

dnsop
Internet-Draft
Updates: [7583](#) (if approved)
Intended status: Standards Track
Expires: June 2, 2018

W. Hardaker
USC/ISI
W. Kumari
Google
November 29, 2017

Security Considerations for [RFC5011](#) Publishers
draft-ietf-dnsop-rfc5011-security-considerations-08

Abstract

This document extends the [RFC5011](#) rollover strategy with timing advice that must be followed in order to maintain security. Specifically, this document describes the math behind the minimum time-length that a DNS zone publisher must wait before signing exclusively with recently added DNSKEYs. It contains much math and complicated equations, but the summary is that the key rollover / revocation time is much longer than intuition would suggest. If you are not both publishing a DNSSEC DNSKEY, and using [RFC5011](#) to advertise this DNSKEY as a new Secure Entry Point key for use as a trust anchor, you probably don't need to read this document.

This document also describes the minimum time-length that a DNS zone publisher must wait after publishing a revoked DNSKEY before assuming that all active [RFC5011](#) resolvers should have seen the revocation-marked key and removed it from their list of trust anchors.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <http://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on June 2, 2018.

Copyright Notice

Copyright (c) 2017 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](#) and the IETF Trust's Legal Provisions Relating to IETF Documents (<http://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

Table of Contents

1.	Introduction	3
1.1.	Document History and Motivation	3
1.2.	Safely Rolling the Root Zone's KSK in 2017/2018	3
1.3.	Requirements notation	4
2.	Background	4
3.	Terminology	4
4.	Timing Associated with RFC5011 Processing	5
4.1.	Timing Associated with Publication	5
4.2.	Timing Associated with Revocation	6
5.	Denial of Service Attack Walkthrough	6
5.1.	Enumerated Attack Example	6
5.1.1.	Attack Timing Breakdown	7
6.	Minimum RFC5011 Timing Requirements	9
6.1.	Equation Components	9
6.1.1.	addHoldDownTime	9
6.1.2.	sigExpirationTimeRemaining	9
6.1.3.	activeRefresh	9
6.1.4.	activeRefreshOffset	9
6.1.5.	safetyMargin	10
6.2.	Timing Requirements For Adding a New KSK	11
6.2.1.	Wait Timer Based Calculation	11
6.2.2.	Wall-Clock Based Calculation	12
6.2.3.	Timing Constraint Summary	12
6.2.4.	Additional Considerations for RFC7583	13
6.2.5.	Example Scenario Calculations	13
6.3.	Timing Requirements For Revoking an Old KSK	13
6.3.1.	Wait Timer Based Calculation	14
6.3.2.	Wall-Clock Based Calculation	14
6.3.3.	Additional Considerations for RFC7583	15
6.3.4.	Example Scenario Calculations	15
7.	IANA Considerations	15

8.	Operational Considerations	15
9.	Security Considerations	16
10.	Acknowledgements	16
11.	Normative References	16
Appendix A.	Real World Example: The 2017 Root KSK Key Roll . . .	17
	Authors' Addresses	17

[1.](#) Introduction

[RFC5011] defines a mechanism by which DNSSEC validators can update their list of trust anchors when they've seen a new key published in a zone or revoke a properly marked key from a trust anchor list. However, [RFC5011](#) [intentionally] provides no guidance to the publishers of DNSKEYs about how long they must wait before switching to exclusively using recently published keys for signing records, or how long they must wait before ceasing publication of a revoked key. Because of this lack of guidance, zone publishers may derive incorrect assumptions about safe usage of the [RFC5011](#) DNSKEY advertising, rolling and revocation process. This document describes the minimum security requirements from a publisher's point of view and is intended to complement the guidance offered in [RFC5011](#) (which is written to provide timing guidance solely to a Validating Resolver's point of view).

[1.1.](#) Document History and Motivation

To verify this lack of understanding is wide-spread, the authors reached out to 5 DNSSEC experts to ask them how long they thought they must wait before signing a zone exclusively with a new KSK [[RFC4033](#)] that was being introduced according to the 5011 process. All 5 experts answered with an insecure value, and we determined that this lack of operational guidance might cause security concerns in deployment and wrote this companion document to [RFC5011](#). We hope that this document will rectify this understanding and provide better guidance to zone publishers that wish to make use of the [RFC5011](#) rollover process.

[1.2.](#) Safely Rolling the Root Zone's KSK in 2017/2018

One important note about ICANN's (currently in process) 2017/2018 KSK rollover plan for the root zone: the timing values chosen for rolling the KSK in the root zone appear completely safe, and are not affected by the timing concerns introduced by this draft

1.3. Requirements notation

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [[RFC2119](#)].

2. Background

The [RFC5011](#) process describes a process by which a [RFC5011](#) Resolver may accept a newly published KSK as a trust anchor for validating future DNSSEC signed records. It also describes the process for publicly revoking a published KSK. This document augments that information with additional constraints, from the DNSKEY publication and revocation's points of view. Note that this document does not define any other operational guidance or recommendations about the [RFC5011](#) process and restricts itself to solely the security and operational ramifications of switching to exclusively using recently added keys or removing a revoked keys too soon.

Failure of a DNSKEY publisher to follow the minimum recommendations associated with this draft can result in potential denial-of-service attack opportunities against validating resolvers. Failure of a DNSKEY publisher to publish a revoked key for a long enough period of time may result in [RFC5011](#) Resolvers leaving that key in their trust anchor storage beyond the key's expected lifetime.

3. Terminology

SEP Publisher The entity responsible for publishing a DNSKEY (with the Secure Entry Point (SEP) bit set) that can be used as a trust anchor.

Zone Signer The owner of a zone intending to publish a new Key-Signing-Key (KSK) that may become a trust anchor for validators following the [RFC5011](#) process.

[RFC5011](#) Resolver A DNSSEC Resolver that is using the [RFC5011](#) processes to track and update trust anchors.

Attacker An entity intent on foiling the [RFC5011](#) Resolver's ability to successfully adopt the Zone Signer's new DNSKEY as a new trust anchor or to prevent the [RFC5011](#) Resolver from removing an old DNSKEY from its list of trust anchors.

lastSigExpirationTime The latest value of any RRSIG Signature Expiration field (which is a date and time) that has signed the previous DNSKEY RRset before a new DNSKEY is introduced to a publish DNSKEY RRset, or the DNSKEY RRset of a DNSKEY that is to

be revoked. Note that for organizations pre-creating signatures this time may be fairly far in the future unless they can be significantly assured that none of their pre-generated signatures can be replayed at a later date.

`sigExpirationTime` The amount of time between the DNSKEY RRSIG's Signature Inception field and the Signature Expiration field.

`sigExpirationTimeRemaining` The amount of time remaining before `latestSigExpirationTime` is reached.

Also see [Section 2 of \[RFC4033\]](#) and [\[RFC7719\]](#) for additional terminology.

4. Timing Associated with [RFC5011](#) Processing

These sections define a high-level overview of [\[RFC5011\]](#) processing. These steps are not sufficient for proper [RFC5011](#) implementation, but provide enough background for the reader to follow the discussion in this document. Readers need to fully understand [\[RFC5011\]](#) as well to fully comprehend the content and importance of this document.

4.1. Timing Associated with Publication

[RFC5011](#)'s process of safely publishing a new DNSKEY and then assuming [RFC5011](#) Resolvers have adopted it for trust falls into a number of high-level steps to be performed by the SEP Publisher. This document discusses the following scenario, which the principle way [RFC5011](#) is currently being used (even though [Section 6 of RFC5011](#) suggests having a stand-by key available):

1. Publish a new DNSKEY in a zone, but continue to sign the zone with the old one.
2. Wait a period of time.
3. Begin to exclusively use recently published DNSKEYs to sign the appropriate resource records.

This document discusses the time required to wait during step 2 of the above process. Some interpretations of [RFC5011](#) have erroneously determined that the wait time is equal to [RFC5011](#)'s "hold down time". [Section 5](#) describes an attack based on this (common) erroneous belief, which can result in a denial of service attack against the zone.

[4.2.](#) Timing Associated with Revocation

[RFC5011](#)'s process of advertising that an old key is to be revoked from [RFC5011](#) Resolvers falls into a number of high-level steps:

1. Set the revoke bit on the DNSKEY to be revoked.
2. Sign the revoked DNSKEY with itself.
3. Wait a period of time.
4. Remove the revoked key from the zone.

This document discusses the time required to wait in step 3 of the above process. Some interpretations of [RFC5011](#) have erroneously determined that the wait time is equal to [RFC5011](#)'s "hold down time". This document describes an attack based on this (common) erroneous belief, which results in a revoked DNSKEY potentially remaining as a trust anchor in a [RFC5011](#) Resolver long past its expected usage.

[5.](#) Denial of Service Attack Walkthrough

This section serves as an illustrative example of the problem being discussed in this document. Note that in order to keep the example simple enough to understand, some simplifications were made (such as by not creating a set of pre-signed RRSIGs and by not using values that result in the addHoldDownTime not being evenly divisible by the activeRefresh value); the mathematical formulas in [Section 6](#), however, are complete.

If an attacker is able to provide a [RFC5011](#) Resolver with past responses, such as when it is in-path or able to perform any number of cache poisoning attacks, the attacker may be able to leave compliant [RFC5011](#) Resolvers without an appropriate DNSKEY trust anchor. This scenario will remain until an administrator manually fixes the situation.

The time-line below illustrates this situation.

[5.1.](#) Enumerated Attack Example

The following example settings are used in the example scenario within this section:

TTL (all records) 1 day

sigExpirationTime 10 days

Zone resigned every 1 day

Given these settings, the sequence of events in [Section 5.1.1](#) depicts how a SEP Publisher that waits for only the [RFC5011](#) hold time timer length of 30 days subjects its users to a potential Denial of Service attack. The timing schedule listed below is based on a SEP Publisher publishing a new Key Signing Key (KSK), with the intent that it will later be used as a trust anchor. We label this publication time as "T+0". All numbers in this sequence refer to days before and after this initial publication event. Thus, T-1 is the day before the introduction of the new key, and T+15 is the 15th day after the key was introduced into the fictitious zone being discussed.

In this dialog, we consider two keys within the example zone:

K_old: An older KSK and Trust Anchor being replaced.

K_new: A new KSK being transitioned into active use and expected to become a Trust Anchor via the [RFC5011](#) automated trust anchor update process.

[5.1.1](#). Attack Timing Breakdown

The steps shows an attack that foils the adoption of a new DNSKEY by a 5011 Resolver when the SEP Publisher that starts signing and publishing with the new DNSKEY too quickly.

T-1 The K_old based RRSIGs are being published by the Zone Signer. [It may also be signing ZSKs as well, but they are not relevant to this event so we will not talk further about them; we are only considering the RRSIGs that cover the DNSKEYs in this document.] The Attacker queries for, retrieves and caches this DNSKEY set and corresponding RRSIG signatures.

T+0 The Zone Signer adds K_new to their zone and signs the zone's key set with K_old. The [RFC5011](#) Resolver (later to be under attack) retrieves this new key set and corresponding RRSIGs and notices the publication of K_new. The [RFC5011](#) Resolver starts the (30-day) hold-down timer for K_new. [Note that in a more real-world scenario there will likely be a further delay between the point where the Zone Signer publishes a new RRSIG and the [RFC5011](#) Resolver notices its publication; though not shown in this example, this delay is accounted for in the equation in [Section 6](#) below]

T+5 The [RFC5011](#) Resolver queries for the zone's keyset per the [RFC5011](#) Active Refresh schedule, discussed in [Section 2.3 of RFC5011](#). Instead of receiving the intended published keyset, the

Attacker successfully replays the keyset and associated signatures recorded at T-1. Because the signature lifetime is 10 days (in this example), the replayed signature and keyset is accepted as valid (being only 6 days old, which is less than `sigExpirationTime`) and the [RFC5011](#) Resolver cancels the (30-day) hold-down timer for `K_new`, per the [RFC5011](#) algorithm.

T+10 The [RFC5011](#) Resolver queries for the zone's keyset and discovers a signed keyset that includes `K_new` (again), and is signed by `K_old`. Note: the attacker is unable to replay the records cached at T-1, because they have now expired. Thus at T+10, the [RFC5011](#) Resolver starts (anew) the hold-timer for `K_new`.

T+11 through T+29 The [RFC5011](#) Resolver continues checking the zone's key set at the prescribed regular intervals. During this period, the attacker can no longer replay traffic to their benefit.

T+30 The Zone Signer knows that this is the first time at which some validators might accept `K_new` as a new trust anchor, since the hold-down timer of a [RFC5011](#) Resolver not under attack that had queried and retrieved `K_new` at T+0 would now have reached 30 days. However, the hold-down timer of our attacked [RFC5011](#) Resolver is only at 20 days.

T+35 The Zone Signer (mistakenly) believes that all validators following the Active Refresh schedule ([Section 2.3 of RFC5011](#)) should have accepted `K_new` as a the new trust anchor (since the hold down time (30 days) + the query interval [which is just 1/2 the signature validity period in this example] would have passed). However, the hold-down timer of our attacked [RFC5011](#) Resolver is only at 25 days (T+35 minus T+10); thus the [RFC5011](#) Resolver won't consider it a valid trust anchor addition yet, as the required 30 days have not yet elapsed.

T+36 The Zone Signer, believing `K_new` is safe to use, switches their active signing KSK to `K_new` and publishes a new RRSIG, signed with (only) `K_new`, covering the DNSKEY set. Non-attacked [RFC5011](#) validators, with a hold-down timer of at least 30 days, would have accepted `K_new` into their set of trusted keys. But, because our attacked [RFC5011](#) Resolver now has a hold-down timer for `K_new` of only 26 days, it failed to ever accept `K_new` as a trust anchor. Since `K_old` is no longer being used to sign the zone's DNSKEYs, all the DNSKEY records from the zone will be treated as invalid. Subsequently, all of the records in the DNS tree below the zone's apex will be deemed invalid by DNSSEC.

6. Minimum [RFC5011](#) Timing Requirements

This section defines the minimum timing requirements for making exclusive use of newly added DNSKEYs and timing requirements for ceasing the publication of DNSKEYs to be revoked. First, we define the term components used in both equations in [Section 6.1](#).

6.1. Equation Components

6.1.1. addHoldDownTime

The addHoldDownTime is defined in [Section 2.4.1 of \[RFC5011\]](#) as:

The add hold-down time is 30 days or the expiration time of the original TTL of the first trust point DNSKEY RRSset that contained the new key, whichever is greater. This ensures that at least two validated DNSKEY RRSets that contain the new key MUST be seen by the resolver prior to the key's acceptance.

6.1.2. sigExpirationTimeRemaining

sigExpirationTimeRemaining is defined in [Section 3](#).

6.1.3. activeRefresh

activeRefresh time is defined by [RFC5011](#) by

A resolver that has been configured for an automatic update of keys from a particular trust point MUST query that trust point (e.g., do a lookup for the DNSKEY RRsset and related RRSIG records) no less often than the lesser of 15 days, half the original TTL for the DNSKEY RRsset, or half the RRSIG expiration interval and no more often than once per hour.

This translates to:

```
activeRefresh = MAX(1 hour,  
                    MIN(sigExpirationTime / 2,  
                        MAX(TTL of K_old DNSKEY RRsset) / 2,  
                        15 days)  
                    )
```

6.1.4. activeRefreshOffset

The activeRefreshOffset term must be added for situations where the activeRefresh value is not a factor of the addHoldDownTime. Specifically, activeRefreshOffset will be "addHoldDownTime %

activeRefresh", where % is the mathematical mod operator (calculating the remainder in a division problem). This will frequently be zero, but could be nearly as large as activeRefresh itself. For simplicity, setting the activeRefreshOffset to the activeRefresh value itself is always safe.

6.1.5. safetyMargin

The `safetyMargin` is an extra period of time to account for caching, network delays, dropped packets, and other operational concerns otherwise beyond the scope of this document. The value operators should chose is highly dependent on the deployment siptuation associated with their zone. Note that no value of a `safetyMargin` can protect against resolvers that are "down". None the less, we do offer the following as one method considering reasonable values to select from.

The following list of variables need to be considered when selecting an appropriate safetyMargin value:

successRate: A likely success rate for client queries and retries

numResolvers: The number of client [RFC5011](#) Resolvers

Note that [RFC5011](#) defines retryTime as:

If the query fails, the resolver MUST repeat the query until satisfied no more often than once an hour and no less often than the lesser of 1 day, 10% of the original TTL, or 10% of the original expiration interval. That is,

$$\text{retryTime} = \text{MAX} (1 \text{ hour}, \text{MIN} (1 \text{ day}, .1 * \text{origTTL}, .1 * \text{expireInterval})).$$

With these values selected and the definition of retryTime from [RFC5011](#), one method for determining how many retryTime intervals to wait in order to reduce the set of uncompleted servers to 0 assuming normal probability is thus:

$$x = (1/(1 - \text{successRate}))$$

```
retryCountWait = Log_base_x(numResolvers)
```

To reduce the need for readers to pull out a scientific calculator, we offer the following lookup table based on `successRate` and `numResolvers`:

retryCountWait lookup table

		Number of client RFC5011 Resolvers (numResolvers)				
		10,000	100,000	1,000,000	10,000,000	100,000,000
Probability of Success Per Retry Interval (successRate)	0.01	917	1146	1375	1604	1833
	0.05	180	225	270	315	360
	0.10	88	110	132	153	175
	0.15	57	71	86	100	114
	0.25	33	41	49	57	65
	0.50	14	17	20	24	27
	0.90	4	5	6	7	8
	0.95	4	4	5	6	7
	0.99	2	3	3	4	4
	0.999	2	2	2	3	3

Finally, a suggested value of safetyMargin can then be this
 retryCountWait number multiplied by the retryTime from [RFC5011](#):

$$\text{safetyMargin} = \text{retryCountWait} * \text{retryTime}$$

6.2. Timing Requirements For Adding a New KSK

This section defines a method for calculating the amount of time to wait until it is safe to start signing exclusively with a new key [Section 6.2.1](#) (especially useful for writing code involving sleep based timers), and an a method for calculating a wall-clock value after which it is safe to start signing exclusively with a new key [Section 6.2.2](#) (especially useful for writing code based on clock-based event triggers).

6.2.1. Wait Timer Based Calculation

Given the attack description in [Section 5](#), the correct minimum length of time required for the Zone Signer to wait after publishing K_new but before exclusively using it and newer keys is:

```
addWaitTime = addHoldDownTime
              + sigExpirationTimeRemaining
              + activeRefresh
              + activeRefreshOffset
              + safetyMargin
```

6.2.1.1. Fully expanded equation

The full expanded equation is:


```
addWaitTime = addHoldDownTime
              + sigExpirationTimeRemaining
              + 2 * MAX(1 hour,
                        MIN(sigExpirationTime / 2,
                            MAX(TTL of K_old DNSKEY RRSets) / 2,
                            15 days)
                      )
              + (addHoldDownTime % activeRefresh)
              + MAX(1.5 hours, 2 * MAX(TTL of all records))
              + safetyMargin
```

6.2.2. Wall-Clock Based Calculation

The above equations are defined based upon how long to wait from a particular moment in time. An alternative, but equivalent, method is to calculate the date and time before which it is unsafe to use a key for signing. This calculation thus becomes:

```
addWallClockTime = lastSigExpirationTime
                  + addHoldDownTime
                  + activeRefresh
                  + activeRefreshOffset
                  + safetyMargin
```

where lastSigExpirationTime is the latest value of any sigExpirationTime for which RRSIGs were created that could potentially be replayed. Fully expanded, this becomes:

```
addWallClockTime = lastSigExpirationTime
                  + addHoldDownTime
                  + 2 * MAX(1 hour,
                        MIN(sigExpirationTime / 2,
                            MAX(TTL of K_old DNSKEY RRSets) / 2,
                            15 days)
                      )
                  + (addHoldDownTime % activeRefresh)
                  + MAX(1.5 hours, 2 * MAX(TTL of all records))
                  + safetyMargin
```

6.2.3. Timing Constraint Summary

The important timing constraint introduced by this memo relates to the last point at which a [RFC5011](#) Resolver may have received a replayed original DNSKEY set, containing K_old and not K_new. The next query of the [RFC5011](#) validator at which K_new will be seen without the potential for a replay attack will occur after the publication time plus sigExpirationTime. Thus, the latest time that a [RFC5011](#) Validator may begin their hold down timer is an "Active

Refresh" period after the last point that an attacker can replay the K_old DNSKEY set. The worst case scenario of this attack is if the attacker can replay K_old just seconds before the (DNSKEY RRSIG Signature Validity) field of the last K_old only RRSIG.

6.2.4. Additional Considerations for [RFC7583](#)

Note: our notion of addWaitTime is called "Itrp" in [Section 3.3.4.1 of \[RFC7583\]](#). The equation for Itrp in [RFC7583](#) is insecure as it does not include the sigExpirationTime listed above. The Itrp equation in [RFC7583](#) also does not include the 2*TTL safety margin, though that is an operational consideration and not necessarily as critical.

6.2.5. Example Scenario Calculations

For the parameters listed in [Section 5.1](#), the activeRefreshOffset is 0, since 30 days is evenly divisible by activeRefresh (1/2 day), and our resulting addWaitTime is:

```
addWaitTime = 30
              + 10
              + 1 / 2
              + 2 * (1)          (days)

addWaitTime = 42.5              (days)
```

This addWaitTime of 42.5 days is 12.5 days longer than just the hold down timer.

6.3. Timing Requirements For Revoking an Old KSK

This issue affects not just the publication of new DNSKEYs intended to be used as trust anchors, but also the length of time required to continuously publish a DNSKEY with the revoke bit set.

This section defines a method for calculating the amount of time operators need to wait until it is safe to cease publishing a DNSKEY [Section 6.2.1](#) (especially useful for writing code involving sleep based timers), and an a method for calculating a minimal wall-clock value after which it is safe to cease publishing a DNSKEY [Section 6.2.2](#) (especially useful for writing code based on clock-based event triggers).

[6.3.1.](#) Wait Timer Based Calculation

Both of these publication timing requirements are affected by the attacks described in this document, but with revocation the key is revoked immediately and the addHoldDown timer does not apply. Thus the minimum amount of time that a SEP Publisher must wait before removing a revoked key from publication is:

```
remWaitTime = sigExpirationTimeRemaining
              + MAX(1 hour,
                    MIN((sigExpirationTime) / 2,
                        MAX(TTL of K_old DNSKEY RRSets) / 2,
                          15 days),
                    1 hour)
              + 2 * MAX(TTL of all records)
```

Note that the activeRefreshOffset time does not apply to this equation.

Note also that adding retryTime intervals to the remWaitTime may be wise, just as it was for addWaitTime in [Section 6](#).

[6.3.2.](#) Wall-Clock Based Calculation

Like before, the above equations are defined based upon how long to wait from a particular moment in time. An alternative, but equivalent, method is to calculate the date and time before which it is unsafe to cease publishing a revoked key. This calculation thus becomes:

```
remWallClockTime = lastSigExpirationTime
                  + activeRefresh
                  + activeRefreshOffset
                  + safetyMargin
```

where lastSigExpirationTime is the latest value of any sigExpirationTime for which RRSIGs were created that could potentially be replayed. Fully expanded, this becomes:

```
remWallClockTime = lastSigExpirationTime
                  + 2 * MAX(1 hour,
                          MIN(sigExpirationTime / 2,
                              MAX(TTL of K_old DNSKEY RRSets) / 2,
                                15 days)
                          )
                  + (addHoldDownTime % activeRefresh)
                  + MAX(1.5 hours, 2 * MAX(TTL of all records))
```


[6.3.3.](#) Additional Considerations for [RFC7583](#)

Note that our notion of `remWaitTime` is called "Irev" in [Section 3.3.4.2 of \[RFC7583\]](#). The equation for Irev in [RFC7583](#) is insecure as it does not include the `sigExpirationTime` listed above. The Irev equation in [RFC7583](#) also does not include the $2 \times \text{TTL}$ safety margin, though that is an operational consideration and not necessarily as critical.

[6.3.4.](#) Example Scenario Calculations

For the parameters listed in [Section 5.1](#), our example:

```
remwaitTime = 10
              + 1 / 2
              + 2 * (1)          (days)

remwaitTime = 12.5              (days)
```

Note that for the values in this example produce a length shorter than the recommended 30 days in [RFC5011's section 6.6](#), step 3. Other values of `sigExpirationTime` and the original TTL of the `K_old` DNSKEY RRSets, however, can produce values longer than 30 days.

Note that because revocation happens immediately, an attacker has a much harder job tricking a [RFC5011](#) Resolver into leaving a trust anchor in place, as the attacker must successfully replay the old data for every query a [RFC5011](#) Resolver sends, not just one.

[7.](#) IANA Considerations

This document contains no IANA considerations.

[8.](#) Operational Considerations

A companion document to [RFC5011](#) was expected to be published that describes the best operational practice considerations from the perspective of a zone publisher and PEP Publisher. However, this companion document has yet to be published. The authors of this document hope that it will at some point in the future, as [RFC5011](#) timing can be tricky as we have shown, and a BCP is clearly warranted. This document is intended only to fill a single operational void which, when left misunderstood, can result in serious security ramifications. This document does not attempt to document any other missing operational guidance for zone publishers.

9. Security Considerations

This document, is solely about the security considerations with respect to the SEP Publisher's ability to advertise new DNSKEYs via the [RFC5011](#) automated trust anchor update process. Thus the entire document is a discussion of Security Considerations when adding or removing DNSKEYs from trust anchor storage using the [RFC5011](#) process.

For simplicity, this document assumes that the SEP Publisher will use a consistent RRSIG validity period. SEP Publishers that vary the length of RRSIG validity periods will need to adjust the sigExpirationTime value accordingly so that the equations in [Section 6](#) and [Section 6.3](#) use a value that coincides with the last time a replay of older RRSIGs will no longer succeed.

10. Acknowledgements

The authors would like to especially thank to Michael StJohns for his help and advice and the care and thought he put into [RFC5011](#) itself. We would also like to thank Bob Harold, Shane Kerr, Matthijs Mekking, Duane Wessels, Petr Petr Spacek, Ed Lewis, and the dnsop working group who have assisted with this document.

11. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997.
- [RFC4033] Arends, R., Austein, R., Larson, M., Massey, D., and S. Rose, "DNS Security Introduction and Requirements", [RFC 4033](#), DOI 10.17487/RFC4033, March 2005, <<http://www.rfc-editor.org/info/rfc4033>>.
- [RFC5011] StJohns, M., "Automated Updates of DNS Security (DNSSEC) Trust Anchors", STD 74, [RFC 5011](#), DOI 10.17487/RFC5011, September 2007, <<http://www.rfc-editor.org/info/rfc5011>>.
- [RFC7583] Morris, S., Ihren, J., Dickinson, J., and W. Mekking, "DNSSEC Key Rollover Timing Considerations", [RFC 7583](#), DOI 10.17487/RFC7583, October 2015, <<https://www.rfc-editor.org/info/rfc7583>>.
- [RFC7719] Hoffman, P., Sullivan, A., and K. Fujiwara, "DNS Terminology", [RFC 7719](#), DOI 10.17487/RFC7719, December 2015, <<http://www.rfc-editor.org/info/rfc7719>>.

[Appendix A](#). Real World Example: The 2017 Root KSK Key Roll

In 2017, ICANN expects to (or has, depending on when you're reading this) roll the key signing key (KSK) for the root zone. The relevant parameters associated with the root zone at the time of this writing is as follows:

addHoldDownTime:	30 days
Old DNSKEY sigExpirationTime:	21 days
Old DNSKEY TTL:	2 days

Thus, sticking this information into the equation in [Section 6](#) yields (in days):

```
addWaitTime = 30
              + (21)
              + MAX(MIN((21) / 2,
                        MAX(2 / 2,
                          15 days)),
                    1 hour)
              + 2 * MAX(2)

addWaitTime = 30 + 21 + MAX(MIN(11.5, 1, 15)), 1 hour) + 4

addWaitTime = 30 + 21 + 1 + 4

addWaitTime = 56 days
```

Note that we use a activeRefreshOffset of 0, since 30 days is evenly divisible by activeRefresh (1 day).

Thus, ICANN should wait a minimum of 56 days before switching to the newly published KSK (and 26 days before removing the old revoked key once it is published as revoked). ICANN's current plans are to wait 70 days before using the new KEY and 69 days before removing the old, revoked key. Thus, their current rollover plans are sufficiently secure from the attack discussed in this memo.

Authors' Addresses

Wes Hardaker
USC/ISI
P.O. Box 382
Davis, CA 95617
US

Email: ietf@hardakers.net

Warren Kumari
Google
1600 Amphitheatre Parkway
Mountain View, CA 94043
US

Email: warren@kumari.net