Roll, Roll, Roll Your Root

A Comprehensive Analysis of the First Ever DNSSEC Root KSK Rollover

NLUUG Najaarsconferentie 2019 – Utrecht, 2019-11-21

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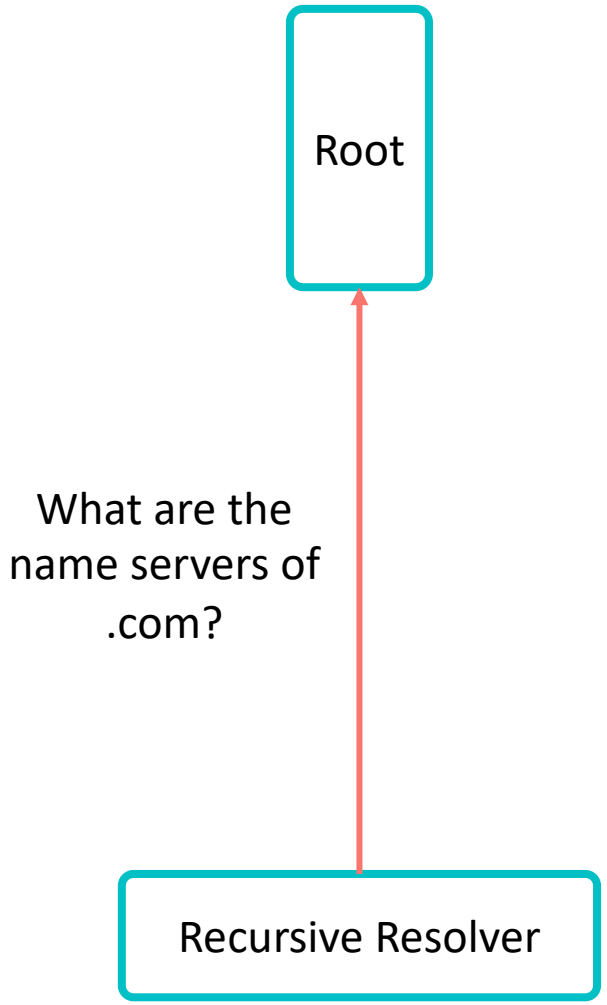
[1]NLnet Labs, [2]Rochester Institute of Technology, [3]SIDN Labs, [4]University of Twente, [5]USC/Information Sciences Institute, [6]Verisign

Introduction

- DNSSEC brings **integrity** to the DNS
- Validators need the public key of the Root and configure it as *trust-anchor*
- In 2018, the trust-anchor was replaced (or "*rolled*") for the *first time*

- The old key: **KSK-2010**
- The new key: **KSK-2017**



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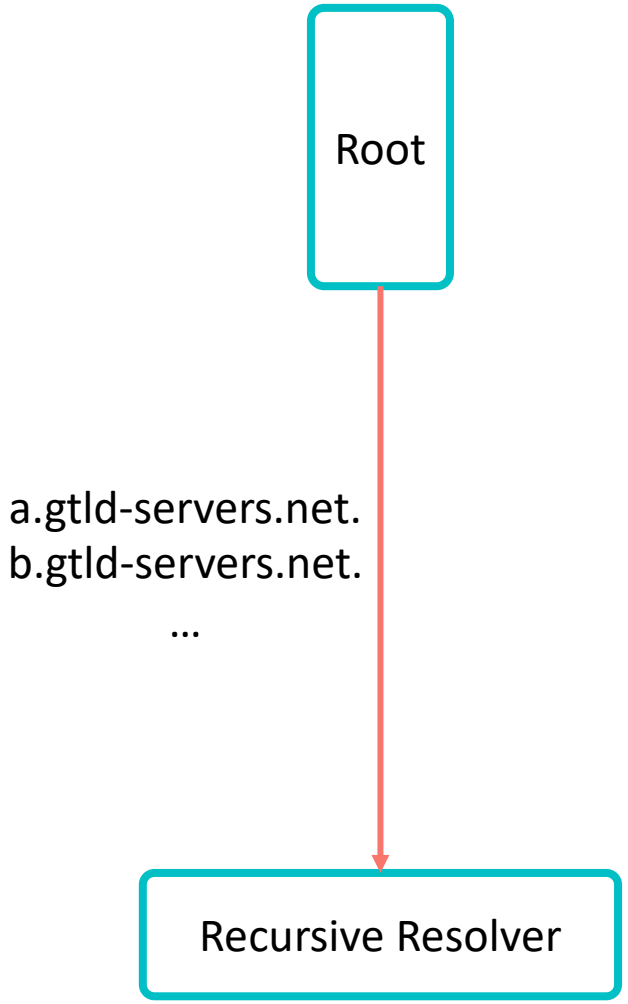

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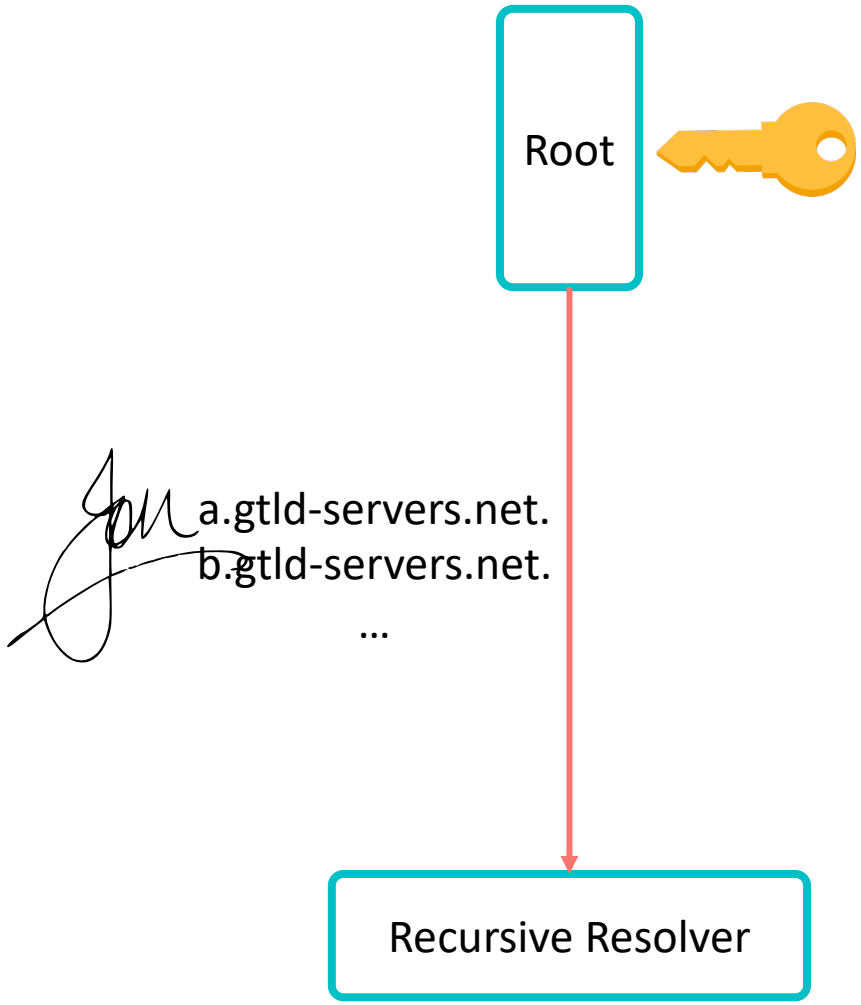

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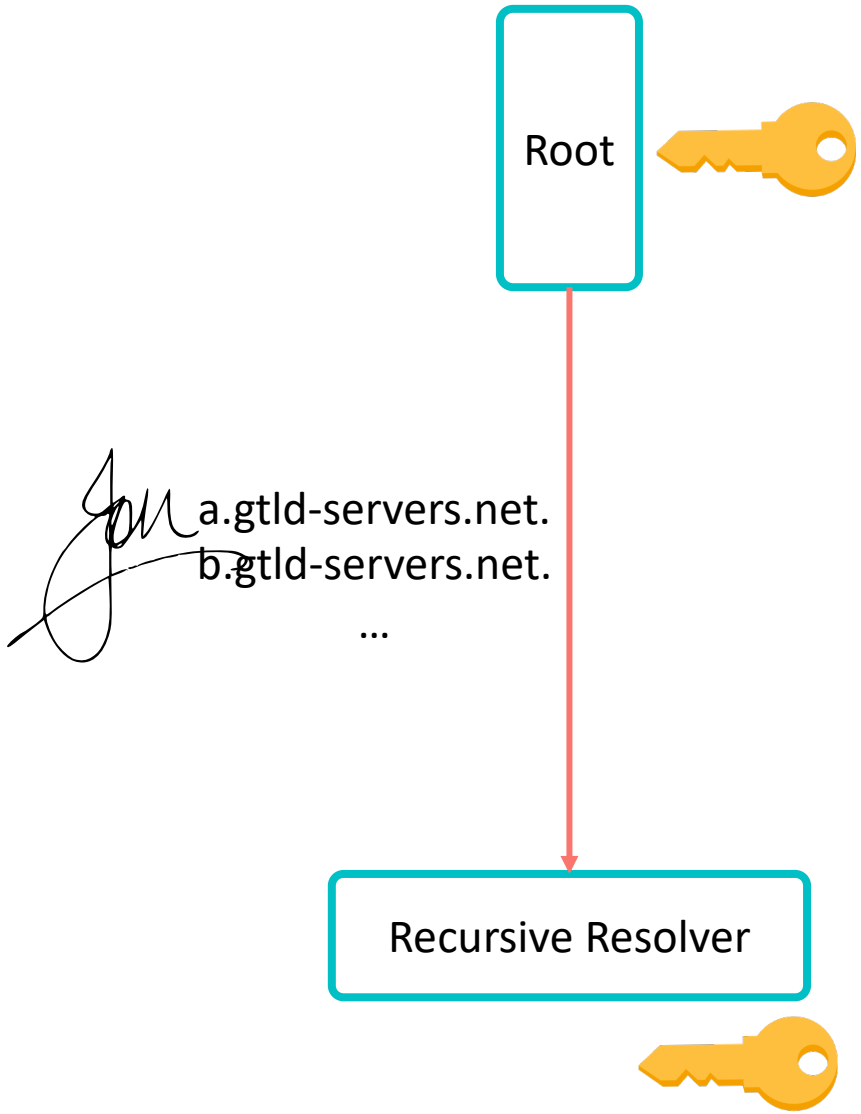

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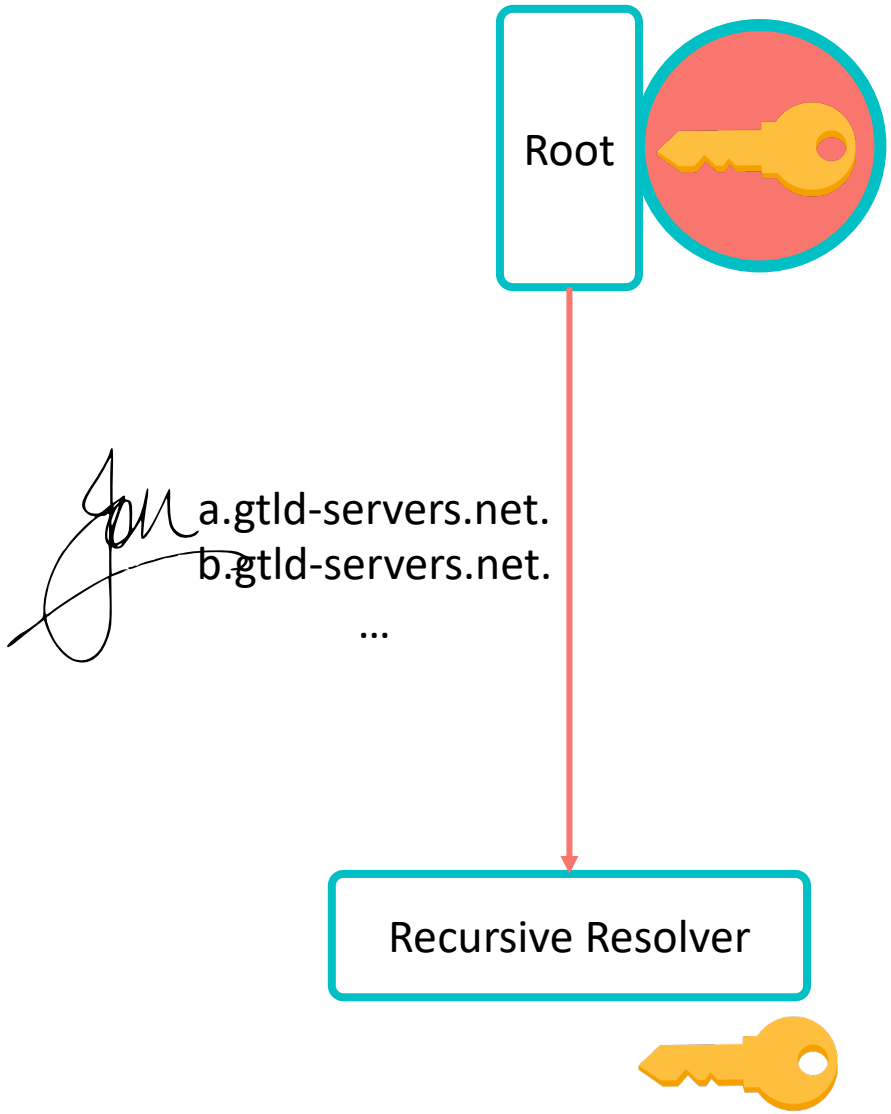
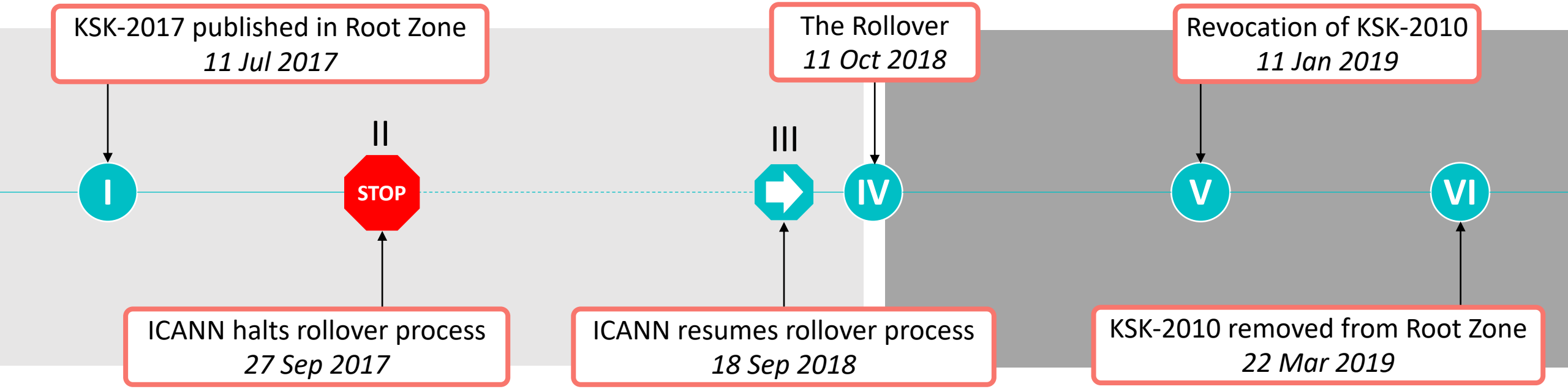


Why is rolling hard?

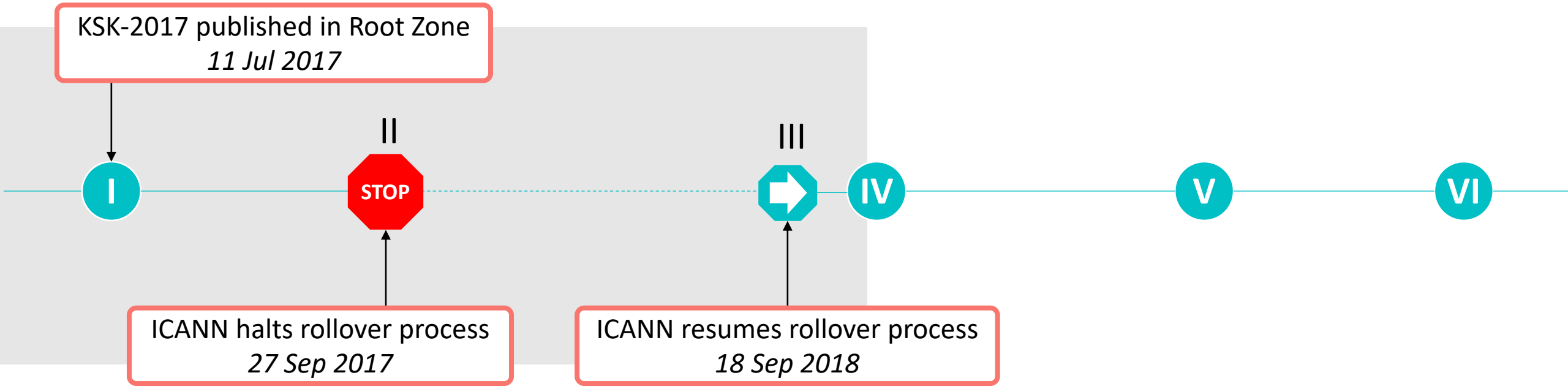
- No key → No validation → No DNS responses
- **Every** validator needs to have KSK-2017, but:
  - Validators use hard-coded keys
  - Containers challenge key update
  - People tend to forget about DNS

Photo by Icons8 team on Unsplash

Timeline

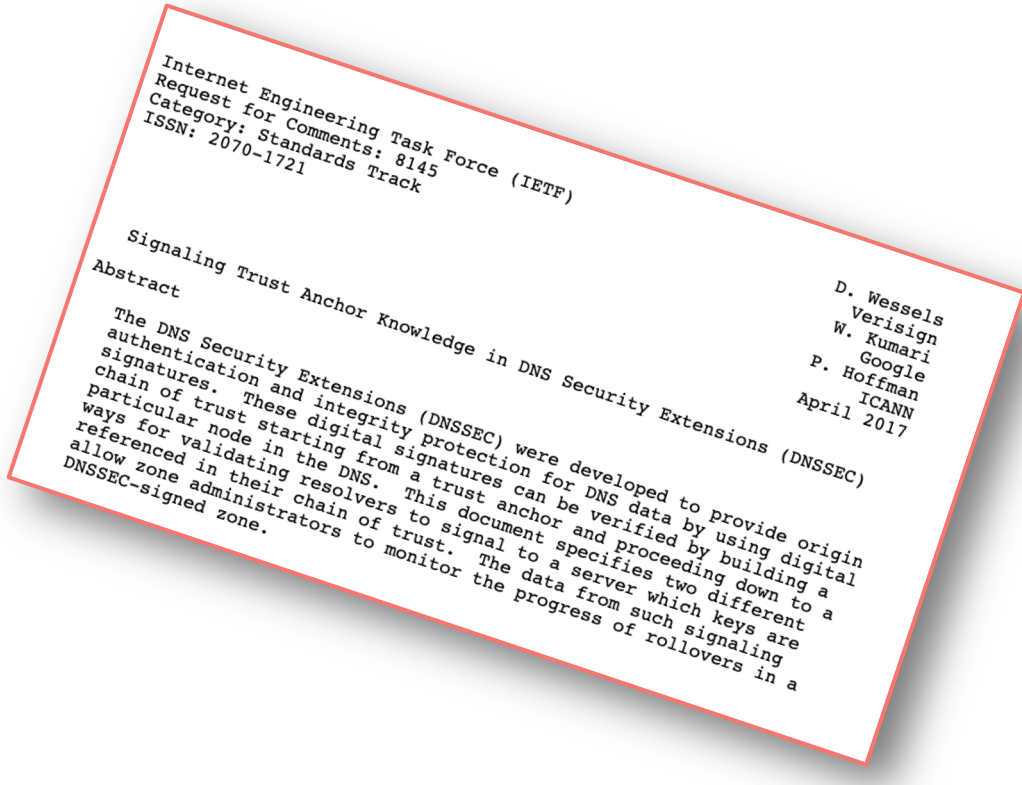

KSK-2017 published in Root Zone
11 Jul 2017
I
II
STOP
ICANN halts rollover process
27 Sep 2017
III
ICANN resumes rollover process
18 Sep 2018
The Rollover
11 Oct 2018
IV
Revocation of KSK-2010
11 Jan 2019
V
VI
KSK-2010 removed from Root Zone
22 Mar 2019

Before the Rollover



Resolver Telemetry: RFC 8145

- The goal: estimating how many validators had KSK-2017
- The solution: resolvers signal to the root which keys they trust



Internet Engineering Task Force (IETF)
Request for Comments: 8145
Category: Standards Track
ISSN: 2070-1721

D. Wessels
Verisign
W. Kumari
Google
P. Hoffman
ICANN
April 2017

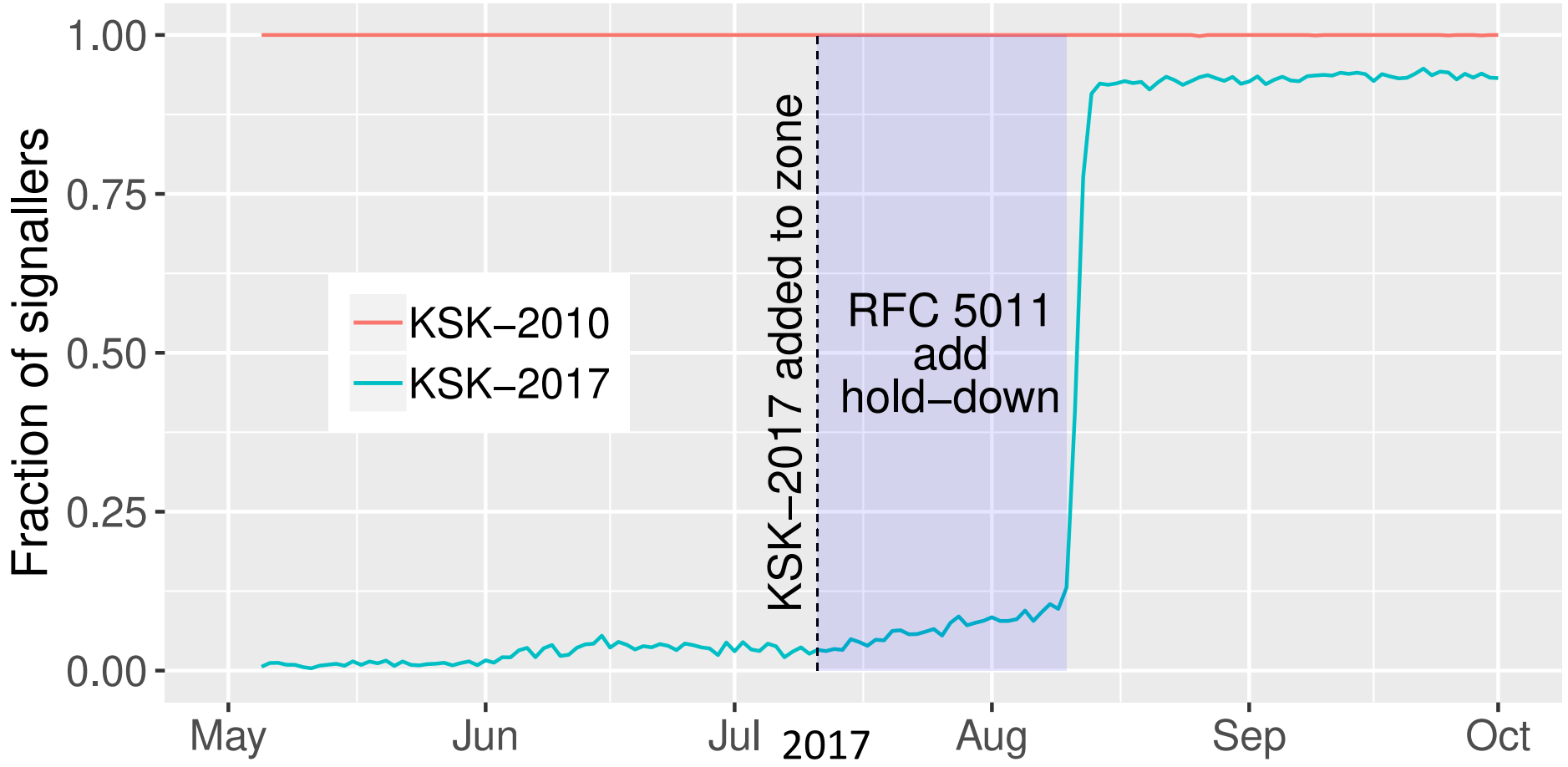
Signaling Trust Anchor Knowledge in DNS Security Extensions (DNSSEC)

Abstract

The DNS Security Extensions (DNSSEC) were developed to provide origin authentication and integrity protection for DNS data by using digital signatures. These digital signatures can be verified by building a chain of trust starting from a trust anchor and proceeding down to a particular node in the DNS. This document specifies two different ways for validating resolvers to signal to a server which keys are referenced in their chain of trust. The data from such signaling allow zone administrators to monitor the progress of rollovers in a DNSSEC-signed zone.

- Data from ICANN from A, B, and J root
- Signals from up to 100,000 validators daily

Uptake of KSK-2017



Uptake of KSK-2017

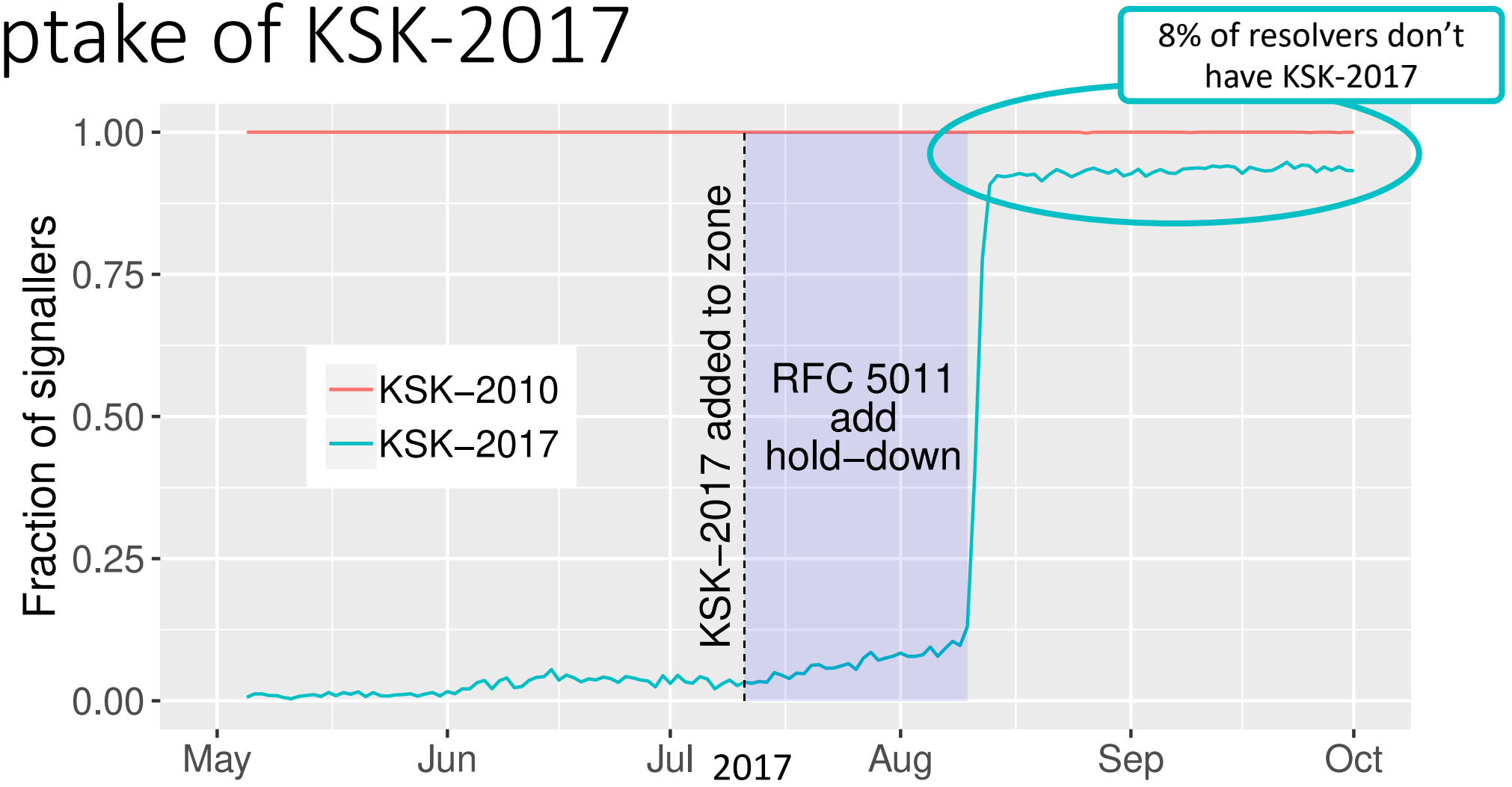


Photo by John Matychuk on Unsplash

I

STOP

IV

V

VI

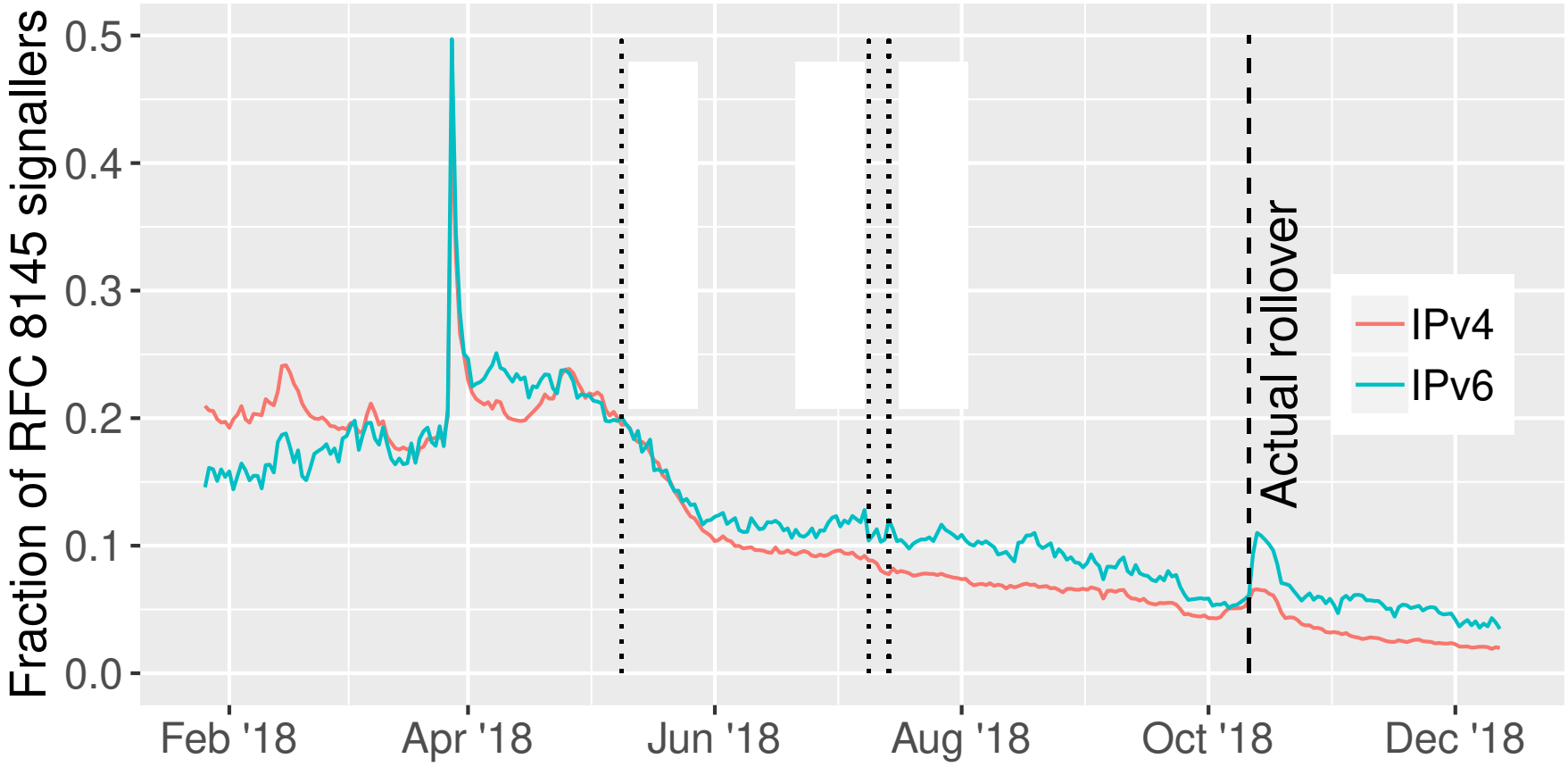
Zooming in on resolvers that only have KSK-2010

- Lots of RFC 8145 sources sent only one signal
- Many sent only a few queries

Query	Count
_ta-4a5c	15,447
.	9,182
VPN domain	3,156
VPN alternate domain	415
_sip._udp.otherdomain	86

Domains, queried by resolvers

Zooming in on resolvers that only have KSK-2010



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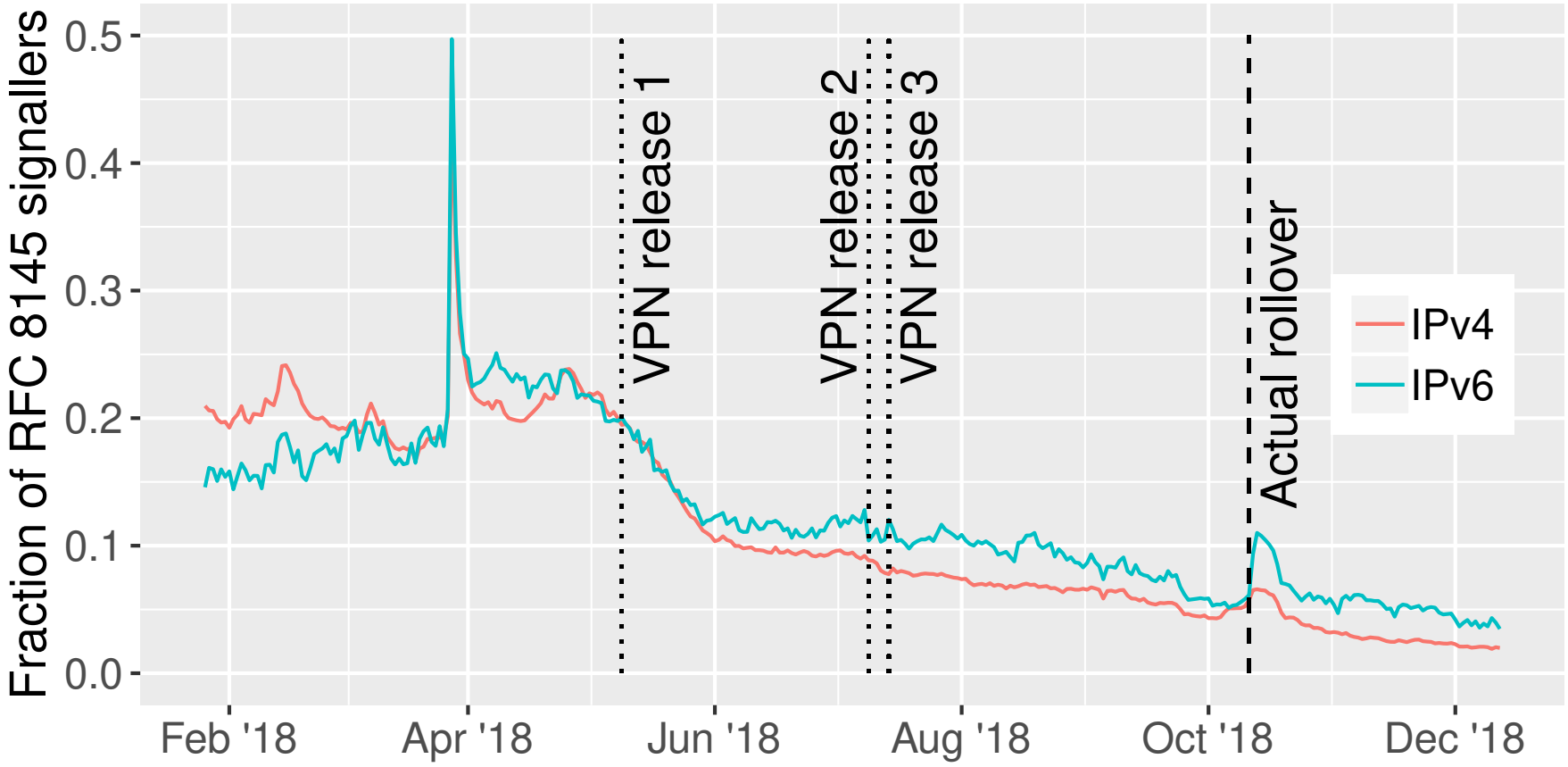
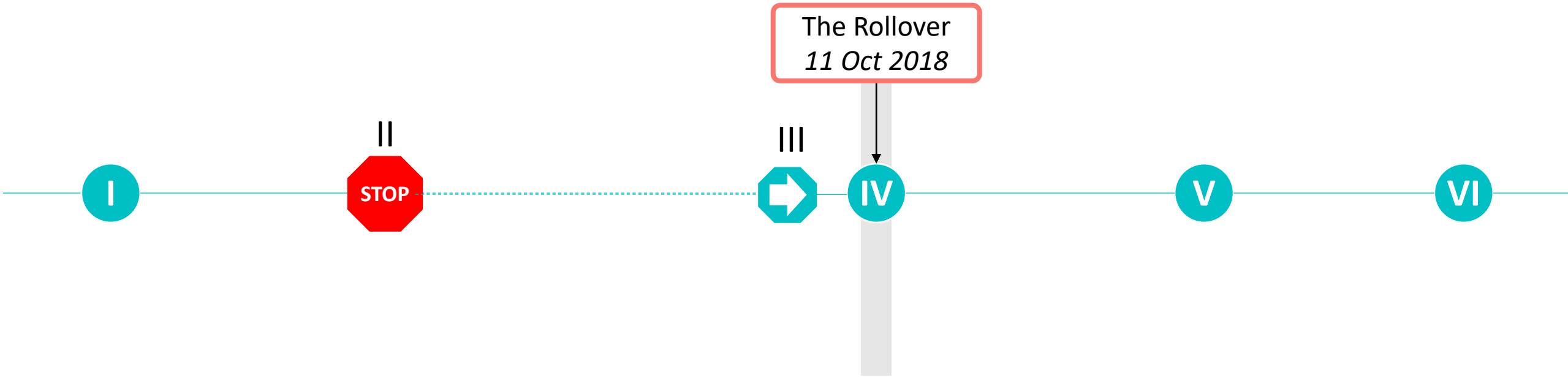


Takeaways from *before* the Rollover

- **Most** validators correctly picked up KSK-2017
- But **one single application** can influence the trust-anchor signal
- Validation in applications might become more common

  → **Influence on telemetry**

During the Rollover

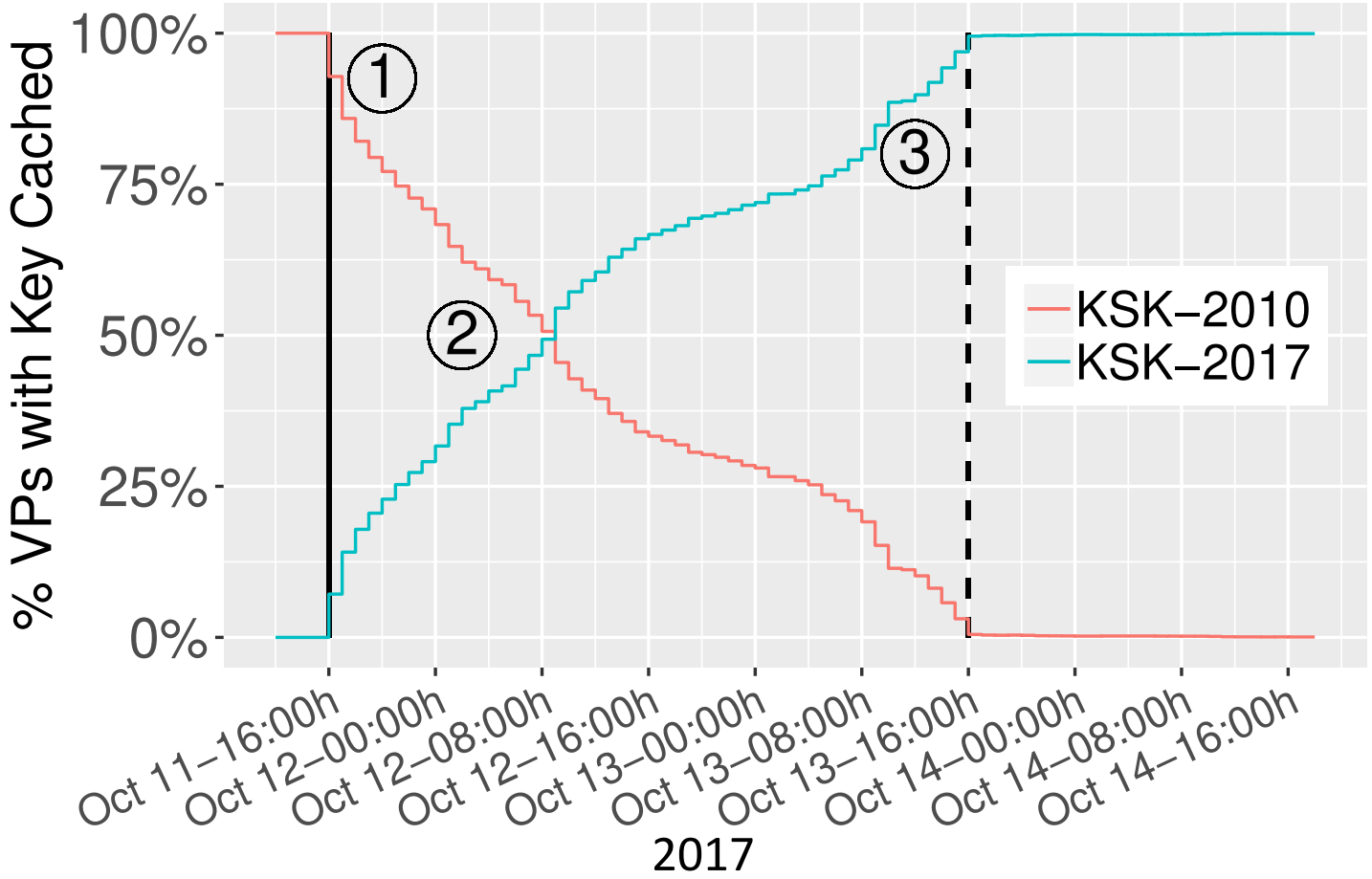


The User's Perspective: RIPE Atlas

- The goal: measuring how **users** perceive the rollover
- The approach: Measuring with all RIPE Atlas probes once per hour
    a) If they have cached KSK-2017
    b) If they validate correctly

- We observed **35,719 resolver addresses** in **3,141 ASes** and correlated failing resolvers with DNSKEY queries with DITL data

Activating KSK-2017



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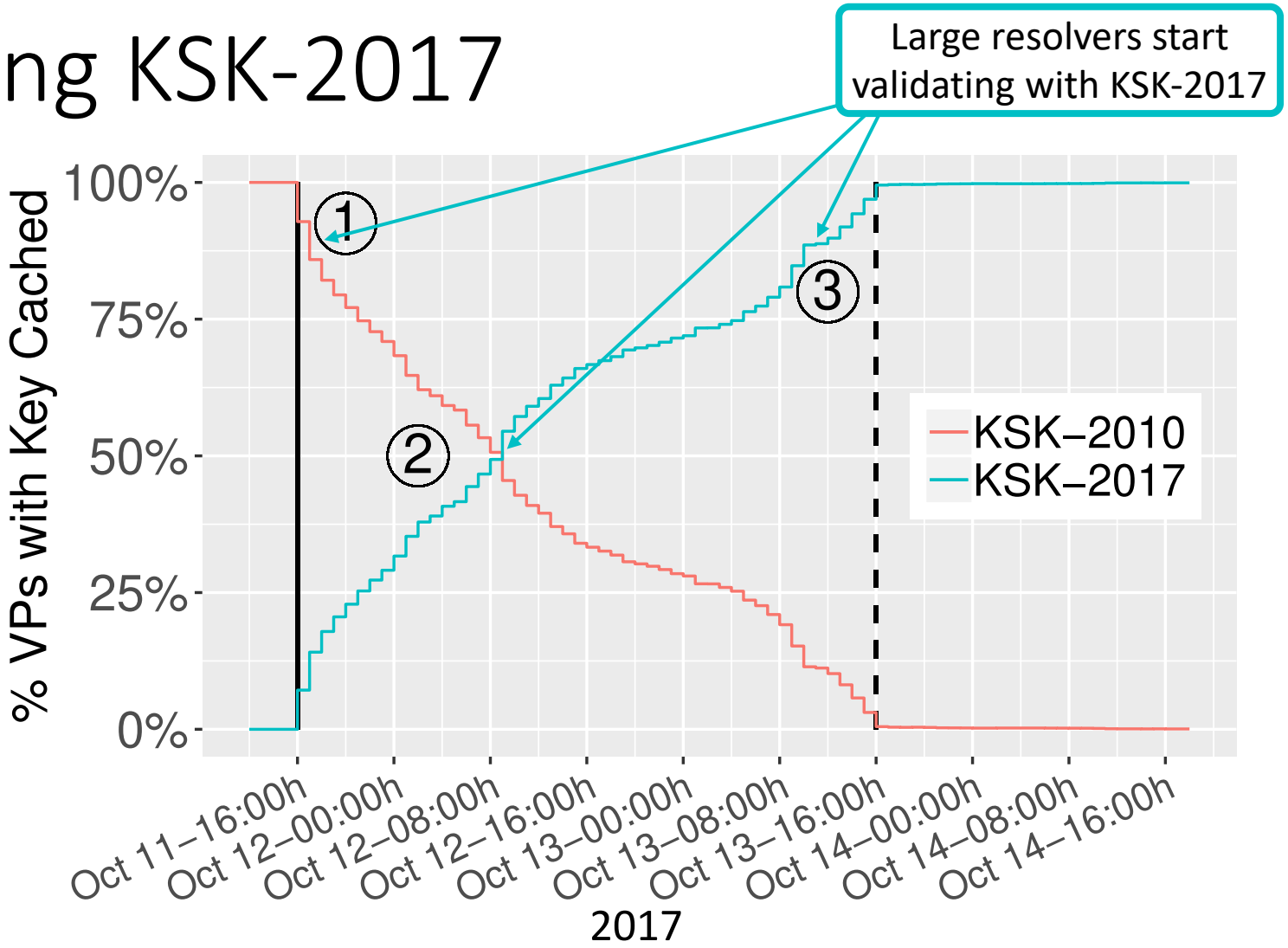
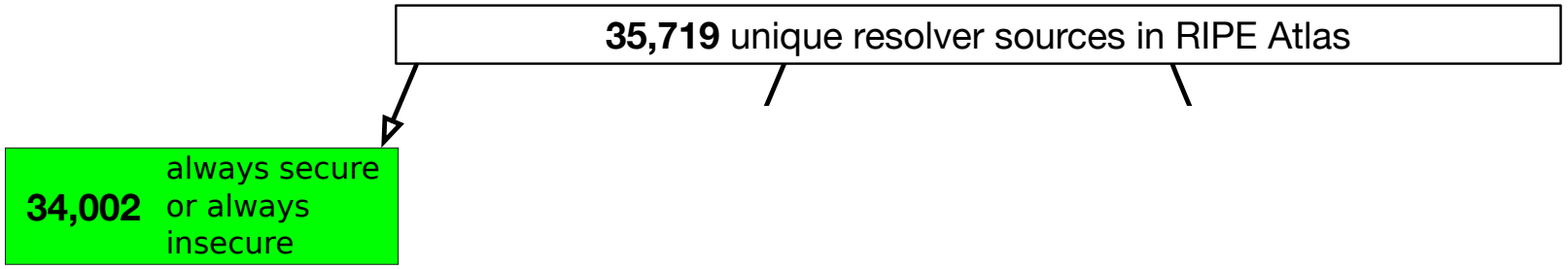


Reaction to Validation Failures



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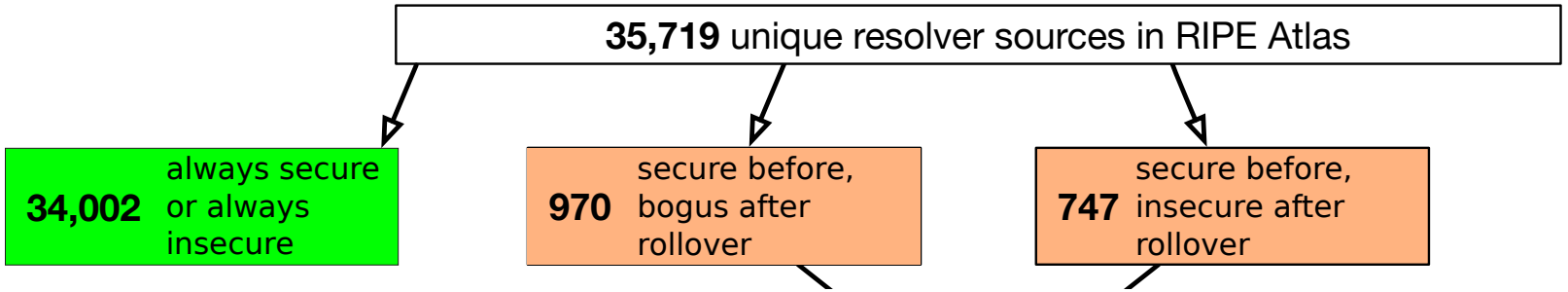

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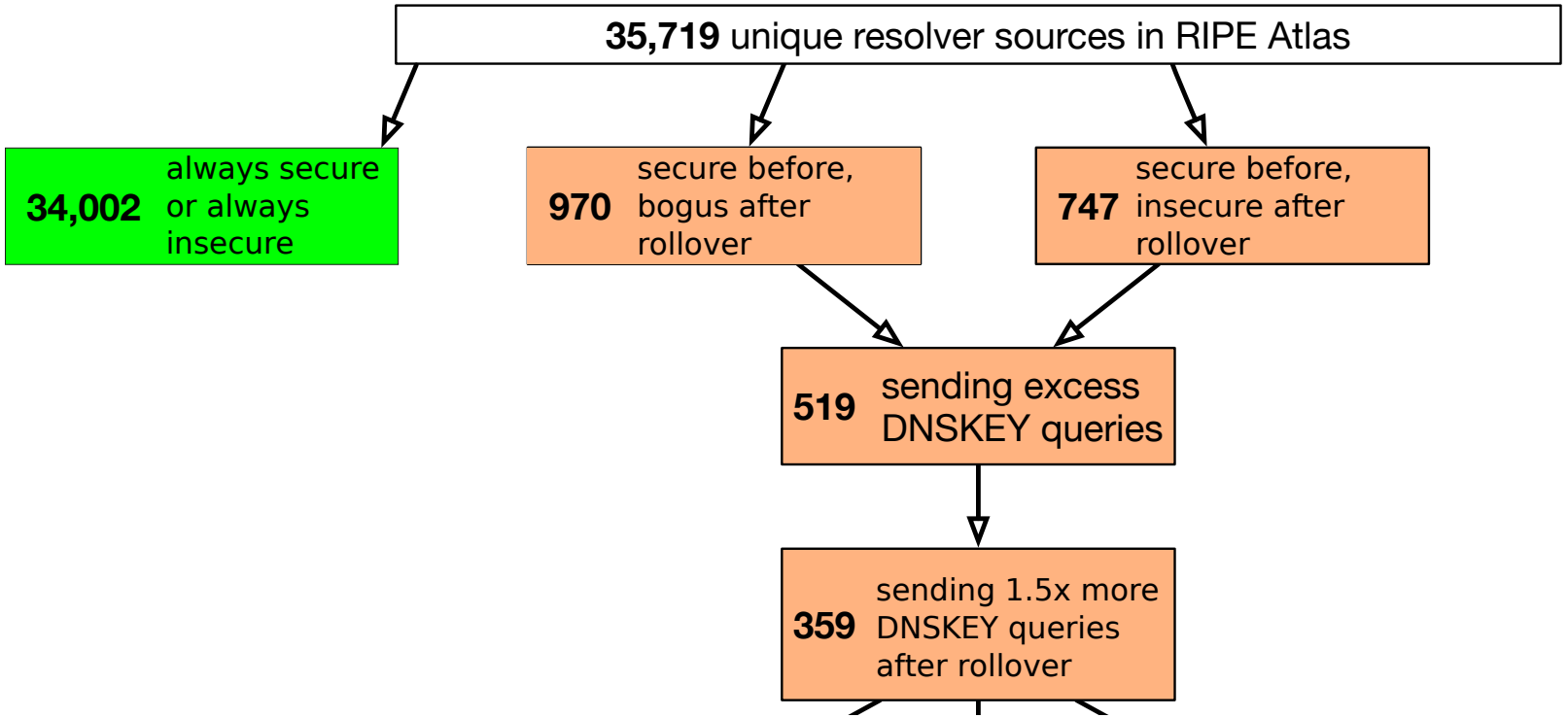

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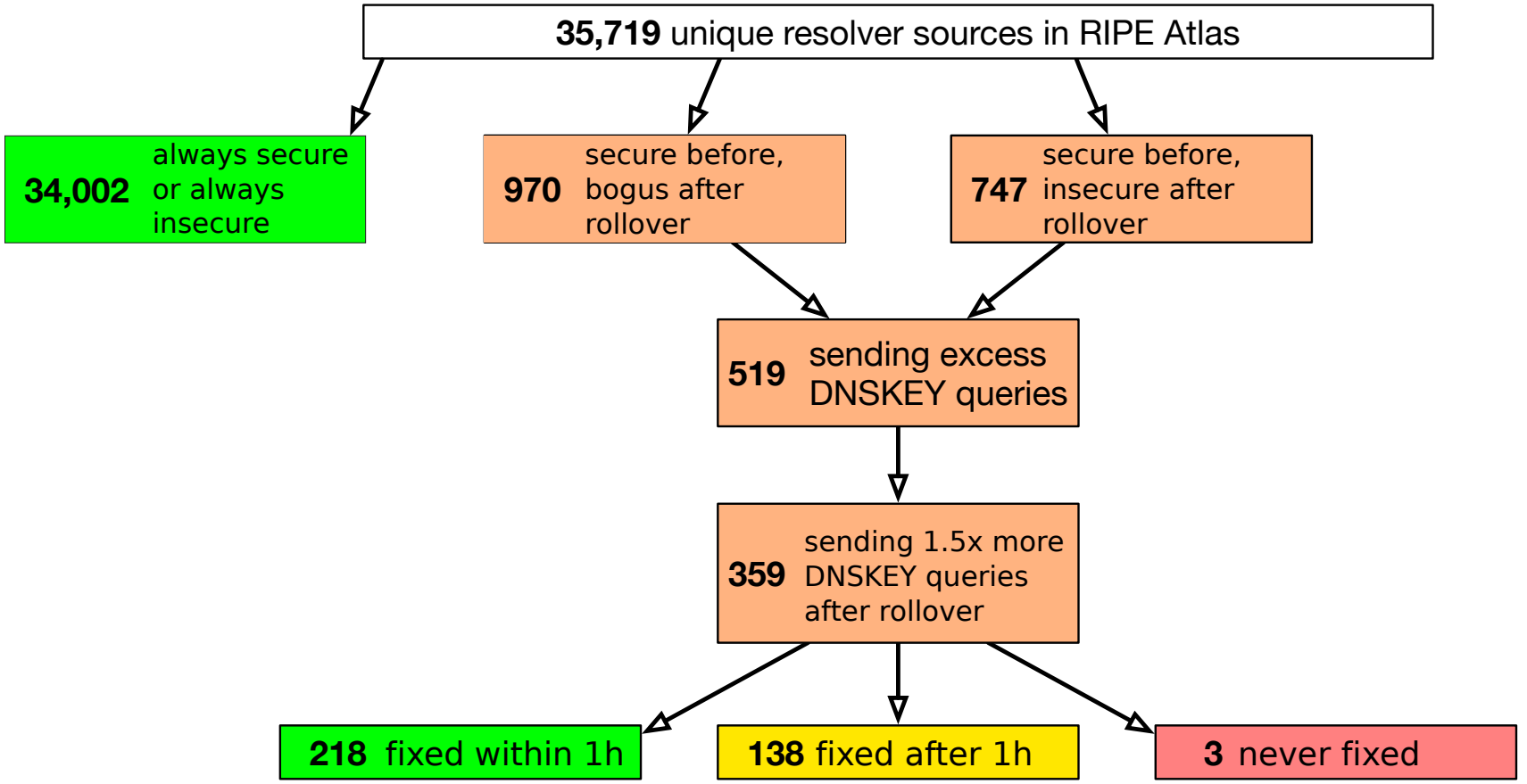


Broadband restored to Eir customers after outage

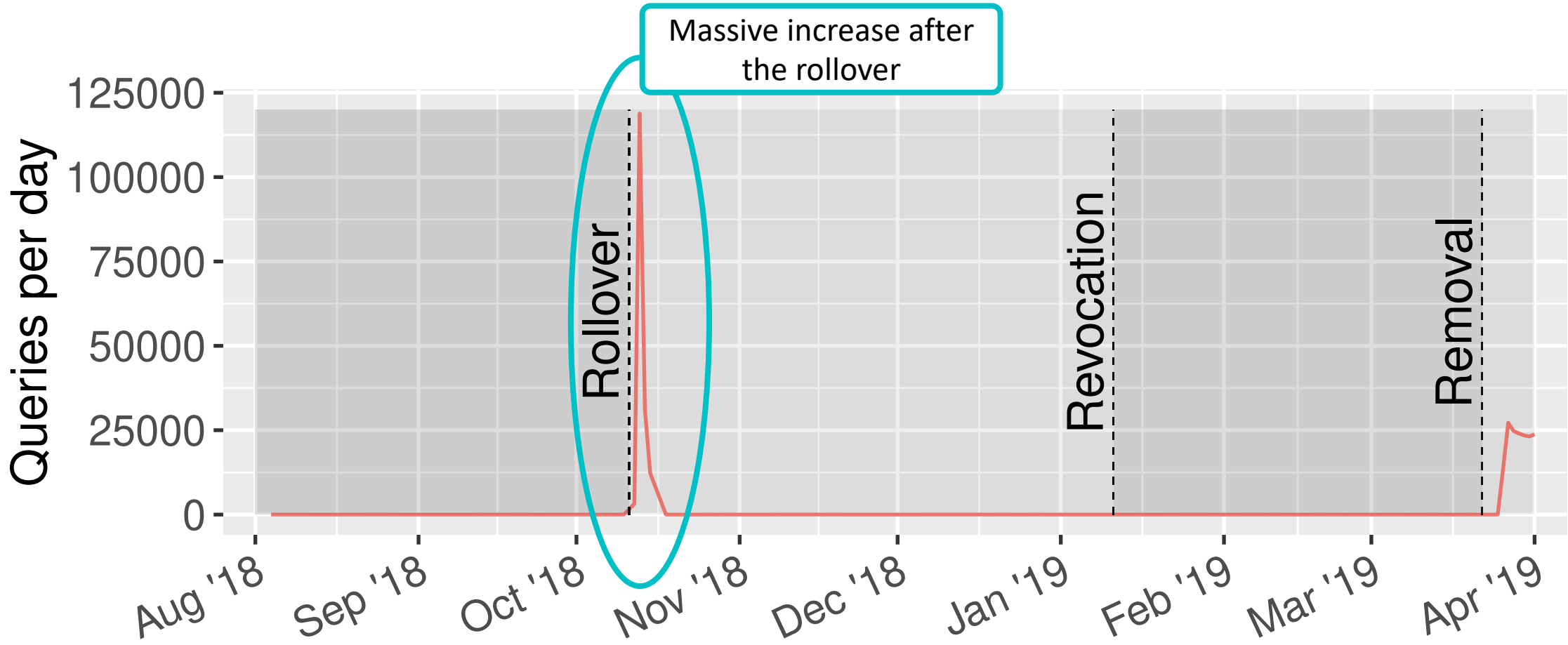
Company says problem with DNS server led to outage across the country

Sat, Oct 13, 2018, 21:23 | Updated: Sun, Oct 14, 2018, 07:55

File photograph: Maxwells

https://www.irishtimes.com/business/technology/broadband-restored-to-eir-customers-after-outage-1.3663004

EIR Outage - Was it DNS(SEC)?



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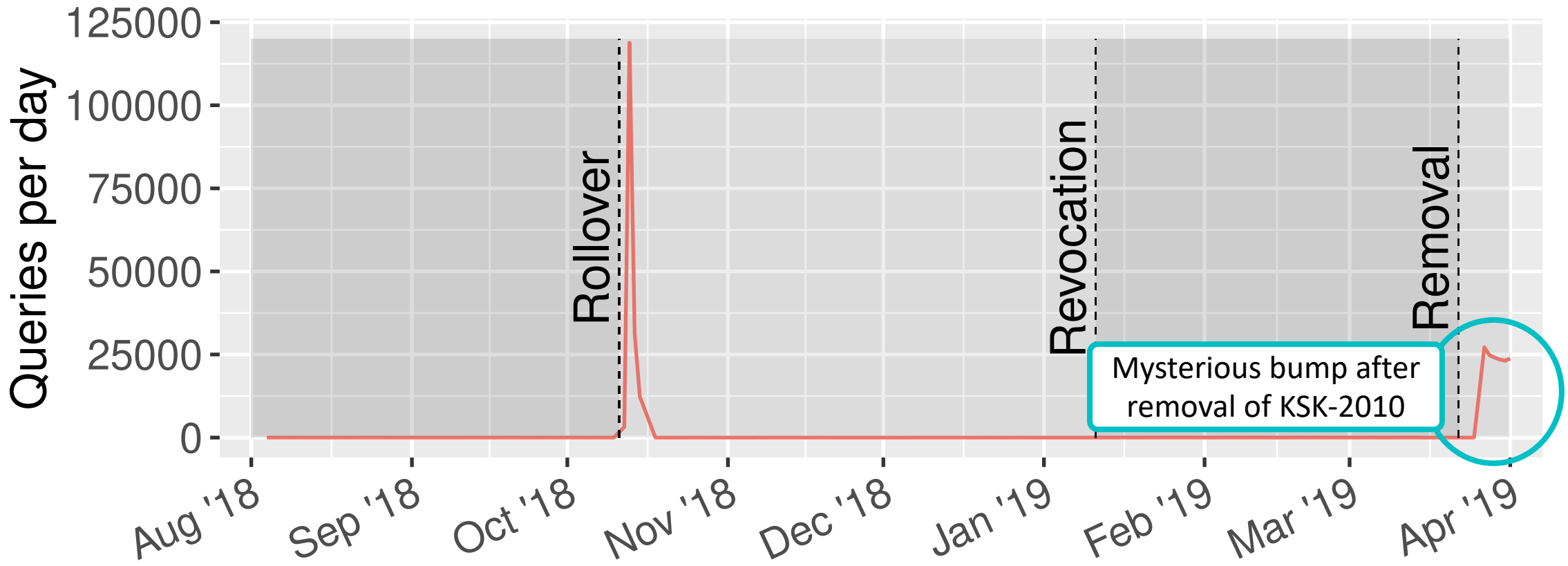
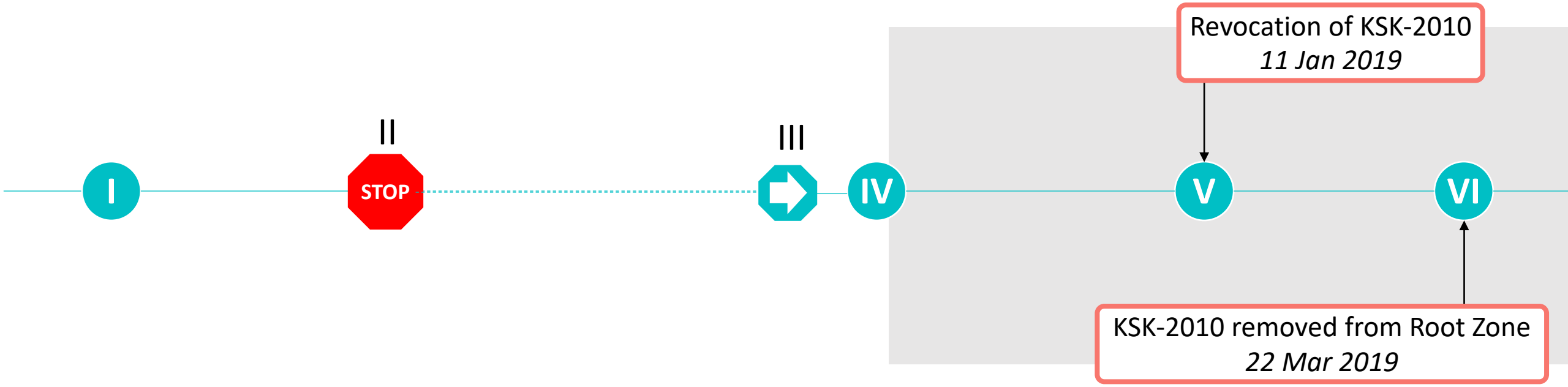


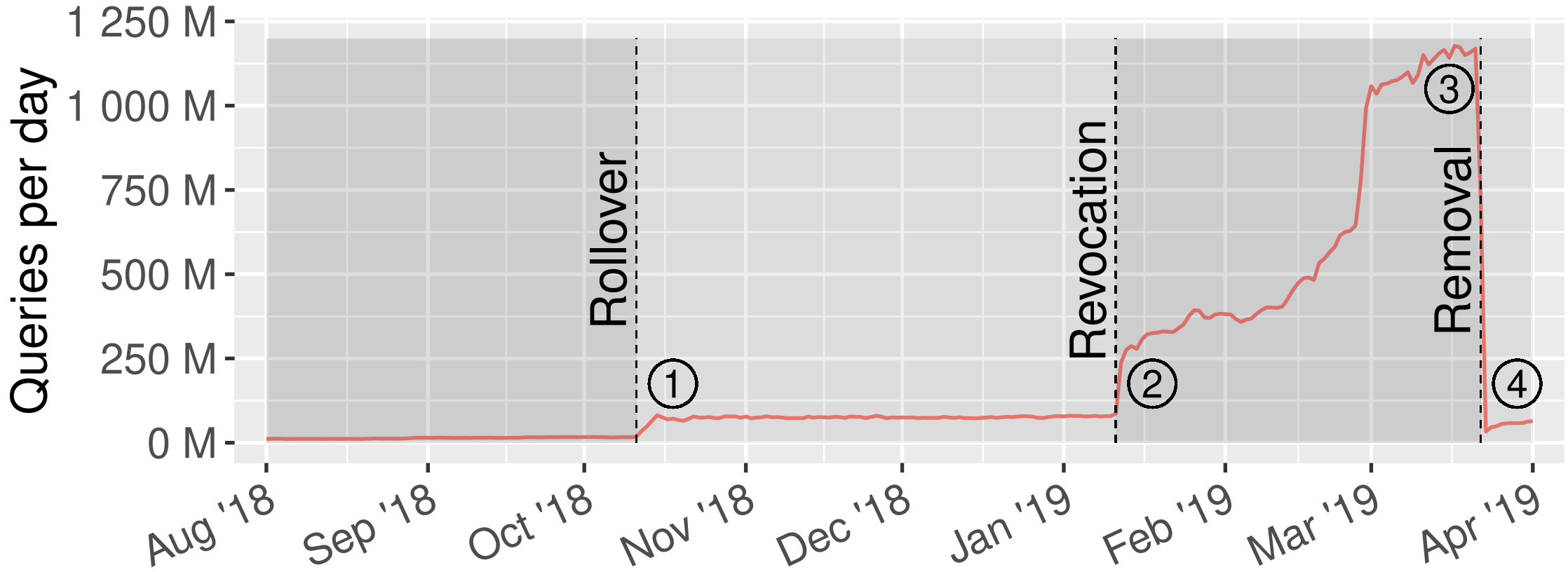
Takeaways from *during* the Rollover

- **Few** resolvers had **serious problems**
- The ones that had problems **recovered fast**
- Less than **0.01%** of the resolvers we monitored experienced problems

After the Rollover



Increase in DNSKEY queries



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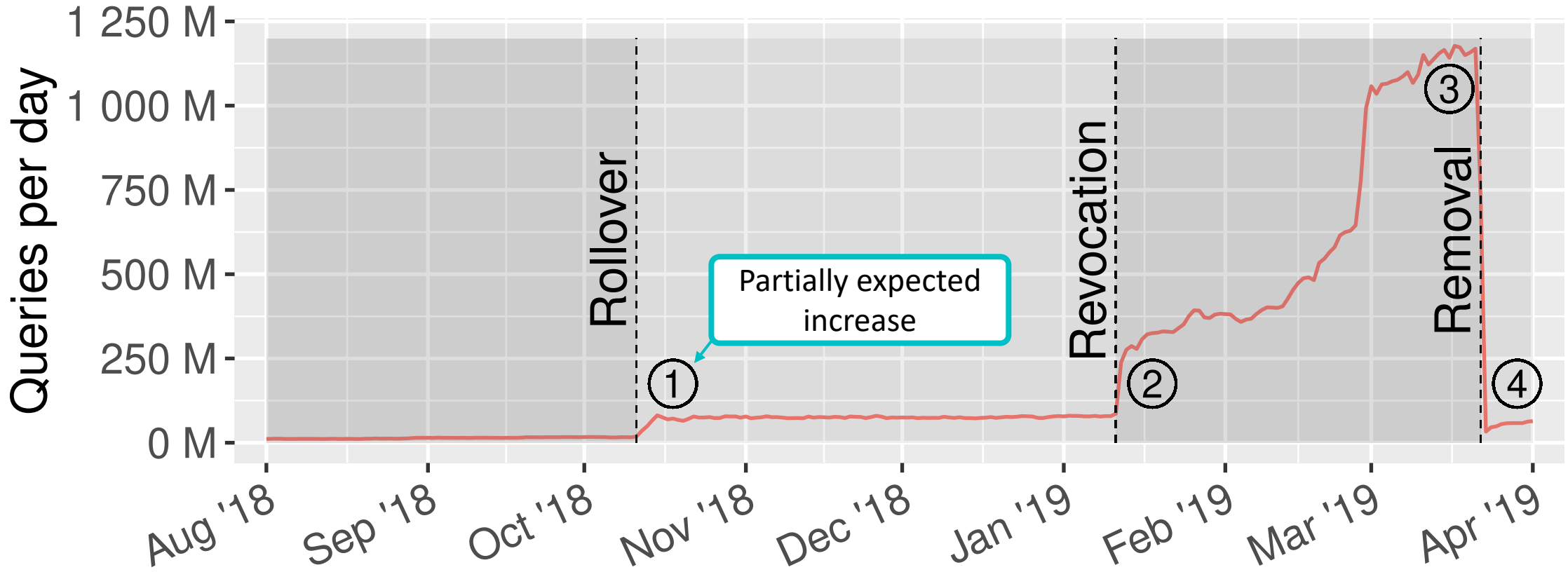

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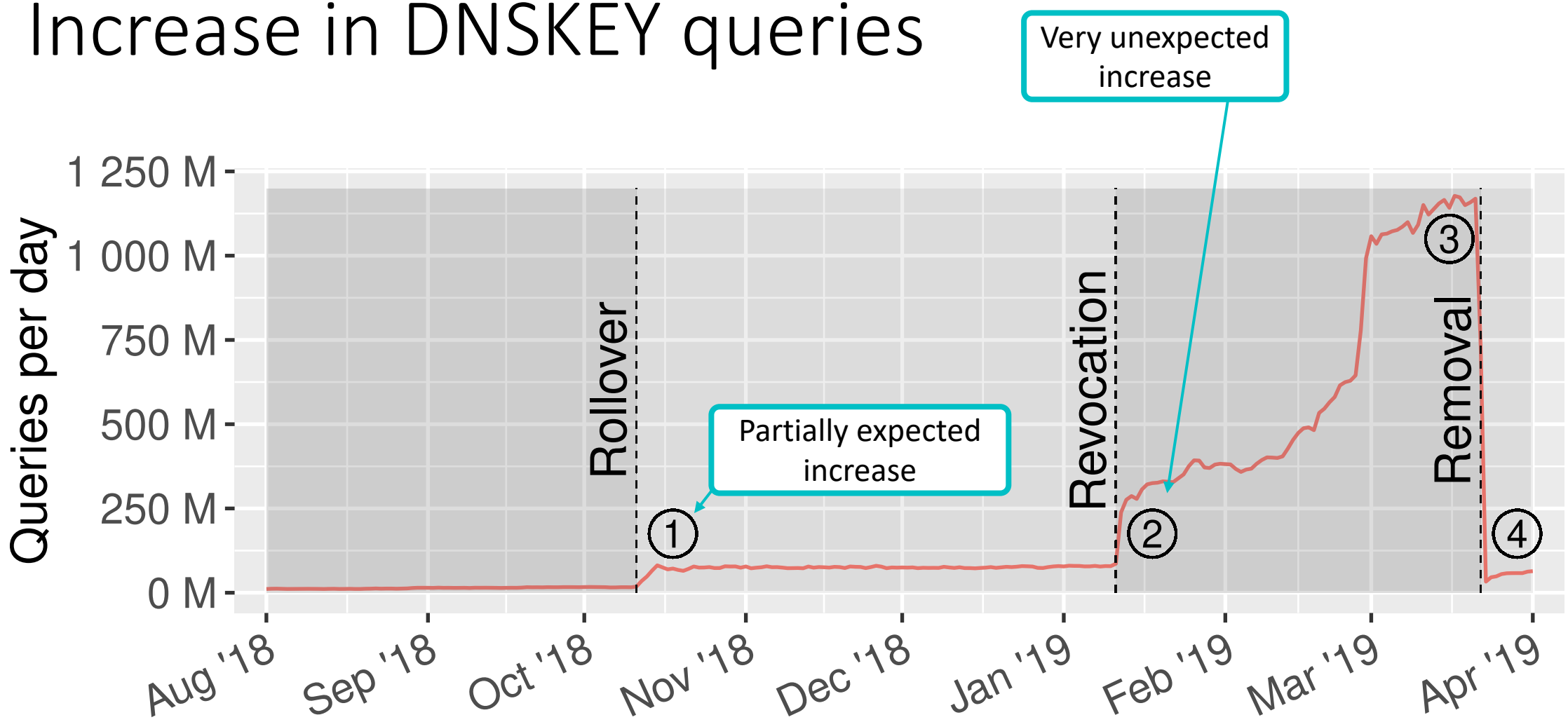

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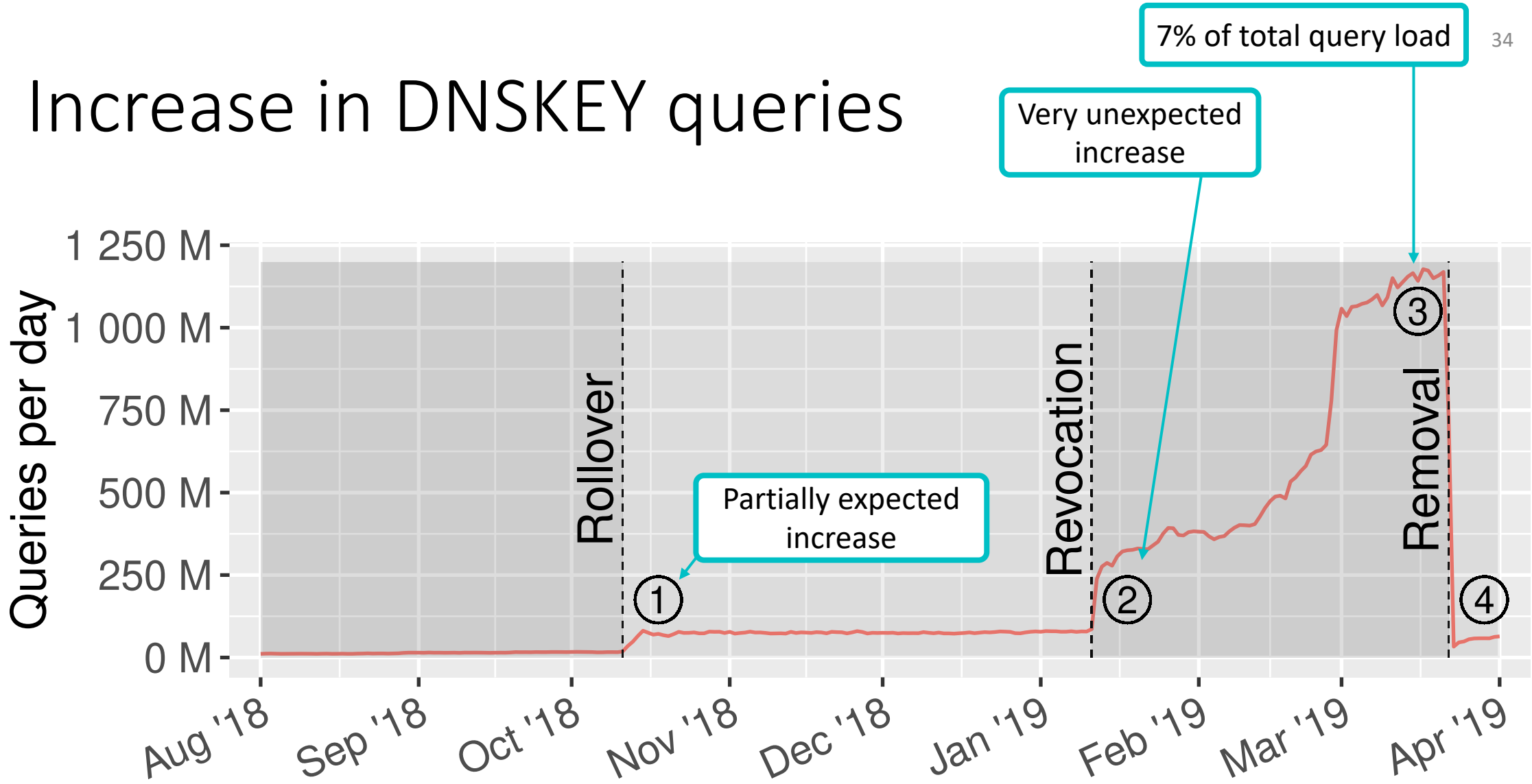

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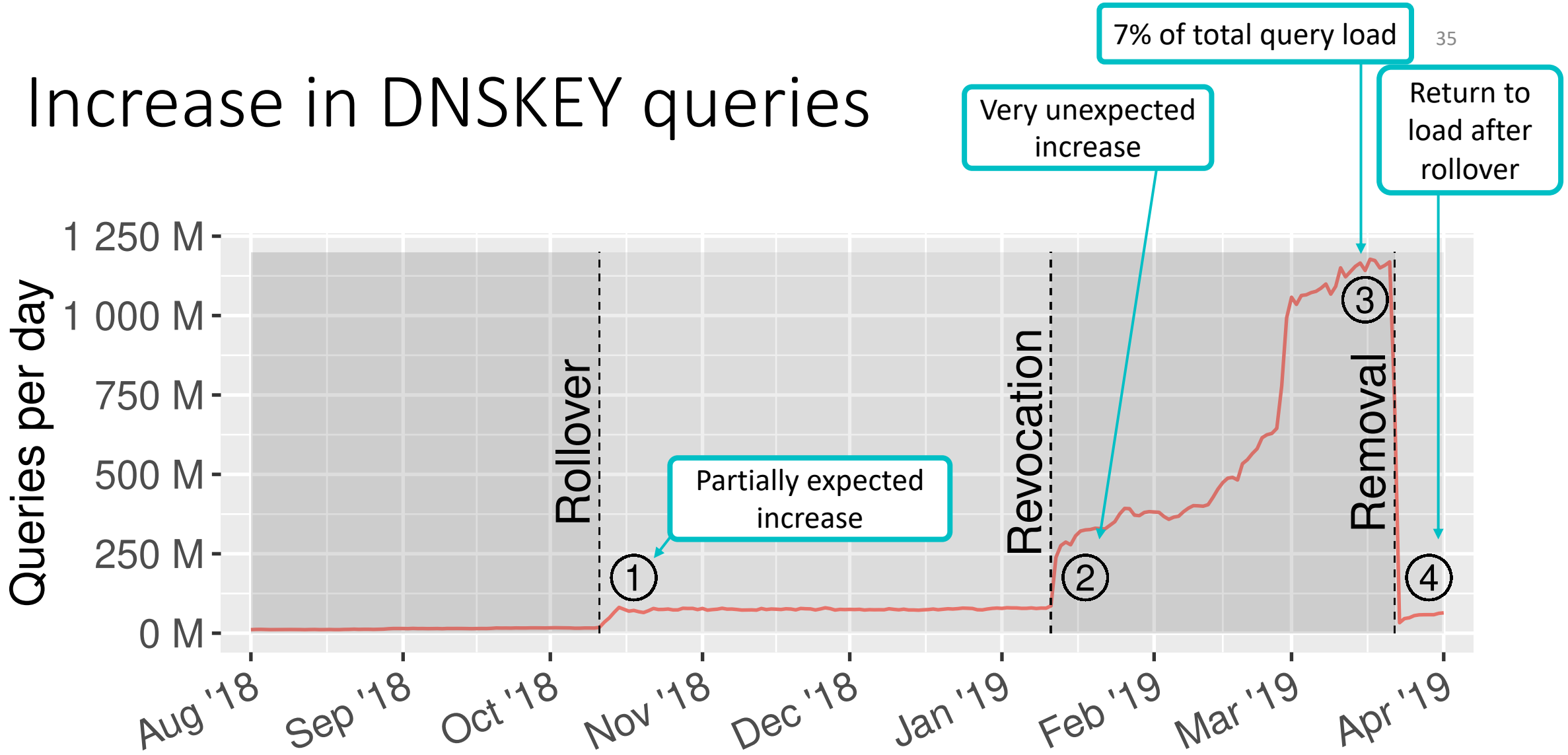
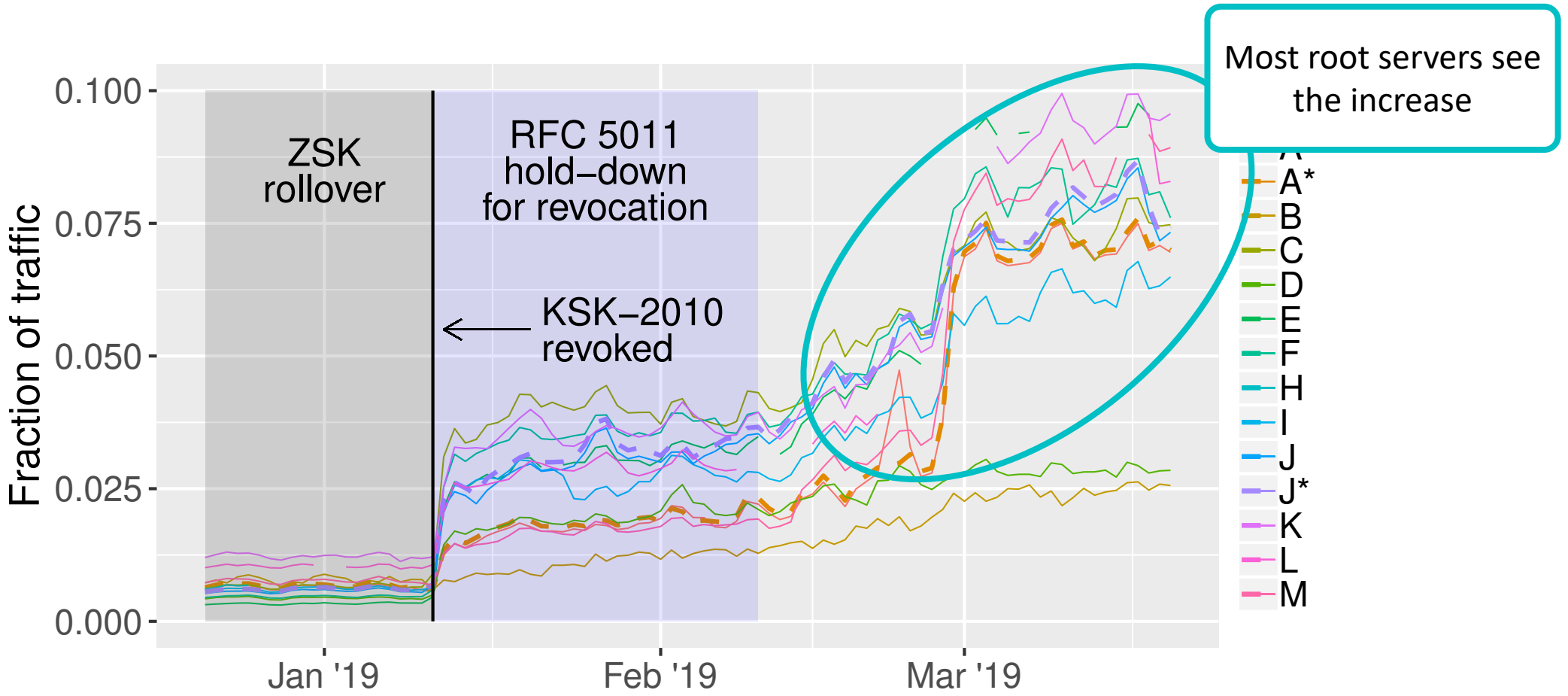


Increase in DNSKEY queries after revocation



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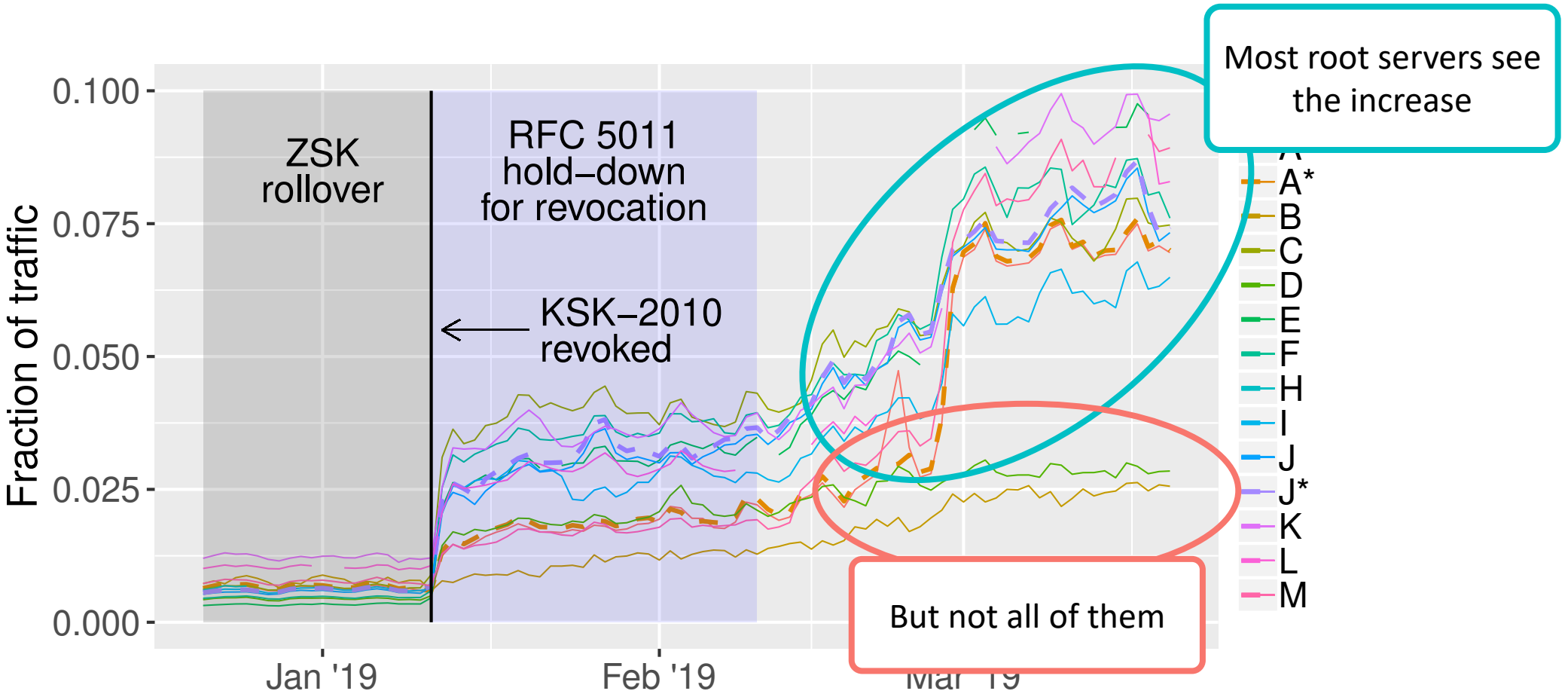

Who's behind the query floods?

- DNS CHAOS queries to sources reveal mostly older versions of BIND
- Outreach
  - A large French cloud hosting provider confirmed a source running BIND 9.8.2 on CentOS
  - Large midwestern university confirmed DNS lab exercise and provided BIND config

Photo by Kelly Sikkema on Unsplash

Reproducing Key Floods with BIND

- Conditions for reproducing DNSKEY floods with BIND:
  - DNSSEC managed keys contains KSK-2010, but not KSK-2017
  - The dnssec-enable flag was set to false
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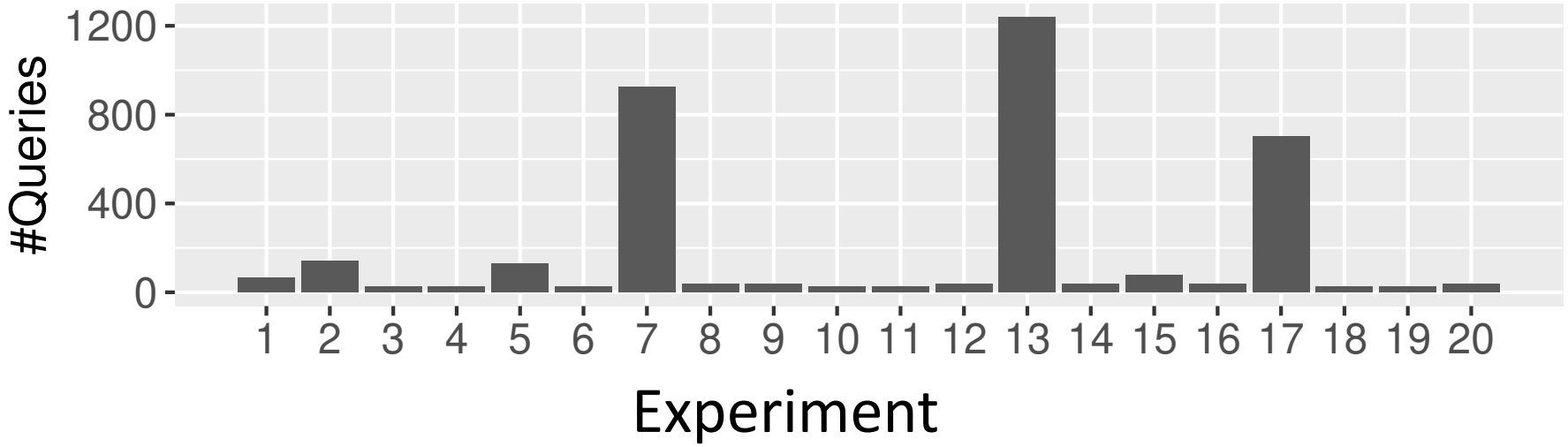

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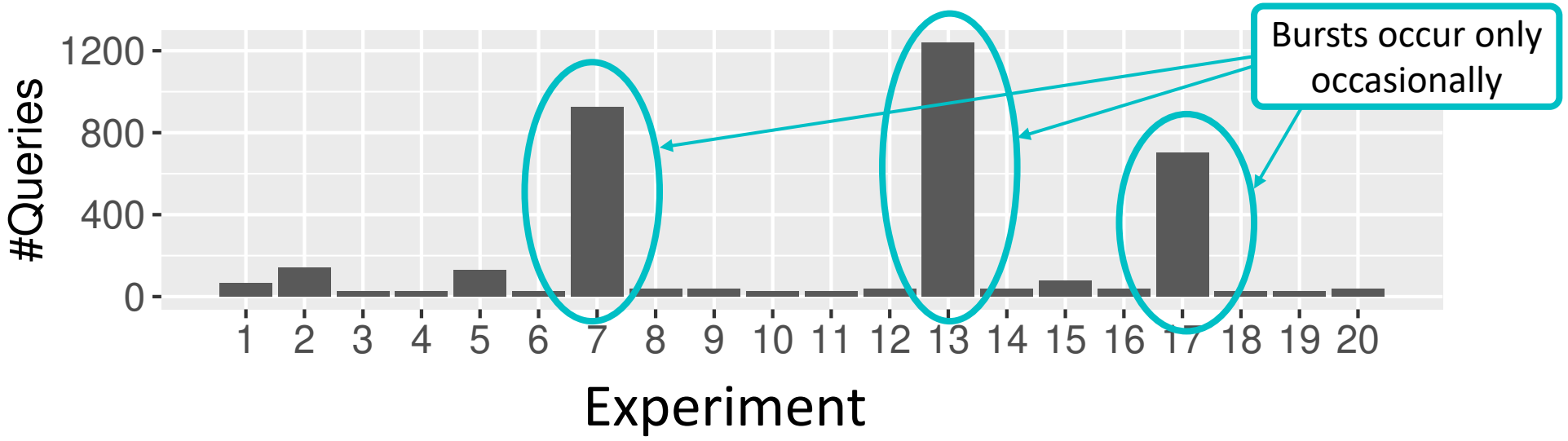
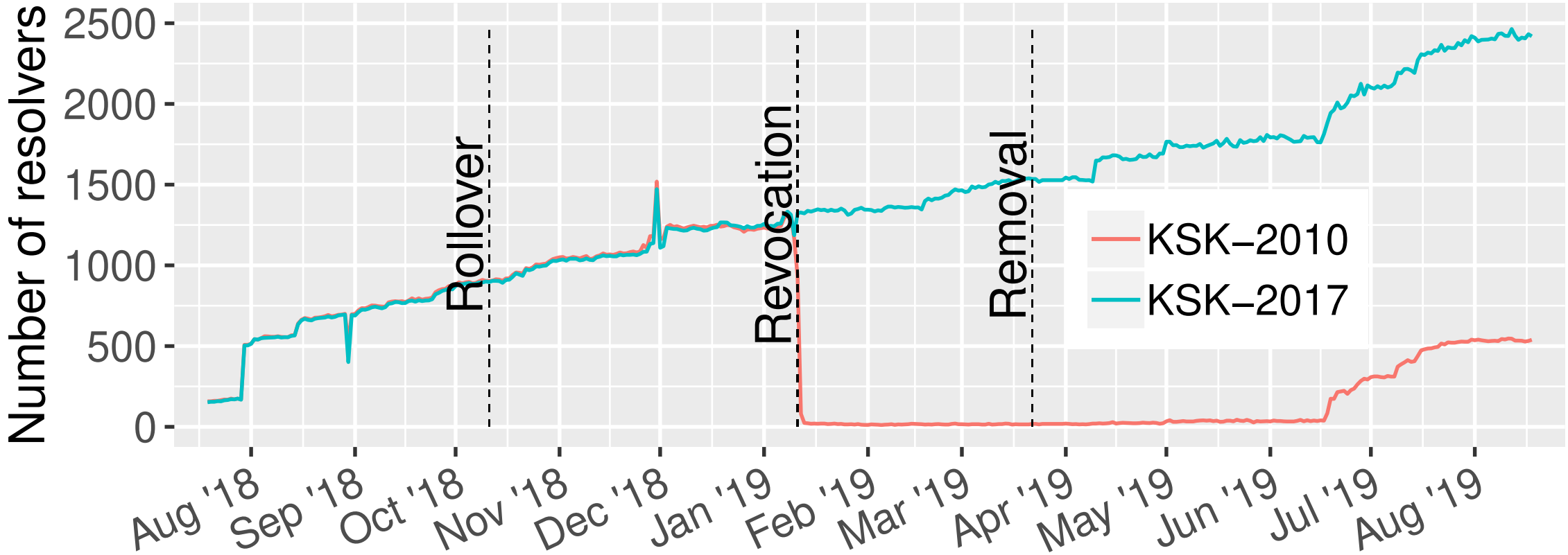


Resolver Telemetry: RFC 8509 “Root Sentinel”



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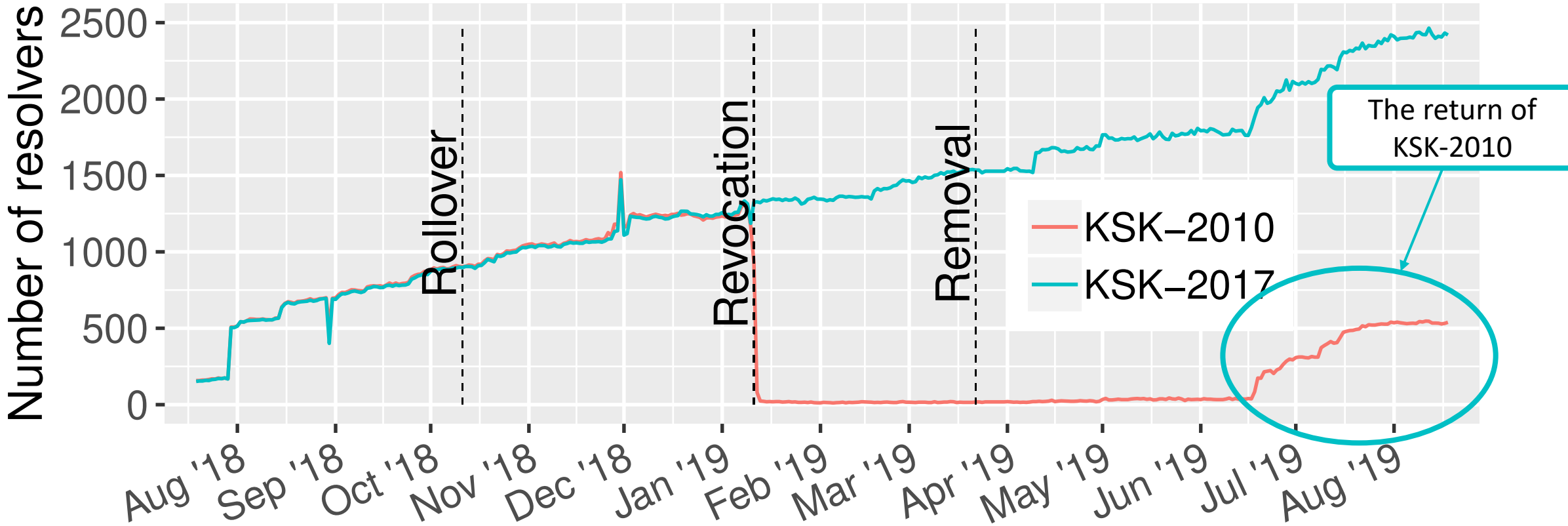
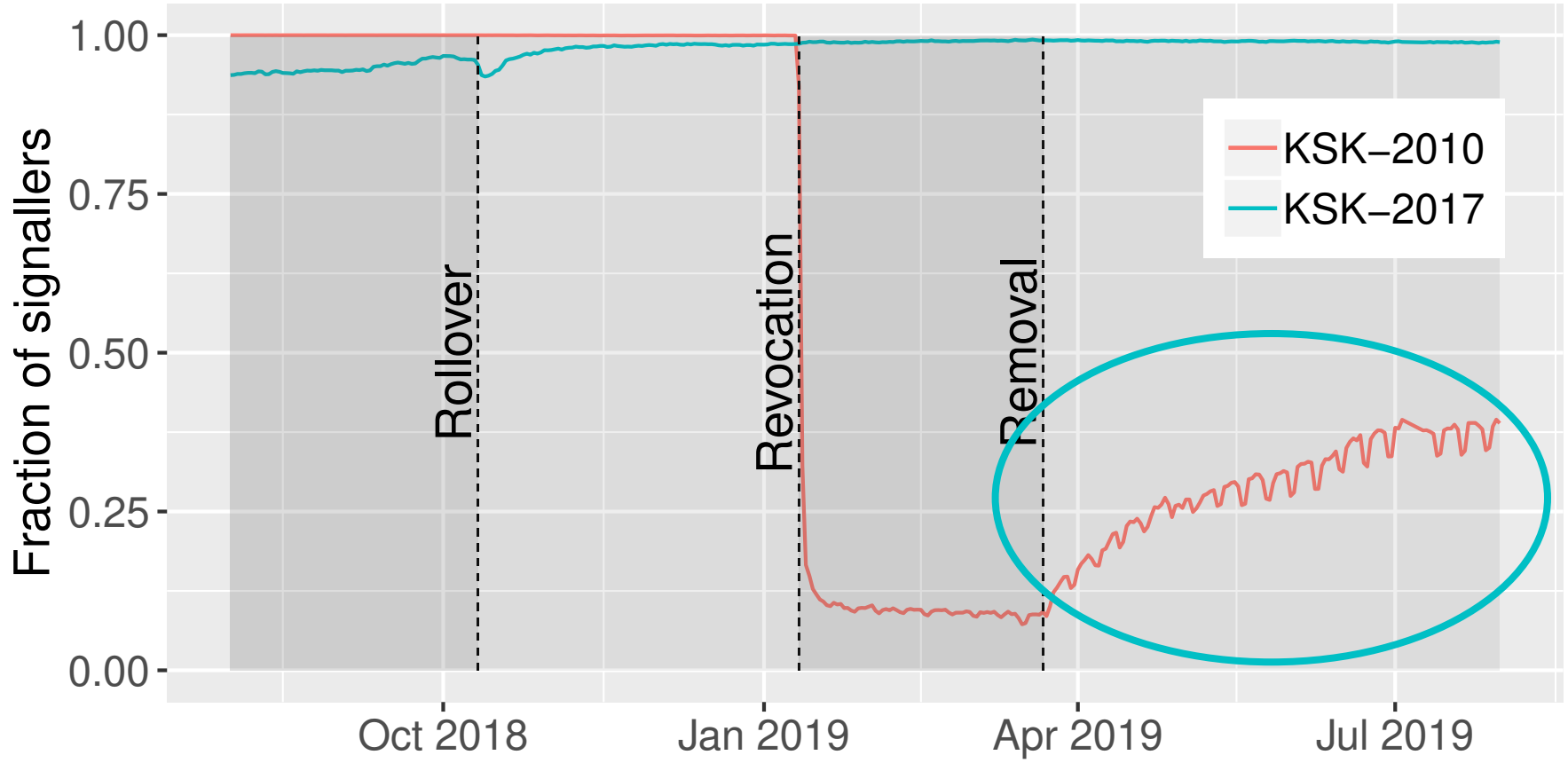
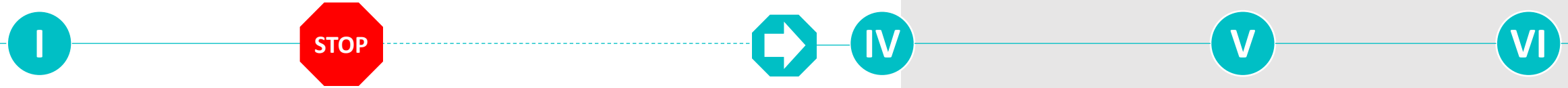


Resolver Telemetry: The return of KSK-2010



Takeaways from *after* the Rollover

- **No one** expected the massive flood of DNSKEY queries
- Trust anchor management comes in **different shapes and colors**
- Shipping trust anchors with software has **long-lasting effects**



Discussion

VI

Do we need to improve telemetry?

- RFC 8145 and RFC 8509 are useful but should be improved
  - Allowing to identify the true source of a signal
  - Provide an estimate for how many users a signal represents

Photo by Chunlea Ju on Unsplash

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Do we need to change trust anchor management?

E.g. shipping TAs centrally in OSes?

Photo by Chunlea Ju on Unsplash

Conclusions and broader Lessons

- The rollover was a **success**
- **Independent analysis** and measurements on the internet are valuable
- Telemetry must be kept in mind **at an early stage** of protocol development
- Trust anchors should be **managed centrally**

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Paper available at

https://bit.ly/2OxKWc3

Data available at

https://github.com/SIDN/RollRollRollYourRoot

Questions, suggestions, comments?

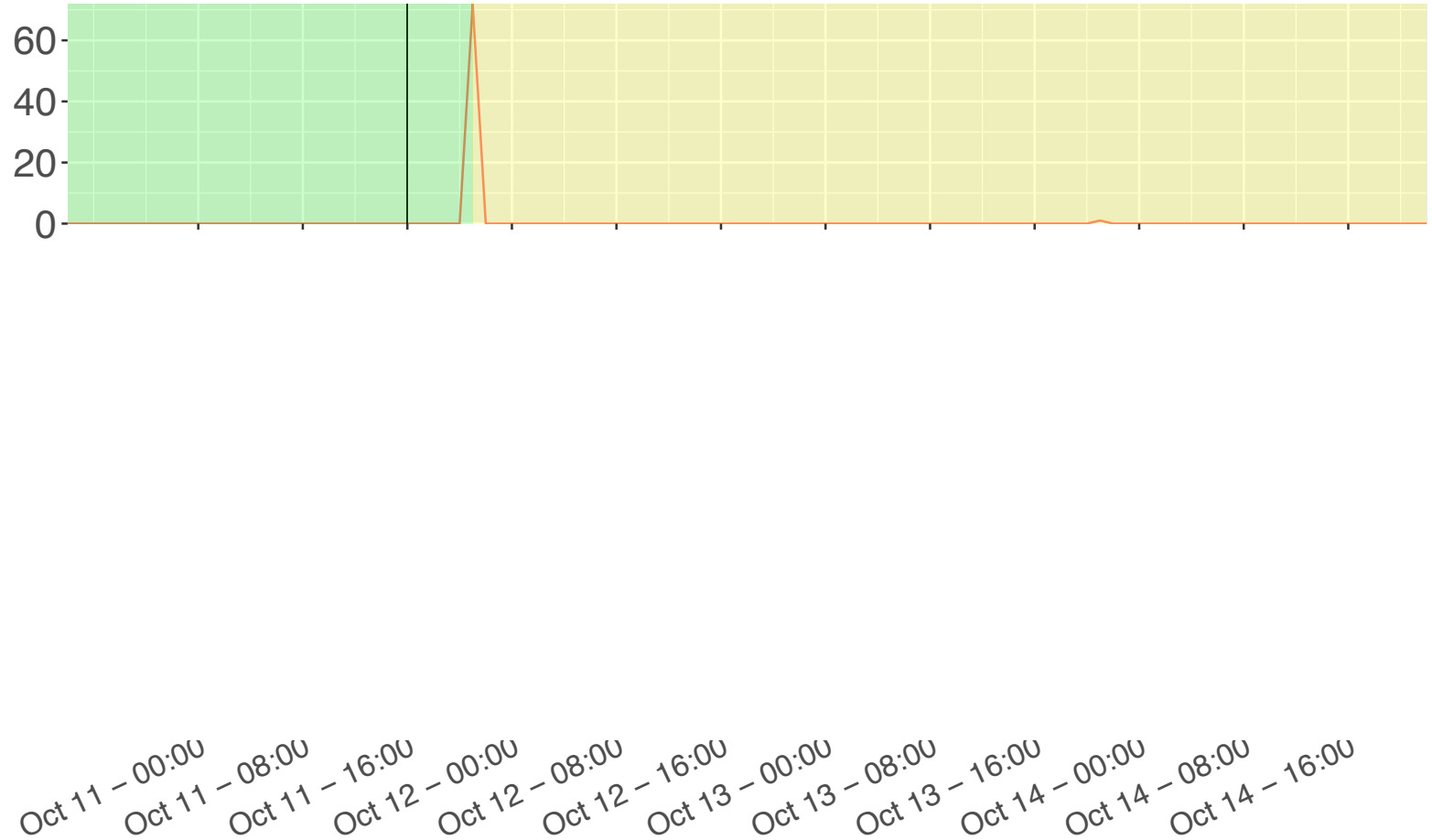
Contact

Moritz Müller | moritz.muller@sidn.nl | sidnlabs.nl

Bonus Slides

Failure Modes

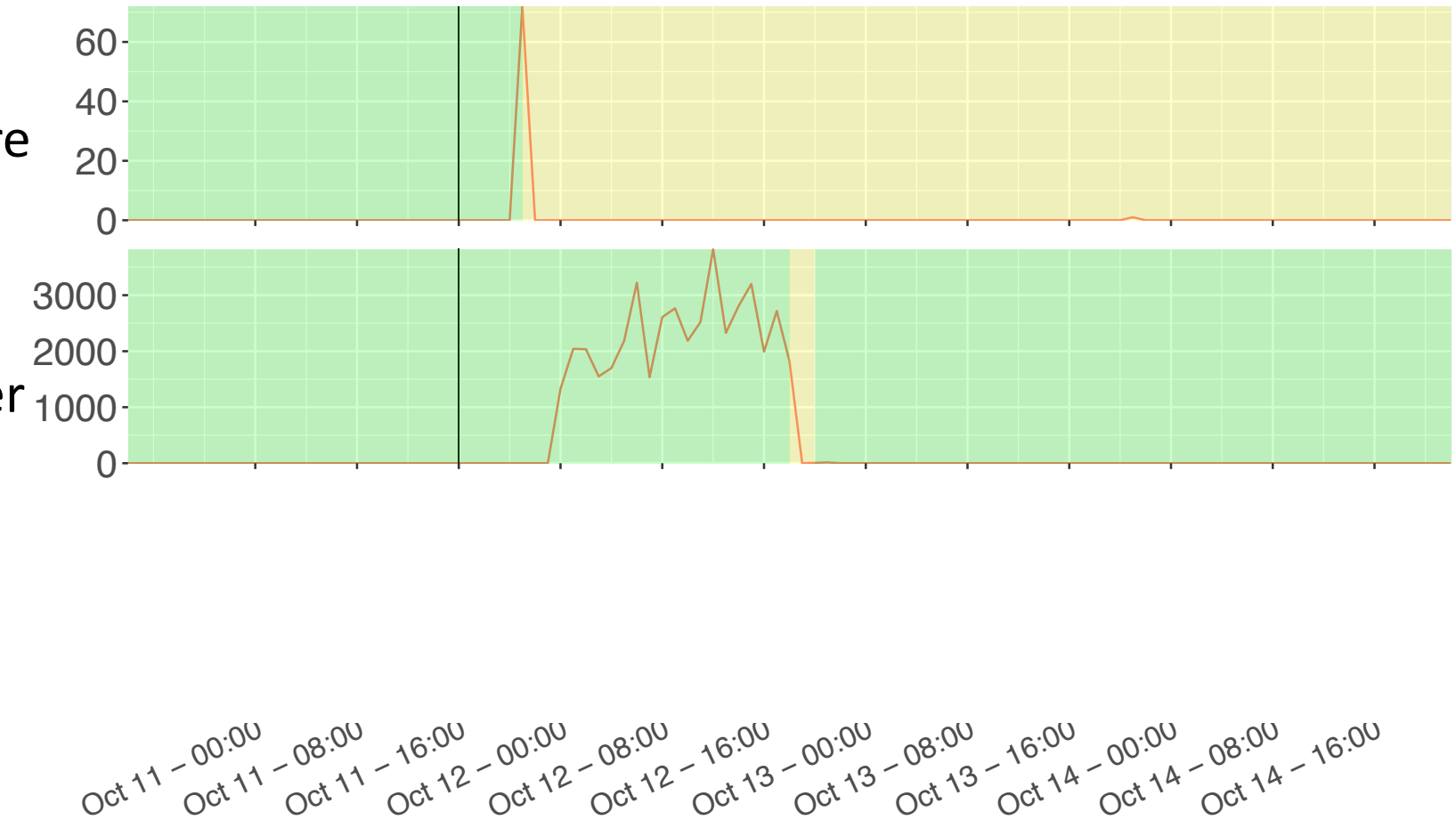
Failing and then Insecure



Validation Failure Modes

Failing and then Insecure

Failing and then Recover



Validation Failure Modes

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Failing and then Bogus