         Elliptic Curve Digital Signature Algorithm (DSA) for DNSSEC

Abstract

   This document describes how to specify Elliptic Curve Digital
   Signature Algorithm (DSA) keys and signatures in DNS Security
   (DNSSEC). It lists curves of different sizes and uses the SHA-2
   family of hashes for signatures.

Status of This Memo

   This is an Internet Standards Track document.

   This document is a product of the Internet Engineering Task Force
   (IETF). It represents the consensus of the IETF community. It has
   received public review and has been approved for publication by the
   Internet Engineering Steering Group (IESG). Further information on
   Internet Standards is available in Section 2 of RFC 5741.

   Information about the current status of this document, any errata,
   and how to provide feedback on it may be obtained at
   http://www.rfc-editor.org/info/rfc6605.

1. Introduction

   DNSSEC, which is broadly defined in RFCs 4033, 4034, and 4035
   ([RFC4033], [RFC4034], and [RFC4035]), uses cryptographic keys and
   digital signatures to provide authentication of DNS data. Currently,
   the most popular signature algorithm is RSA with SHA-1, using keys
   that are 1024 or 2048 bits long.

   This document defines the DNSKEY and RRSIG resource records (RRs) of
   two new signing algorithms: ECDSA (Elliptic Curve DSA) with curve
   P-256 and SHA-256, and ECDSA with curve P-384 and SHA-384. (A
   description of ECDSA can be found in [FIPS-186-3].) This document
   also defines the DS RR for the SHA-384 one-way hash algorithm; the
   associated DS RR for SHA-256 is already defined in RFC 4509
   [RFC4509]. [RFC6090] provides a good introduction to implementing
   ECDSA.

   Current estimates are that ECDSA with curve P-256 has an approximate
   equivalent strength to RSA with 3072-bit keys. Using ECDSA with
   curve P-256 in DNSSEC has some advantages and disadvantages relative
   to using RSA with SHA-256 and with 3072-bit keys. ECDSA keys are
   much shorter than RSA keys; at this size, the difference is 256
   versus 3072 bits. Similarly, ECDSA signatures are much shorter than
   RSA signatures. This is relevant because DNSSEC stores and transmits
   both keys and signatures.

   In the two signing algorithms defined in this document, the size of
   the key for the elliptic curve is matched with the size of the output
   of the hash algorithm. This design is based on the widespread belief
   that the equivalent strength of P-256 and P-384 is half the length of
   the key, and also that the equivalent strength of SHA-256 and SHA-384
   is half the length of the key. Using matched strengths prevents an
   attacker from choosing the weaker half of a signature algorithm. For
   example, in a signature that uses RSA with 2048-bit keys and SHA-256,
   the signing portion is significantly weaker than the hash portion,
   whereas the two algorithms here are balanced.

   Signing with ECDSA is significantly faster than with RSA (over 20
   times in some implementations). However, validating RSA signatures
   is significantly faster than validating ECDSA signatures (about 5
   times faster in some implementations).

   Some of the material in this document is copied liberally from RFC
   6460 [RFC6460].

   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 RFC 2119 [RFC2119].

2. SHA-384 DS Records

   SHA-384 is defined in FIPS 180-3 [FIPS-180-3] and RFC 6234 [RFC6234],
   and is similar to SHA-256 in many ways. The implementation of SHA-
   384 in DNSSEC follows the implementation of SHA-256 as specified in
   RFC 4509 except that the underlying algorithm is SHA-384, the digest
   value is 48 bytes long, and the digest type code is 4.

3. ECDSA Parameters

   Verifying ECDSA signatures requires agreement between the signer and
   the verifier of the parameters used. FIPS 186-3 [FIPS-186-3] lists
   some NIST-recommended elliptic curves. (Other documents give more
   detail on ECDSA than is given in FIPS 186-3.) These are the same
   curves listed in RFC 5114 [RFC5114]. The curves used in this
   document are:

   FIPS 186-3   RFC 5114

   P-256 (Section D.1.2.3)   256-bit Random ECP Group (Section 2.6)
   P-384 (Section D.1.2.4)   384-bit Random ECP Group (Section 2.7)

4. DNSKEY and RRSIG Resource Records for ECDSA

   ECDSA public keys consist of a single value, called "Q" in FIPS
   186-3. In DNSSEC keys, Q is a simple bit string that represents the
   uncompressed form of a curve point, "x | y".

   The ECDSA signature is the combination of two non-negative integers,
   called "r" and "s" in FIPS 186-3. The two integers, each of which is
   formatted as a simple octet string, are combined into a single longer
   octet string for DNSSEC as the concatenation "r | s". (Conversion of
   the integers to bit strings is described in Section C.2 of FIPS
   186-3.) For P-256, each integer MUST be encoded as 32 octets; for
   P-384, each integer MUST be encoded as 48 octets.

   The algorithm numbers associated with the DNSKEY and RRSIG resource
   records are fully defined in the IANA Considerations section. They
   are:

   o DNSKEY and RRSIG RRs signifying ECDSA with the P-256 curve and
      SHA-256 use the algorithm number 13.

   o DNSKEY and RRSIG RRs signifying ECDSA with the P-384 curve and
      SHA-384 use the algorithm number 14.

   Conformant implementations that create records to be put into the DNS
   MUST implement signing and verification for both of the above
   algorithms. Conformant DNSSEC verifiers MUST implement verification
   for both of the above algorithms.

5. Support for NSEC3 Denial of Existence

   RFC 5155 [RFC5155] defines new algorithm identifiers for existing
   signing algorithms to indicate that zones signed with these algorithm
   identifiers can use NSEC3 as well as NSEC records to provide denial
   of existence. That mechanism was chosen to protect implementations
   predating RFC 5155 from encountering resource records they could not
   know about. This document does not define such algorithm aliases.

   A DNSSEC validator that implements the signing algorithms defined in
   this document MUST be able to validate negative answers in the form
   of both NSEC and NSEC3 with hash algorithm 1, as defined in RFC 5155.
   An authoritative server that does not implement NSEC3 MAY still serve
   zones that use the signing algorithms defined in this document with
   NSEC denial of existence.

6. Examples

   The following are some examples of ECDSA keys and signatures in DNS
   format.

6.1. P-256 Example

   Private-key-format: v1.2
   Algorithm: 13 (ECDSAP256SHA256)
   PrivateKey: GU6SnQ/Ou+xC5RumuIUIuJZteXT2z0O/ok1s38Et6mQ=

   example.net. 3600 IN DNSKEY 257 3 13 (
           GojIhhXUN/u4v54ZQqGSnyhWJwaubCvTmeexv7bR6edb
           krSqQpF64cYbcB7wNcP+e+MAnLr+Wi9xMWyQLc8NAA==)

   example.net. 3600 IN DS 55648 13 2 (
           b4c8c1fe2e7477127b27115656ad6256f424625bf5c1
           e2770ce6d6e37df61d17)

   www.example.net. 3600 IN A 192.0.2.1
   www.example.net. 3600 IN RRSIG A 13 3 3600 (
           20100909100439 20100812100439 55648 example.net.
           qx6wLYqmh+l9oCKTN6qIc+bw6ya+KJ8oMz0YP107epXA
           yGmt+3SNruPFKG7tZoLBLlUzGGus7ZwmwWep666VCw==)

6.2. P-384 Example

       Private-key-format: v1.2
       Algorithm: 14 (ECDSAP384SHA384)
       PrivateKey: WURgWHCcYIYUPWgeLmiPY2DJJk02vgrmTfitxgqcL4vw
       W7BOrbawVmVe0d9V94SR

       example.net. 3600 IN DNSKEY 257 3 14 (
               xKYaNhWdGOfJ+nPrL8/arkwf2EY3MDJ+SErKivBVSum1
               w/egsXvSADtNJhyem5RCOpgQ6K8X1DRSEkrbYQ+OB+v8
               /uX45NBwY8rp65F6Glur8I/mlVNgF6W/qTI37m40)

       example.net. 3600 IN DS 10771 14 4 (
               72d7b62976ce06438e9c0bf319013cf801f09ecc84b8
               d7e9495f27e305c6a9b0563a9b5f4d288405c3008a94
               6df983d6)

       www.example.net. 3600 IN A 192.0.2.1
       www.example.net. 3600 IN RRSIG A 14 3 3600 (
               20100909102025 20100812102025 10771 example.net.
               /L5hDKIvGDyI1fcARX3z65qrmPsVz73QD1Mr5CEqOiLP
               95hxQouuroGCeZOvzFaxsT8Glr74hbavRKayJNuydCuz
               WTSSPdz7wnqXL5bdcJzusdnI0RSMROxxwGipWcJm)

7. IANA Considerations

   This document updates the IANA registry for digest types in DS
   records, currently called "Delegation Signer (DS) Resource Record
   (RR) Type Digest Algorithms". The following entry has been added:

   Value   4
   Digest Type SHA-384
   Status   OPTIONAL

   This document updates the IANA registry "Domain Name System Security
   (DNSSEC) Algorithm Numbers". The following two entries have been
   added to the registry:

   Number   13
   Description ECDSA Curve P-256 with SHA-256
   Mnemonic   ECDSAP256SHA256
   Zone Signing Y
   Trans. Sec. *
   Reference   This document

   Number   14
   Description ECDSA Curve P-384 with SHA-384
   Mnemonic   ECDSAP384SHA384
   Zone Signing Y
   Trans. Sec. *
   Reference   This document

   * There has been no determination of standardization of the
     use of this algorithm with Transaction Security.

8. Security Considerations

   The cryptographic work factor of ECDSA with curve P-256 or P-384 is
   generally considered to be equivalent to half the size of the key, or
   128 bits and 192 bits, respectively. Such an assessment could, of
   course, change in the future if new attacks that work better than the
   ones known today are found.

   The security considerations listed in RFC 4509 apply here as well.

9. References

9.1. Normative References

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   [RFC2119]   Bradner, S., "Key words for use in RFCs to Indicate
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   [RFC4033]   Arends, R., Austein, R., Larson, M., Massey, D., and S.
                 Rose, "DNS Security Introduction and Requirements",
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                 Rose, "Resource Records for the DNS Security
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   [RFC4509]   Hardaker, W., "Use of SHA-256 in DNSSEC Delegation
                 Signer (DS) Resource Records (RRs)", RFC 4509,
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   [RFC5155]   Laurie, B., Sisson, G., Arends, R., and D. Blacka, "DNS
                 Security (DNSSEC) Hashed Authenticated Denial of
                 Existence", RFC 5155, March 2008.

9.2. Informative References

   [RFC6090]   McGrew, D., Igoe, K., and M. Salter, "Fundamental
                 Elliptic Curve Cryptography Algorithms", RFC 6090,
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   [RFC6234]   Eastlake 3rd, D. and T. Hansen, "US Secure Hash
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   [RFC6460]   Salter, M. and R. Housley, "Suite B Profile for
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