A Review of the KSK Roll

Created By: Geoff Huston

APNIC Labs

Presented By: Tim April

SSAC

Why am I presenting this?

- I ’m not part of ICANN or the PTI
- APNIC is not a root server operator
- I’m not a member of the root server cabal
- I can’t see root server query data

- Geoff is not here this week, but all of the above still apply

Why am I presenting this?

But …

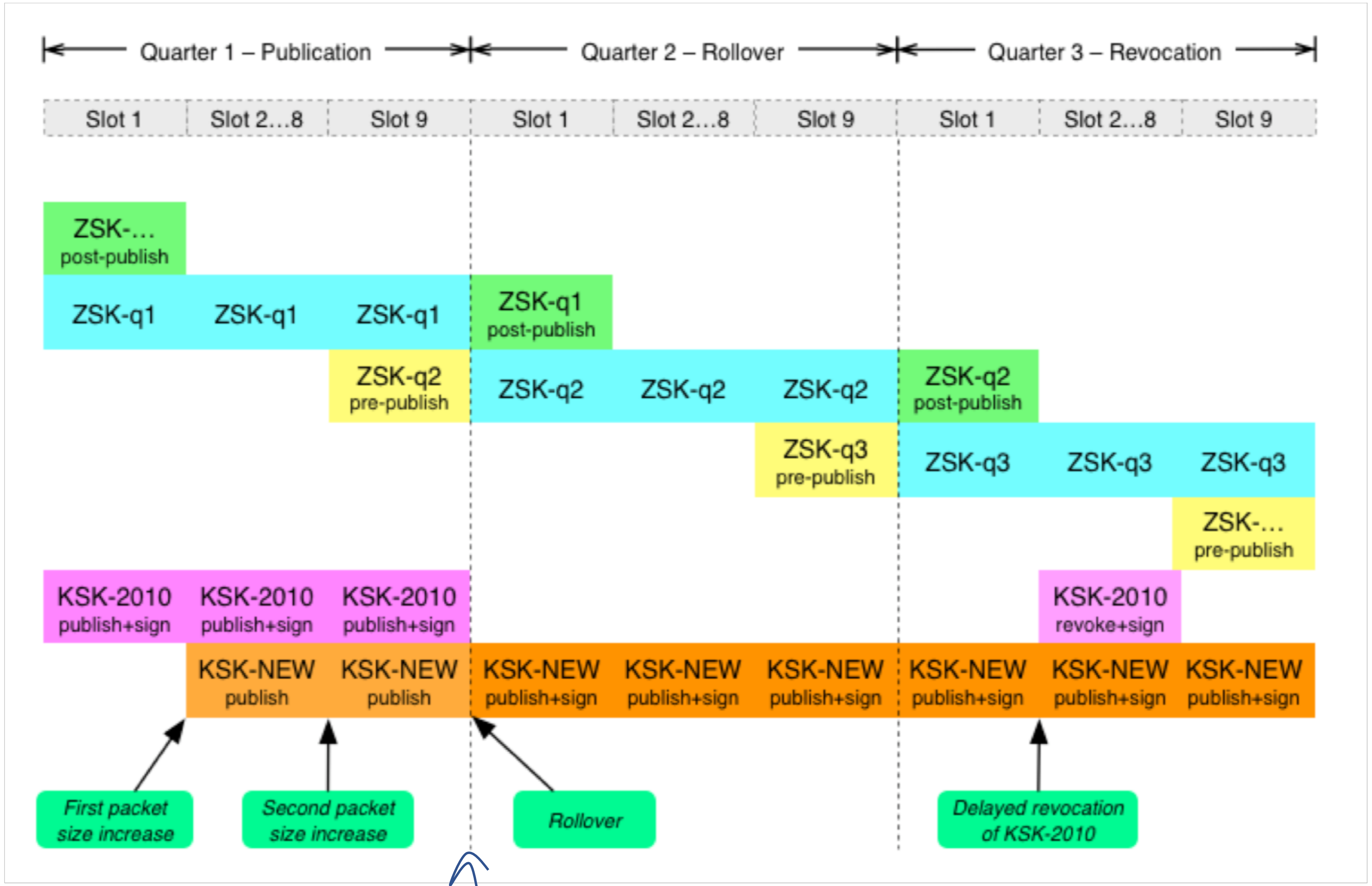
I’m one of almost 4 billion consumers of the DNS, and the stability, integrity and robustness of the DNS root matters for me

So I’m an interested member of the community of DNS consumers

The Plan

- The KSK is “special”
- There is no “parent” key for the root
- Every DNSSEC-validating resolver needs to load (and trust) the new KSK
- The plan is to use “old-signs-new” approach
  - The old key signs over the new key for some minimum hold-down period
  - DNSSEC-validating resolvers are supposed to add the new key to their local trusted key collection once they have seen a stable sign-over for the hold-down period

The Plan - V1



Quarter 1 – Publication

Quarter 2 – Rollover

Quarter 3 – Revocation

Slot 1 | Slot 2…8 | Slot 9 | Slot 1 | Slot 2…8 | Slot 9 | Slot 1 | Slot 2…8 | Slot 9

ZSK-… post-publish

ZSK-q1 ZSK-q1 ZSK-q1

ZSK-q1 post-publish

ZSK-q2 pre-publish

ZSK-q2 ZSK-q2 ZSK-q2

ZSK-q2 post-publish

ZSK-q3 pre-publish

ZSK-q3 ZSK-q3 ZSK-q3

ZSK-… pre-publish

KSK-2010 publish+sign KSK-2010 publish+sign KSK-2010 publish+sign

KSK-2010 revoke+sign

KSK-NEW publish KSK-NEW publish

KSK-NEW publish+sign KSK-NEW publish+sign KSK-NEW publish+sign KSK-NEW publish+sign KSK-NEW publish+sign KSK-NEW publish+sign

First packet size increase

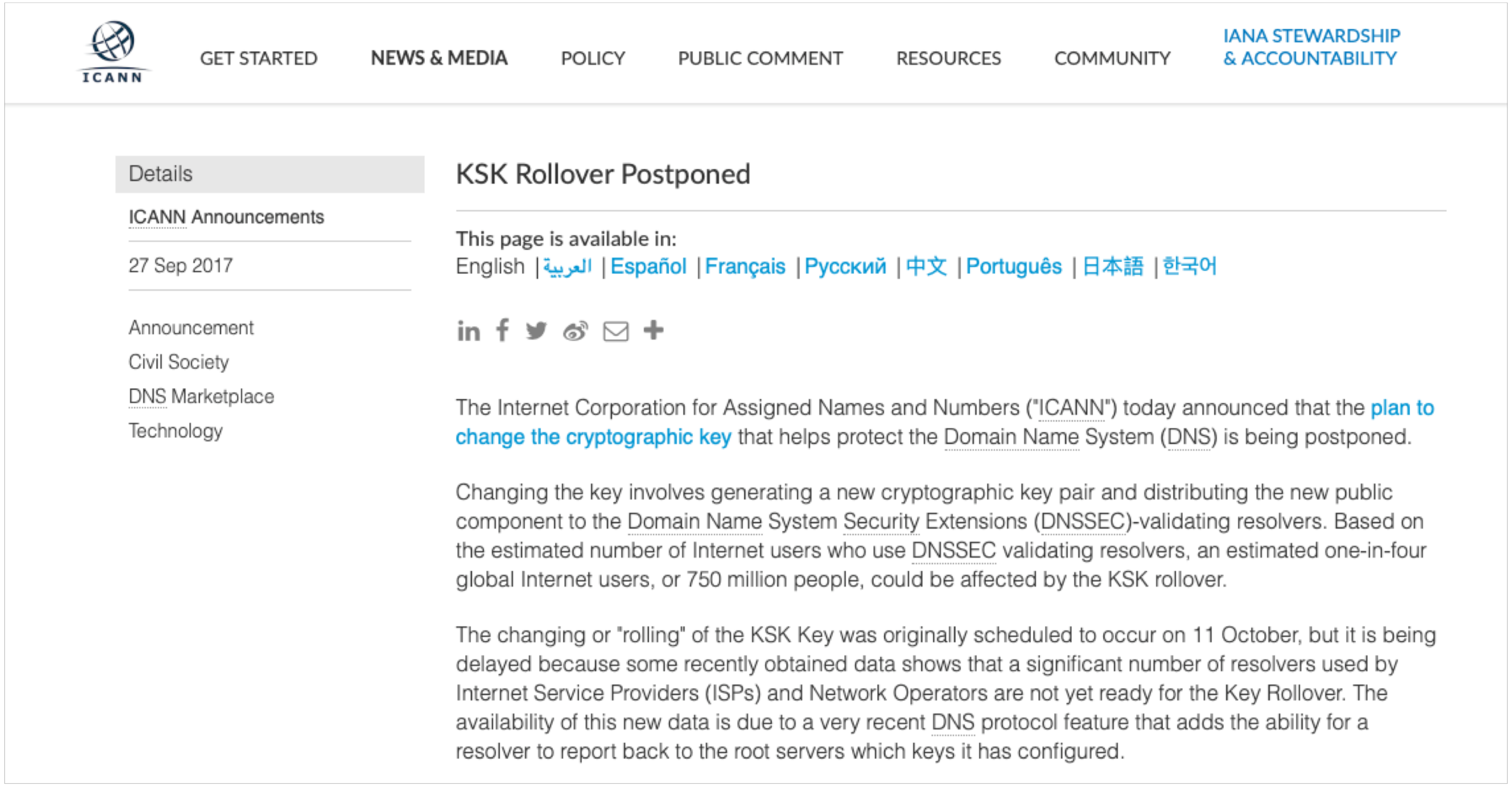
Second packet size increase

Rollover

Delayed revocation of KSK-2010

11 October 2017

The best laid plans…



Details

ICANN Announcements

27 Sep 2017

Announcement
Civil Society
DNS Marketplace
Technology

KSK Rollover Postponed

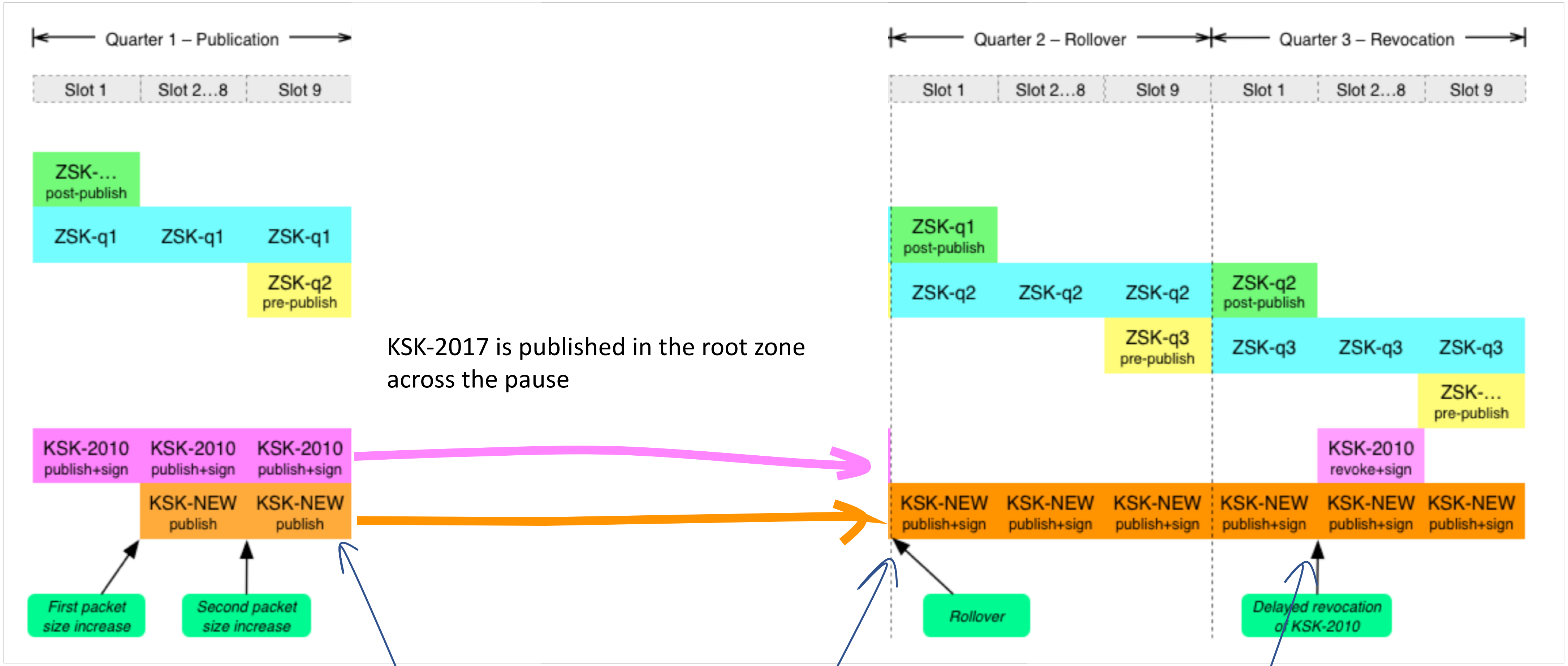
This page is available in:
English | العربية | Español | Français | Русский | 中文 | Português | 日本語 | 한국어

The Internet Corporation for Assigned Names and Numbers ("ICANN") today announced that the plan to change the cryptographic key that helps protect the Domain Name System (DNS) is being postponed.

Changing the key involves generating a new cryptographic key pair and distributing the new public component to the Domain Name System Security Extensions (DNSSEC)-validating resolvers. Based on the estimated number of Internet users who use DNSSEC validating resolvers, an estimated one-in-four global Internet users, or 750 million people, could be affected by the KSK rollover.

The changing or "rolling" of the KSK Key was originally scheduled to occur on 11 October, but it is being delayed because some recently obtained data shows that a significant number of resolvers used by Internet Service Providers (ISPs) and Network Operators are not yet ready for the Key Rollover. The availability of this new data is due to a very recent DNS protocol feature that adds the ability for a resolver to report back to the root servers which keys it has configured.

The Plan - V2



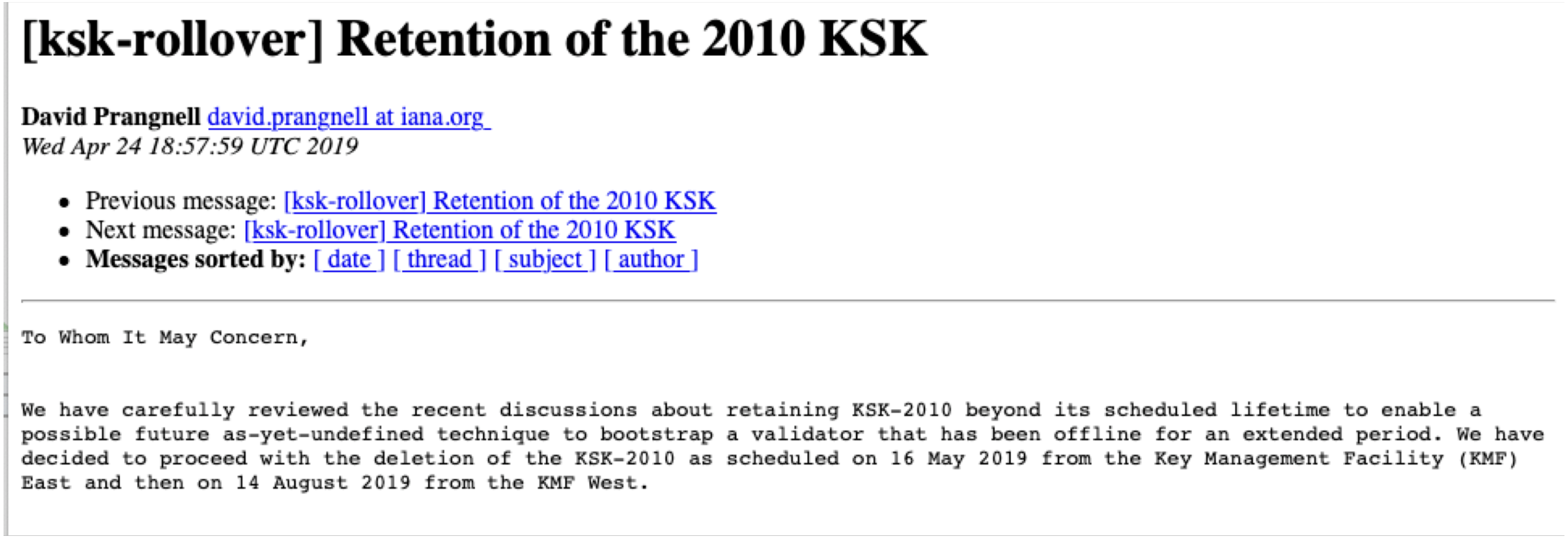
KSK-2017 is published in the root zone across the pause

27 September 2017

11 October 2018

11 January 2019

Goodbye KSK-2010



[ksk-rollover] Retention of the 2010 KSK

David Prangnell david.prangnell at iana.org
Wed Apr 24 18:57:59 UTC 2019

- Previous message: [ksk-rollover] Retention of the 2010 KSK
- Next message: [ksk-rollover] Retention of the 2010 KSK
- **Messages sorted by:** [date] [thread] [subject] [author]

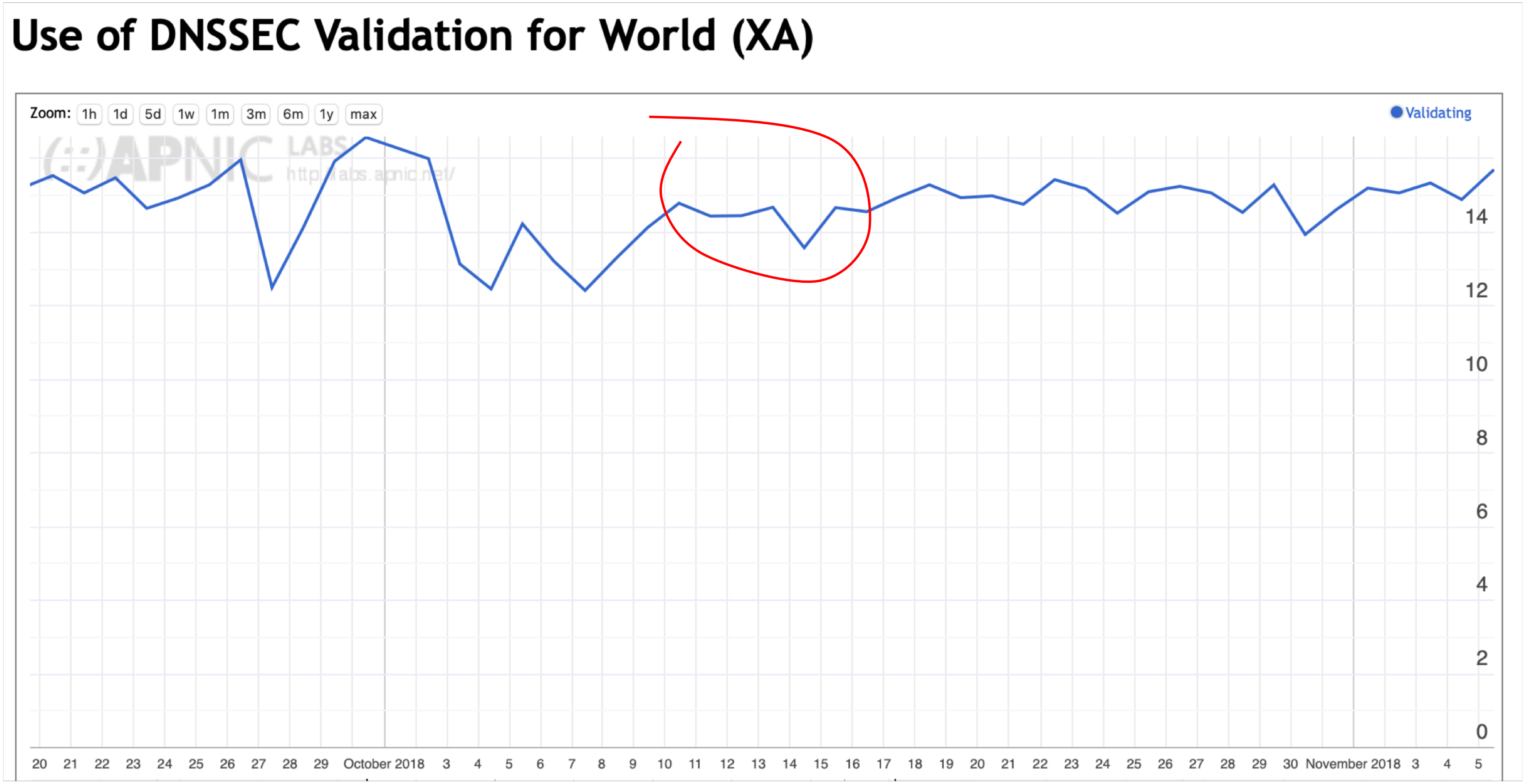
```
To Whom It May Concern,


We have carefully reviewed the recent discussions about retaining KSK-2010 beyond its scheduled lifetime to enable a
possible future as-yet-undefined technique to bootstrap a validator that has been offline for an extended period. We have
decided to proceed with the deletion of the KSK-2010 as scheduled on 16 May 2019 from the Key Management Facility (KMF)
East and then on 14 August 2019 from the KMF West.
```

What Worked

The KSK was rolled

Internet-wide DNSSEC validation levels were not significantly impacted

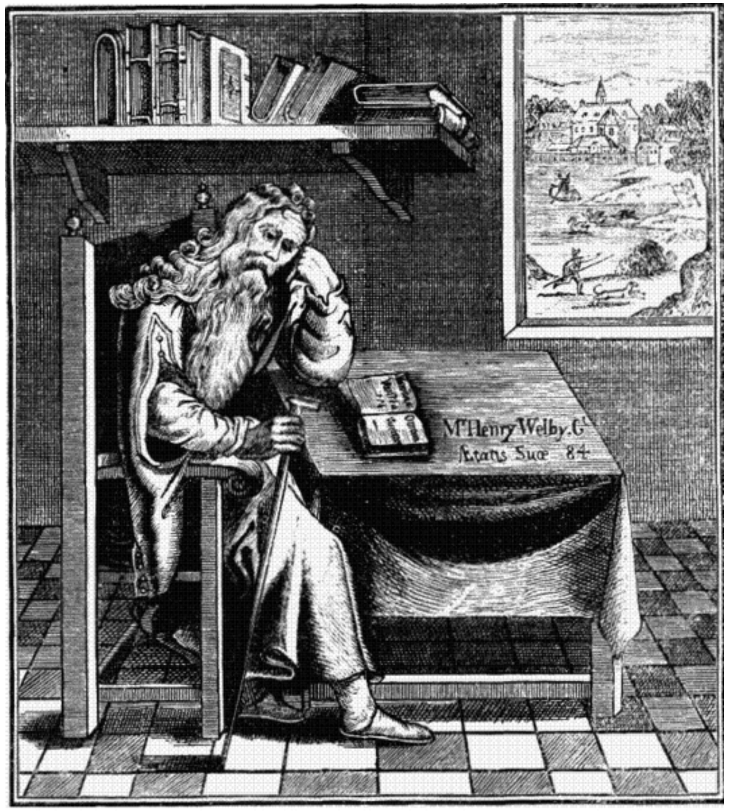


What Did Not

- The exercise was not exactly incident free
- There were issues with:
  - Predicting the impact of the KSK roll
  - Measuring the impact of the KSK roll
  - Predicting the impact of KSK revocation

KSK Measurement Objective

What number of users are at risk of being impacted by the KSK Roll?



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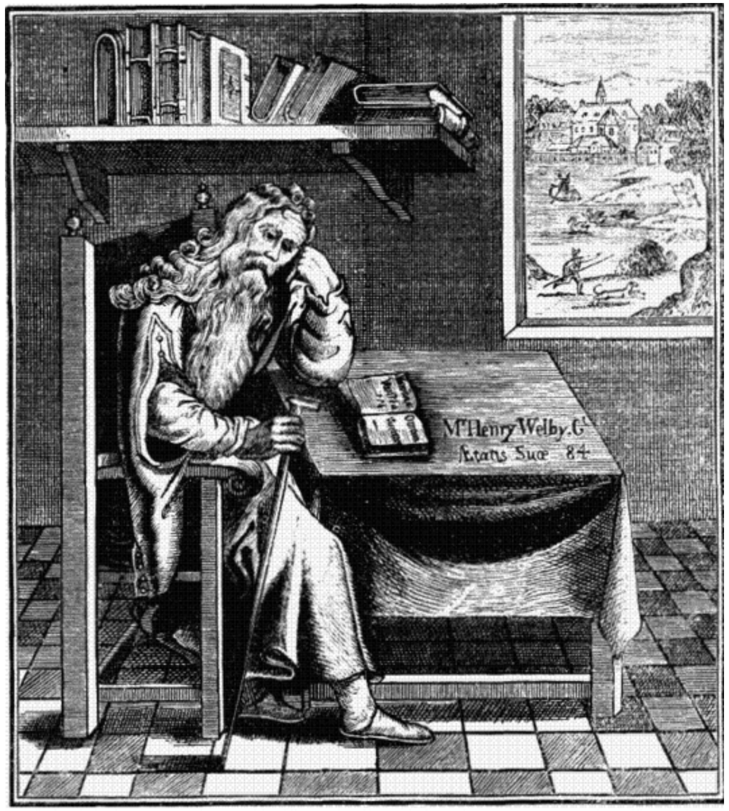
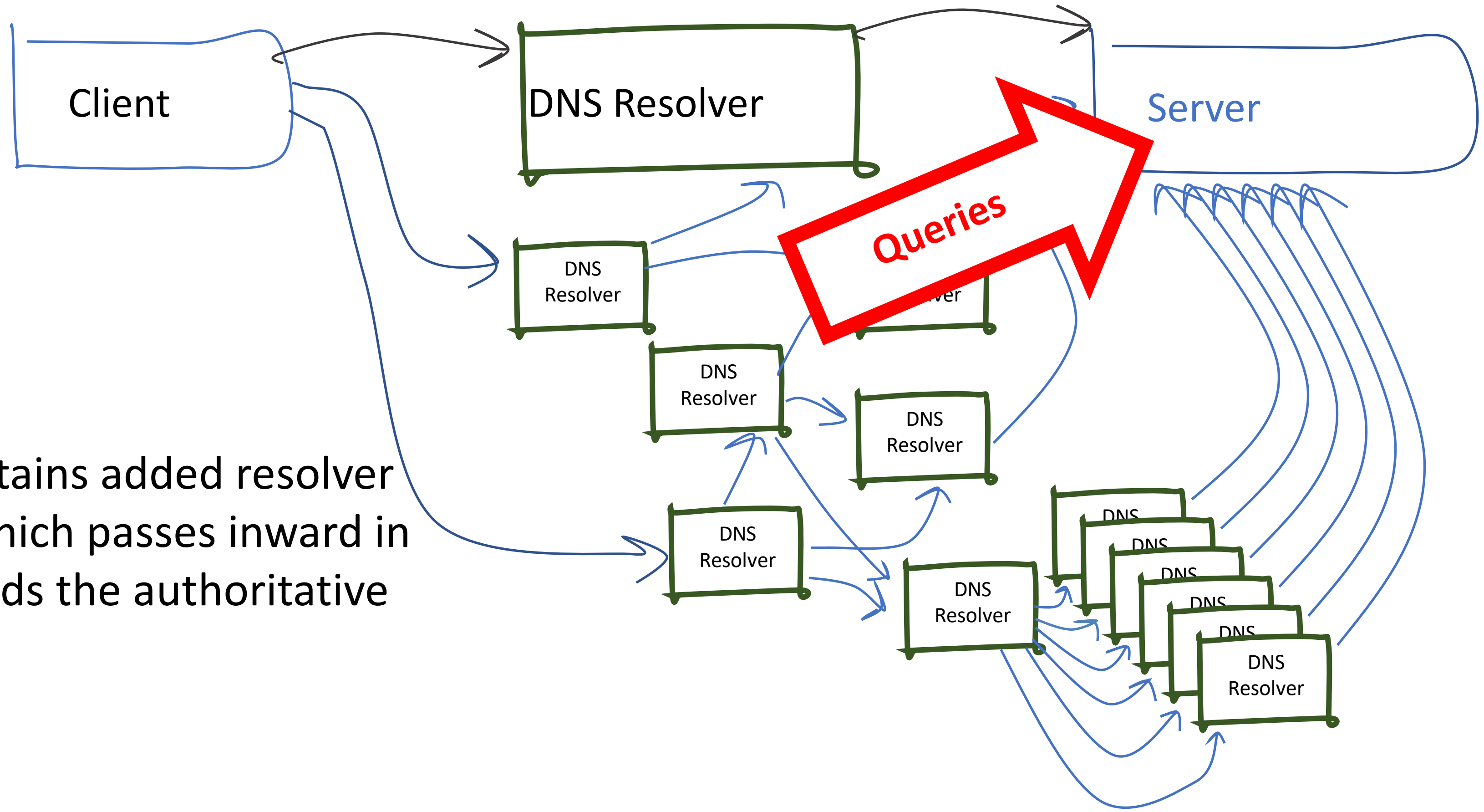


We can't do this measurement directly

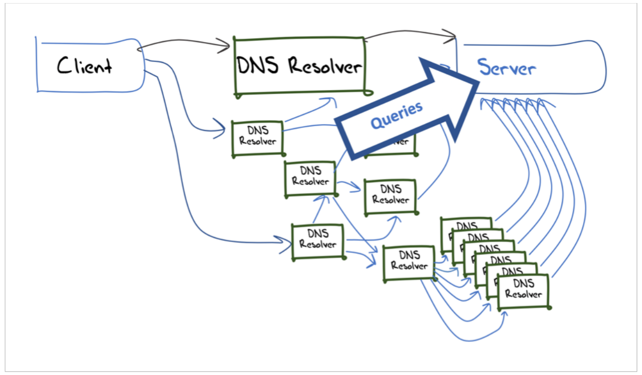
We can only measure the capabilities of the DNS infrastructure and estimate the impact

Signalling via Queries



The query contains added resolver information which passes inward in the DNS towards the authoritative server(s)

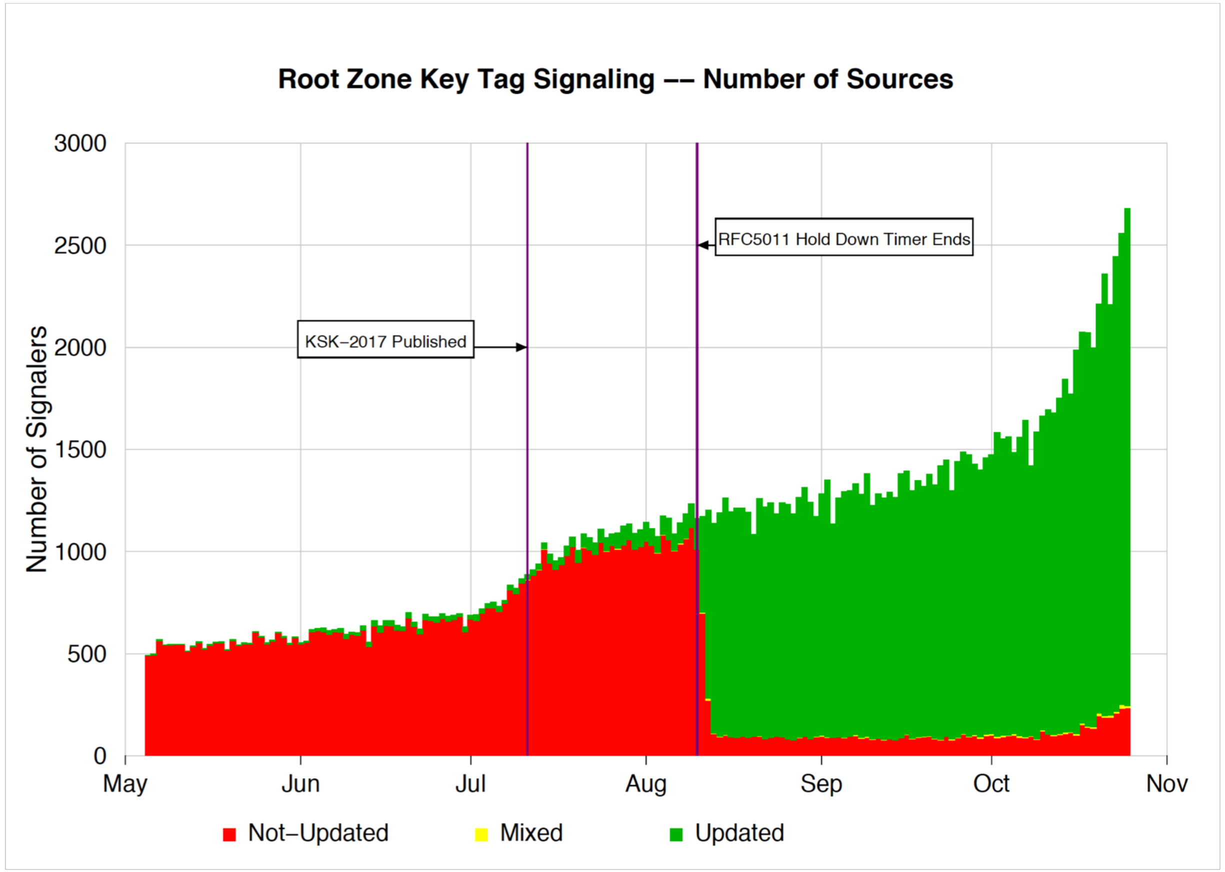
Measuring Resolvers with RFC 8145

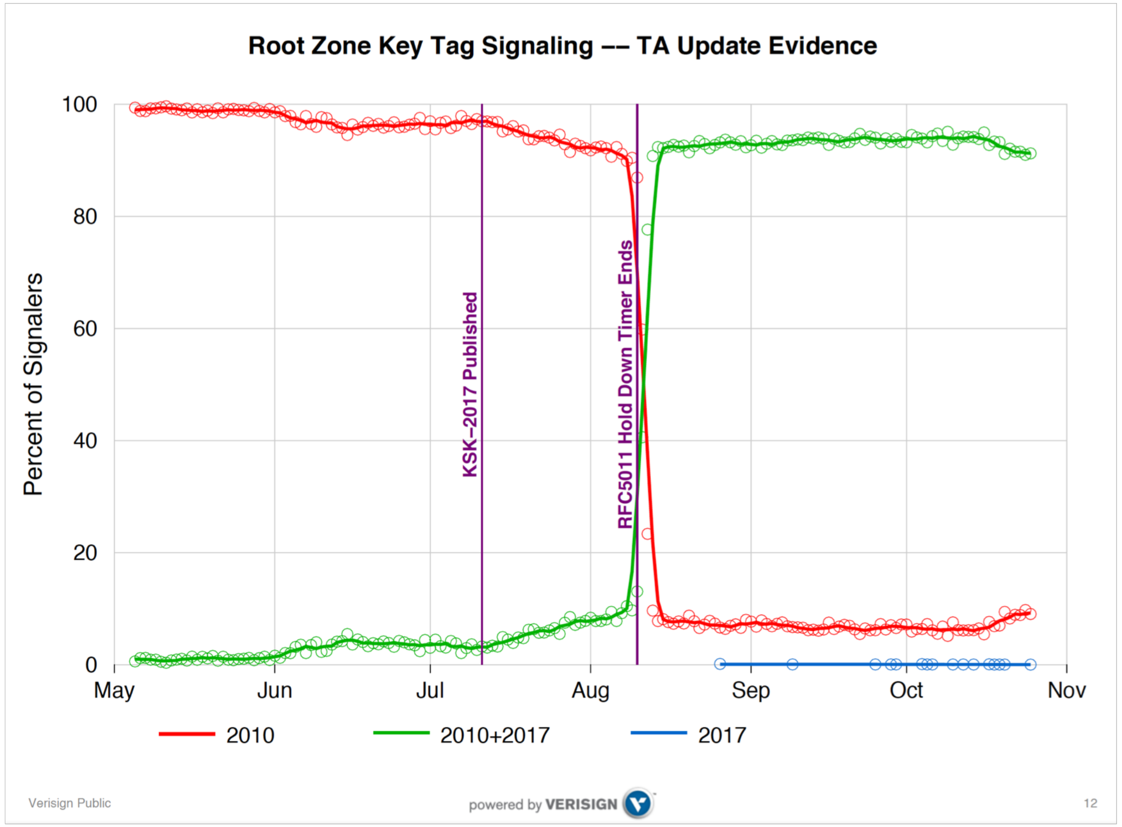


Getting resolvers to report on their local trusted key state

- A change to resolver behavior that requires deployment of new resolver code
- Resolvers that support the RFC 8145 signal mechanism periodically include the key tag of their locally trusted keys into a query directed towards the root servers

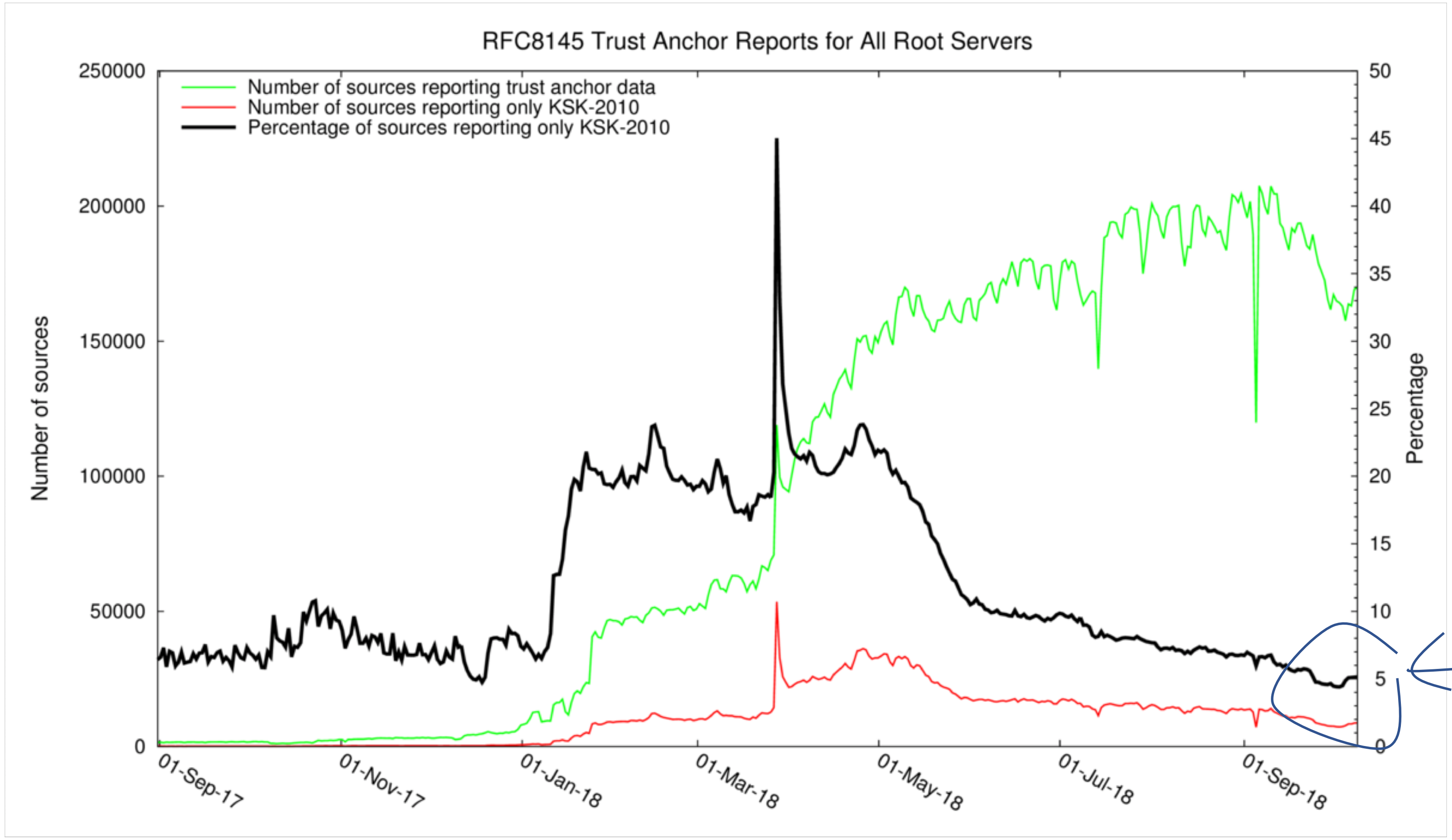
What did ~~we~~ root service operators see at the roots?


Root Zone Key Tag Signaling –– Number of Sources


Root Zone Key Tag Signaling –– TA Update Evidence

Duane Wessels VeriSign RFC 8145 Signaling Trust Anchor Knowledge In DNS Security Extensions
Presentation to DNSSEC Workshop @ ICANN 60 – 1 Nov 2017
https://schd.ws/hosted_files/icann60abudhabi2017/ea/Duane%20Wessels-VeriSign-RFC%208145-Signaling%20Trust%20Anchor%20Knowledge%20in%20DNS%20Security%20Extensions.pdf

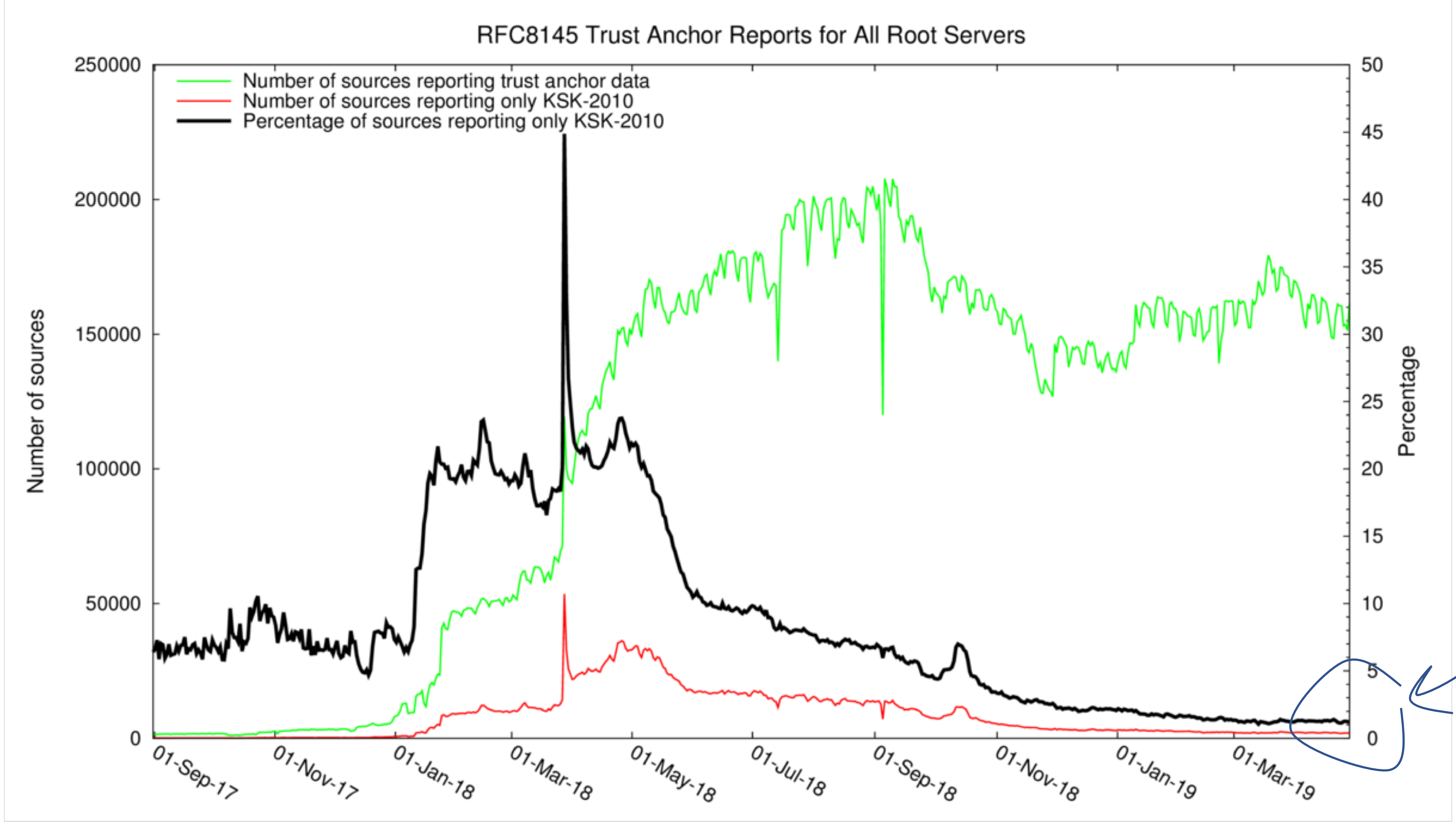
12 months of RFC8145 signalling



Yes, with just a few days to go this mechanism was still reporting 5% 'breakage'

http://root-trust-anchor-reports.research.icann.org

20 months of RFC8145 signalling



This mechanism is still reporting 1% 'breakage'

http://root-trust-anchor-reports.research.icann.org

What is this saying?

It’s clear that there is some residual set of resolvers that are signalling that they have not yet learned to trust KSK-2017

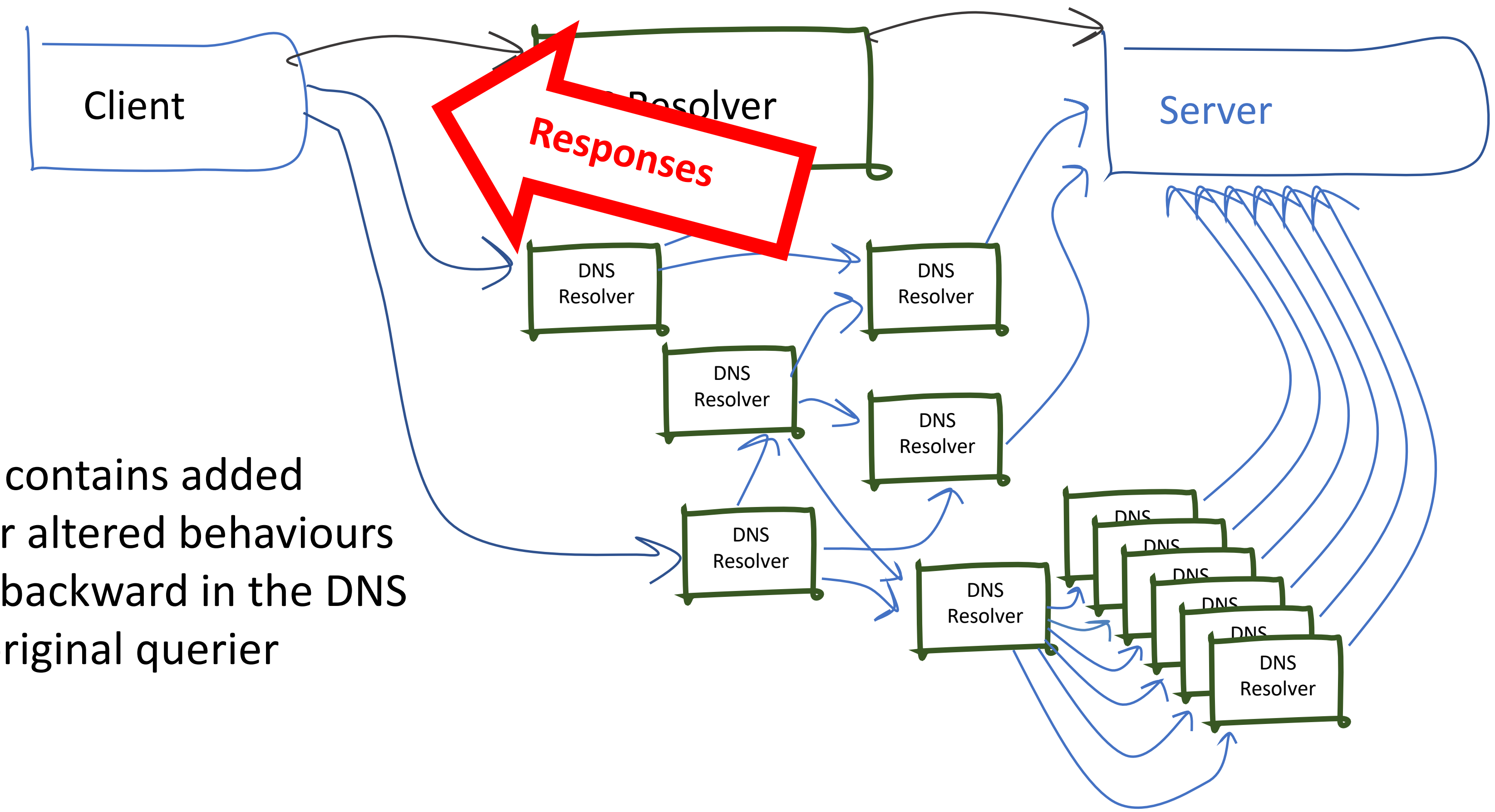
But its **not** clear if:

- This is an accurate signal about the state of this resolver
- This is an accurate signal about the identity of this resolver
- Whether the resolver attempts DNSSEC validation
- How many users sit ‘behind’ this resolver
- Whether these uses rely solely on this resolver, or if they also have alternate resolvers that they can use

Why?

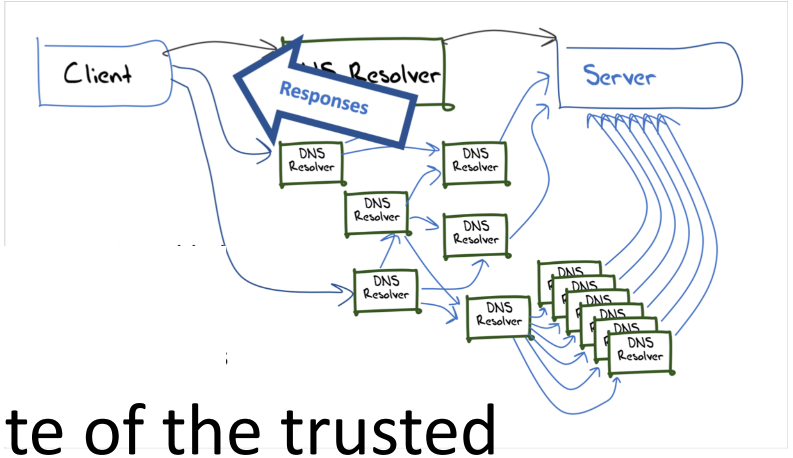
- Because the DNS does not disclose the antecedents of a query
  - If A forwards a query to B, who queries a Root Server then if the query contains an implicit signal (as in this case) then it appears that B is querying, not A
  - At no time is the user made visible in the referred query
- Because caching
  - If A and B both forward their queries via C, then it may be that one or both of these queries may be answered from C’s cache
  - In this case the signal is being suppressed
- Because its actually measuring a cause, not the outcome
  - Its measuring resolvers’ uptake of the new KSK, but is not able to measure the user impact of this

Signalling via Responses



The response contains added information or altered behaviours which passes backward in the DNS towards the original querier

User-Side Measurement



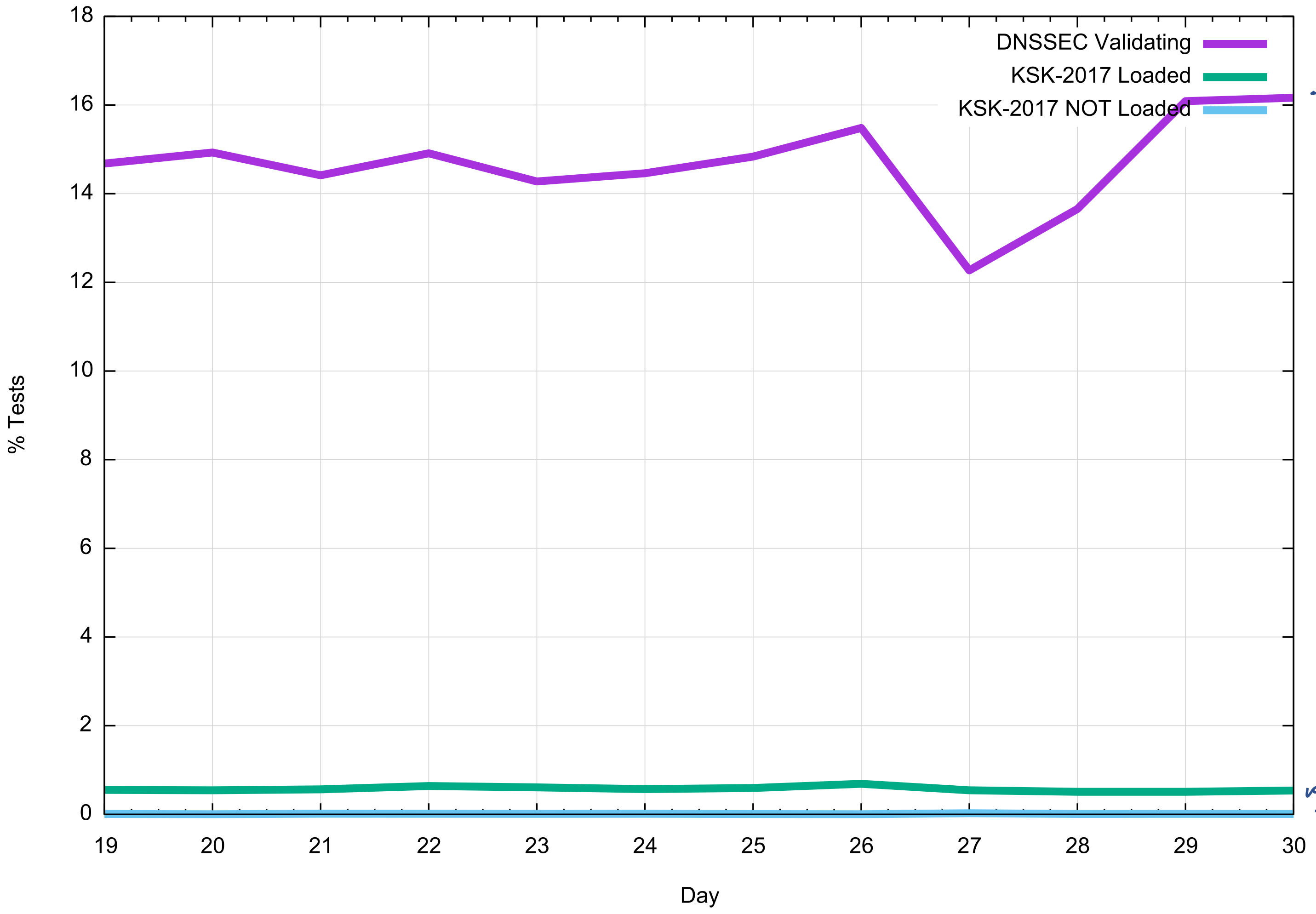
Can we devise a DNS query that could reveal the state of the trusted keys of the resolvers back to the user?

- What about a change to the resolver's reporting of validation outcome depending on the resolver's local trusted key state?
  - If a query contains the label **"root-key-sentinel-is-ta-<key-tag>**" then a validating resolver will report validation failure (SERVFAIL) if the key is NOT in the local trusted key store
  - If a query contains the label **"root-key-sentinel-not-ta-<key-tag>"** then a validating resolver will report validation failure (SERVFAIL) if the key IS in the local trusted key store

DNS + Web

- How can you tell if a user is able to resolve a DNS name?
  - Be the user (get the user to run a script of some sort)
  - Look at the DNS server AND the Web server
    - The Web object is fetched only when the DNS provides a resolution answer
    - But the opposite is not necessarily the case, so there is a noise component in such an approach

Prior to the KSK Roll



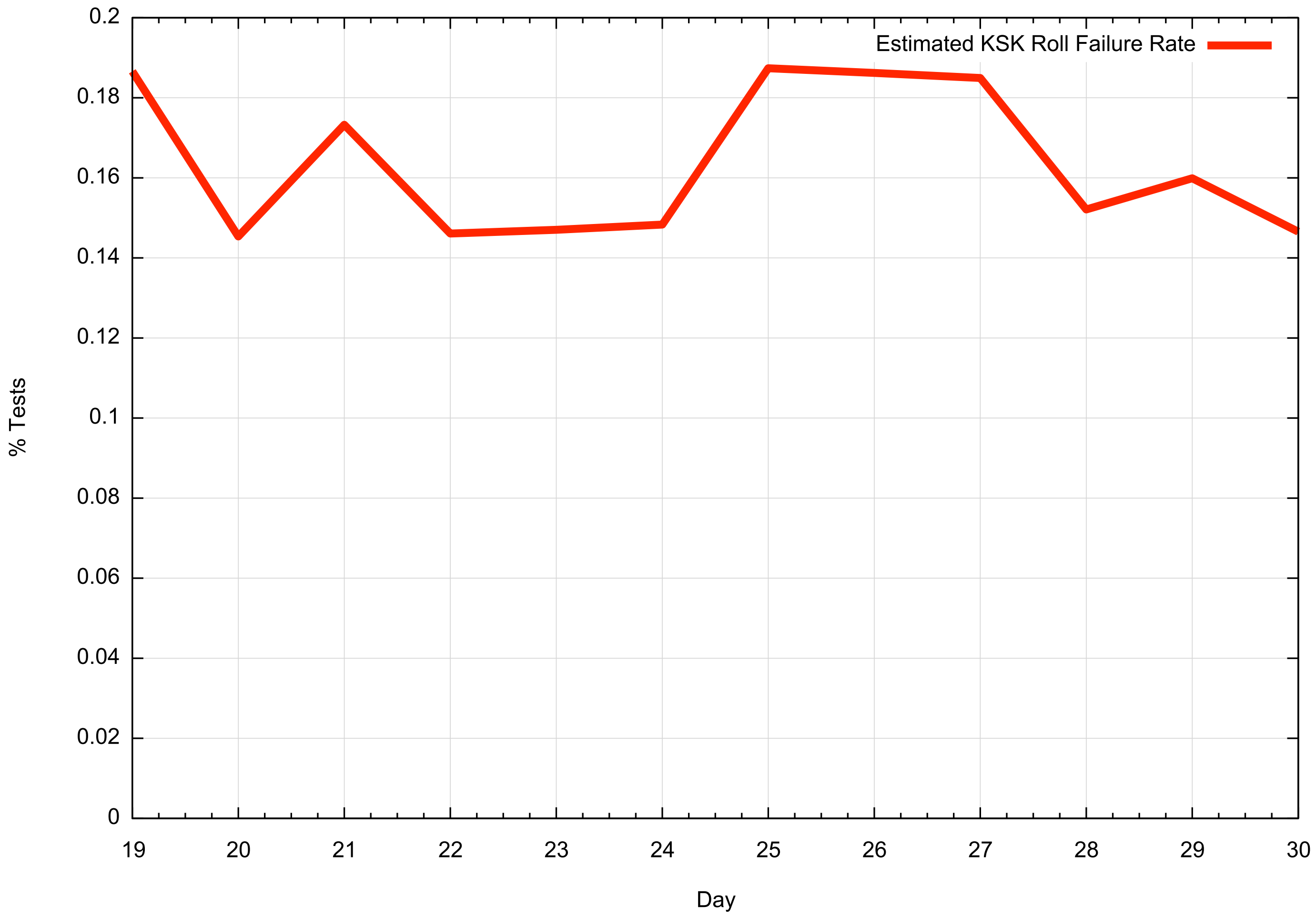
16% of users use DNSSEC-validating resolvers

15% of users do not report their KSK trust-state

0.5% of users report KSK-2017 loaded

0.005% of users report KSK-2017 NOT loaded

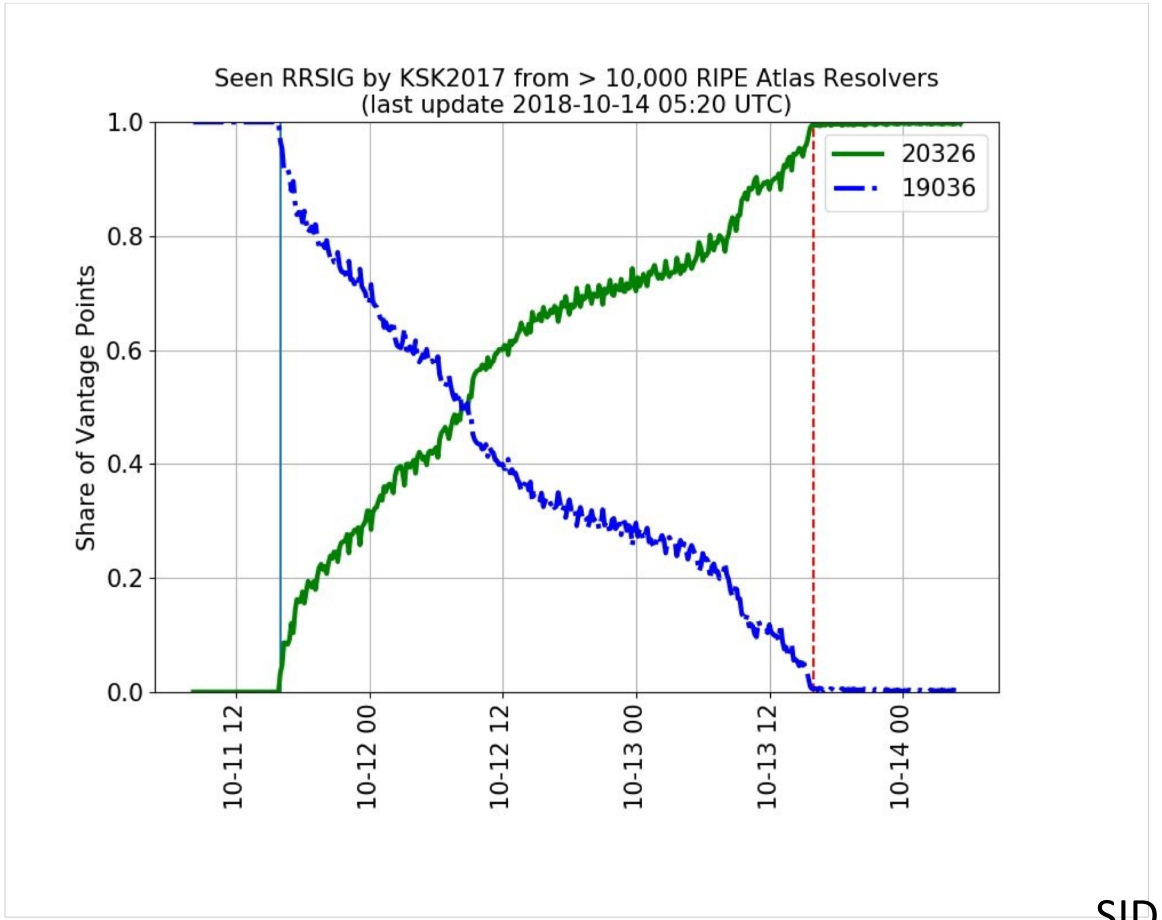
Possibly Affected Users



Between 0.1% to 0.2% of users are reporting that their resolvers have not loaded KSK-2017 as a trust anchor

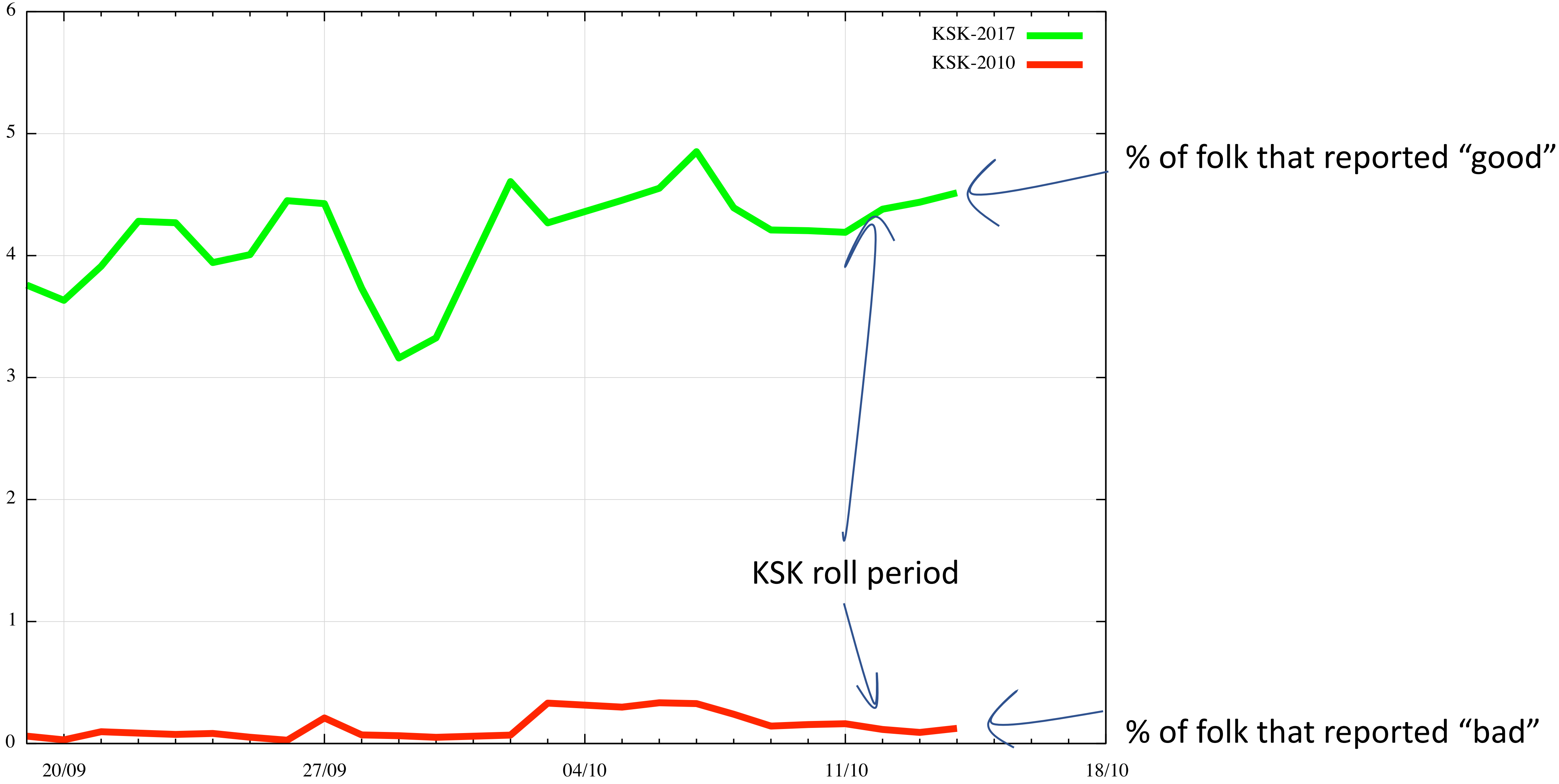
The measurement has many uncertainties and many sources of noise so this is an upper bound of the pool of users who may encounter DNS failure due to to the KSK roll

What happened



SIDN Labs Atlas Measurement

What we saw

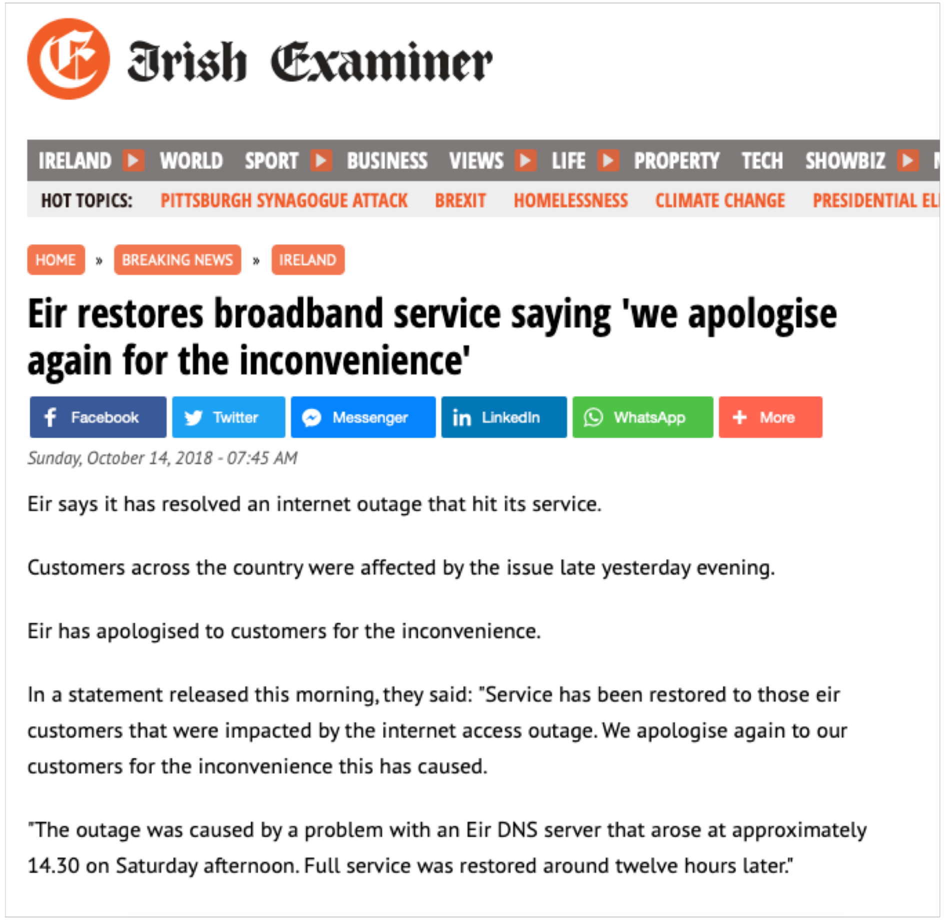


% of folk that reported “good”

KSK roll period

% of folk that reported “bad”

What we heard



Eir restores broadband service saying 'we apologise again for the inconvenience'

Sunday, October 14, 2018 - 07:45 AM

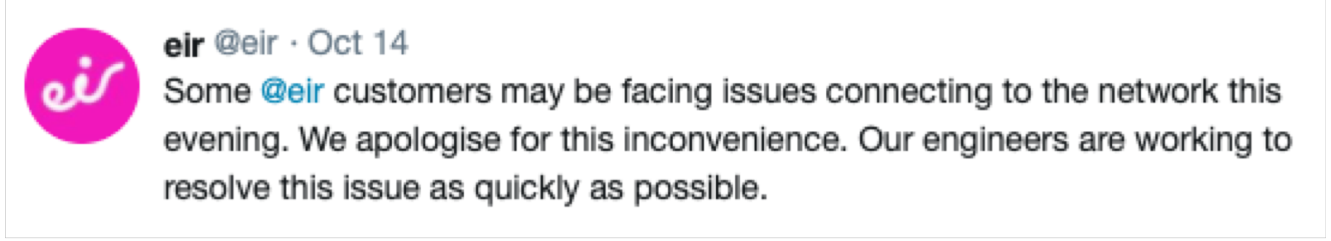
Eir says it has resolved an internet outage that hit its service.

Customers across the country were affected by the issue late yesterday evening.

Eir has apologised to customers for the inconvenience.

In a statement released this morning, they said: "Service has been restored to those eir customers that were impacted by the internet access outage. We apologise again to our customers for the inconvenience this has caused.

"The outage was caused by a problem with an Eir DNS server that arose at approximately 14.30 on Saturday afternoon. Full service was restored around twelve hours later."



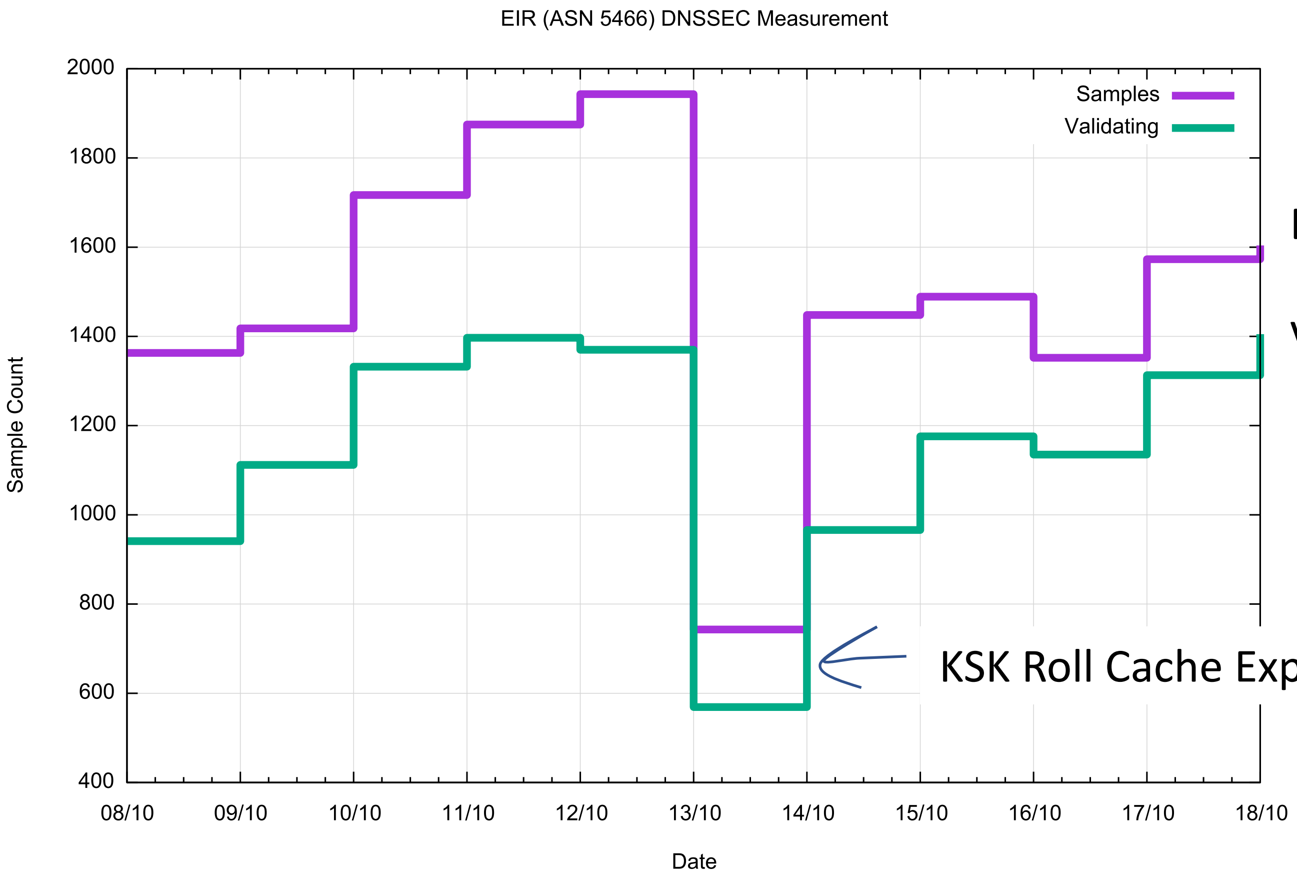
eir @eir · Oct 14

Some @eir customers may be facing issues connecting to the network this evening. We apologise for this inconvenience. Our engineers are working to resolve this issue as quickly as possible.

What happens when you lose track of the KSK?

Everything goes black

EIR - AS5466 DNSSEC Data

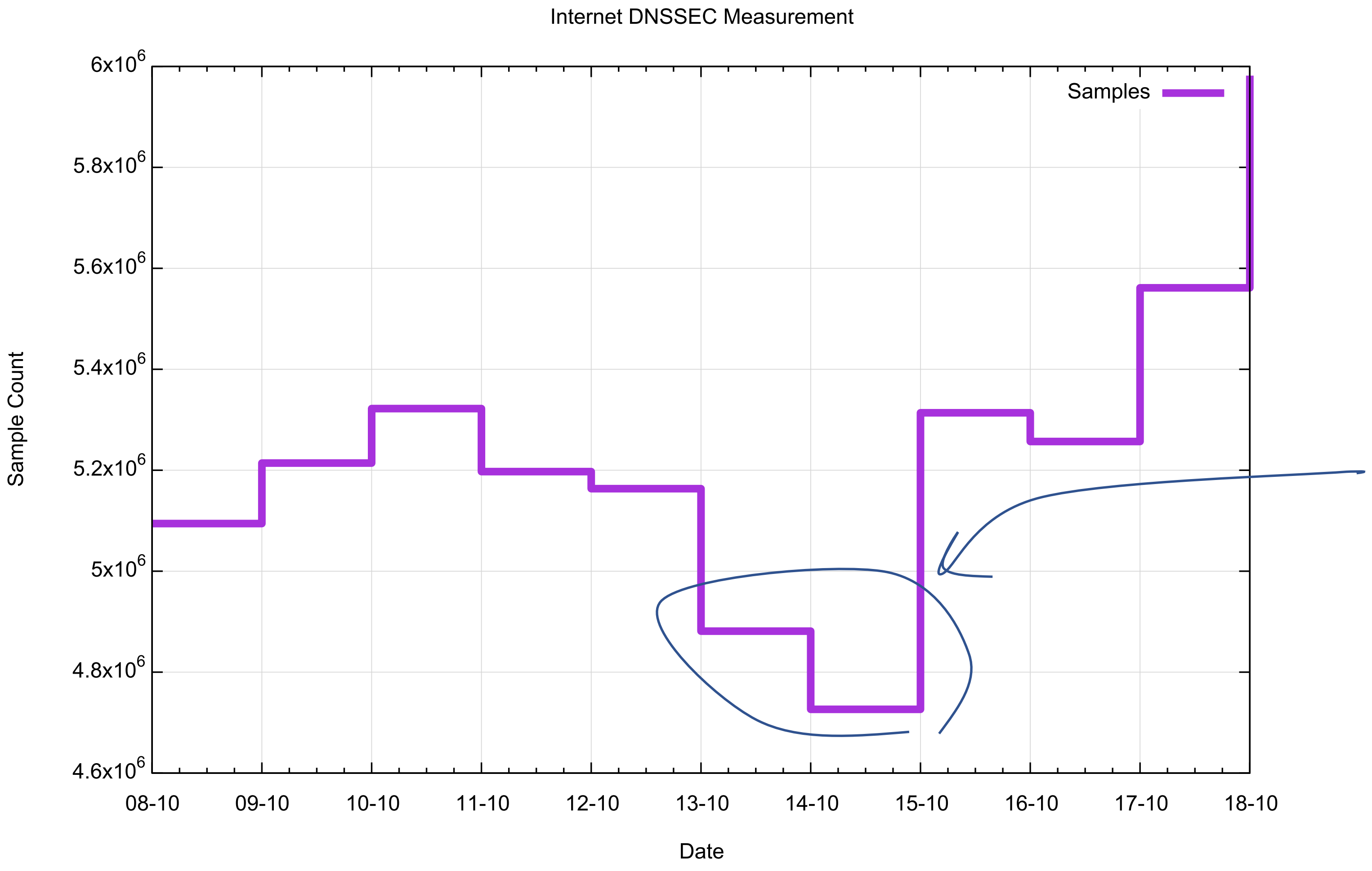


Daily Sample Count

Validating Sample Count

KSK Roll Cache Expiry

Internet DNSSEC Data



Is this part-related to the KSK Roll?

Looking for Affected Networks

- Lets use the following filter:
  - More than 400 samples / day in the lead up to the KSK roll (using weighted sample count)
  - DNSSEC validation level more than 30% prior to the KSK roll
  - Drop of more than 33% in DNSSEC validation during the KSK roll

```
Rank AS       CC Seen                     Validating           As Name
                 Before During After   Before During After
  1  AS2018   ZA 1,858  1,122  1,473      694    220    288  TENET, South Africa
  2  AS10396  PR 1,789  1,673  1,988    1,647    276     33  COQUI-NET - DATACOM CARIBE, Puerto Rico
  3  AS45773  PK 1,553    388  1,393      606    178    540  HECPERN-AS-PK PERN, Pakistan
  4  AS15169  IN 1,271    438  1,286    1,209    438  1,242  GOOGLE - Google LLC, India
  5  AS22616  US 1,264    503  1,526      883    377  1,014  ZSCALER- SJC, US
  6  AS53813  IN 1,213    689  1,862    1,063    582  1,419  ZSCALER, India
  7  AS1916   BR 1,062     94    991      326     37    277  Rede Nacional de Ensino e Pesquisa, Brazil
  8  AS9658   PH   931    281    842      440    136    404  ETPI-IDS-AS-AP Eastern Telecoms, Philippines
  9  AS37406  SS   888    486    972      582    365    599  RCS, South Sudan
 10  AS263327 BR   882    345    438      776    289    359  ONLINE SERVICOS DE TELECOMUNICACOES, Brazil
 11  AS17557  PK   835    430    777      431    277    413  Pakistan Telecommunication, Pakistan
 12  AS36914  KE   834    476    937      583    354    670  KENET , Kenya
 13  AS327687 UG   802    473    834      390    189    332  RENU, Uganda
 14  AS680    DE   773    966  1,332      268    117    289  DFN Verein zur Foerderung, Germany
 15  AS201767 UZ   761    538    729      461    200    371  UZMOBILE, Uzbekistan
 16  AS37682  NG   695    401    728      593    274    568  TIZETI, Nigeria
 17  AS7470   TH   674    214    507      219     94    182  True Internet, Thailand
 18  AS51167  DE   670    378    479      214     78    156  CONTABO, Germany
 19  AS15525  PT   600    260    593      287    125    284  MEO-EMPRESAS, Portugal
 20  AS14061  GB   594    468    672      260    169    313  DigitalOcean, United Kingdom
 21  AS37130  ZA   585      5    464      414      0    260  SITA, South Africa
 22  AS30998  NG   583    264    484      192     54    143  NAL, Nigeria
 23  AS135407 PK   569    227    457      419    207    344  TES-PL-AS-AP Trans World, Pakistan
 24  AS16814  AR   565    235    456      258    120    208  NSS, Argentina
 25  AS132335 IN   563     17     30      538     17     23  NETWORK-LEAPSWITCH-IN LeapSwitch Networks, India
 26  AS5438   TN   559    532    579      526    171     27  ATI,Tunisia
 27  AS5466   IE   547    240    401      419    184    329  EIRCOM Internet House, IE Ireland
 28  AS18002  IN   538    467    614      277    176    242  WORLDPHONE-IN AS, India
 29  AS37209  NG   532    109    438      269     45    194  HYPERIA, Nigeria
 30  AS37100  ZA   454    161    401      168     95    131  SEACOM-AS, South Africa
 31  AS5588   CZ   453    175    430      186    102    162  GTSCE GTS Central Europe, Czechia
 32  AS1103   NL   446     38    363      189      7    132  SURFnet, The Netherlands
 33  AS17563  PK   402    117    359      207     64    199  Nexlinx,  Pakistan
 34  AS327724 UG   401    120    538      208    103    266  NITA, Uganda
 35  AS7590   PK   400    122    329      266     84    224  COMSATS, Pakistan
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 35  AS7590   PK   400    122    329    266     84    224  COMSATS, Pakistan
```

These networks
turned DNSSEC
validation off!

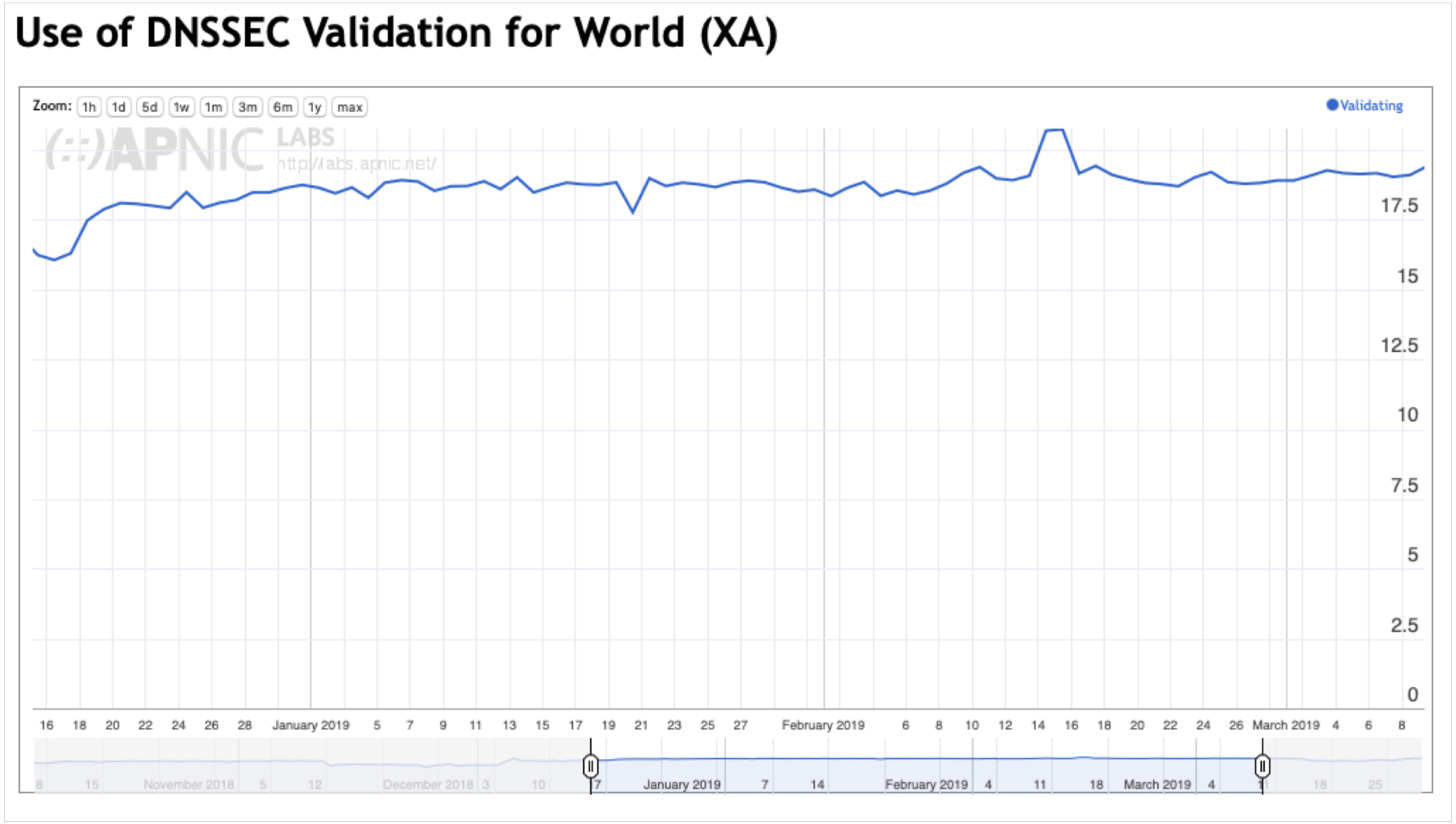
Impact of the KSK Roll

- The immediate impact appears to be some 0.2% - 0.3% of users
- In 32 ISP cases service was restored with DNSSEC validation enabled
- In 3 ISP cases DNSSEC validation was turned off

But that's not the end of the story…

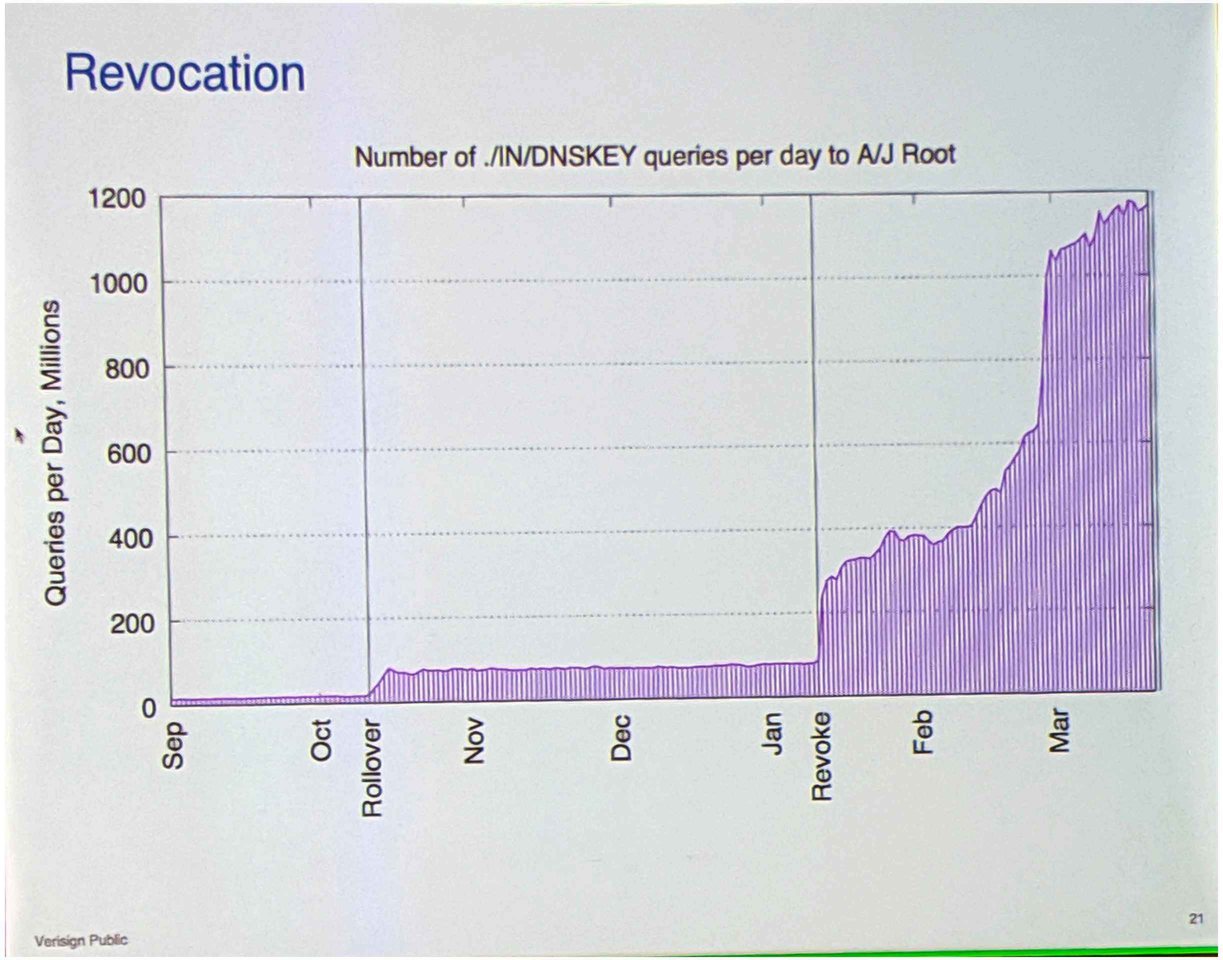
- The next event was the revocation of KSK-2010 at 1400 UTC, 11 January 2019
    - This was meant to be easy
    - It required no trust transition on the part of DNSSEC-validating resolvers
    - KSK-2010 was published as a signing KEY for DNSSEC with the ”revoke bit” set in the key flags
    - While the DNSKEY response was large (1,449 octets) other parts of the DNS generate larger responses for validating resolvers

And for clients the revocation was uneventful



Use of DNSSEC Validation for World (XA)

But Root Servers reported a different story



Revocation

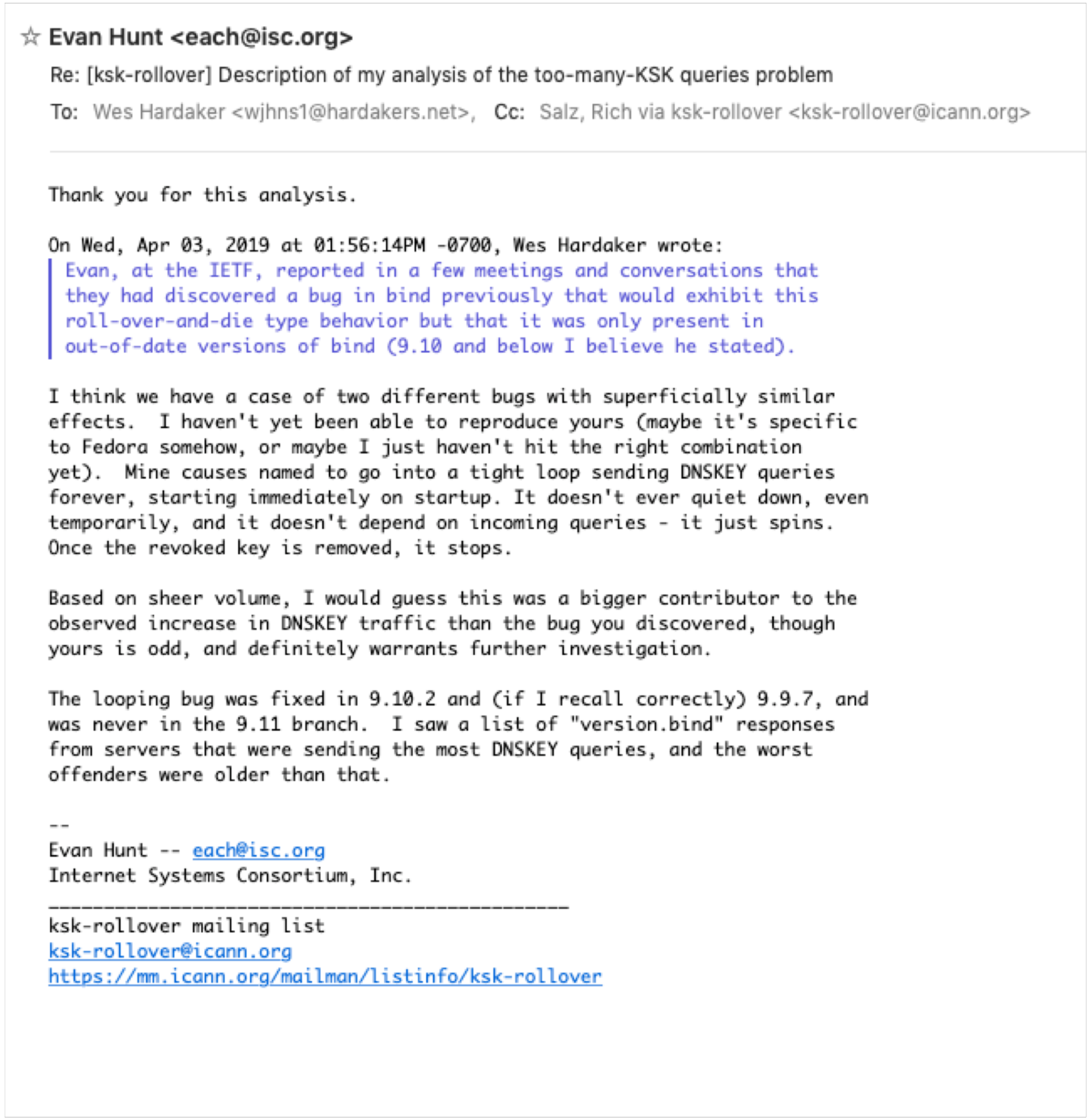
Verisign Public

21

Duane Wessels, KSK Roller Post Analysis, DNS OARC, May 2019

Why?

Query spin in old versions of a popularly deployed resolver



☆ Evan Hunt <each@isc.org>

Re: [ksk-rollover] Description of my analysis of the too-many-KSK queries problem

To: Wes Hardaker <wjhns1@hardakers.net>, Cc: Salz, Rich via ksk-rollover <ksk-rollover@icann.org>

Thank you for this analysis.

On Wed, Apr 03, 2019 at 01:56:14PM -0700, Wes Hardaker wrote:

> Evan, at the IETF, reported in a few meetings and conversations that they had discovered a bug in bind previously that would exhibit this roll-over-and-die type behavior but that it was only present in out-of-date versions of bind (9.10 and below I believe he stated).

I think we have a case of two different bugs with superficially similar effects. I haven't yet been able to reproduce yours (maybe it's specific to Fedora somehow, or maybe I just haven't hit the right combination yet). Mine causes named to go into a tight loop sending DNSKEY queries forever, starting immediately on startup. It doesn't ever quiet down, even temporarily, and it doesn't depend on incoming queries - it just spins. Once the revoked key is removed, it stops.

Based on sheer volume, I would guess this was a bigger contributor to the observed increase in DNSKEY traffic than the bug you discovered, though yours is odd, and definitely warrants further investigation.

The looping bug was fixed in 9.10.2 and (if I recall correctly) 9.9.7, and was never in the 9.11 branch. I saw a list of "version.bind" responses from servers that were sending the most DNSKEY queries, and the worst offenders were older than that.

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Lessons Learned

- Yes, we can roll the KSK!
- Yes, the extensive contact campaign helped

BUT

- The DNS is VERY opaque!
- Instrumentation was extremely challenging

What Next?

Observations

- The operation was an experiment
- DNS trust state signalling (both forms) seems to add more noise rather than clarity
- We could think about making the DNS more transparent
  - But there is a clear trade-off between greater transparency and exposing end user behaviours
  - So maybe we might not want to go there!

Observations

- Is DNSSEC validation most appropriately a resolver function or an edge function?
    - Envisaged in DANE Chain Extensions in the TLS - requires edge devices to hold the current KSK value and perform DNSSEC validation
    - Is 5011 really the best way for edge devices to maintain their KSK copy?
    - Really?

If we want to think about scaling DNSSEC validation to every host device what KSK management practices will scale?

One View

- We should perform this operation often
  - Maybe we just need to keep rolling every year
  - That way we train the manual loaders to keep up!
- We should now look at an Elliptical Curve algorithm roll
- We should now look at standing a backup KSK provision

Another View

- Why are we rolling the KSK?
- Actual key compromise might not play out in the same staged manner as a planned key roll
- If these planned key rolls are not a rehearsal for some unforeseen potential calamity then why are we deliberately adding instability into DNSSEC?
- Is doing this again going to teach us anything new?
- Is old-signs-new really the best way to do this?
- How should we scale the KSK?

Thanks!