COMPOSITE CRYPTO FOR PKIX AND CMS

IETF LAMPS 113

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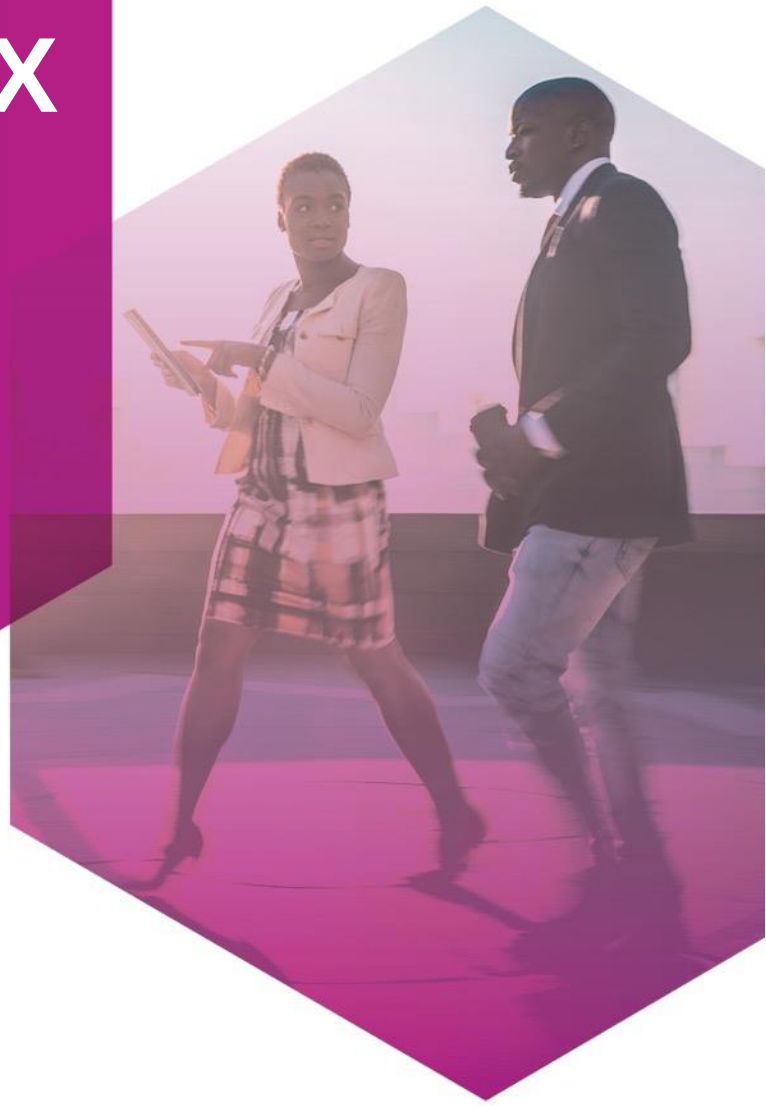


Composite crypto for PKIX and CMS

Outline

- Status of composite drafts
- Changes coming in composite-keys-02
  - Generic and Explicit now share a wire encoding
  - Combiner Modes in alg params
  - Added “K of N” mode
- Changes coming in composite-kem-00
  - Defines a KEM algorithm which composes arbitrary KeyEx, KeyTrans, KEM components.
- Terminology:
  - “Hybrid” is problematic
  - We need a hero to volunteer for an Informative terminology draft.

Composite at IETF LAMPS (current drafts)

draft-ounsworth-pq-composite-keys-01
- Defines composite public and private keys

draft-ounsworth-pq-explicit-composite-keys-01
- Defines a structure for defining explicit pairs of algorithms
  - Ex.: RsaAndDilithium

draft-ounsworth-pq-composite-sigs-06
- Defines composite signatures

draft-ounsworth-pq-composite-encryption-01
- Defines composite encryption using EnvelopedData

Composite at IETF LAMPS (upcoming drafts)

draft-ounsworth-pq-composite-keys-02

- Defines composite public and private keys
- -02 is coming **very soon**
- Working copy:
  - https://github.com/EntrustCorporation/draft-ounsworth-pq-composite-keys

Almost ready for WG Adoption

Merged into

~~draft-ounsworth-pq-explicit-composite-keys-01~~

- Defines a structure for defining explicit pairs of algorithms
  - Ex.: RsaAndDilithium
- Merged into and deprecated by keys-02

draft-ounsworth-pq-composite-sigs-06

- Defines composite signatures
- Mature and stable
- Needs minor work to sync with new modes added to keys-02

~~draft-ounsworth-pq-composite-encryption-01~~

- Defines composite encryption using EnvelopedData
- Replaced by kem-00

Replaced by

Next draft to put work into

draft-ounsworth-pq-composite-kem-00

- NEW (not yet published)
- Defines composite as a KEM (Key Encapsulation Mechanism)
- Useable anywhere that accepts KEMs.

Composite-Keys: Changes from -01 to -02

- Backwards compatible: keys produced under -01 (mostly) still parse with the same semantics under -02.
- Working copy in github[1]
- Additions:
  - Merged with Intelligent Composed Algorithms spec from D-Trust[2].
  - Generic and Explicit now share a wire encoding; only differ in the OID used.
  - Combiner Modes (AND, OR, ANY, K of N, Custom) now specified via alg params (breaking change for modes other than AND).
    (please don't hate me Russ, we tried so hard to avoid params >.<)
  - Differentiated between OR, ANY, and Custom modes.
  - Added "K of N" mode.

1: https://github.com/EntrustCorporation/draft-ounsworth-pq-composite-keys
2: "Intelligent Composed Algorithms", 15 June 2021: https://eprint.iacr.org/2021/813

ENTRUST

Generic and Explicit now share a wire encoding

Wire encoding (s. 2.2, 2.3)

```
CompositePublicKey ::= SEQUENCE SIZE (2..MAX) OF SubjectPublicKeyInfo

CompositePrivateKey ::= SEQUENCE SIZE (2..MAX) OF OneAsymmetricKey
```

Generic (s. 2.5.1)

Top-level AlgorithmIdentifier is: `id-composite-key OBJECT IDENTIFIER`

Component algs may use any algorithm.

Explicit (s. 2.5.2)

Top-level AlgorithmIdentifier is defined by explicit algorithm.

Component algs MUST use the algorithms defined by the explicit algorithm.

Generic and Explicit examples

ASN.1 decoding of the same {EC, RSA} pair in Generic and Explicit modes. Identical except for OIDs.

`id-composite-key` is defined in the draft.
Assume: `id-pk-example-ECandRSA OBJECT IDENTIFIER ::= { 1 2 3 4 }`

Generic

```
algorithm: AlgorithmIdentifier{id-composite-key}
params: CompositeParams{id-composite-or}

subjectPublicKey: CompositePublicKey {
    SubjectPublicKeyInfo {
      algorithm: AlgorithmIdentifier {
        algorithm: ecPublicKey
        parameters: prime256v1
        }
      subjectPublicKey: <ec key octet string>
      },
      SubjectPublicKeyInfo {
      algorithm: AlgorithmIdentifier {
        algorithm: rsaEncryption
        parameters: NULL
        }
      subjectPublicKey: <rsa key octet string>
      }
    }
```

Explicit

```
algorithm: AlgorithmIdentifier{id-pk-example-ECandRSA}
params: CompositeParams{id-composite-or}

<same as Generic>
```

CompositeParams: Combiner Modes

Combiner mode is now specified via algorithm params (s. 2.2.1, 2.6)

```
2.2.1.  CompositeParams

   CompositeParams ::= AlgorithmIdentifier

   where the algorithm and parameters represent a combiner mode as

   defined in Section 2.6.
```

Section “2.6 Combiner Modes” defines OIDs for:

- AND: implicit by ABSENT params
- OR: id-composite-or
  - Params ABSENT
- ANY: id-composite-any
  - Params ABSENT
- K of N: id-composite-k-of-n
  - CompositeKofNParams ::= INTEGER
- Custom
  - Allows implementors to define their own mode under their own OID.

K of N Mode – semantics

- K=N and K=1 are equivalent to AND and OR respectively
  - AND / OR modes should be used instead to improve interop.
- Exact semantics to be defined when we work on composite sigs and composite kem / encryption drafts.
  - Proposal: signer / encryptor chooses k of the n pub keys (or more??).
    Proceed as in AND mode with the chosen k keys; leave NULLs for the other sig / ciphertext values.

```
AlgorithmIdentifier {

algId : id-composite-key

params : AlgorithmIdentifier {

      algId : id-composite-k-of-n

      params: 3

  }

}
```

k

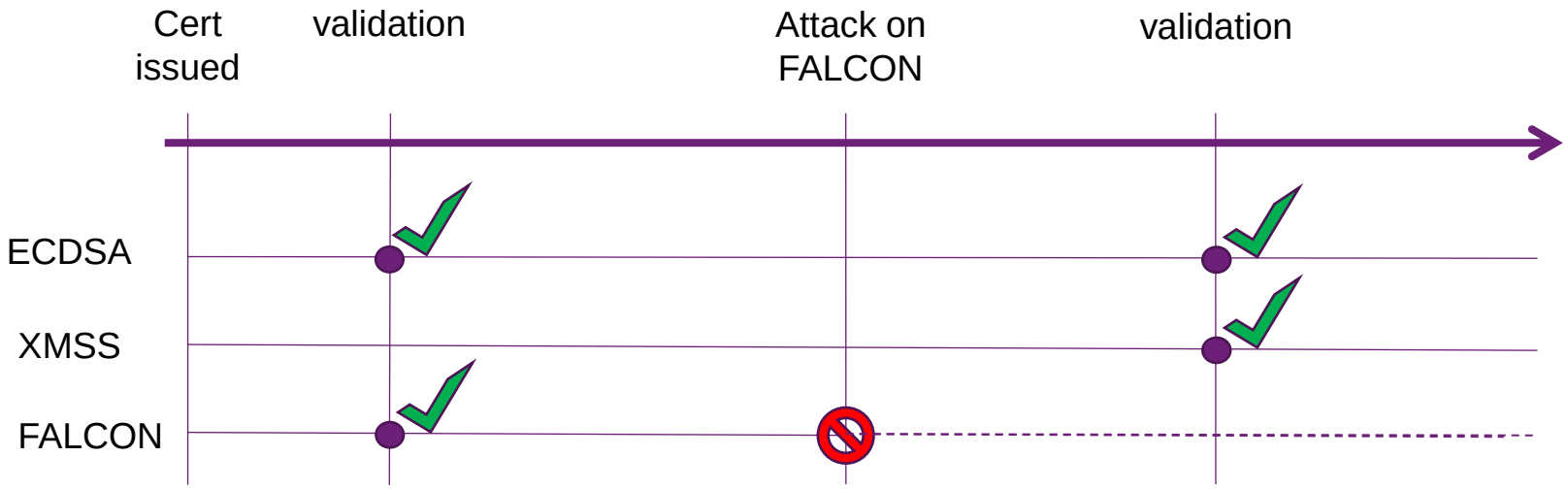
You get n by counting the components

K of N Mode – motivating use case

- **Combining Security of AND mode with flexibility of OR mode**
  - **Security of PQCs is uncertain in near future**

  → PKIs with 1 traditional, 2 PQC

    - **Traditional algorithm shall be kept due to known security**
    - **If 1st PQC is broken, 2nd can be used without reissuing certificate**



Composite KEM

- Defines a KEM algorithm which internally combines two or more Key Ex, Key Trans, KEM component algorithms.
- Follows the RSA-KEM pattern from RFC 5990 + NIST SP 800-56Cr2 KDF combiner.

```
ForEach component pub key PKi:
  if (isKeyExOrKEM(PKi):
    SSi, CTi := encaps(PKi);
  if (isKeyTrans(PKi):
    SSi := random_bits(SIZE);
    CTi := encrypt(SSi, PKi);

SS := KDF( SS1 || SS2 || … )
Transmit: CT1, CT2, …
```

- Open questions:
  1. Is this better presented as a KEM where SS is derived (as shown here), or as a KeyTrans by including an AES_Wrap() step of a provided content encryption key?
     - Perret & Prat are working on a generic KEM-TRANS structure for CMS[1] which does the AES_Wrap(), so we have opted to present a KEM and fit in their draft.
  2. Cryptographic review of combiner, and security considerations around choice of algorithms.
     - See maillist discussion *"Re: draft-ounsworth-pq-composite-encryption key combination"*
  3. Synchronize with TLS WG hybrid KEMs.

1: draft-perret-prat-cms-pq-kem-00

Terminology

- “Hybrid” and “dual” are the NIST terms for multi-algorithm key exchange and signatures, respectively.
- “Hybrid” is problematic because it collides with https://en.wikipedia.org/wiki/Hybrid_cryptosystem
  - Especially with “hybrid” CMS content encryption aligned with draft-ietf-tls-hybrid-design.
- Multiple terms get used with confusing overlap:
  - Hybrid / dual / composite / multi-cert / multi-key
- We need a hero to volunteer for an Informative terminology draft.