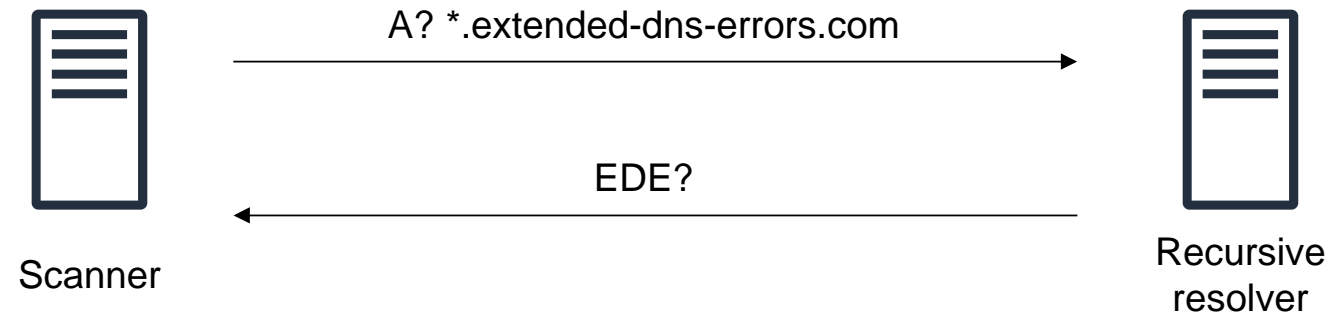
- Cloudflare (1.1.1.1)
- Google (8.8.8.8)
- Quad9 (9.9.9.9)
- DNS4ALL (194.0.5.3)
- OpenDNS (208.67.222.222)

# extended-dns-errors.com

Subdomain	Configuration
valid	The correctly configured control domain
unsigned	The domain name is not signed with DNSSEC
allow-query-none	Nameserver does not accept queries for the subdomain
allow-query-localhost	Nameserver only accepts queries from the localhost
no-ds	The subdomain is correctly signed but no DS record was published at the parent zone
ds-bad-tag	The key tag field of the DS record at the parent zone does not correspond to the KSK DNSKEY ID at the child zone
ds-bad-key-algo	The algorithm field of the DS record at the parent zone does not correspond to the KSK DNSKEY algorithm at the child zone
ds-unassigned-key-algo	The algorithm value of the DS record at the parent zone is unassigned (100)
ds-reserved-key-algo	The algorithm value of the DS record at the parent zone is reserved (200)
ds-unassigned-digest-algo	The digest algorithm value of the DS record at the parent zone is unassigned (100)

# Methodology

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# OpenDNS Censored?

```
$ dig @208.67.222.222 extended-dns-errors.com

; <<>> DiG 9.16.48-Debian <<>> @208.67.222.222 extended-dns-errors.com
; (1 server found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: REFUSED, id: 16690
;; flags: qr rd ra; QUERY: 1, ANSWER: 0, AUTHORITY: 0, ADDITIONAL: 2

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 1410
; EDE: 16 (Censored)
;; QUESTION SECTION:
;extended-dns-errors.com.      IN      A

;; ADDITIONAL SECTION:
extended-dns-errors.com. 0      IN      TXT      "The OpenDNS service is currently unavailable in France and some
French territories due to a court order under Article L.333-10 of the French Sport Code. See
https://support.opendns.com/hc/en-us"
```

# Results

	Cloudflare	Google	Quad9	OpenDNS	DNS4ALL	bind9-9.19.23	unbound-1.20.0	pdns-recursor-5.0.4	knot-resolver-5.7.3
<b>valid</b>	None	None	None	None	None	None	None	None	None
<b>no-ds</b>	None	None	None	None	None	None	None	None	None
<b>ds-bad-tag</b>	9	9	6	6	6	None	6	9	6
<b>ds-bad-key-algo</b>	9	9	6	6	6	None	6	9	None
<b>rrsig-no-a</b>	10	10	10	None	10	None	10	10	None
<b>ds-unassigned-key-algo</b>	9	None	None	6	None	None	None	None	None
<b>ed448</b>	1	None	None	None	None	None	None	None	None
<b>nsec3-iter-151</b>	6,27	5	None	12	None	None	None	None	None
<b>allow-query-none</b>	9,18,22	18,22,23	22	18	3	None	None	22	None

# Results: EDE consistency

	Cloudflare	Google	Quad9	OpenDNS	DNS4ALL	bind9-9.19.23	unbound-1.20.0	pdns-recursor-5.0.4	knot-resolver-5.7.3
<b>valid</b>	None	None	None	None	None	None	None	None	None
<b>no-ds</b>	None	None	None	None	None	None	None	None	None
<b>ds-bad-tag</b>	9	9	6	6	6	None	6	9	6
<b>ds-bad-key-algo</b>	9	9	6	6	6	None	6	9	None
<b>rrsig-no-a</b>	10	10	10	None	10	None	10	10	None
<b>ds-unassigned-key-algo</b>	9	None	None	6	None	None	None	None	None
<b>ed448</b>	1	None	None	None	None	None	None	None	None
<b>nsec3-iter-151</b>	6,27	5	None	12	None	None	None	None	None
<b>allow-query-none</b>	9,18,22	18,22,23	22	18	3	None	None	22	None

# Results: resolver configurations

	Cloudflare	Google	Quad9	OpenDNS	DNS4ALL	bind9-9.19.23	unbound-1.20.0	pdns-recursor-5.0.4	knot-resolver-5.7.3
<b>valid</b>	None	None	None	None	None	None	None	None	None
<b>no-ds</b>	None	None	None	None	None	None	None	None	None
<b>ds-bad-tag</b>	9	9	6	6	6	None	6	9	6
<b>ds-bad-key-algo</b>	9	9	6	6	6	None	6	9	None
<b>rrsig-no-a</b>	10	10	10	None	10	None	10	10	None
<b>ds-unassigned-key-algo</b>	9	None	None	6	None	None	None	None	None
<b>ed448</b>	1	None	None	None	None	None	None	None	None
<b>nsec3-iter-151</b>	6,27	5	None	12	None	None	None	None	None
<b>allow-query-none</b>	9,18,22	18,22,23	22	18	3	None	None	22	None

# Results: resolver configurations

```
$ dig @1.1.1.1 foo.nsec3-iter-151.extended-dns-errors.com
...
;; ->>HEADER<<- opcode: QUERY, status: SERVFAIL, id: 7907
...
; EDE: 6 (DNSSEC Bogus): (proof of non-existence of foo.nsec3-iter-151.extended-dns-errors.com. A)
; EDE: 27: (NSEC3 iterations limit exceeded)
```

```
$ dig @8.8.8.8 foo.nsec3-iter-151.extended-dns-errors.com
...
;; ->>HEADER<<- opcode: QUERY, status: NXDOMAIN, id: 15632
...
; EDE: 5 (DNSSEC Indeterminate): (NSEC3 iteration count 151 is too high (RFC9276) at foo.nsec3-iter-151.extended-dns-errors.com/a)
```

```
$ dig @208.67.222.222 foo.nsec3-iter-151.extended-dns-errors.co
...
;; ->>HEADER<<- opcode: QUERY, status: SERVFAIL, id: 4004
...
; EDE: 12 (NSEC Missing)
```

# Results: resolver capabilities

	Cloudflare	Google	Quad9	OpenDNS	DNS4ALL	bind9-9.19.23	unbound-1.20.0	pdns-recursor-5.0.4	knot-resolver-5.7.3
<b>valid</b>	None	None	None	None	None	None	None	None	None
<b>no-ds</b>	None	None	None	None	None	None	None	None	None
<b>ds-bad-tag</b>	9	9	6	6	6	None	6	9	6
<b>ds-bad-key-algo</b>	9	9	6	6	6	None	6	9	None
<b>rrsig-no-a</b>	10	10	10	None	10	None	10	10	None
<b>ds-unassigned-key-algo</b>	9	None	None	6	None	None	None	None	None
<b>ed448</b>	1	None	None	None	None	None	None	None	None
<b>nsec3-iter-151</b>	6,27	5	None	12	None	None	None	None	None
<b>allow-query-none</b>	9,18,22	18,22,23	22	18	3	None	None	22	None

# Results: EDE-6 (DNSSEC Bogus)

	Cloudflare	Google	Quad9	OpenDNS	DNS4ALL	bind9-9.19.23	unbound-1.20.0	pdns-recursor-5.0.4	knot-resolver-5.7.3
<b>valid</b>	None	None	None	None	None	None	None	None	None
<b>no-ds</b>	None	None	None	None	None	None	None	None	None
<b>ds-bad-tag</b>	9	9	6	6	6	None	6	9	6
<b>ds-bad-key-algo</b>	9	9	6	6	6	None	6	9	None
<b>rrsig-no-a</b>	10	10	10	None	10	None	10	10	None
<b>ds-unassigned-key-algo</b>	9	None	None	6	None	None	None	None	None
<b>ed448</b>	1	None	None	None	None	None	None	None	None
<b>nsec3-iter-151</b>	6,27	5	None	12	None	None	None	None	None
<b>allow-query-none</b>	9,18,22	18,22,23	22	18	3	None	None	22	None

# Why important?

Status: Proposed Standard  
 More info: [Datatracker](#) | [IPR](#) | [Info page](#)

Stream: Internet Engineering Task Force (IETF)  
 RFC: [9567](#)  
 Category: Standards Track  
 Published: April 2024  
 ISSN: 2070-1721  
 Authors: R. Arends M. Larson  
*ICANN ICANN*

## RFC 9567 DNS Error Reporting

### Abstract

DNS error reporting is a lightweight reporting mechanism that provides the operator of an authoritative server with reports on DNS resource records that fail to resolve or validate. A domain owner or DNS hosting organization can use these reports to improve domain hosting. The reports are based on extended DNS errors as described in RFC 8914.

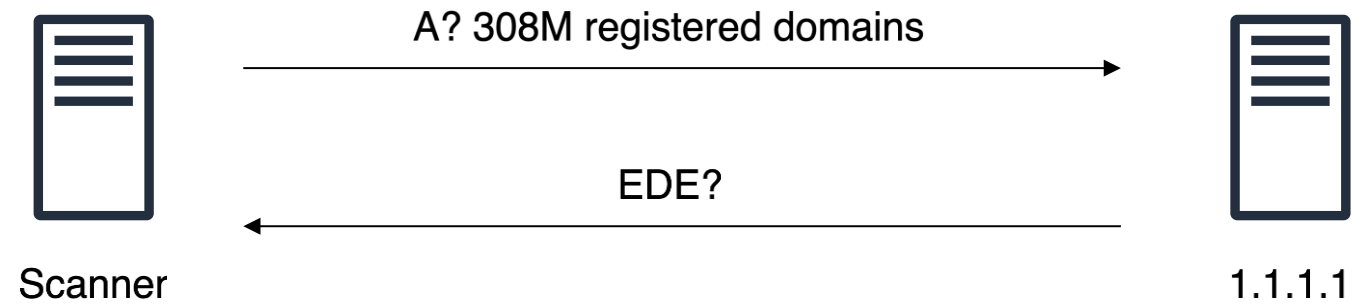
Source: <https://www.rfc-editor.org/rfc/rfc9567.html>



**What are the most common  
misconfigurations in the wild?**

# Methodology

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# Results

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- 19.1M domains trigger EDEs
- 19 unique EDE codes
- 240 combinations of up to 5 individual EDEs

# EDE 22 (No Reachable Authority)

---

The resolver could not reach any of the authoritative name servers (or they potentially refused to reply).

```
$ dig @1.1.1.1 example.com
...
;; ->>HEADER<<- opcode: QUERY, status: SERVFAIL, id: 32496
...
; EDE: 22 (No Reachable Authority): (at delegation example.com.)
```

14.1 million domains

# EDE 23 (Network Error)

---

An unrecoverable error occurred while communicating with another server.

```
$ dig @1.1.1.1 example.com
...
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 32496
...
; EDE: 23 (Network Error): (X.X.X.X:53 rcode=REFUSED for example.com A)
```

10.2 million domains

# EDE 22 + EDE 23

---

The most common combination of EDEs.

```
$ dig @1.1.1.1 example.com
...
;; ->>HEADER<<- opcode: QUERY, status: SERVFAIL, id: 32496
...
; EDE: 22 (No Reachable Authority): (at delegation example.com.)
; EDE: 23 (Network Error): (X.X.X.X:53 timed out for example.com A)
```

8.6 million domains

# EDE 20 (Not Authoritative)

---

An authoritative server that receives a query with the Recursion Desired (RD) bit clear, or when it is not configured for recursion for a domain for which it is not authoritative, SHOULD include this EDE code in the REFUSED response. A resolver that receives a query with the RD bit clear SHOULD include this EDE code in the REFUSED response.

```
$ dig @1.1.1.1 example.com
...
;; ->>HEADER<<- opcode: QUERY, status: SERVFAIL, id: 17365
...
; EDE: 20 (Not Authoritative): (zone not managed by server)
; EDE: 22 (No Reachable Authority): (at delegation example.com.)
```

2.2 million domains

# EDE 18 (Prohibited)

---

An authoritative server or recursive resolver that receives a query from an "unauthorized" client can annotate its REFUSED message with this code. Examples of "unauthorized" clients are recursive queries from IP addresses outside the network, blocklisted IP addresses, local policy, etc.

```
$ dig @1.1.1.1 example.com
...
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 17365
...
; EDE: 18 (Prohibited)
```

1.6 million domains



# EDE 10 (RRSIGs Missing)

---

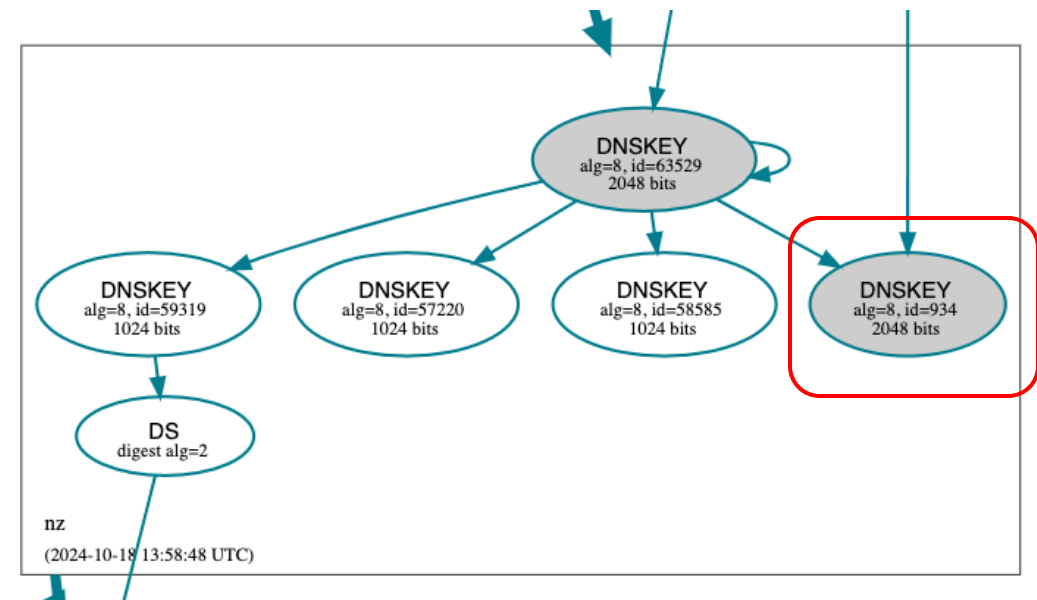
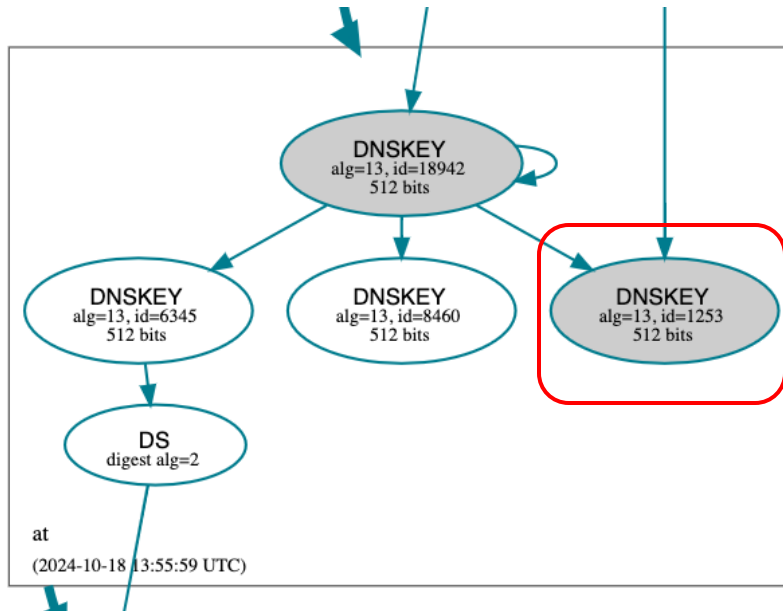
The resolver attempted to perform DNSSEC validation, but no RRSIGs could be found for at least one RRset where RRSIGs were expected.

```
$ dig @1.1.1.1 nic.at
...
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 6033
...
; EDE: 10 (RRSIGs Missing): (for DNSKEY at., id = 1253)
```

```
$ dig @1.1.1.1 internetnz.nz
...
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 4234
...
; EDE: 10 (RRSIGs Missing): (for DNSKEY nz., id = 934)
```

2.2 million domains

# EDE 10 (RRSIGs Missing)



Source: <https://dnsviz.net/d/nic.at/dnssec/>

# EDE 10 (RRSIGs Missing)

---

10 RRSIGs Missing

```
EDE: 10 (RRSIGs Missing): (for DNSKEY  
example.com., id = 12345)
```

1.1.1.1 was unable to retrieve Resource Record Signatures (RRSigs) to verify the authenticity of the records. Check your DNS configuration and the response code. If the response code is not `SERVFAIL`, this error indicates that there is a non-operational key issue somewhere along the path, but the resolver found at least one successful path for validation. Examples of non-operational key issues include but are not limited to key rollover in-progress, stand-by key, and attacker stripping signatures made by a certain key.

Source: <https://developers.cloudflare.com/1.1.1.1/infrastructure/extended-dns-error-codes/>

**Many more interesting cases  
to dig into ...**

# Conclusions

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- Supported by major DNS systems
- Identifies the root cause of problems
- Efficient at scale

# Thanks!

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