dnssec-detect项目年度报告

- illuminate
- iwbtfy

1.项目背景与要求

1.1 梳理错误类型

INFO-CODE	PURPOSE	DESCRIPTION
0	other error	does not match known extended error
1	Unsupported DNSKEY Algorithm	DNSKEY RRset contained only unsupported DNSSEC algorithms.
2	Unsupported DS Digest Type	a DS RRset contained only unsupported Digest Types.
3	stale Answer	The resolver was unable to resolve the answer within its time limits
4	Forged Answer	provide a forged answer for some reasons
5	DNSSEC Indeterminate	DNSSEC validation by resolver ended in the indeterminate state
6	DNSSEC Bogus	DNSSEC validation by resolver ended in the bogus state
7	Signature Expired	no signatures are presently valid and some (often all) are expired
8	Signature Not Yet Valid	no signatures are presently valid and at least some are not yet valid.

INFO-CODE	PURPOSE	DESCRIPTION
9	DNSKEY Missing	A DS record existed at a parent, but no supported matching DNSKEY record could be found for the child
10	RRSIGs Missing	no RRSIGs could be found for at least one RRset where RRSIGs were expected.
11	No Zone Key Bit Set	no Zone Key Bit was set in a DNSKEY
12	NSEC Missing	the requested data was missing and a covering NSEC or NSEC3 was not provided.
13	Cached Error	The resolver is returning the SERVFAIL RCODE from its cache.
14	Not Ready	The server is unable to answer the query, as it was not fully functional when the query was received.
15	Blocked	The server is unable to respond to the request because the domain is on a blocklist
16	Censored	The server is unable to respond to the request because the domain is on a blocklist due to an external requirement imposed by an entity
17	Filtered	the request domain is on a blocklist as requested by the client
18	Prohibited	a query from an "unauthorized" client can annotate its REFUSED message with this code
19	Stale NXDomain Answer	answer with a previously cached NXDOMAIN answer
20	Not Authoritative	
21	Not Supported	The requested operation or query is not supported
22	No Reachable Authority	The resolver could not reach any of the authoritative name servers (or they potentially refused to reply).
23	Network Error	An unrecoverable error occurred while communicating with another server.

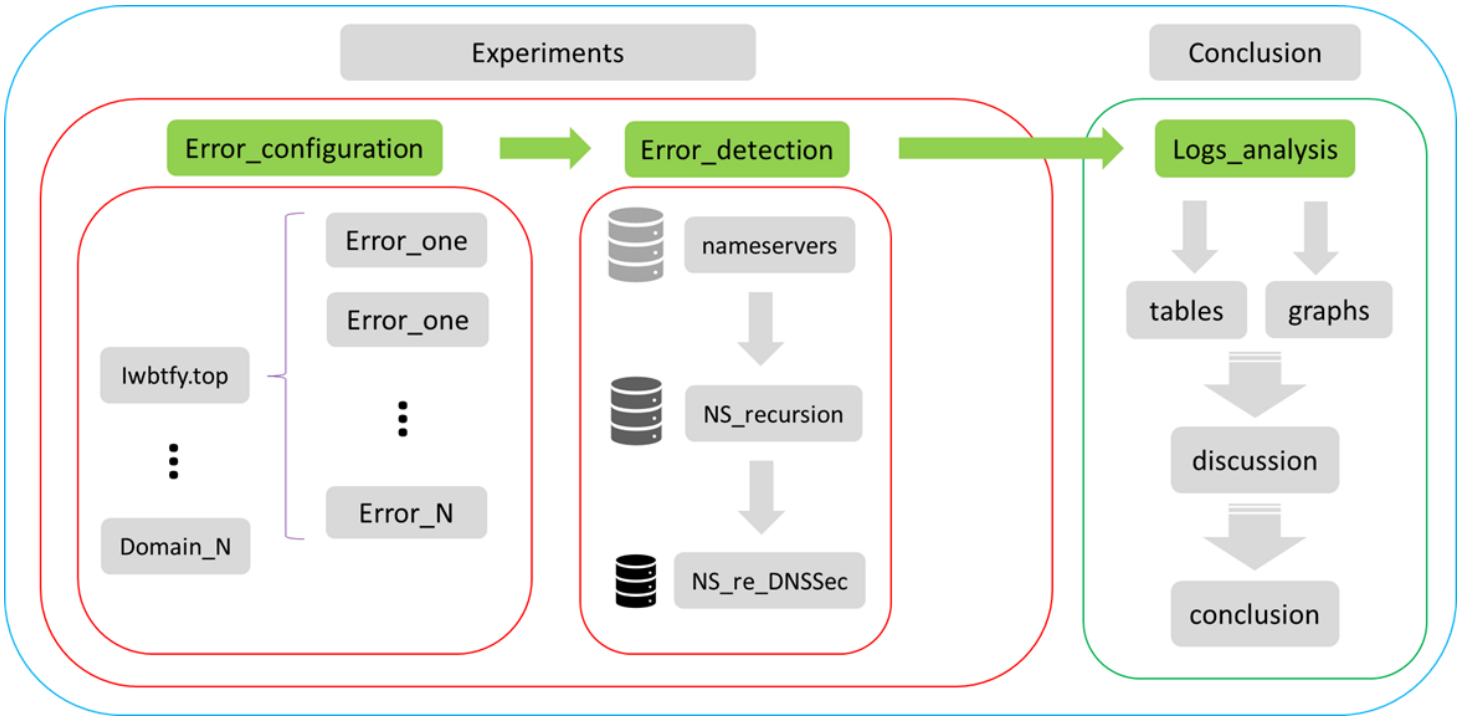
INFO-CODE	PURPOSE	DESCRIPTION
24	Invalid Data	The authoritative server cannot answer with data for a zone it is otherwise configured to support
25-49151	Unassigned	
49151-65535	reserved for private use	

1.2 配置梳理的错误并且验证服务器是否可以检测错误

- 在梳理完错误的基础上，拟搭建测试环境，将多个支持DNSSEC的权威域名设置不同错误配置，通过命令行和脚本的形式发数据包请求，对开放的支持DNSSEC的重要递归解析服务器进行探测，分析递归解析服务器是否提供相应的错误提示，以判定递归服务器对DNSSEC配置错误是否有效验证。

2.项目方案

首先，我们基于 RFC8914 等标准，全面梳理DNSSEC的错误配置类型；
接着，我们搭建了域名iwbtfy.top，配置好了可以配置的相关错误；
同时，为了配置更多的错误，我们扩展到三级域，并且进行相应的配置；
然后，我们从全球前百万的dns服务器表中筛选了支持dnssec的递归服务器；
最后，编写好python脚本探测程序，以及python结果统计程序，对这一错误进行检错统计。大致方案流程如下图：

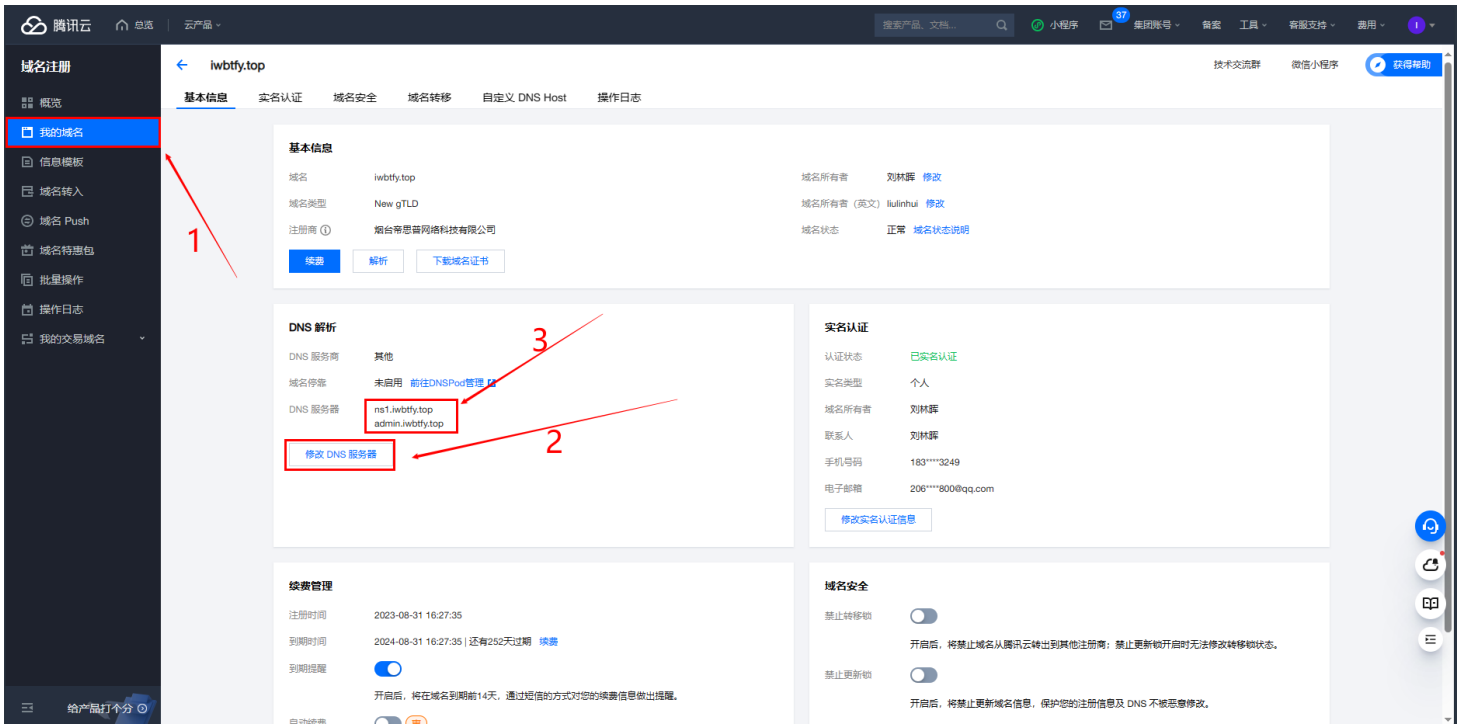


2.1 环境准备

- 一台腾讯云服务器：123.207.59.193
- 一个腾讯云的域名：iwbtfy.top

2.2 配置域名iwbtfy.top

1. 将租借的iwbtfy.top域名解析的dns服务器指向租借的腾讯云服务器



2. 在腾讯云服务器中配置该域名的域配置文件，使其可以成功解析域名

- 下载安装bind

```
yum install bind -y
```

- 配置/etc/named.conf文件

```
zone "iwbtfy.top" IN {
    type master;
    auto-dnssec maintain;
    update-policy local;
    file "iwbtfy.top.zone";
    key-directory "/var/named/keys";
};
```

- 配置/var/named/iwbtfy.top.zone文件

```
$TTL 600
iwbtfy.top.     IN      SOA     ns      admin.iwbtfy.top. (
                3
                1H
                5M
                2D
                6H )
iwbtfy.top.     IN      NS      ns.iwbtfy.top.
iwbtfy.top.     IN      MX  10  mail.iwbtfy.top.
ns              IN      A       123.207.59.193
mail            IN      A       123.207.59.193
;www            IN      A       123.207.59.193
;ftp            IN      CNAME   www
@               IN      A       123.207.59.193
www             IN      NS      ns1.www
ns1.www         IN      A       123.207.59.193
```

3. 在腾讯云服务器中进一步配置该域名的dnssec配置

- 生成keys

```
mkdir  /var/named/keys                          # 创建文件夹
cd  /var/named/keys
dnssec-keygen -f KSK -a RSASHA1 -r /dev/urandom -b 512 -n ZONE iwbtfy.top.
dnssec-keygen -a RSASHA1 -r /dev/urandom -b 512 -n ZONE iwbtfy.top.

kSK  Kiwbtfy.top.+005+16429.key
ZSK  Kiwbtfy.top.+005+63462.key
```

- 将keys添加到/var/named/iwbtfy.top.zone

```
vi  iwbtfy.top.zone 添加
$INCLUDE "/var/named/keys/Kiwbtfy.top.+005+16429.key"
$INCLUDE "/var/named/keys/Kiwbtfy.top.+005+63462.key"
```

- 用keys签名zone

```
dnssec-signzone -K /var/named/keys -o iwbtfy.top. /var/named/iwbtfy.top.zone
```

- 修改/etc/named.conf文件

```
zone "iwbtfy.top" IN {
    type master;
    auto-dnssec maintain;
    update-policy local;
    file "iwbtfy.top.zone.signal";                    # 改成签名过的域文件
    key-directory "/var/named/keys";
};
```

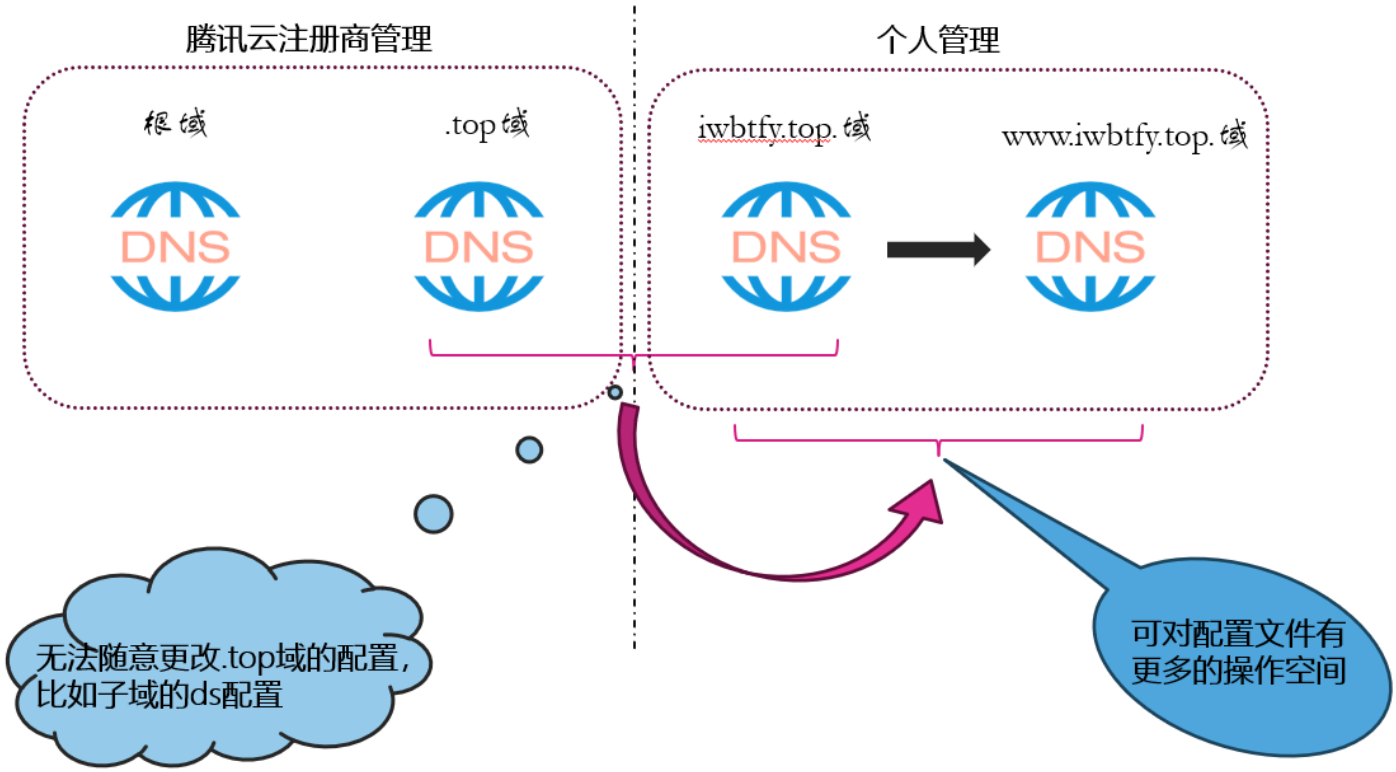
- 生成ds记录

```
dnssec-dsfromkey -2 Kiwbtfy.top.+005+16429.key

iwbtfy.top. IN DS 16429 5 2 C86EDB0E66548551236FDF978CB92E12F005C033FA2B7DC21AA4FD98BF0E5E8
```

- 将ds记录添加到腾讯云控制台

2.3 扩展三级域——www.iwbtfy.top



2.4 修改域名dnssec配置——配置错误

具体修改------> 3.项目方案实施结果总结

2.5 筛选支持dnssec的递归服务器

- **收集dns服务器**
  - 网址：https://public-dns.info/
- **筛选支持dnssec的递归服务器**
  - recursion

```
# 筛选递归服务器
# flag字段中含有RA ---> recursion available
# 参数说明
# nameserver：需要检测的dns服务器ip
def is_recursion(nameserver):
  # 定义dig命令和参数
  dig_command = ['dig', '+norecurse', 'example.com', '@' + nameserver]

  # 执行dig命令
  try:
      dig_output = subprocess.check_output(dig_command)
  except subprocess.CalledProcessError as e:
      print("Error running dig:", e)
      exit(1)

  # 在输出中查找包含"flags"的行
  flags_line = None
  for line in dig_output.split('\n'):
      if "flags".encode("utf-8") in line:
          flags_line = line
          break

  # 从含有flags的行中进一步查询是否有RA字段
  if "ra".encode("utf-8") in flags_line:
      return True
  else:
      return False
```

  - dnssec

```python
# 筛选递归服务器中的支持dnssec的递归服务器
# flag字段中含有AD ---> authenticated data
# 参数说明
# nameserver：需要检测的dns服务器ip
def is_dnssec(nameserver):
  # 定义dig命令和参数
  dig_command_two = ['dig', '+norecurse', 'example.com', '@' + nameserver]

  # 执行dig命令
  try:
      dig_output = subprocess.check_output(dig_command_two)
  except subprocess.CalledProcessError as e:
      print("Error running dig:", e)
      exit(1)

  # 在输出中查找包含"flags"的行
  flags_line = None
  for line in dig_output.split('\n'):
      if "flags".encode("utf-8") in line:
          flags_line = line
          break

  # 从含有flags的行中进一步查询是否有RA字段
  if "ad".encode("utf-8") in flags_line:
      return True
  else:
      return False
```

2.6 编写脚本探测服务器检错能力

```
# 检测dnssec的配置错误并且写入文件
# 参数说明
# errors: 配置的错误(如果不知道可以填NULL)        domain_name: 需要检测的域名
# nameserver_file: 使用的递归服务器的文件路径      key_file: 根服务器的key的路径
# logs: 存储日志的列表                            record_types: 需要查询域名的记录类型
# project_root_file: 项目的根路径
def detect_error(errors, domain_names, nameserver_file, key_file, logs, record_types, project_r
    log_file = os.path.join(project_root_file, "data", "detect_logs",
                            "detect_logs_" + domain_names.split('.')[0] + '_' +
                            errors + ".txt")
    nameserver_re_dnssec = np.loadtxt(nameserver_file, delimiter=',', dtype=str)
    errors_set = set()
    for nameserver in nameserver_re_dnssec:
        # 创建dig命令
        dig_command = ['dig', '@' + nameserver, '+sigchase', '+trusted-key=' + key_file, domain_
        try:
            # 日志
            logs.append(nameserver)
            result = subprocess.check_output(dig_command)
            lines = result.splitlines()
            if lines:
                last_line = lines[-1]
                if not last_line:
                    last_line = lines[-2]
                print(last_line)
                errors_set.add(last_line)
            # 保存日志
            logs.append(result)
        except subprocess.CalledProcessError as e:
            errors_set.add("DIG command failed")
            logs.append("DIG command failed")
            print("connection time out")
        except FileNotFoundError:
            print('DIG command not found. Make sure dig is installed on your system.')

    # 将log这个list写入txt文件
    np.savetxt(log_file, logs, delimiter=',', fmt='%s')
    # 将error_set 写入txt文件
    error_list = list(errors_set)
    error_list_file = os.path.join(project_root_file, "data", "error_list",
                                   "errors_list_" + domain_names.split('.')[0] + '_' +
```

```
                                        errors + ".txt")
    np.savetxt(error_list_file, error_list, delimiter=',', fmt='%s')
```

2.7 结果统计与分析

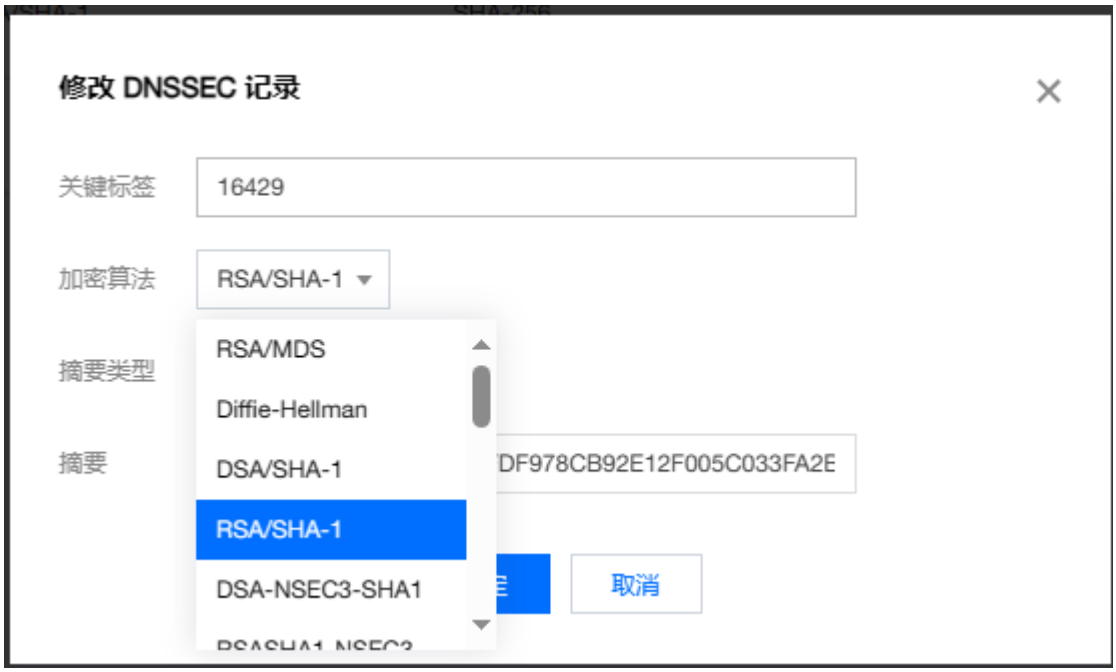
具体统计分析------> 3.项目方案实施结果总结

3.项目方案实施结果总结

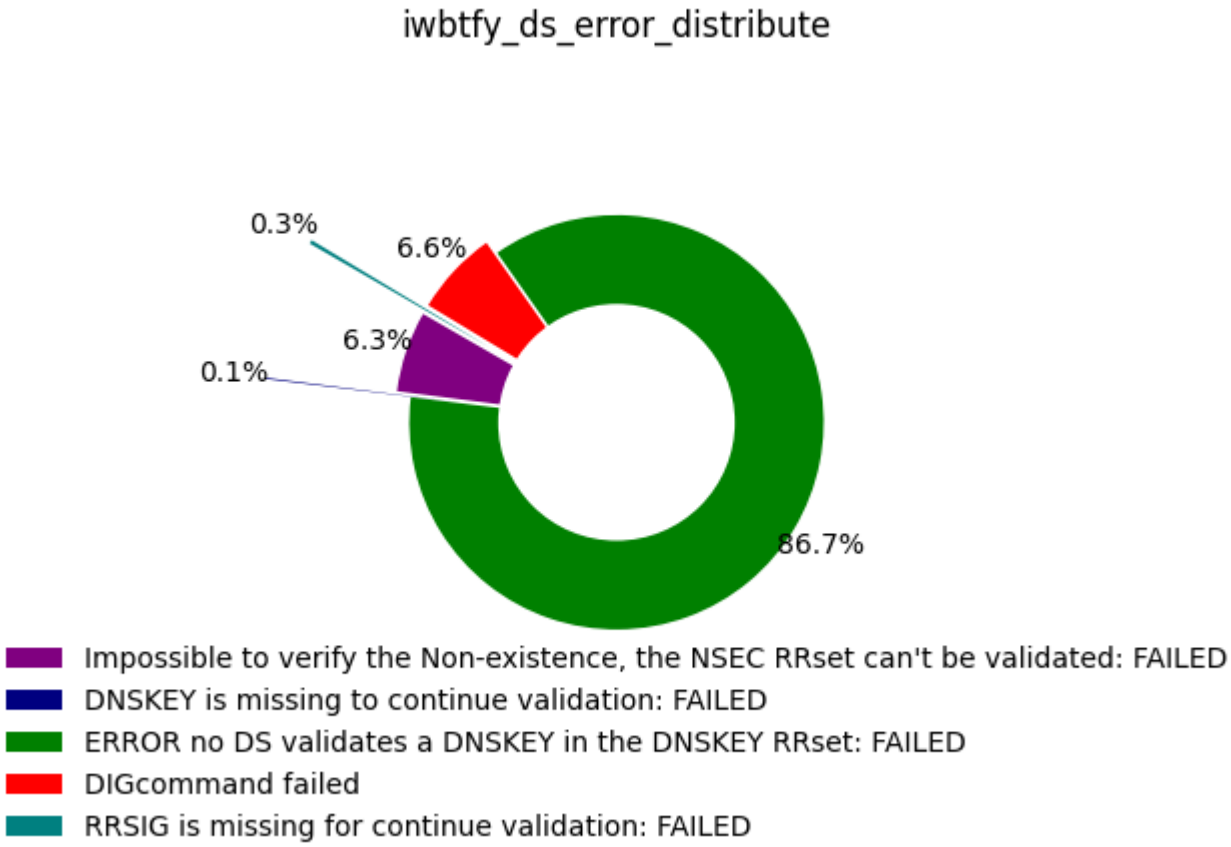
3.1 iwbtfy.top上配置的错误

1. **错误的ds**

- 配置：修改ds记录的摘要算法



- 结果：



- 说明：
  - Error no DS validates a DNSKEY in the DNSKEY RRset：期望的正确返回
  - DIGcommand failed：无法连接到dns服务器
  - Impossible to verify the non-existence, the NSEC RRset can’t be validated：服务器探测不到域名的A地址时的返回，即当服务器发现域名的DNSSEC配置有问题后就不再进一步解析，也可算是一种检错的结果
  - DSKEY is missing to Ncontinue validation：检测错误
  - RRSIG is missing to continue validation：检测错误
  - 针对该配置错误类型，我们以Error no DS validates a DNSKEY in the DNSKEY Rrset为主要判断依据。

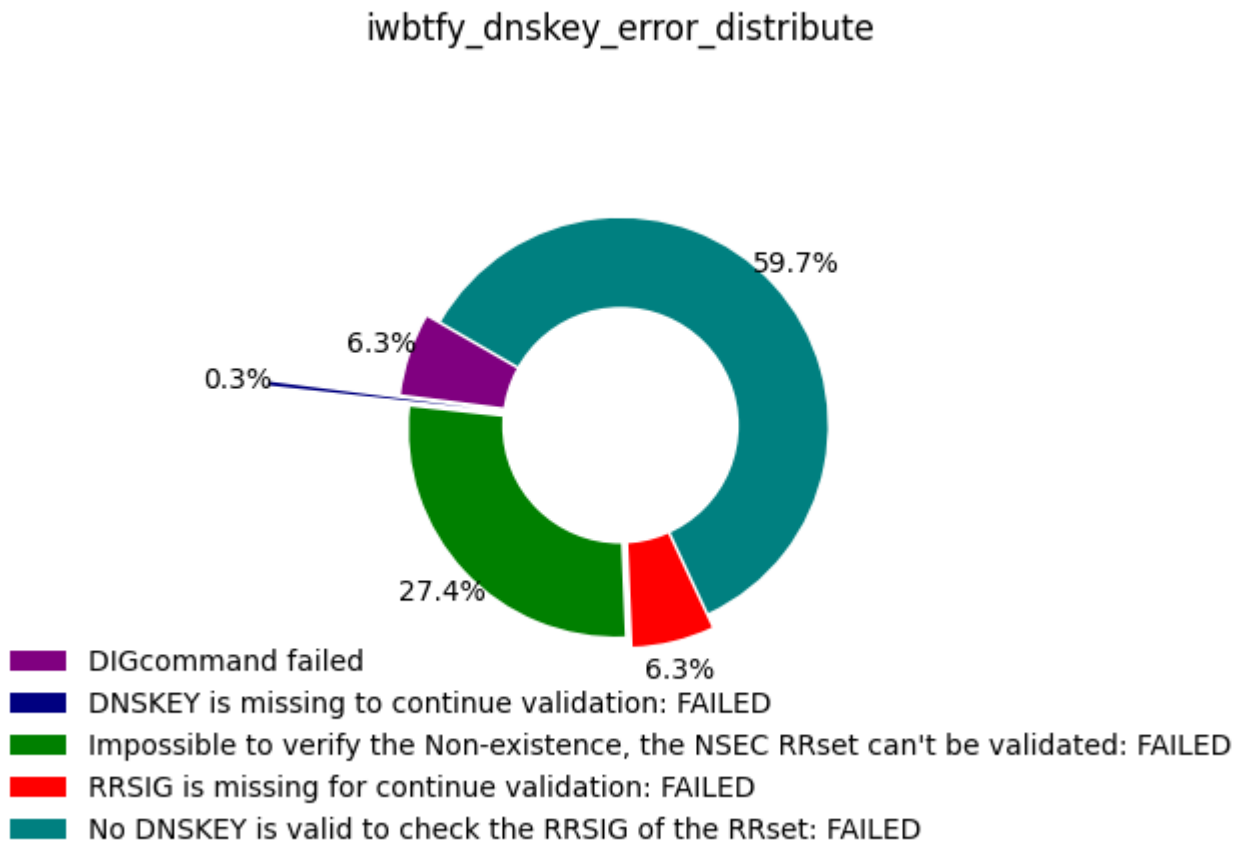
2. **Unsupported DNSKEY Algorithm**

- 配置：将DNSKEY的签名算法值改掉

```
600     DNSKEY  256 3 5 (
        AwEAAdxgYRXnZANzpvCRkDg7chu82TfMMqHa
        U4VB/G0lT5rUlGdi1GZfSgjLmcjWt2X+i0lZ
        QAuojeKlOMRUnIb3h1U=
        ) ; ZSK; alg = RSASHA1 ; key id = 63462

5 ----> 30
```

- 结果:



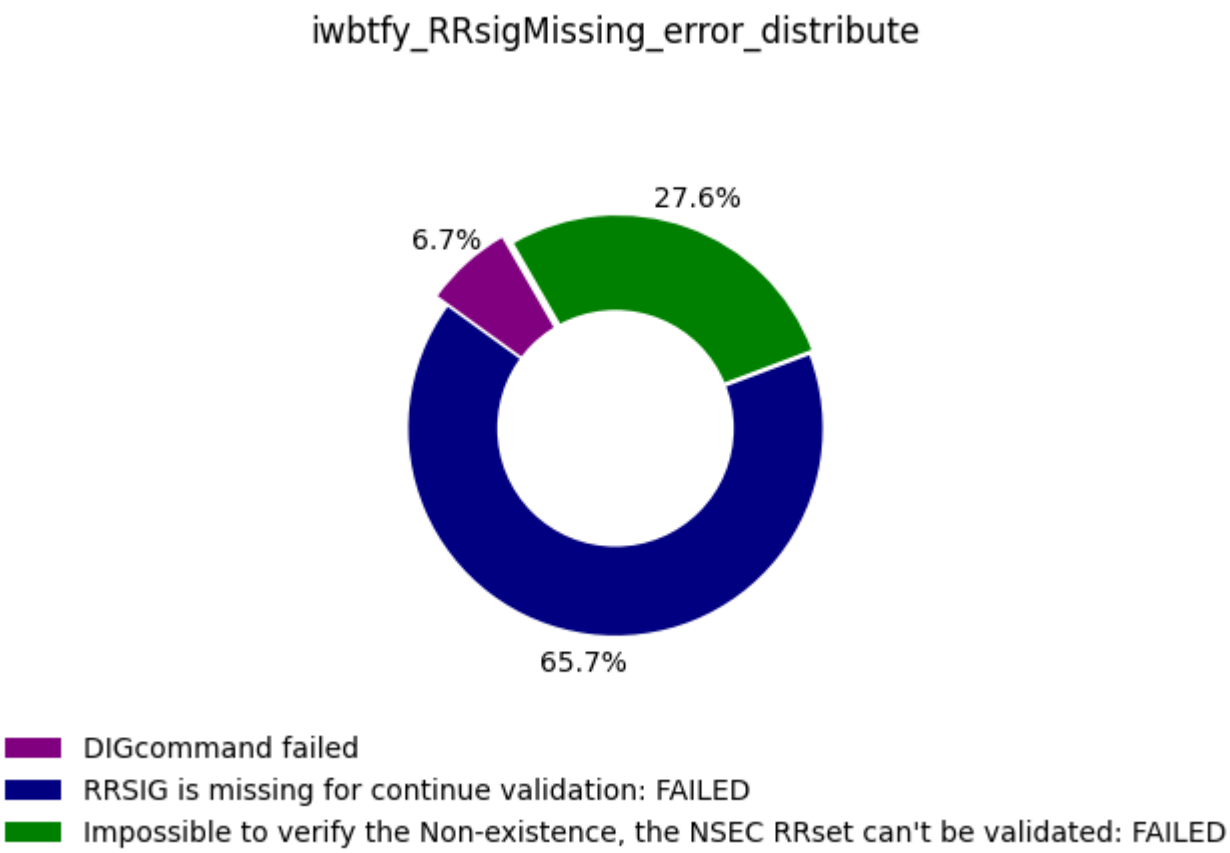
- 说明:
  - No DNSKEY is valid to check the RRSIG of the RRset：期望的正确返回
  - DIGcommand failed：无法连接到dns服务器
  - Impossible to verify the non-existence, the NSEC RRset can’t be validated：服务器探测不到域名的A地址时的返回，即当服务器发现域名的DNSSEC配置有问题后就不再进一步解析，也可算是一种检错的结果
  - DNSKEY is missing to continue validation：检测错误
  - RRSIG is missing to continue validation：检测错误
  - 针对该配置错误类型，我们以No DNSKEY is valid to check the RRSIG of the RRset为主要判断依据。

3. **RRSIG missing**

- 配置: 直接注释掉A记录的RRSIG

```
        600       A       123.207.59.193
;       600       RRSIG   A 5 2 600 (
;                 20240112145536 20231213145536 63462 iwbtfy.top.
;                 hdCiDnQ11MYeqRhx+PzKMFrFgsujDoD/PWSe
;                 hWR9KwawsoDabXWjmryhT5PzwpIsuVim09Qw
;                 BwYqeLtjCvguFQ== )
```

- 结果:



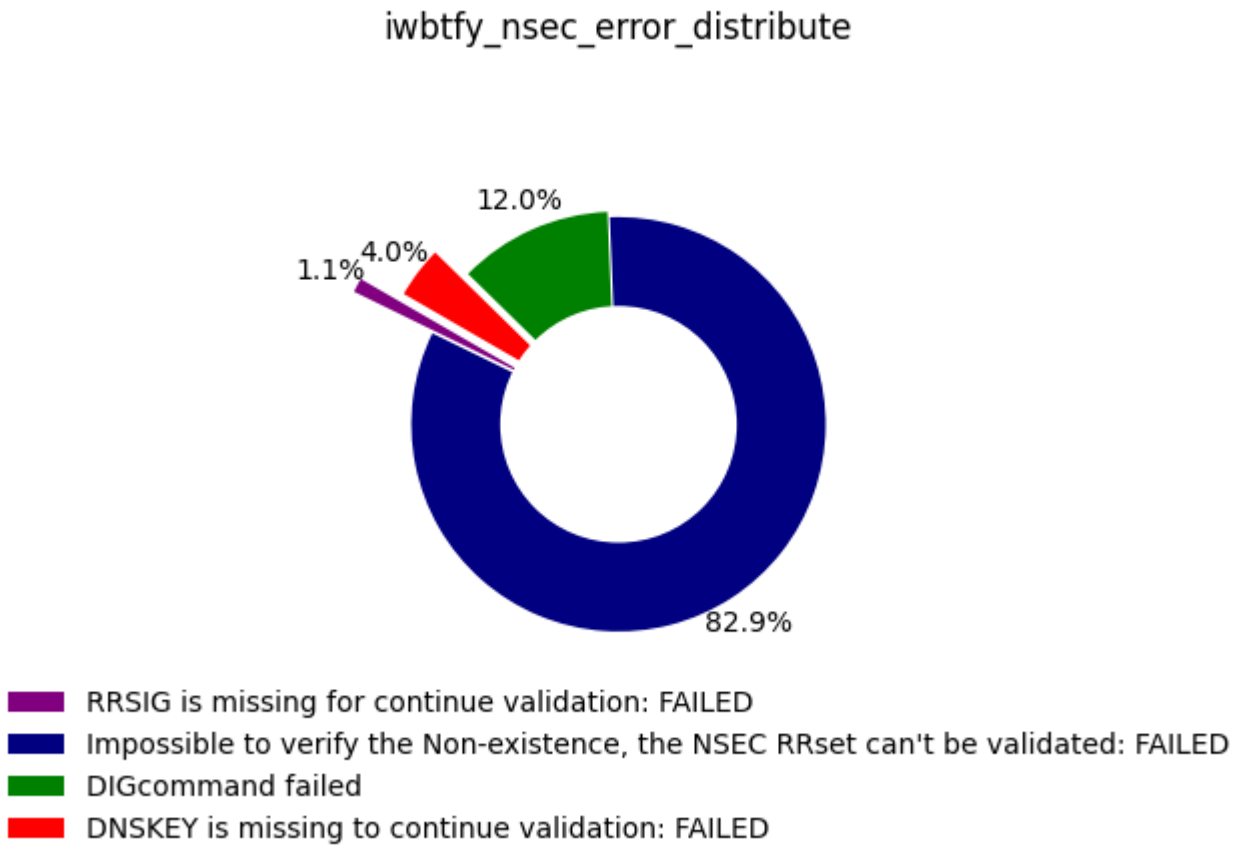
- 说明:
  - RRSIG is missing to continue validation：期望的正确返回
  - DIGcommand failed：无法连接到dns服务器
  - Impossible to verify the non-existence, the NSEC RRset can’t be validated：服务器探测不到域名的A地址时的返回，即当服务器发现域名的DNSSEC配置有问题后就不再进一步解析，也可算是一种检错的结果
  - 针对该配置错误类型，我们以RRSIG is missing to continue validation为主要判断依据。

4. **NSEC missing**

- 配置: 直接注释掉nsec

```
;                       21600   NSEC    mail.iwbtfy.top. A NS SOA MX RRSIG NSEC DNSKEY
;                       21600   RRSIG   NSEC 5 2 21600 (
;                                       20240112145536 20231213145536 63462 iwbtfy.top.
;                                       HVTpaXHK2/gQXtj6MEaL0f1KntSWRSk2gHnl
;                                       3F9cjYttR/jcLWYdJOshXBNjSWokpvF7auih
;                                       3+li4ADLAIFMYw== )
```

- 结果:



- 说明:
  - Impossible to verify the non-existence, the NSEC RRset can’t be validated：期望的正确返回
  - DIGcommand failed：无法连接到dns服务器
  - DNSKEY is missing to continue validation：检测错误
  - RRSIG is missing to continue validation：检测错误
  - 针对该配置错误类型，我们以Impossible to verify the non-existence, the NSEC RRset can’t be validated为主要判断依据。

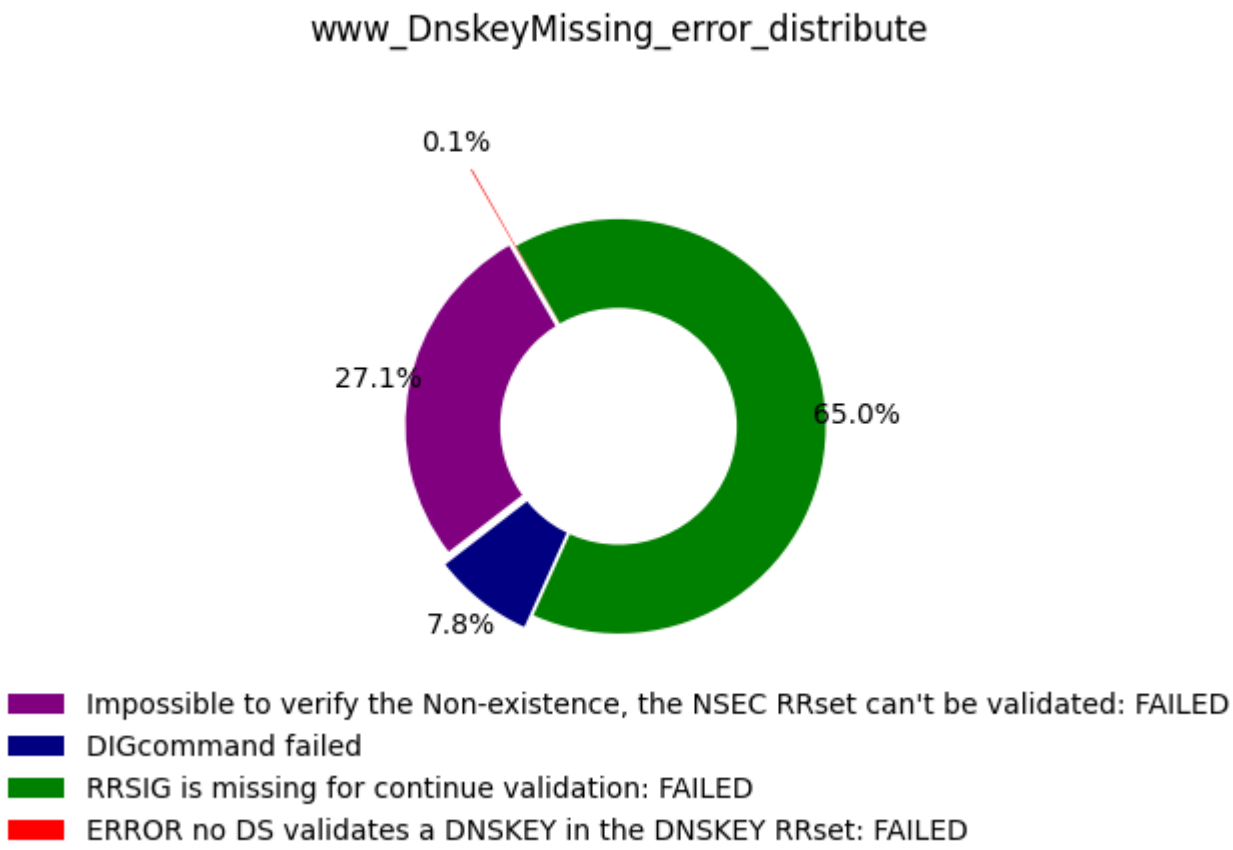
3.2 www.iwbtfy.top上配置的错误

1. **DNSKEY missing**

- 配置: 直接注释掉DNSKEY

```
;       600       DNSKEY  256 3 5 (
;               AwEAAZjFG/UFHijzwJ5d2TpLl7XYwKJodDpJ
;               LrSxRAHMEqAd7O0t0NVtXRooQPO+RjgGIqmp
;               D9BB3cpzhuqeQSLHI3k=
;               ) ; ZSK; alg = RSASHA1 ; key id = 24216
```

- 结果:



- 说明:
  - RRSIG is missing to continue validation：期望的正确返回
  - DIGcommand failed：无法连接到dns服务器
  - Impossible to verify the non-existence, the NSEC RRset can’t be validated：服务器探测不到域名的A地址时的返回，即当服务器发现域名的DNSSEC配置有问题后就不再进一步解析，也可算是一种检错的结果
  - Error no DS validates a DNSKEY in the DNSKEY RRset：检测错误

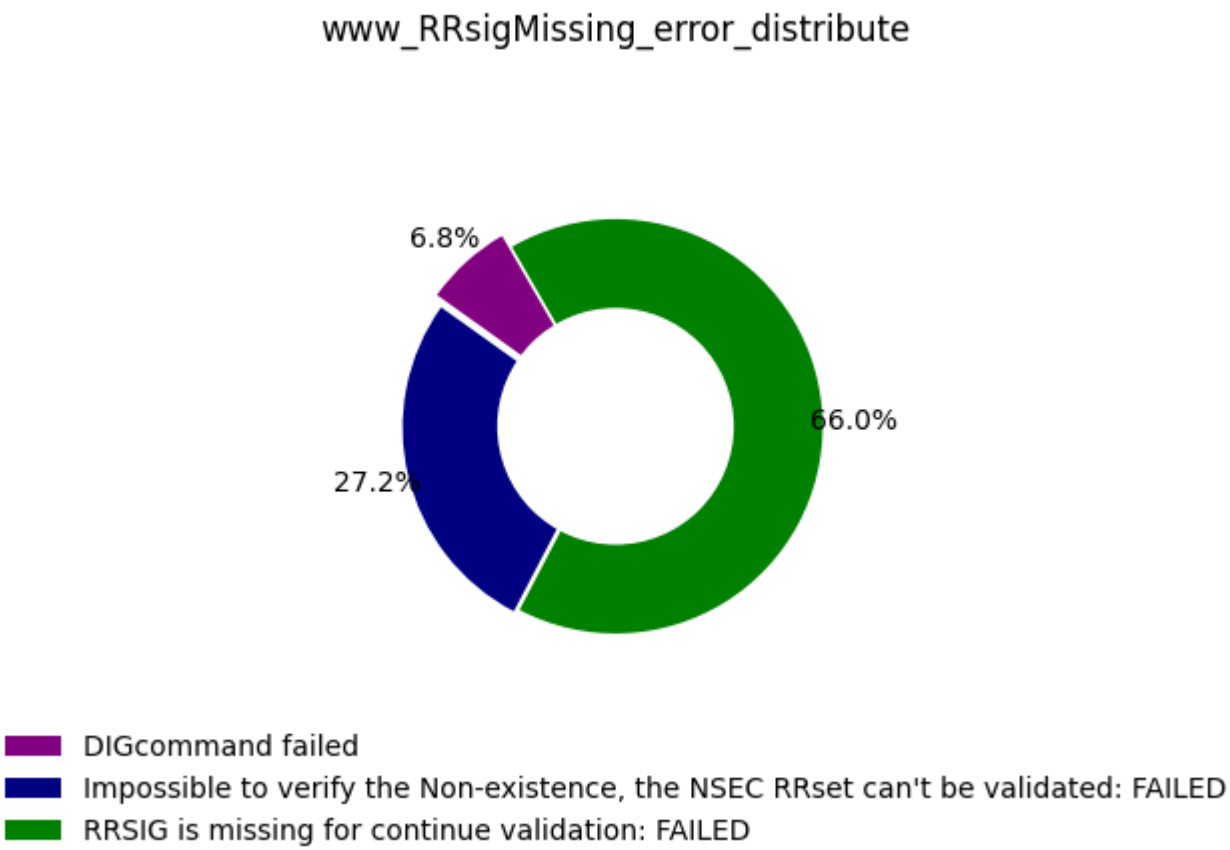
- 针对该配置错误类型，我们以RRSIG is missing to continue validation为主要判断依据。

2. **RRSIG missing**

- 配置: 直接注释掉RRSIG

```
        600     A       123.207.59.193
;       600     RRSIG   A 5 3 600 (
;                20240113102237 20231214102237 24216 www.iwbtfy.top.
;                fHjWKPUHJdUhWZiZmQJyVG23gPZdEcNbhwe1
;                ievRpFmRvUa9dAiCtTqeHXWhxy+U8i6EjSNM
;                4Tv7HXZc/OKpPw== )
```

- 结果:



- 说明:
  - RRSIG is missing to continue validation：期望的正确返回
  - DIGcommand failed：无法连接到dns服务器
  - Impossible to verify the non-existence, the NSEC RRset can’t be validated：服务器探测不到域名的A地址时的返回，即当服务器发现域名的DNSSEC配置有问题后就不再进一步解析，也可算是一种检错的结果

- 针对该配置错误类型，我们以RRSIG is missing to continue validation为主要判断依据。

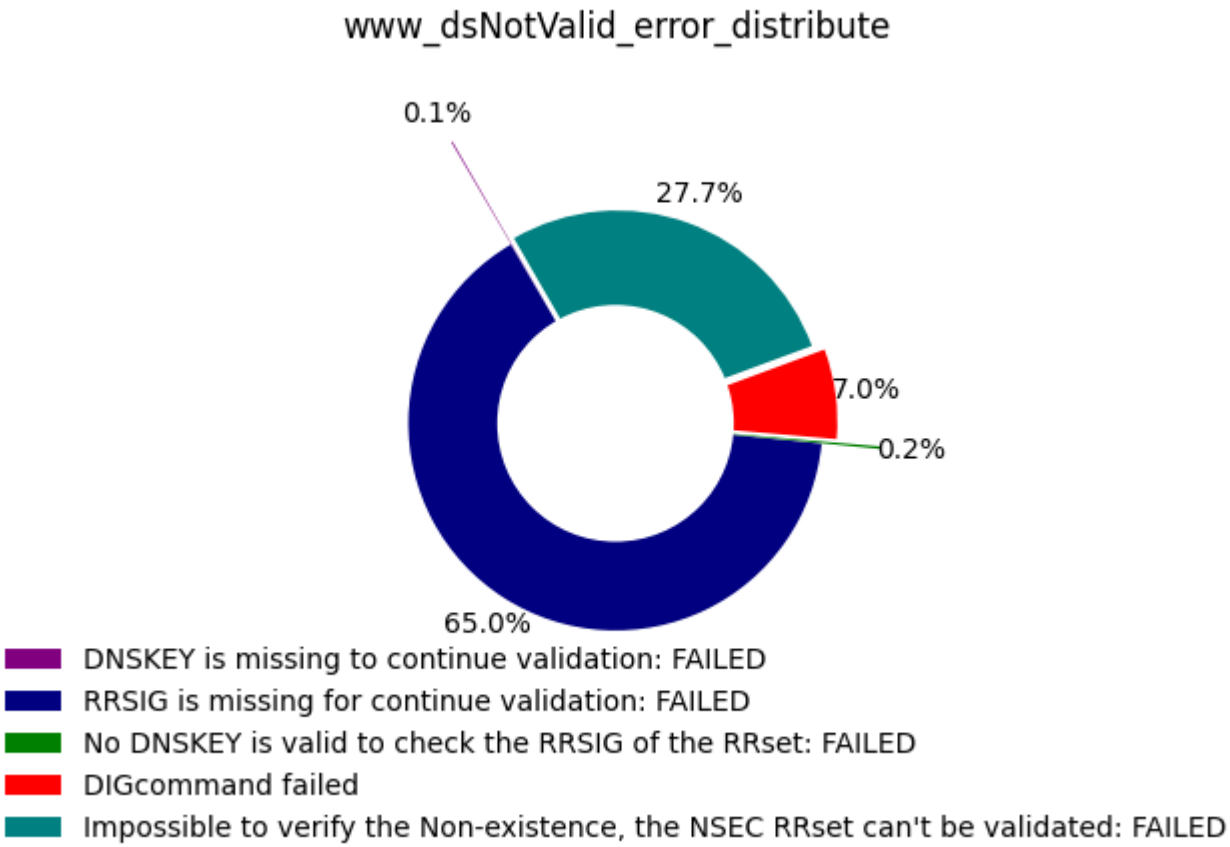
3. **Signature Not Yet Valid**

- 配置: 将签名的起始时间改为比当前的时间晚

```
600     DS      19291 5 2 (
        4B91D8C3CBD8F956D8CF35FF7E7369EE307C
        526F9A0F5C9B3BFA720158D98970 )
600     RRSIG   DS 5 3 600 (
        20240112145536 20231213145536 63462 iwbtfy.top.
        BJyUMVBGzFZ1Xq3eCp7/FK4cwZUFq8gBBqt/
        cMQFSxGoz4XeQssiBysQlX33kzlR5TA4KYTT
        sntsqqDLxZJ/+Q== )
```

目前时间-->20231223234345
结束有效时间-->20240112145536
开始有效时间-->20231213145536 改成 20231224432432

- 结果:



- 说明:

- RRSIG is missing to continue validation：期望的正确返回
- DIGcommand failed：无法连接到dns服务器
- Impossible to verify the non-existence, the NSEC RRset can’t be validated：服务器探测不到域名的A地址时的返回，即当服务器发现域名的DNSSEC配置有问题后就不再进一步解析，也可算是一种检错的结果
- DNSKEY is missing to continue validation：检测错误
- No DNSKEY is valid to check the RRSIG of the RRset：检测错误
- 针对该配置错误类型，我们以RRSIG is missing to continue validation为主要判断依据。

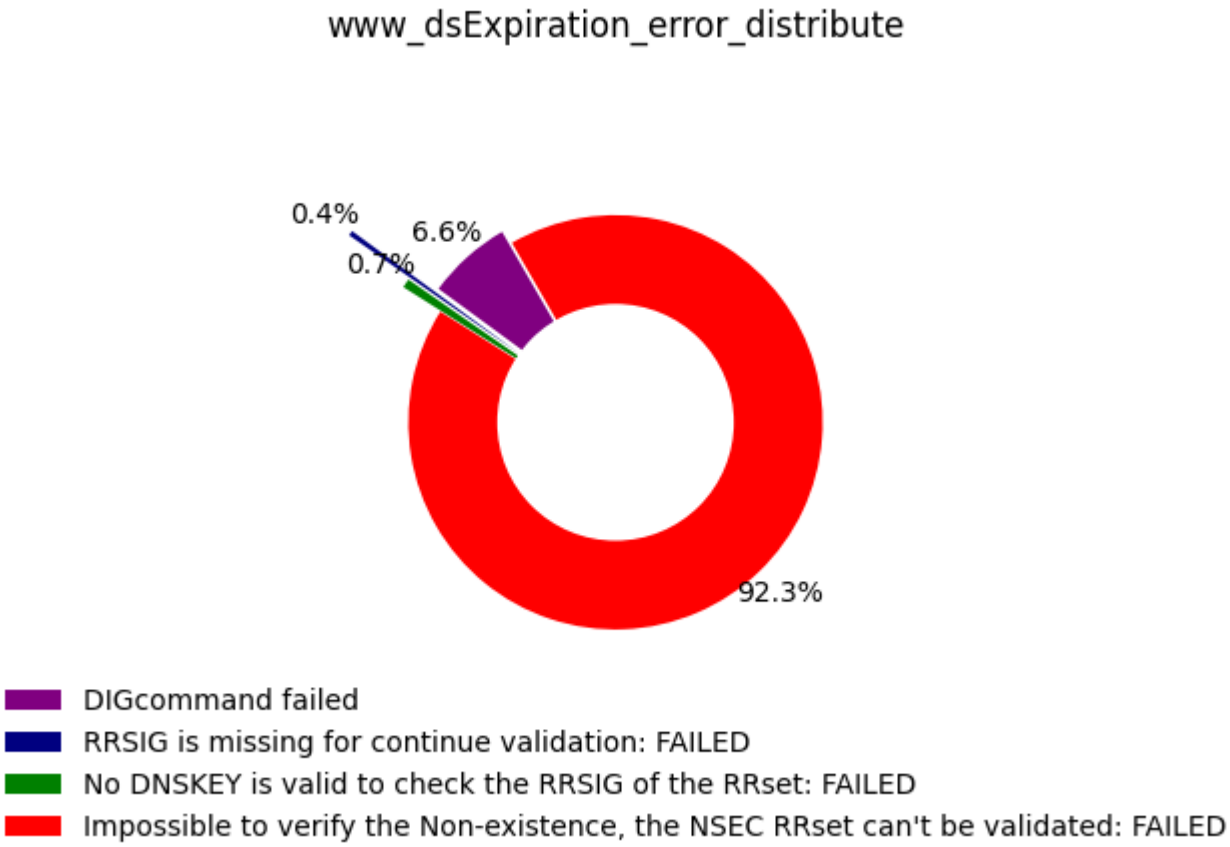
4. **Signature Expired**

- 配置: 将签名的结束时间改成比当前的早

```
600     DS      19291 5 2 (
        4B91D8C3CBD8F956D8CF35FF7E7369EE307C
        526F9A0F5C9B3BFA720158D98970 )
600     RRSIG   DS 5 3 600 (
        20240112145536 20231213145536 63462 iwbtfy.top.
        BJyUMVBGzFZ1Xq3eCp7/FK4cwZUFq8gBBqt/
        cMQFSxGoz4XeQssiBysQlX33kzlR5TA4KYTT
        sntsqqDLxZJ/+Q== )
```

目前时间-->20231223234345
结束有效时间-->20240112145536 改成 20231222432432
开始有效时间-->20231213145536

- 结果:



- 说明:
  - Impossible to verify the non-existence, the NSEC RRset can’t be validated：期望的正确返回
  - DIGcommand failed：无法连接到dns服务器
  - DNSKEY is missing to continue validation：检测错误
  - RRSIG is missing to continue validation：检测错误
  - 针对该配置错误类型，我们以Impossible to verify the non-existence, the NSEC RRset can’t be validated为主要判断依据。

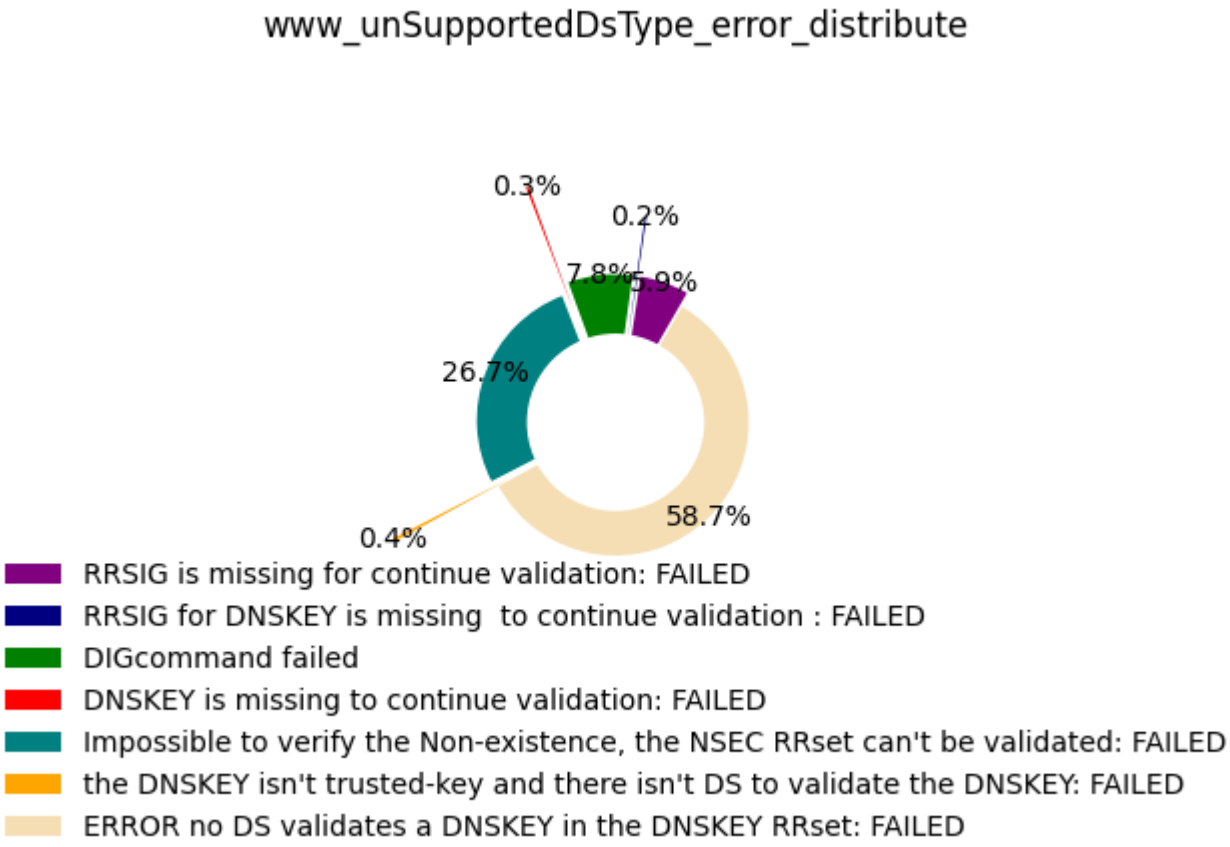
5. **Unsupported DS Digest Type**

- 配置: 将ds记录的摘要类型改成支持范围外

```
600     DS      19291 5 2 (
        4B91D8C3CBD8F956D8CF35FF7E7369EE307C
        526F9A0F5C9B3BFA720158D98970 )

5 ---> 50
```

- 结果:



- 说明:
  - Error no DS validates a DNSKEY in the DNSKEY RRset：期望的正确返回
  - DIGcommand failed：无法连接到dns服务器
  - Impossible to verify the non-existence, the NSEC RRset can’t be validated：服务器探测不到域名的A地址时的返回，即当服务器发现域名的DNSSEC配置有问题后就不再进一步解析，也可算是一种检错的结果
  - DNSKEY is missing to continue validation：检测错误
  - RRSIG is missing for continue validation：检测错误
  - RRSIG for DNSKEY is missing to continue validation：检测错误
  - the DNSKEY isn't trusted-key and there isn't DS to validate the DNSKEY：检测错误
  - 针对该配置错误类型，我们以Error no DS validates a DNSKEY in the DNSKEY RRset为主要判断依据。

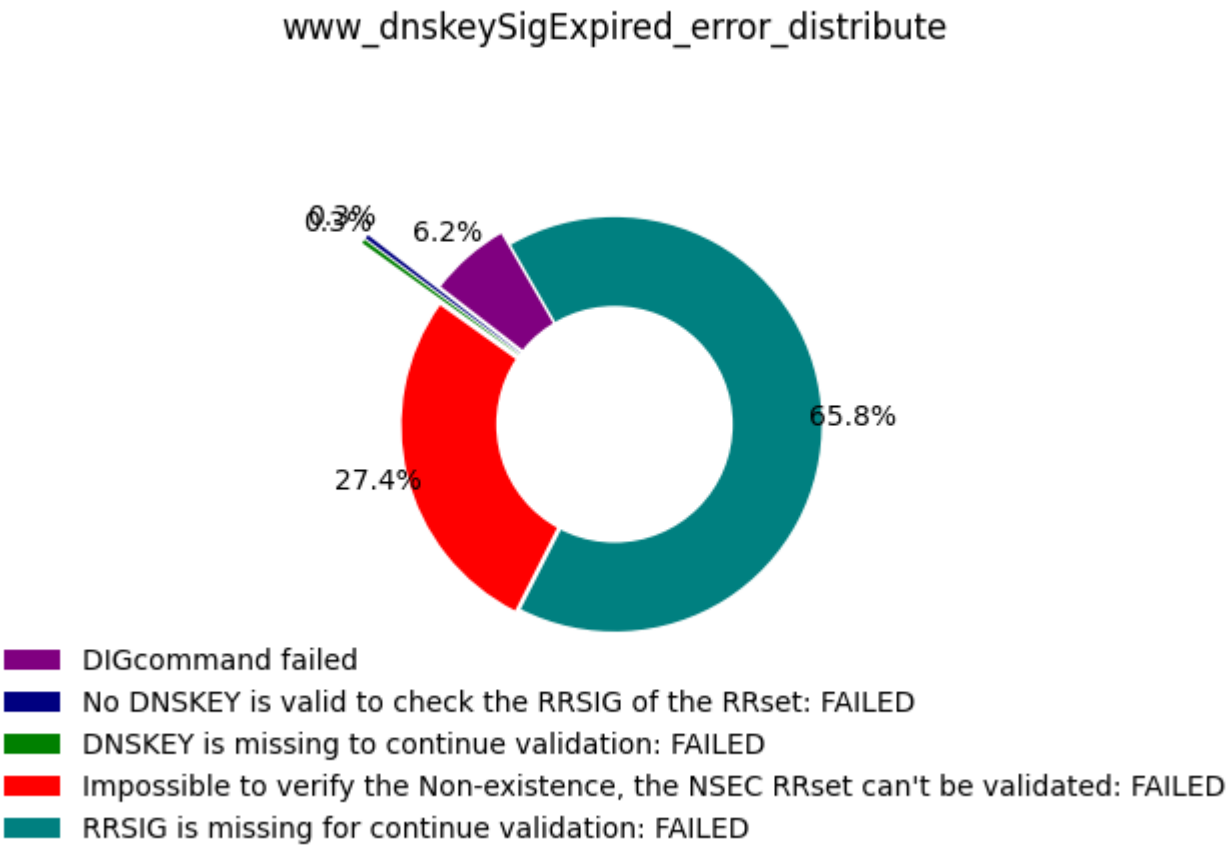
6. **DNSKEY Signature expired**

- 配置: 修改dnskey的签名时间比当前早

```
600     RRSIG   DNSKEY 5 3 600 (
        20240113102237 20231214102237 19291 www.iwbtfy.top.
        dbcIJCaP6qFlpf5rc7tB76qE0ijYEPd8T+8k
        Yt6vj+ZzyvMdPcqHlOAt8GPOMtuf4x1swmD7
        ZanW8Y/Sc1Rojg== )
```

目前时间-->20231223234345
结束有效时间-->20240113102237 改成 20231222432432
开始有效时间-->20231214102237

- 结果:



- 说明:
  - RRSIG is missing for continue validation：期望的正确返回
  - DIGcommand failed：无法连接到dns服务器
  - Impossible to verify the non-existence, the NSEC RRset can’t be validated：服务器探测不到域名的A地址时的返回，即当服务器发现域名的DNSSEC配置有问题后就不再进一步解析，也可算是一种检错的结果
  - DNSKEY is missing to continue validation：检测错误

- No DNSKEY is valid to check the RRSIG of the RRset：检测错误
- 针对该配置错误类型，我们以RRSIG is missing for continue validation为主要判断依据。

4.未来推进方向探究

在于陈老师开会讨论后，陈老师提出了新的思路，即通过修改dig版本，使其支持edns，将其他返回的错误文本信息都统一转换为error_code，如下图，以更好的说明服务器的检测能力。同时，为了搭建一个整体的检测系统，我们后续将为每一种错误类型申请一个三级域名并配置错误，最后再封装成递归解析安全增强措施部署分析的原型系统。

```
[root@iZ2zefficks3mlt6hhu5tyZ ~]# dig  9yangmao.cn @1.0.0.2

; <<>> DiG 9.11.26-RedHat-9.11.26-6.el8 <<>> 9yangmao.cn @1.0.0.2
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: SERVFAIL, id: 18025
;; flags: qr rd ra; QUERY: 1, ANSWER: 0, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 1232
; EDE: 6 (DNSSEC Bogus): (invalid SEP for 9yangmao.cn.)
;; QUESTION SECTION:
;9yangmao.cn.                   IN      A

;; Query time: 872 msec
;; SERVER: 1.0.0.2#53(1.0.0.2)
;; WHEN: Sun Dec 17 19:14:31 CST 2023
;; MSG SIZE  rcvd: 74
```