# Happy Key: HPKE implementation (RFC9180)

https://github.com/sftcd/happykey

Generated by Doxygen 1.9.1

# Chapter 1

# Data Structure Index

## 1.1 Data Structures

Here are the data structures with brief descriptions:

# Chapter 2

# File Index

## 2.1 File List

Here is a list of all documented files with brief descriptions:

# Chapter 3

# Data Structure Documentation

## 3.1 hpke_aead_info_t Struct Reference

info about an AEAD

### Data Fields

- uint16_t aead_id

  *code point for aead alg*
- const EVP_CIPHER ∗(∗ aead_init_func )(void)

  *the aead we're using*
- const char ∗ **name**
- size_t taglen

  *aead tag len*
- size_t Nk

  *size of a key for this aead*
- size_t Nn

  *length of a nonce for this aead*

### 3.1.1 Detailed Description

info about an AEAD

The documentation for this struct was generated from the following file:

- hpke.c

## 3.2 hpke_kdf_info_t Struct Reference

info about a KDF

## Data Fields

- uint16_t kdf_id

  *code point for KDF*
- const EVP_MD ∗(∗ hash_init_func )(void)

  *the hash alg we're using*
- size_t Nh

  *length of hash/extract output*

### 3.2.1 Detailed Description

info about a KDF

The documentation for this struct was generated from the following file:

- hpke.c

## 3.3 hpke_kem_info_t Struct Reference

info about a KEM

## Data Fields

- uint16_t kem_id

  *code point for key encipherment method*
- const char ∗ keytype

  *string form of algtype "EC"/"X25519"/"X448"*
- const char ∗ groupname

  *string form of EC group for NIST curves*
- int groupid

  *NID of KEM.*
- const EVP_MD ∗(∗ hash_init_func )(void)

  *hash alg for the HKDF*
- size_t Nsecret

  *size of secrets*
- size_t Nenc

  *length of encapsulated key*
- size_t Npk

  *length of public key*
- size_t Npriv

  *length of raw private key*

### 3.3.1 Detailed Description

info about a KEM

The documentation for this struct was generated from the following file:

- hpke.c

## 3.4 hpke_suite_t Struct Reference

ciphersuite combination

```
#include <hpke.h>
```

### Data Fields

- uint16_t kem_id

  *Key Encryption Method id.*
- uint16_t kdf_id

  *Key Derivation Function id.*
- uint16_t aead_id

  *AEAD alg id.*

### 3.4.1 Detailed Description

ciphersuite combination

The documentation for this struct was generated from the following file:

- hpke.h

## 3.5 hpke_tv_encs_t Struct Reference

Encryption(s) Test Vector structure using field names from published JSON file.

```
#include <hpketv.h>
```

### Data Fields

- const char ∗ aad

  *ascii-hex encoded additional authenticated data*
- const char ∗ nonce

  *aascii-hex encoded nonce*
- const char ∗ plaintext

  *aascii-hex encoded plaintext*
- const char ∗ ciphertext

  *ascii-hex encoded ciphertext*

### 3.5.1 Detailed Description

Encryption(s) Test Vector structure using field names from published JSON file.

The documentation for this struct was generated from the following file:

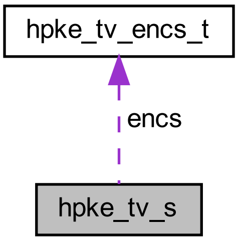
- hpketv.h

## 3.6 hpke_tv_s Struct Reference

HKPE Test Vector structure using field names from published JSON file.

```
#include <hpketv.h>
```

Collaboration diagram for hpke_tv_s:



### Data Fields

- uint8_t **mode**
- uint16_t **kdf_id**
- uint16_t **aead_id**
- uint16_t **kem_id**
- const char ∗ **info**
- const char ∗ **exporter_secret**
- const char ∗ **enc**
- const char ∗ **key_schedule_context**
- const char ∗ **nonce**
- const char ∗ **secret**
- const char ∗ **shared_secret**
- const char ∗ **skEm**
- const char ∗ **skRm**
- const char ∗ **skSm**
- const char ∗ **pkEm**
- const char ∗ **pkRm**
- const char ∗ **pkSm**
- const char ∗ **seedE**
- const char ∗ **seedR**
- const char ∗ **seedS**
- const char ∗ **psk_id**
- const char ∗ **psk**
- int **nencs**
- hpke_tv_encs_t ∗ **encs**
- void ∗ jobj

  *pointer to json-c object into which the char∗ pointers above point*

### 3.6.1 Detailed Description

HKPE Test Vector structure using field names from published JSON file.

The jobj field (at the end) is the json-c object from which all these are derived and into which most of the char ∗ pointers point. When we make an array of hpke_tv_s then the same jobj will be pointed at by all, so when it's time to call hpke_tv_free then we'll just free one of those using the json-c API.

The documentation for this struct was generated from the following file:

- hpketv.h

# Chapter 4

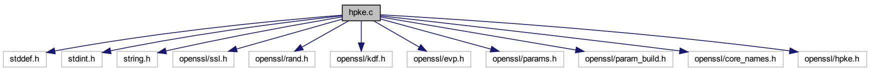
# File Documentation

## 4.1 hpke.c File Reference

An OpenSSL-based HPKE implementation of RFC9180.

```
#include <stddef.h>
#include <stdint.h>
#include <string.h>
#include <openssl/ssl.h>
#include <openssl/rand.h>
#include <openssl/kdf.h>
#include <openssl/evp.h>
#include <openssl/params.h>
#include <openssl/param_build.h>
#include <openssl/core_names.h>
#include <openssl/hpke.h>
```

Include dependency graph for hpke.c:



### Data Structures

- struct hpke_aead_info_t

  *info about an AEAD*
- struct hpke_kem_info_t

  *info about a KEM*
- struct hpke_kdf_info_t

  *info about a KDF*

## Macros

- #define HPKE_A2B(__c__)

    *Map ascii to binary - utility macro used in $>$1 place.*
- #define HPKE_VERLABEL "HPKE-v1"

    *version string label*
- #define HPKE_SEC41LABEL "KEM"

    *"suite_id" label for 4.1*
- #define HPKE_SEC51LABEL "HPKE"

    *"suite_id" label for 5.1*
- #define HPKE_EAE_PRK_LABEL "eae_prk"

    *label in ExtractAndExpand*
- #define HPKE_PSKIDHASH_LABEL "psk_id_hash"

    *in key_schedule_context*
- #define HPKE_INFOHASH_LABEL "info_hash"

    *in key_schedule_context*
- #define HPKE_SS_LABEL "shared_secret"

    *Yet another label.*
- #define HPKE_NONCE_LABEL "base_nonce"

    *guess?*
- #define HPKE_EXP_LABEL "exp"

    *guess again?*
- #define HPKE_KEY_LABEL "key"

    *guess again?*
- #define HPKE_PSK_HASH_LABEL "psk_hash"

    *guess again?*
- #define HPKE_SECRET_LABEL "secret"

    *guess again?*
- #define HPKE_5869_MODE_PURE 0

    *Do "pure" RFC5869.*
- #define HPKE_5869_MODE_KEM 1

    *Abide by HPKE section 4.1.*
- #define HPKE_5869_MODE_FULL 2

    *Abide by HPKE section 5.1.*
- #define **PEM_PRIVATEHEADER** "-----BEGIN PRIVATE KEY-----\n"
- #define **PEM_PRIVATEFOOTER** "\n-----END PRIVATE KEY-----\n"
- #define **HPKE_MSMATCH**(inp, known) (strlen(inp) == strlen(known) && !strcasecmp(inp, known))

## Functions

- int hpke_ah_decode (size_t ahlen, const char ∗ah, size_t ∗blen, unsigned char ∗∗buf)

    *decode ascii hex to a binary buffer*
- static int hpke_kem_id_check (uint16_t kem_id)

    *Check if kem_id is ok/known to us.*
- static int hpke_kem_id_nist_curve (uint16_t kem_id)

    *check if KEM uses NIST curve or not*
- static EVP_PKEY ∗ hpke_EVP_PKEY_new_raw_nist_public_key (int curve, unsigned char ∗buf, size_t buflen)

    *hpke wrapper to import NIST curve public key as easily as x25519/x448*

- static int hpke_aead_dec (hpke_suite_t suite, unsigned char ∗key, size_t keylen, unsigned char ∗iv, size_t ivlen, unsigned char ∗aad, size_t aadlen, unsigned char ∗cipher, size_t cipherlen, unsigned char ∗plain, size_t ∗plainlen)

  *do the AEAD decryption*
- static int hpke_aead_enc (hpke_suite_t suite, unsigned char ∗key, size_t keylen, unsigned char ∗iv, size_t ivlen, unsigned char ∗aad, size_t aadlen, unsigned char ∗plain, size_t plainlen, unsigned char ∗cipher, size_t ∗cipherlen)

  *do the AEAD encryption as per the I-D*
- static int hpke_extract (const hpke_suite_t suite, const int mode5869, const unsigned char ∗salt, const size_t saltlen, const char ∗label, const size_t labellen, const unsigned char ∗ikm, const size_t ikmlen, unsigned char ∗secret, size_t ∗secretlen)

  *RFC5869 HKDF-Extract.*
- static int hpke_expand (const hpke_suite_t suite, const int mode5869, const unsigned char ∗prk, const size_t prklen, const char ∗label, const size_t labellen, const unsigned char ∗info, const size_t infolen, const uint32_t L, unsigned char ∗out, size_t ∗outlen)

  *RFC5869 HKDF-Expand.*
- static int hpke_extract_and_expand (hpke_suite_t suite, int mode5869, unsigned char ∗shared_secret, size_t shared_secretlen, unsigned char ∗context, size_t contextlen, unsigned char ∗secret, size_t ∗secretlen)

  *ExtractAndExpand.*
- static int hpke_do_kem (int encrypting, hpke_suite_t suite, EVP_PKEY ∗key1, size_t key1enclen, unsigned char ∗key1enc, EVP_PKEY ∗key2, size_t key2enclen, unsigned char ∗key2enc, EVP_PKEY ∗akey, size_t apublen, unsigned char ∗apub, unsigned char ∗∗ss, size_t ∗sslen)

  *run the KEM with two keys as required*
- static int hpke_mode_check (unsigned int mode)

  *check mode is in-range and supported*
- static int hpke_psk_check (unsigned int mode, char ∗pskid, size_t psklen, unsigned char ∗psk)

  *check psk params are as per spec*
- static int hpke_enc_int (unsigned int mode, hpke_suite_t suite, char ∗pskid, size_t psklen, unsigned char ∗psk, size_t publen, unsigned char ∗pub, size_t authprivlen, unsigned char ∗authpriv, EVP_PKEY ∗authpriv_evp, size_t clearlen, unsigned char ∗clear, size_t aadlen, unsigned char ∗aad, size_t infolen, unsigned char ∗info, size_t seqlen, unsigned char ∗seq, size_t extsenderpublen, unsigned char ∗extsenderpub, EVP_PKEY ∗extsenderpriv, size_t rawsenderprivlen, unsigned char ∗rawsenderpriv, size_t ∗senderpublen, unsigned char ∗senderpub, size_t ∗cipherlen, unsigned char ∗cipher)

  *Internal HPKE single-shot encryption function.*
- int hpke_enc (unsigned int mode, hpke_suite_t suite, char ∗pskid, size_t psklen, unsigned char ∗psk, size_t publen, unsigned char ∗pub, size_t authprivlen, unsigned char ∗authpriv, EVP_PKEY ∗authpriv_evp, size_t clearlen, unsigned char ∗clear, size_t aadlen, unsigned char ∗aad, size_t infolen, unsigned char ∗info, size_t seqlen, unsigned char ∗seq, size_t ∗senderpublen, unsigned char ∗senderpub, size_t ∗cipherlen, unsigned char ∗cipher)

  *HPKE single-shot encryption function.*
- int hpke_enc_evp (unsigned int mode, hpke_suite_t suite, char ∗pskid, size_t psklen, unsigned char ∗psk, size_t publen, unsigned char ∗pub, size_t authprivlen, unsigned char ∗authpriv, EVP_PKEY ∗authpriv_evp, size_t clearlen, unsigned char ∗clear, size_t aadlen, unsigned char ∗aad, size_t infolen, unsigned char ∗info, size_t seqlen, unsigned char ∗seq, size_t extsenderpublen, unsigned char ∗extsenderpub, EVP_PKEY ∗extsenderpriv, size_t ∗cipherlen, unsigned char ∗cipher)

  *Internal HPKE single-shot encryption function.*
- int hpke_dec (unsigned int mode, hpke_suite_t suite, char ∗pskid, size_t psklen, unsigned char ∗psk, size_t authpublen, unsigned char ∗authpub, size_t privlen, unsigned char ∗priv, EVP_PKEY ∗evppriv, size_t enclen, unsigned char ∗enc, size_t cipherlen, unsigned char ∗cipher, size_t aadlen, unsigned char ∗aad, size_t infolen, unsigned char ∗info, size_t seqlen, unsigned char ∗seq, size_t ∗clearlen, unsigned char ∗clear)

  *HPKE single-shot decryption function.*
- int hpke_kg (unsigned int mode, hpke_suite_t suite, size_t ∗publen, unsigned char ∗pub, size_t ∗privlen, unsigned char ∗priv)

  *generate a key pair*

- int hpke_kg_evp (unsigned int mode, hpke_suite_t suite, size_t ∗publen, unsigned char ∗pub, EVP_PKEY ∗∗priv)

  *generate a key pair keeping private inside API*
- int hpke_suite_check (hpke_suite_t suite)

  *check if a suite is supported locally*
- int hpke_prbuf2evp (unsigned int kem_id, unsigned char ∗prbuf, size_t prbuf_len, unsigned char ∗pubuf, size_t pubuf_len, EVP_PKEY ∗∗retpriv)

  *: map a kem_id and a private key buffer into an EVP_PKEY*
- static int hpke_random_suite (hpke_suite_t ∗suite)

  *randomly pick a suite*
- int hpke_good4grease (hpke_suite_t ∗suite_in, hpke_suite_t suite, unsigned char ∗pub, size_t ∗pub_len, unsigned char ∗cipher, size_t cipher_len)

  *return a (possibly) random suite, public key, ciphertext for GREASErs*
- int hpke_str2suite (char ∗suitestr, hpke_suite_t ∗suite)

  *map a string to a HPKE suite*
- int hpke_expansion (hpke_suite_t suite, size_t clearlen, size_t ∗cipherlen)

  *tell the caller how big the cipertext will be*
- int hpke_setlibctx (OSSL_LIB_CTX ∗libctx)

  *set a non-default OSSL_LIB_CTX if needed*

## Variables

- static hpke_aead_info_t hpke_aead_tab [ ]

  *table of AEADs*
- static hpke_kem_info_t hpke_kem_tab [ ]

  *table of KEMs*
- static hpke_kdf_info_t hpke_kdf_tab [ ]

  *table of KDFs*
- static OSSL_LIB_CTX ∗ **hpke_libctx** = NULL

## 4.1.1 Detailed Description

An OpenSSL-based HPKE implementation of RFC9180.

## 4.1.2 Macro Definition Documentation

### 4.1.2.1 HPKE_A2B

```
#define HPKE_A2B(
              __c__ )
```

**Value:**

```
(__c__>=’0’&&__c__<=’9’?(__c__-’0’):\
(__c__>=’A’&&__c__<=’F’?(__c__-’A’+10):\
(__c__>=’a’&&__c__<=’f’?(__c__-’a’+10):0)))
```

Map ascii to binary - utility macro used in >1 place.

## 4.1.3 Function Documentation

### 4.1.3.1 hpke_aead_dec()

```
static int hpke_aead_dec (
            hpke_suite_t suite,
            unsigned char * key,
            size_t keylen,
            unsigned char * iv,
            size_t ivlen,
            unsigned char * aad,
            size_t aadlen,
            unsigned char * cipher,
            size_t cipherlen,
            unsigned char * plain,
            size_t * plainlen )  [static]
```

do the AEAD decryption

**Parameters**

| | |
|---|---|
| *suite* | is the ciphersuite |
| *key* | is the secret |
| *keylen* | is the length of the secret |
| *iv* | is the initialisation vector |
| *ivlen* | is the length of the iv |
| *aad* | is the additional authenticated data |
| *aadlen* | is the length of the aad |
| *cipher* | is obvious |
| *cipherlen* | is the ciphertext length |
| *plain* | is an output |
| *plainlen* | input/output, better be big enough on input, exact on output |

**Returns**

1 for good otherwise bad

### 4.1.3.2 hpke_aead_enc()

```
static int hpke_aead_enc (
            hpke_suite_t suite,
            unsigned char * key,
            size_t keylen,
            unsigned char * iv,
            size_t ivlen,
            unsigned char * aad,
            size_t aadlen,
            unsigned char * plain,
            size_t plainlen,
            unsigned char * cipher,
            size_t * cipherlen )  [static]
```

do the AEAD encryption as per the I-D

**Parameters**

| | |
|---|---|
| *suite* | is the ciphersuite |
| *key* | is the secret |
| *keylen* | is the length of the secret |
| *iv* | is the initialisation vector |
| *ivlen* | is the length of the iv |
| *aad* | is the additional authenticated data |
| *aadlen* | is the length of the aad |
| *plain* | is an output |
| *plainlen* | is the length of plain |
| *cipher* | is an output |
| *cipherlen* | input/output, better be big enough on input, exact on output |

**Returns**

1 for good otherwise bad

### 4.1.3.3 hpke_ah_decode()

```
int hpke_ah_decode (
            size_t ahlen,
            const char * ah,
            size_t * blen,
            unsigned char ** buf )
```

decode ascii hex to a binary buffer

```
Since I always have to reconstruct this again in my head...
Bash command line hashing starting from ascii hex example:

   $ echo -e "4f6465206f6e2061204772656369616e2055726e" | \
      xxd -r -p | openssl sha256
   (stdin)= 55c4040629c64c5efec2f7230407d612d16289d7c5d7afcf9340280abd2de1ab

The above generates the Hash(info) used in Appendix A.2

If you'd like to regenerate the zero_sha256 value above, feel free
   $ echo -n "" | openssl sha256
   echo -n "" | openssl sha256
   (stdin)= e3b0c44298fc1c149afbf4c8996fb92427ae41e4649b934ca495991b7852b855
Or if you'd like to re-caclulate the sha256 of nothing...
 SHA256_CTX sha256;
 SHA256_Init(&sha256);
 char* buffer = NULL;
 int bytesRead = 0;
 SHA256_Update(&sha256, buffer, bytesRead);
 SHA256_Final(zero_sha256, &sha256);
...but I've done it for you, so no need:-)
static const unsigned char zero_sha256[SHA256_DIGEST_LENGTH] = {
    0xe3, 0xb0, 0xc4, 0x42, 0x98, 0xfc, 0x1c, 0x14,
    0x9a, 0xfb, 0xf4, 0xc8, 0x99, 0x6f, 0xb9, 0x24,
    0x27, 0xae, 0x41, 0xe4, 0x64, 0x9b, 0x93, 0x4c,
    0xa4, 0x95, 0x99, 0x1b, 0x78, 0x52, 0xb8, 0x55};
```

**Parameters**

| | |
|---|---|
| *ahlen* | is the ascii hex string length |
| *ah* | is the ascii hex string |
| *blen* | is a pointer to the returned binary length |
| *buf* | is a pointer to the internally allocated binary buffer |

**Returns**

1 for good otherwise bad

#### 4.1.3.4 hpke_dec()

```
int hpke_dec (
            unsigned int mode,
            hpke_suite_t suite,
            char * pskid,
            size_t psklen,
            unsigned char * psk,
            size_t authpublen,
            unsigned char * authpub,
            size_t privlen,
            unsigned char * priv,
            EVP_PKEY * evppriv,
            size_t enclen,
            unsigned char * enc,
            size_t cipherlen,
            unsigned char * cipher,
            size_t aadlen,
            unsigned char * aad,
            size_t infolen,
            unsigned char * info,
            size_t seqlen,
            unsigned char * seq,
            size_t * clearlen,
            unsigned char * clear )
```

HPKE single-shot decryption function.

**Parameters**

| | |
|---|---|
| *mode* | is the HPKE mode |
| *suite* | is the ciphersuite |
| *pskid* | is the pskid string fpr a PSK mode (can be NULL) |
| *psklen* | is the psk length |
| *psk* | is the psk |
| *publen* | is the length of the public (authentication) key |
| *pub* | is the encoded public (authentication) key |
| *privlen* | is the length of the private key |
| *priv* | is the encoded private key |
| *evppriv* | is a pointer to an internal form of private key |
| *enclen* | is the length of the peer's public value |
| *enc* | is the peer's public value |
| *cipherlen* | is the length of the ciphertext |
| *cipher* | is the ciphertext |
| *aadlen* | is the lenght of the additional data |
| *aad* | is the encoded additional data |
| *infolen* | is the lenght of the info data (can be zero) |
| *info* | is the encoded info data (can be NULL) |
| *seqlen* | is the length of the sequence data (can be zero) |
| *seq* | is the encoded sequence data (can be NULL) |
| *clearlen* | length of the input buffer for cleartext |
| *clear* | is the encoded cleartext |

**Returns**

1 for good (OpenSSL style), not 1 for error

### 4.1.3.5 hpke_do_kem()

```
static int hpke_do_kem (
             int encrypting,
             hpke_suite_t suite,
             EVP_PKEY * key1,
             size_t key1enclen,
             unsigned char * key1enc,
             EVP_PKEY * key2,
             size_t key2enclen,
             unsigned char * key2enc,
             EVP_PKEY * akey,
             size_t apublen,
             unsigned char * apub,
             unsigned char ** ss,
             size_t * sslen )  [static]
```

run the KEM with two keys as required

**Parameters**

| | |
|---|---|
| *encrypting* | is 1 if we're encrypting, 0 for decrypting |
| *suite* | is the ciphersuite |
| *key1* | is the first key, for which we have the private value |
| *key1enclen* | is the length of the encoded form of key1 |
| *key1en* | is the encoded form of key1 |
| *key2* | is the peer's key |
| *key2enclen* | is the length of the encoded form of key1 |
| *key2en* | is the encoded form of key1 |
| *akey* | is the authentication private key |
| *apublen* | is the length of the encoded the authentication public key |
| *apub* | is the encoded form of the authentication public key |
| *ss* | is (a pointer to) the buffer for the shared secret result |
| *sslen* | is the size of the buffer (octets-used on exit) |

**Returns**

1 for good, not 1 for not good

### 4.1.3.6 hpke_enc()

```
int hpke_enc (
            unsigned int mode,
            hpke_suite_t suite,
            char * pskid,
            size_t psklen,
            unsigned char * psk,
            size_t publen,
            unsigned char * pub,
            size_t authprivlen,
            unsigned char * authpriv,
            EVP_PKEY * authpriv_evp,
            size_t clearlen,
            unsigned char * clear,
            size_t aadlen,
            unsigned char * aad,
            size_t infolen,
            unsigned char * info,
            size_t seqlen,
            unsigned char * seq,
            size_t * senderpublen,
            unsigned char * senderpub,
            size_t * cipherlen,
            unsigned char * cipher )
```

HPKE single-shot encryption function.

**Parameters**

| | |
|---|---|
| *mode* | is the HPKE mode |
| *suite* | is the ciphersuite to use |
| *pskid* | is the pskid string fpr a PSK mode (can be NULL) |
| *psklen* | is the psk length |
| *psk* | is the psk |
| *publen* | is the length of the recipient public key |
| *pub* | is the encoded recipient public key |
| *authprivlen* | is the length of the private (authentication) key |
| *authpriv* | is the encoded private (authentication) key |
| *authpriv_evp* | is the EVP_PKEY* form of private (authentication) key |
| *clearlen* | is the length of the cleartext |
| *clear* | is the encoded cleartext |
| *aadlen* | is the lenght of the additional data (can be zero) |
| *aad* | is the encoded additional data (can be NULL) |
| *infolen* | is the lenght of the info data (can be zero) |
| *info* | is the encoded info data (can be NULL) |
| *seqlen* | is the length of the sequence data (can be zero) |
| *seq* | is the encoded sequence data (can be NULL) |
| *senderpublen* | length of the input buffer for the sender's public key |
| *senderpub* | is the input buffer for ciphertext |
| *cipherlen* | length of the input buffer for ciphertext |
| *cipher* | is the input buffer for ciphertext |

**Returns**

1 for good (OpenSSL style), not 1 for error

### 4.1.3.7 hpke_enc_evp()

```
int hpke_enc_evp (
             unsigned int mode,
             hpke_suite_t suite,
             char * pskid,
             size_t psklen,
             unsigned char * psk,
             size_t publen,
             unsigned char * pub,
             size_t authprivlen,
             unsigned char * authpriv,
             EVP_PKEY * authpriv_evp,
             size_t clearlen,
             unsigned char * clear,
             size_t aadlen,
             unsigned char * aad,
             size_t infolen,
             unsigned char * info,
             size_t seqlen,
             unsigned char * seq,
             size_t extsenderpublen,
             unsigned char * extsenderpub,
             EVP_PKEY * extsenderpriv,
             size_t * cipherlen,
             unsigned char * cipher )
```

Internal HPKE single-shot encryption function.

**Parameters**

| | |
|---|---|
| *mode* | is the HPKE mode |
| *suite* | is the ciphersuite to use |
| *pskid* | is the pskid string fpr a PSK mode (can be NULL) |
| *psklen* | is the psk length |
| *psk* | is the psk |
| *publen* | is the length of the recipient public key |
| *pub* | is the encoded recipient public key |
| *authprivlen* | is the length of the private (authentication) key |
| *authpriv* | is the encoded private (authentication) key |
| *authpriv_evp* | is the EVP_PKEY* form of private (authentication) key |
| *clearlen* | is the length of the cleartext |
| *clear* | is the encoded cleartext |
| *aadlen* | is the lenght of the additional data (can be zero) |
| *aad* | is the encoded additional data (can be NULL) |
| *infolen* | is the lenght of the info data (can be zero) |
| *info* | is the encoded info data (can be NULL) |
| *seqlen* | is the length of the sequence data (can be zero) |
| *seq* | is the encoded sequence data (can be NULL) |
| *senderpublen* | length of the input buffer with the sender's public key |
| *senderpub* | is the input buffer for sender public key |
| *senderpriv* | has the handle for the sender private key |
| *cipherlen* | length of the input buffer for ciphertext |
| *cipher* | is the input buffer for ciphertext |

**Returns**

1 for good (OpenSSL style), not 1 for error

### 4.1.3.8 hpke_enc_int()

```
static int hpke_enc_int (
            unsigned int mode,
            hpke_suite_t suite,
            char * pskid,
            size_t psklen,
            unsigned char * psk,
            size_t publen,
            unsigned char * pub,
            size_t authprivlen,
            unsigned char * authpriv,
            EVP_PKEY * authpriv_evp,
            size_t clearlen,
            unsigned char * clear,
            size_t aadlen,
            unsigned char * aad,
            size_t infolen,
            unsigned char * info,
            size_t seqlen,
            unsigned char * seq,
            size_t extsenderpublen,
            unsigned char * extsenderpub,
            EVP_PKEY * extsenderpriv,
            size_t rawsenderprivlen,
            unsigned char * rawsenderpriv,
            size_t * senderpublen,
            unsigned char * senderpub,
            size_t * cipherlen,
            unsigned char * cipher )  [static]
```

Internal HPKE single-shot encryption function.

**Parameters**

| | |
|---|---|
| *mode* | is the HPKE mode |
| *suite* | is the ciphersuite to use |
| *pskid* | is the pskid string fpr a PSK mode (can be NULL) |
| *psklen* | is the psk length |
| *psk* | is the psk |
| *publen* | is the length of the recipient public key |
| *pub* | is the encoded recipient public key |
| *authprivlen* | is the length of the private (authentication) key |
| *authpriv* | is the encoded private (authentication) key |
| *authpriv_evp* | is the EVP_PKEY* form of private (authentication) key |
| *clearlen* | is the length of the cleartext |
| *clear* | is the encoded cleartext |
| *aadlen* | is the lenght of the additional data (can be zero) |
| *aad* | is the encoded additional data (can be NULL) |
| *infolen* | is the lenght of the info data (can be zero) |
| *info* | is the encoded info data (can be NULL) |
| *seqlen* | is the length of the sequence data (can be zero) |
| *seq* | is the encoded sequence data (can be NULL) |
| *extsenderpublen* | length of the input buffer for sender's public key |
| *extsenderpub* | is the input buffer for sender public key |
| *extsenderpriv* | has the handle for the sender private key |
| *senderpublen* | length of the input buffer for sender's public key |
| *senderpub* | is the input buffer for ciphertext |
| *cipherlen* | is the length of the input buffer for ciphertext |
| *cipher* | is the input buffer for ciphertext |

**Returns**

1 for good (OpenSSL style), not 1 for error

### 4.1.3.9 hpke_EVP_PKEY_new_raw_nist_public_key()

```
static EVP_PKEY* hpke_EVP_PKEY_new_raw_nist_public_key (
            int curve,
            unsigned char * buf,
            size_t buflen )  [static]
```

hpke wrapper to import NIST curve public key as easily as x25519/x448

**Parameters**

| | |
|---|---|
| *curve* | is the curve NID |
| *buf* | is the binary buffer with the (uncompressed) public value |
| *buflen* | is the length of the private key buffer |

**Returns**

a working EVP_PKEY ∗ or NULL

### 4.1.3.10 hpke_expand()

```
static int hpke_expand (
            const hpke_suite_t suite,
            const int mode5869,
            const unsigned char * prk,
            const size_t prklen,
            const char * label,
            const size_t labellen,
            const unsigned char * info,
            const size_t infolen,
            const uint32_t L,
            unsigned char * out,
            size_t * outlen )  [static]
```

RFC5869 HKDF-Expand.

**Parameters**

| | |
|---|---|
| *suite* | is the ciphersuite |
| *mode5869* | - controls labelling specifics |
| *prk* | - the initial pseudo-random key material |
| *prk* | - length of above |
| *label* | - label to prepend to info |

**Parameters**

| | |
|---|---|
| *labellen* | - label to prepend to info |
| *context* | - the info |
| *contextlen* | - length of above |
| *L* | - the length of the output desired |
| *out* | - the result of expansion (allocated by caller) |
| *outlen* | - buf size on input |

**Returns**

1 for good otherwise bad

#### 4.1.3.11 hpke_expansion()

```
int hpke_expansion (
            hpke_suite_t suite,
            size_t clearlen,
            size_t * cipherlen )
```

tell the caller how big the cipertext will be

AEAD algorithms add a tag for data authentication. Those are almost always, but not always, 16 octets long, and who know what'll be true in the future. So this function allows a caller to find out how much data expansion they'll see with a given suite.

**Parameters**

| | |
|---|---|
| *suite* | is the suite to be used |
| *clearlen* | is the length of plaintext |
| *cipherlen* | points to what'll be ciphertext length |

**Returns**

1 for success, otherwise failure

#### 4.1.3.12 hpke_extract()

```
static int hpke_extract (
            const hpke_suite_t suite,
            const int mode5869,
            const unsigned char * salt,
            const size_t saltlen,
            const char * label,
            const size_t labellen,
            const unsigned char * ikm,
            const size_t ikmlen,
            unsigned char * secret,
            size_t * secretlen )  [static]
```

RFC5869 HKDF-Extract.

**Parameters**

| | |
|---|---|
| *suite* | is the ciphersuite |
| *mode5869* | - controls labelling specifics |
| *salt* | - surprisingly this is the salt;-) |
| *saltlen* | - length of above |
| *label* | - label for separation |
| *labellen* | - length of above |
| *zz* | - the initial key material (IKM) |
| *zzlen* | - length of above |
| *secret* | - the result of extraction (allocated inside) |
| *secretlen* | - bufsize on input, used size on output |

**Returns**

1 for good otherwise bad

Mode can be:

- HPKE_5869_MODE_PURE meaning to ignore all the HPKE-specific labelling and produce an output that's RFC5869 compliant (useful for testing and maybe more)
- HPKE_5869_MODE_KEM meaning to follow section 4.1 where the suite_id is used as: concat("KEM", I2OSP(kem_id, 2))
- HPKE_5869_MODE_FULL meaning to follow section 5.1 where the suite_id is used as: concat("HPKE", I2OSP(kem_id, 2), I2OSP(kdf_id, 2), I2OSP(aead_id, 2))

Isn't that a bit of a mess!

#### 4.1.3.13 hpke_extract_and_expand()

```
static int hpke_extract_and_expand (
            hpke_suite_t suite,
            int mode5869,
            unsigned char * shared_secret,
            size_t shared_secretlen,
            unsigned char * context,
            size_t contextlen,
            unsigned char * secret,
            size_t * secretlen )  [static]
```

ExtractAndExpand.

**Parameters**

| | |
|---|---|
| *suite* | is the ciphersuite |
| *mode5869* | - controls labelling specifics |
| *shared_secret* | - the initial DH shared secret |
| *shared_secretlen* | - length of above |
| *context* | - the info |
| *contextlen* | - length of above |
| *secret* | - the result of extract&expand |
| *secretlen* | - buf size on input |

**Returns**

1 for good otherwise bad

### 4.1.3.14 hpke_good4grease()

```
int hpke_good4grease (
            hpke_suite_t * suite_in,
            hpke_suite_t suite,
            unsigned char * pub,
            size_t * pub_len,
            unsigned char * cipher,
            size_t cipher_len )
```

return a (possibly) random suite, public key, ciphertext for GREASErs

get a (possibly) random suite, public key and ciphertext for GREASErs

As usual buffers are caller allocated and lengths on input are buffer size.

**Parameters**

| | |
|---|---|
| *suite-in* | specifies the preferred suite or NULL for a random choice |
| *suite* | is the chosen or random suite |
| *pub* | a random value of the appropriate length for sender public value |
| *pub_len* | is the length of pub (buffer size on input) |
| *cipher* | buffer with random value of the appropriate length |
| *cipher_len* | is the length of cipher |

**Returns**

1 for success, otherwise failure

#### 4.1.3.15 hpke_kem_id_check()

```
static int hpke_kem_id_check (
             uint16_t kem_id )  [static]
```

Check if kem_id is ok/known to us.

**Parameters**

| | |
|---|---|
| *kem←_id* | is the externally supplied kem_id |

**Returns**

1 for good, not 1 for error

#### 4.1.3.16 hpke_kem_id_nist_curve()

```
static int hpke_kem_id_nist_curve (
             uint16_t kem_id )  [static]
```

check if KEM uses NIST curve or not

**Parameters**

| | |
|---|---|
| *kem←_id* | is the externally supplied kem_id |

**Returns**

1 for NIST, 0 otherwise, -1 for error

#### 4.1.3.17 hpke_kg()

```
int hpke_kg (
             unsigned int mode,
             hpke_suite_t suite,
             size_t * publen,
             unsigned char * pub,
             size_t * privlen,
             unsigned char * priv )
```

generate a key pair

**Parameters**

| | |
|---|---|
| *mode* | is the mode (currently unused) |
| *suite* | is the ciphersuite |
| *publen* | is the size of the public key buffer (exact length on output) |
| *pub* | is the public value |
| *privlen* | is the size of the private key buffer (exact length on output) |
| *priv* | is the private key |

**Returns**

1 for good (OpenSSL style), not 1 for error

### 4.1.3.18 hpke_kg_evp()

```
int hpke_kg_evp (
             unsigned int mode,
             hpke_suite_t suite,
             size_t * publen,
             unsigned char * pub,
             EVP_PKEY ** priv )
```

generate a key pair keeping private inside API

generate a key pair but keep private inside API

**Parameters**

| | |
|---|---|
| *mode* | is the mode (currently unused) |
| *suite* | is the ciphersuite |
| *publen* | is the size of the public key buffer (exact length on output) |
| *pub* | is the public value |
| *priv* | is the private key pointer |

**Returns**

1 for good (OpenSSL style), not 1 for error

### 4.1.3.19 hpke_mode_check()

```
static int hpke_mode_check (
             unsigned int mode )  [static]
```

check mode is in-range and supported

**Parameters**

| | |
|---|---|
| *mode* | is the caller's chosen mode |

**Returns**

1 for good (OpenSSL style), not 1 for error

#### 4.1.3.20 hpke_prbuf2evp()

```
int hpke_prbuf2evp (
             unsigned int kem_id,
             unsigned char * prbuf,
             size_t prbuf_len,
             unsigned char * pubuf,
             size_t pubuf_len,
             EVP_PKEY ** retpriv )
```

: map a kem_id and a private key buffer into an EVP_PKEY

Note that the buffer is expected to be some form of the PEM encoded private key, but could still have the PEM header or not, and might or might not be base64 encoded. We'll try handle all those options.

**Parameters**

| | |
|---|---|
| *kem_id* | is what'd you'd expect (using the HPKE registry values) |
| *prbuf* | is the private key buffer |
| *prbuf_len* | is the length of that buffer |
| *pubuf* | is the public key buffer (if available) |
| *pubuf_len* | is the length of that buffer |
| *priv* | is a pointer to an EVP_PKEY * for the result |

**Returns**

1 for success, otherwise failure

#### 4.1.3.21 hpke_psk_check()

```
static int hpke_psk_check (
             unsigned int mode,
             char * pskid,
             size_t psklen,
             unsigned char * psk )  [static]
```

check psk params are as per spec

**Parameters**

| | |
|---|---|
| *mode* | is the mode in use |
| *pskid* | PSK identifier |
| *psklen* | length of PSK |
| *psk* | the psk itself |

**Returns**

1 for good (OpenSSL style), not 1 for error

If a PSK mode is used both pskid and psk must be non-default. Otherwise we ignore the PSK params.

#### 4.1.3.22 hpke_random_suite()

```
static int hpke_random_suite (
            hpke_suite_t * suite )  [static]
```

randomly pick a suite

**Parameters**

| | |
|---|---|
| *suite* | is the result |

**Returns**

1 for success, otherwise failure

If you change the structure of the various *_tab arrays then this code will also need change.

#### 4.1.3.23 hpke_setlibctx()

```
int hpke_setlibctx (
            OSSL_LIB_CTX * libctx )
```

set a non-default OSSL_LIB_CTX if needed

**Parameters**

| | |
|---|---|
| *ctx* | is the context to set |

**Returns**

1 for success, otherwise failure

### 4.1.3.24 hpke_str2suite()

```
int hpke_str2suite (
            char * suitestr,
            hpke_suite_t * suite )
```

map a string to a HPKE suite

**Parameters**

| | |
|---|---|
| *str* | is the string value |
| *suite* | is the resulting suite |

**Returns**

1 for success, otherwise failure

### 4.1.3.25 hpke_suite_check()

```
int hpke_suite_check (
            hpke_suite_t suite )
```

check if a suite is supported locally

**Parameters**

| | |
|---|---|
| *suite* | is the suite to check |

**Returns**

1 for good/supported, not 1 otherwise

## 4.1.4 Variable Documentation

### 4.1.4.1 hpke_aead_tab

```
hpke_aead_info_t hpke_aead_tab[ ]  [static]
```

**Initial value:**

```
= {
    { 0, NULL, NULL, 0, 0, 0 },
    { HPKE_AEAD_ID_AES_GCM_128, EVP_aes_128_gcm, "AES-128-GCM", 16, 16, 12 },
    { HPKE_AEAD_ID_AES_GCM_256, EVP_aes_256_gcm, "AES-256-GCM", 16, 32, 12 },
    { HPKE_AEAD_ID_CHACHA_POLY1305, EVP_chacha20_poly1305,
        "chacha20-poly1305", 16, 32, 12 }
}
```

table of AEADs

### 4.1.4.2 hpke_kdf_tab

```
hpke_kdf_info_t hpke_kdf_tab[ ]  [static]
```

**Initial value:**

```
= {
    { 0, NULL, 0 },
    { HPKE_KDF_ID_HKDF_SHA256, EVP_sha256, 32 },
    { HPKE_KDF_ID_HKDF_SHA384, EVP_sha384, 48 },
    { HPKE_KDF_ID_HKDF_SHA512, EVP_sha512, 64 }
}
```

table of KDFs

### 4.1.4.3 hpke_kem_tab

```
hpke_kem_info_t hpke_kem_tab[ ]  [static]
```

table of KEMs

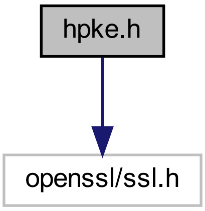
Ok we're wasting space here, but not much and it's ok

## 4.2 hpke.h File Reference

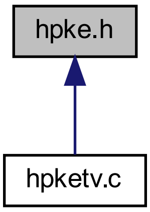
This has the data structures and prototypes (both internal and external) for an OpenSSL-based HPKE implementation of RFC9180.

```
#include <openssl/ssl.h>
```

Include dependency graph for hpke.h:



This graph shows which files directly or indirectly include this file:



## Data Structures

- struct hpke_suite_t

    *ciphersuite combination*

## Macros

- #define HPKE_DEFSIZE (40∗1024)

    *default plaintext/ciphertext buffer size e.g.*
- #define HPKE_MAXSIZE 2∗1024 /∗ 2k is enough for anyone (using this program:-) ∗/

    *biggest/default buffer for keys and internal buffers we use*
- #define HPKE_MODE_BASE 0

    *Base mode*
- #define HPKE_MODE_PSK 1

    *Pre-shared key mode.*
- #define HPKE_MODE_AUTH 2

    *Authenticated mode.*
- #define HPKE_MODE_PSKAUTH 3

    *PSK+authenticated mode.*
- #define HPKE_KEM_ID_RESERVED 0x0000

    *not used*
- #define HPKE_KEM_ID_P256 0x0010

    *NIST P-256.*
- #define HPKE_KEM_ID_P384 0x0011

    *NIST P-256.*
- #define HPKE_KEM_ID_P521 0x0012

    *NIST P-521.*
- #define HPKE_KEM_ID_25519 0x0020

    *Curve25519.*
- #define HPKE_KEM_ID_448 0x0021

    *Curve448.*
- #define HPKE_KDF_ID_RESERVED 0x0000

    *not used*

- #define HPKE_KDF_ID_HKDF_SHA256 0x0001

  *HKDF-SHA256.*
- #define HPKE_KDF_ID_HKDF_SHA384 0x0002

  *HKDF-SHA512.*
- #define HPKE_KDF_ID_HKDF_SHA512 0x0003

  *HKDF-SHA512.*
- #define HPKE_KDF_ID_MAX 0x0003

  *HKDF-SHA512.*
- #define HPKE_AEAD_ID_RESERVED 0x0000

  *not used*
- #define HPKE_AEAD_ID_AES_GCM_128 0x0001

  *AES-GCM-128.*
- #define HPKE_AEAD_ID_AES_GCM_256 0x0002

  *AES-GCM-256.*
- #define HPKE_AEAD_ID_CHACHA_POLY1305 0x0003

  *Chacha20-Poly1305.*
- #define HPKE_AEAD_ID_MAX 0x0003

  *Chacha20-Poly1305.*
- #define HPKE_MODESTR_BASE "base"

  *base mode (1), no sender auth*
- #define HPKE_MODESTR_PSK "psk"

  *psk mode (2)*
- #define HPKE_MODESTR_AUTH "auth"

  *auth (3), with a sender-key pair*
- #define HPKE_MODESTR_PSKAUTH "pskauth"

  *psk+sender-key pair (4)*
- #define HPKE_KEMSTR_P256 "p256"

  *KEM id 0x10.*
- #define HPKE_KEMSTR_P384 "p384"

  *KEM id 0x11.*
- #define HPKE_KEMSTR_P521 "p521"

  *KEM id 0x12.*
- #define HPKE_KEMSTR_X25519 "x25519"

  *KEM id 0x20.*
- #define HPKE_KEMSTR_X448 "x448"

  *KEM id 0x21.*
- #define HPKE_KDFSTR_256 "hkdf-sha256"

  *KDF id 1.*
- #define HPKE_KDFSTR_384 "hkdf-sha384"

  *KDF id 2.*
- #define HPKE_KDFSTR_512 "hkdf-sha512"

  *KDF id 3.*
- #define HPKE_AEADSTR_AES128GCM "aes128gcm"

  *AEAD id 1.*
- #define HPKE_AEADSTR_AES256GCM "aes256gcm"

  *AEAD id 2.*
- #define HPKE_AEADSTR_CP "chachapoly1305"

  *AEAD id 3.*
- #define HPKE_SUITE_DEFAULT { HPKE_KEM_ID_25519, HPKE_KDF_ID_HKDF_SHA256, HPKE_AEAD_ID_AES_GCM_12 }
- #define **HPKE_SUITE_TURNITUPTO11** { HPKE_KEM_ID_448, HPKE_KDF_ID_HKDF_SHA512, HPKE_AEAD_ID_CHACHA_POLY1305 }

## Functions

- int hpke_enc (unsigned int mode, hpke_suite_t suite, char ∗pskid, size_t psklen, unsigned char ∗psk, size_t publen, unsigned char ∗pub, size_t authprivlen, unsigned char ∗authpriv, EVP_PKEY ∗authpriv_evp, size_t clearlen, unsigned char ∗clear, size_t aadlen, unsigned char ∗aad, size_t infolen, unsigned char ∗info, size_t seqlen, unsigned char ∗seq, size_t ∗senderpublen, unsigned char ∗senderpub, size_t ∗cipherlen, unsigned char ∗cipher)

  *HPKE single-shot encryption function.*
- int hpke_enc_evp (unsigned int mode, hpke_suite_t suite, char ∗pskid, size_t psklen, unsigned char ∗psk, size_t publen, unsigned char ∗pub, size_t authprivlen, unsigned char ∗authpriv, EVP_PKEY ∗authpriv←↩ _evp, size_t clearlen, unsigned char ∗clear, size_t aadlen, unsigned char ∗aad, size_t infolen, unsigned char ∗info, size_t seqlen, unsigned char ∗seq, size_t senderpublen, unsigned char ∗senderpub, EVP_PKEY ∗senderpriv, size_t ∗cipherlen, unsigned char ∗cipher)

  *Internal HPKE single-shot encryption function.*
- int hpke_dec (unsigned int mode, hpke_suite_t suite, char ∗pskid, size_t psklen, unsigned char ∗psk, size_t publen, unsigned char ∗pub, size_t privlen, unsigned char ∗priv, EVP_PKEY ∗evppriv, size_t enclen, unsigned char ∗enc, size_t cipherlen, unsigned char ∗cipher, size_t aadlen, unsigned char ∗aad, size_t infolen, unsigned char ∗info, size_t seqlen, unsigned char ∗seq, size_t ∗clearlen, unsigned char ∗clear)

  *HPKE single-shot decryption function.*
- int hpke_kg (unsigned int mode, hpke_suite_t suite, size_t ∗publen, unsigned char ∗pub, size_t ∗privlen, unsigned char ∗priv)

  *generate a key pair*
- int hpke_kg_evp (unsigned int mode, hpke_suite_t suite, size_t ∗publen, unsigned char ∗pub, EVP_PKEY ∗∗priv)

  *generate a key pair but keep private inside API*
- int hpke_ah_decode (size_t ahlen, const char ∗ah, size_t ∗blen, unsigned char ∗∗buf)

  *decode ascii hex to a binary buffer*
- int hpke_suite_check (hpke_suite_t suite)

  *check if a suite is supported locally*
- int hpke_prbuf2evp (unsigned int kem_id, unsigned char ∗prbuf, size_t prbuf_len, unsigned char ∗pubuf, size_t pubuf_len, EVP_PKEY ∗∗priv)

  *: map a kem_id and a private key buffer into an EVP_PKEY*
- int hpke_good4grease (hpke_suite_t ∗suite_in, hpke_suite_t suite, unsigned char ∗pub, size_t ∗pub_len, unsigned char ∗cipher, size_t cipher_len)

  *get a (possibly) random suite, public key and ciphertext for GREASErs*
- int hpke_str2suite (char ∗str, hpke_suite_t ∗suite)

  *map a string to a HPKE suite*
- int hpke_expansion (hpke_suite_t suite, size_t clearlen, size_t ∗cipherlen)

  *tell the caller how big the cipertext will be*
- int hpke_setlibctx (OSSL_LIB_CTX ∗libctx)

  *set a non-default OSSL_LIB_CTX if needed*

### 4.2.1 Detailed Description

This has the data structures and prototypes (both internal and external) for an OpenSSL-based HPKE implementation of RFC9180.

### 4.2.2 Macro Definition Documentation

#### 4.2.2.1 HPKE_DEFSIZE

```
#define HPKE_DEFSIZE (40*1024)
```

default plaintext/ciphertext buffer size e.g.

if processing stdin

#### 4.2.2.2 HPKE_SUITE_DEFAULT

```
#define HPKE_SUITE_DEFAULT  { HPKE_KEM_ID_25519, HPKE_KDF_ID_HKDF_SHA256, HPKE_AEAD_ID_AES_GCM_128
}
```

Two suite constants, use this like:

```
     hpke_suite_t myvar = HPKE_SUITE_DEFAULT;
```

### 4.2.3 Function Documentation

#### 4.2.3.1 hpke_ah_decode()

```
int hpke_ah_decode (
             size_t ahlen,
             const char * ah,
             size_t * blen,
             unsigned char ** buf )
```

decode ascii hex to a binary buffer

**Parameters**

| | |
|---|---|
| *ahlen* | is the ascii hex string length |
| *ah* | is the ascii hex string |
| *blen* | is a pointer to the returned binary length |
| *buf* | is a pointer to the internally allocated binary buffer |

**Returns**

1 for good (OpenSSL style), not-1 for error

```
Since I always have to reconstruct this again in my head...
Bash command line hashing starting from ascii hex example:

   $ echo -e "4f6465206f6e2061204772656369616e2055726e" | \
      xxd -r -p | openssl sha256
   (stdin)= 55c4040629c64c5efec2f7230407d612d16289d7c5d7afcf9340280abd2de1ab
```

```
The above generates the Hash(info) used in Appendix A.2

If you'd like to regenerate the zero_sha256 value above, feel free
   $ echo -n "" | openssl sha256
   echo -n "" | openssl sha256
   (stdin)= e3b0c44298fc1c149afbf4c8996fb92427ae41e4649b934ca495991b7852b855
Or if you'd like to re-caclulate the sha256 of nothing...
 SHA256_CTX sha256;
 SHA256_Init(&sha256);
 char* buffer = NULL;
 int bytesRead = 0;
 SHA256_Update(&sha256, buffer, bytesRead);
 SHA256_Final(zero_sha256, &sha256);
...but I've done it for you, so no need:-)
static const unsigned char zero_sha256[SHA256_DIGEST_LENGTH] = {
    0xe3, 0xb0, 0xc4, 0x42, 0x98, 0xfc, 0x1c, 0x14,
    0x9a, 0xfb, 0xf4, 0xc8, 0x99, 0x6f, 0xb9, 0x24,
    0x27, 0xae, 0x41, 0xe4, 0x64, 0x9b, 0x93, 0x4c,
    0xa4, 0x95, 0x99, 0x1b, 0x78, 0x52, 0xb8, 0x55};
```

**Parameters**

| | |
|---|---|
| *ahlen* | is the ascii hex string length |
| *ah* | is the ascii hex string |
| *blen* | is a pointer to the returned binary length |
| *buf* | is a pointer to the internally allocated binary buffer |

**Returns**

1 for good otherwise bad

#### 4.2.3.2 hpke_dec()

```
int hpke_dec (
            unsigned int mode,
            hpke_suite_t suite,
            char * pskid,
            size_t psklen,
            unsigned char * psk,
            size_t authpublen,
            unsigned char * authpub,
            size_t privlen,
            unsigned char * priv,
            EVP_PKEY * evppriv,
            size_t enclen,
            unsigned char * enc,
            size_t cipherlen,
            unsigned char * cipher,
            size_t aadlen,
            unsigned char * aad,
            size_t infolen,
            unsigned char * info,
            size_t seqlen,
            unsigned char * seq,
            size_t * clearlen,
            unsigned char * clear )
```

HPKE single-shot decryption function.

**Parameters**

| | |
|---|---|
| *mode* | is the HPKE mode |
| *suite* | is the ciphersuite |
| *pskid* | is the pskid string fpr a PSK mode (can be NULL) |
| *psklen* | is the psk length |
| *psk* | is the psk |
| *publen* | is the length of the public (authentication) key |
| *pub* | is the encoded public (authentication) key |
| *privlen* | is the length of the private key |
| *priv* | is the encoded private key |
| *evppriv* | is a pointer to an internal form of private key |
| *enclen* | is the length of the peer's public value |
| *enc* | is the peer's public value |
| *cipherlen* | is the length of the ciphertext |
| *cipher* | is the ciphertext |
| *aadlen* | is the lenght of the additional data |
| *aad* | is the encoded additional data |
| *infolen* | is the lenght of the info data (can be zero) |
| *info* | is the encoded info data (can be NULL) |
| *seqlen* | is the length of the sequence data (can be zero) |
| *seq* | is the encoded sequence data (can be NULL) |
| *clearlen* | length of the input buffer for cleartext |
| *clear* | is the encoded cleartext |

**Returns**

1 for good (OpenSSL style), not 1 for error

### 4.2.3.3 hpke_enc()

```
int hpke_enc (
                unsigned int mode,
                hpke_suite_t suite,
                char * pskid,
                size_t psklen,
                unsigned char * psk,
                size_t publen,
                unsigned char * pub,
                size_t authprivlen,
                unsigned char * authpriv,
                EVP_PKEY * authpriv_evp,
                size_t clearlen,
                unsigned char * clear,
                size_t aadlen,
                unsigned char * aad,
                size_t infolen,
                unsigned char * info,
                size_t seqlen,
                unsigned char * seq,
                size_t * senderpublen,
                unsigned char * senderpub,
                size_t * cipherlen,
                unsigned char * cipher )
```

HPKE single-shot encryption function.

**Parameters**

| | |
|---|---|
| *mode* | is the HPKE mode |
| *suite* | is the ciphersuite to use |
| *pskid* | is the pskid string fpr a PSK mode (can be NULL) |
| *psklen* | is the psk length |
| *psk* | is the psk |
| *publen* | is the length of the recipient public key |
| *pub* | is the encoded recipient public key |
| *authprivlen* | is the length of the private (authentication) key |
| *authpriv* | is the encoded private (authentication) key |
| *authpriv_evp* | is the EVP_PKEY* form of private (authentication) key |
| *clearlen* | is the length of the cleartext |
| *clear* | is the encoded cleartext |
| *aadlen* | is the lenght of the additional data (can be zero) |
| *aad* | is the encoded additional data (can be NULL) |
| *infolen* | is the lenght of the info data (can be zero) |
| *info* | is the encoded info data (can be NULL) |
| *seqlen* | is the length of the sequence data (can be zero) |
| *seq* | is the encoded sequence data (can be NULL) |
| *senderpublen* | length of the input buffer for the sender's public key |
| *senderpub* | is the input buffer for ciphertext |
| *cipherlen* | length of the input buffer for ciphertext |
| *cipher* | is the input buffer for ciphertext |

**Returns**

1 for good (OpenSSL style), not 1 for error

#### 4.2.3.4 hpke_enc_evp()

```
int hpke_enc_evp (
            unsigned int mode,
            hpke_suite_t suite,
            char * pskid,
            size_t psklen,
            unsigned char * psk,
            size_t publen,
            unsigned char * pub,
            size_t authprivlen,
            unsigned char * authpriv,
            EVP_PKEY * authpriv_evp,
            size_t clearlen,
            unsigned char * clear,
            size_t aadlen,
            unsigned char * aad,
            size_t infolen,
            unsigned char * info,
            size_t seqlen,
            unsigned char * seq,
            size_t extsenderpublen,
            unsigned char * extsenderpub,
            EVP_PKEY * extsenderpriv,
            size_t * cipherlen,
            unsigned char * cipher )
```

Internal HPKE single-shot encryption function.

**Parameters**

| | |
|---|---|
| *mode* | is the HPKE mode |
| *suite* | is the ciphersuite to use |
| *pskid* | is the pskid string fpr a PSK mode (can be NULL) |
| *psklen* | is the psk length |
| *psk* | is the psk |
| *publen* | is the length of the recipient public key |
| *pub* | is the encoded recipient public key |
| *authprivlen* | is the length of the private (authentication) key |
| *authpriv* | is the encoded private (authentication) key |
| *authpriv_evp* | is the EVP_PKEY* form of private (authentication) key |
| *clearlen* | is the length of the cleartext |
| *clear* | is the encoded cleartext |
| *aadlen* | is the lenght of the additional data (can be zero) |
| *aad* | is the encoded additional data (can be NULL) |
| *infolen* | is the lenght of the info data (can be zero) |
| *info* | is the encoded info data (can be NULL) |
| *seqlen* | is the length of the sequence data (can be zero) |
| *seq* | is the encoded sequence data (can be NULL) |
| *senderpublen* | length of the input buffer with the sender's public key |
| *senderpub* | is the input buffer for sender public key |
| *senderpriv* | has the handle for the sender private key |
| *cipherlen* | length of the input buffer for ciphertext |
| *cipher* | is the input buffer for ciphertext |

**Returns**

1 for good (OpenSSL style), not 1 for error

### 4.2.3.5 hpke_expansion()

```
int hpke_expansion (
            hpke_suite_t suite,
            size_t clearlen,
            size_t * cipherlen )
```

tell the caller how big the cipertext will be

AEAD algorithms add a tag for data authentication. Those are almost always, but not always, 16 octets long, and who know what'll be true in the future. So this function allows a caller to find out how much data expansion they'll see with a given suite.

**Parameters**

| | |
|---|---|
| *suite* | is the suite to be used |
| *clearlen* | is the length of plaintext |
| *cipherlen* | points to what'll be ciphertext length |

**Returns**

1 for success, otherwise failure

### 4.2.3.6 hpke_good4grease()

```
int hpke_good4grease (
            hpke_suite_t * suite_in,
            hpke_suite_t suite,
            unsigned char * pub,
            size_t * pub_len,
            unsigned char * cipher,
            size_t cipher_len )
```

get a (possibly) random suite, public key and ciphertext for GREASErs

As usual buffers are caller allocated and lengths on input are buffer size.

**Parameters**

| | |
|---|---|
| *suite-in* | specifies the preferred suite or NULL for a random choice |
| *suite* | is the chosen or random suite |
| *pub* | a random value of the appropriate length for a sender public value |
| *pub_len* | is the length of pub (buffer size on input) |
| *cipher* | is a random value of the appropriate length for a ciphertext |
| *cipher_len* | is the length of cipher |

**Returns**

1 for success, otherwise failure

get a (possibly) random suite, public key and ciphertext for GREASErs

As usual buffers are caller allocated and lengths on input are buffer size.

**Parameters**

| | |
|---|---|
| *suite-in* | specifies the preferred suite or NULL for a random choice |
| *suite* | is the chosen or random suite |
| *pub* | a random value of the appropriate length for sender public value |
| *pub_len* | is the length of pub (buffer size on input) |
| *cipher* | buffer with random value of the appropriate length |
| *cipher_len* | is the length of cipher |

**Returns**

1 for success, otherwise failure

### 4.2.3.7 hpke_kg()

```
int hpke_kg (
            unsigned int mode,
            hpke_suite_t suite,
            size_t * publen,
            unsigned char * pub,
            size_t * privlen,
            unsigned char * priv )
```

generate a key pair

**Parameters**

| | |
|---|---|
| *mode* | is the mode (currently unused) |
| *suite* | is the ciphersuite (currently unused) |
| *publen* | is the size of the public key buffer (exact length on output) |
| *pub* | is the public value |
| *privlen* | is the size of the private key buffer (exact length on output) |
| *priv* | is the private key |

**Returns**

1 for good (OpenSSL style), not-1 for error

**Parameters**

| | |
|---|---|
| *mode* | is the mode (currently unused) |
| *suite* | is the ciphersuite |
| *publen* | is the size of the public key buffer (exact length on output) |
| *pub* | is the public value |
| *privlen* | is the size of the private key buffer (exact length on output) |
| *priv* | is the private key |

**Returns**

1 for good (OpenSSL style), not 1 for error

#### 4.2.3.8 hpke_kg_evp()

```
int hpke_kg_evp (
            unsigned int mode,
            hpke_suite_t suite,
            size_t * publen,
            unsigned char * pub,
            EVP_PKEY ** priv )
```

generate a key pair but keep private inside API

**Parameters**

| | |
|---|---|
| *mode* | is the mode (currently unused) |
| *suite* | is the ciphersuite (currently unused) |
| *publen* | is the size of the public key buffer (exact length on output) |
| *pub* | is the public value |
| *priv* | is the private key handle |

**Returns**

1 for good (OpenSSL style), not-1 for error

generate a key pair but keep private inside API

**Parameters**

| | |
|---|---|
| *mode* | is the mode (currently unused) |
| *suite* | is the ciphersuite |
| *publen* | is the size of the public key buffer (exact length on output) |
| *pub* | is the public value |
| *priv* | is the private key pointer |

**Returns**

1 for good (OpenSSL style), not 1 for error

#### 4.2.3.9 hpke_prbuf2evp()

```
int hpke_prbuf2evp (
            unsigned int kem_id,
            unsigned char * prbuf,
            size_t prbuf_len,
            unsigned char * pubuf,
            size_t pubuf_len,
            EVP_PKEY ** retpriv )
```

: map a kem_id and a private key buffer into an EVP_PKEY

**Parameters**

| | |
|---|---|
| *kem_id* | is what'd you'd expect (using the HPKE registry values) |
| *prbuf* | is the private key buffer |
| *prbuf_len* | is the length of that buffer |
| *pubuf* | is the public key buffer (if available) |
| *pubuf_len* | is the length of that buffer |
| *priv* | is a pointer to an EVP_PKEY ∗ for the result |

**Returns**

1 for success, otherwise failure

Note that the buffer is expected to be some form of the PEM encoded private key, but could still have the PEM header or not, and might or might not be base64 encoded. We'll try handle all those options.

Note that the buffer is expected to be some form of the PEM encoded private key, but could still have the PEM header or not, and might or might not be base64 encoded. We'll try handle all those options.

**Parameters**

| | |
|---|---|
| *kem_id* | is what'd you'd expect (using the HPKE registry values) |
| *prbuf* | is the private key buffer |
| *prbuf_len* | is the length of that buffer |
| *pubuf* | is the public key buffer (if available) |
| *pubuf_len* | is the length of that buffer |
| *priv* | is a pointer to an EVP_PKEY ∗ for the result |

**Returns**

1 for success, otherwise failure

#### 4.2.3.10 hpke_setlibctx()

```
int hpke_setlibctx (
             OSSL_LIB_CTX * libctx )
```

set a non-default OSSL_LIB_CTX if needed

**Parameters**

| | |
|---|---|
| *ctx* | is the context to set |

**Returns**

1 for success, otherwise failure

#### 4.2.3.11 hpke_str2suite()

```
int hpke_str2suite (
             char * suitestr,
             hpke_suite_t * suite )
```

map a string to a HPKE suite

**Parameters**

| | |
|---|---|
| *str* | is the string value |
| *suite* | is the resulting suite |

**Returns**

1 for success, otherwise failure

#### 4.2.3.12 hpke_suite_check()

```
int hpke_suite_check (
             hpke_suite_t suite )
```

check if a suite is supported locally

**Parameters**

| | |
|---|---|
| *suite* | is the suite to check |

**Returns**

1 for good/supported, not-1 otherwise

**Parameters**

| | |
|---|---|
| *suite* | is the suite to check |

**Returns**

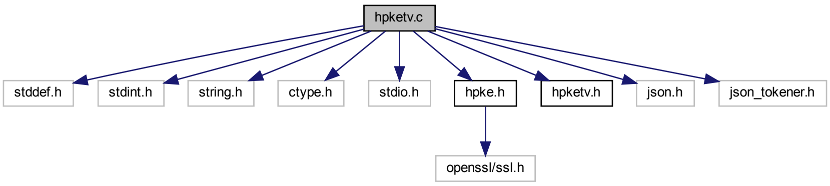
1 for good/supported, not 1 otherwise

## 4.3 hpketv.c File Reference

Implementation related to test vectors for HPKE.

```
#include <stddef.h>
#include <stdint.h>
#include <string.h>
#include <ctype.h>
#include <stdio.h>
#include "hpke.h"
#include "hpketv.h"
#include <json.h>
#include <json_tokener.h>
```

Include dependency graph for hpketv.c:



### Macros

- #define FAIL2BUILD(x) int x;
- #define HPKE_A2B(__c__)

  *Map ascii to binary - utility macro used in >1 place.*
- #define grabnum(_xx) if (!strcmp(key,""#_xx"")) { thearr[i]._xx=json_object_get_int(val); }

  *copy typed/named field from json-c to hpke_tv_t*
- #define grabstr(_xx) if (!strcmp(key,""#_xx"")) { thearr[i]._xx=json_object_get_string(val); }

  *copy typed/named field from json-c to hpke_tv_t*
- #define grabestr(_xx) if (!strcmp(key1,""#_xx"")) { encs[j]._xx=json_object_get_string(val1); }

  *copy typed/named field from json-c to hpke_tv_t*
- #define PRINTIT(_xx) printf("\t"#_xx": %s\n",a->_xx);

  *print the name of a field and the value of that field*

## Functions

- static char ∗ **u2c_transform** (const char ∗uncomp)
- int hpke_tv_load (char ∗fname, int ∗nelems, hpke_tv_t ∗∗array)

  *load test vectors from json file to array*
- void hpke_tv_free (int nelems, hpke_tv_t ∗array)

  *free up test vector array*
- void hpke_tv_print (int nelems, hpke_tv_t ∗array)

  *print test vectors*
- static int **hpke_tv_match** (unsigned int mode, hpke_suite_t suite, hpke_tv_t ∗a)
- int hpke_tv_pick (unsigned int mode, hpke_suite_t suite, int nelems, hpke_tv_t ∗arr, hpke_tv_t ∗∗tv)

  *select a test vector to use based on mode and suite*

## 4.3.1 Detailed Description

Implementation related to test vectors for HPKE.

This is compiled in if TESTVECTORS is #define'd, otherwise not.

The overall plan with test vectors is to:

- define data structures here to store the test vectors
- have global variables with the actual data
- have a #ifdef'd command line argument to generate/check a test vector
- have #ifdef'd additional parameters to _enc/_dec functions for doing generation/checking

Source for test vectors is: `https://raw.githubusercontent.com/cfrg/draft-irtf-cfrg-hpke/master/te` `json` The latest copy from that repo is also in this repo in test-vectors.json

## 4.3.2 Macro Definition Documentation

### 4.3.2.1 FAIL2BUILD

```
#define FAIL2BUILD(
              x ) int x;
```

Crap out if this isn't defined.

### 4.3.2.2 HPKE_A2B

```
#define HPKE_A2B(
              __c__ )
```

**Value:**

```
(__c__>='0'&&__c__<='9'?(__c__-'0'):\
(__c__>='A'&&__c__<='F'?(__c__-'A'+10):\
(__c__>='a'&&__c__<='f'?(__c__-'a'+10):0)))
```

Map ascii to binary - utility macro used in >1 place.

## 4.3.3 Function Documentation

### 4.3.3.1 hpke_tv_free()

```
void hpke_tv_free (
             int nelems,
             hpke_tv_t * array )
```

free up test vector array

**Parameters**

| | |
|---|---|
| *nelems* | is the number of array elements |
| *array* | is a guess what? |

Caller doesn't need to free "parent" array

### 4.3.3.2 hpke_tv_load()

```
int hpke_tv_load (
             char * fname,
             int * nelems,
             hpke_tv_t ** array )
```

load test vectors from json file to array

**Parameters**

| | |
|---|---|
| *fname* | is the json file |
| *nelems* | returns with the number of array elements |
| *array* | returns with the elements |

**Returns**

1 for good, other for bad

### 4.3.3.3 hpke_tv_pick()

```
int hpke_tv_pick (
             unsigned int mode,
             hpke_suite_t suite,
             int nelems,
             hpke_tv_t * arr,
             hpke_tv_t ** tv )
```

select a test vector to use based on mode and suite

**Parameters**

| | |
|---|---|
| *mode* | is the selected mode |
| *suite* | is the ciphersuite |
| *nelems* | is the number of array elements |
| *arr* | is the elements |
| *tv* | is the chosen test vector (doesn't need to be freed) |

**Returns**

1 for good, other for bad

This function will randomly pick a matching test vector that matches the specified criteria.

The string to use is like "0,1,1,2" specifying the mode and suite in the (sorta:-) obvious manner. < array of pointers to matching vectors

#### 4.3.3.4 hpke_tv_print()

```
void hpke_tv_print (
            int nelems,
            hpke_tv_t * array )
```

print test vectors

**Parameters**

| | |
|---|---|
| *nelems* | is the number of array elements |
| *array* | is the elements |

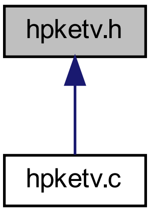
**Returns**

1 for good, other for bad

## 4.4 hpketv.h File Reference

Header file related to test vectors for HPKE.

This graph shows which files directly or indirectly include this file:



## Data Structures

- struct hpke_tv_encs_t

  *Encryption(s) Test Vector structure using field names from published JSON file.*
- struct hpke_tv_s

  *HKPE Test Vector structure using field names from published JSON file.*

## Typedefs

- typedef struct hpke_tv_s hpke_tv_t

  *HKPE Test Vector structure using field names from published JSON file.*

## Functions

- int hpke_tv_load (char *fname, int *nelems, hpke_tv_t **array)

  *load test vectors from json file to array*
- int hpke_tv_pick (unsigned int mode, hpke_suite_t suite, int nelems, hpke_tv_t *arr, hpke_tv_t **tv)

  *select a test vector to use based on mode and suite*
- void hpke_tv_free (int nelems, hpke_tv_t *array)

  *free up test vector array*
- void hpke_tv_print (int nelems, hpke_tv_t *array)

  *print test vectors*

### 4.4.1 Detailed Description

Header file related to test vectors for HPKE.

This is compiled in if TESTVECTORS is #define'd, otherwise not.

The overall plan with test vectors is to:

- define data structures here to store the test vectors
- have global variables with the actual data
- have a #ifdef'd command line argument to generate/check a test vector
- have #ifdef'd additional parameters to _enc/_dec functions for doing generation/checking

Source for test vectors is: `https://raw.githubusercontent.com/cfrg/draft-irtf-cfrg-hpke/master/te json` The latest copy from that repo is also in this repo in test-vectors.json

This should only be included if TESTVECTORS is #define'd.

## 4.4.2 Typedef Documentation

### 4.4.2.1 hpke_tv_t

```
typedef struct hpke_tv_s hpke_tv_t
```

HKPE Test Vector structure using field names from published JSON file.

The jobj field (at the end) is the json-c object from which all these are derived and into which most of the char ∗ pointers point. When we make an array of hpke_tv_s then the same jobj will be pointed at by all, so when it's time to call hpke_tv_free then we'll just free one of those using the json-c API.

## 4.4.3 Function Documentation

### 4.4.3.1 hpke_tv_free()

```
void hpke_tv_free (
             int nelems,
             hpke_tv_t ∗ array )
```

free up test vector array

**Parameters**

| | |
|---|---|
| *nelems* | is the number of array elements |
| *array* | is a guess what? |

Caller doesn't need to free "parent" array

### 4.4.3.2 hpke_tv_load()

```
int hpke_tv_load (
             char ∗ fname,
             int ∗ nelems,
             hpke_tv_t ∗∗ array )
```

load test vectors from json file to array

**Parameters**

| | |
|---|---|
| *fname* | is the json file |
| *nelems* | returns with the number of array elements |
| *array* | returns with the elements |

**Returns**

1 for good, other for bad

### 4.4.3.3 hpke_tv_pick()

```
int hpke_tv_pick (
            unsigned int mode,
            hpke_suite_t suite,
            int nelems,
            hpke_tv_t * arr,
            hpke_tv_t ** tv )
```

select a test vector to use based on mode and suite

**Parameters**

| | |
|---|---|
| *mode* | is the selected mode |
| *suite* | is the ciphersuite |
| *nelems* | is the number of array elements |
| *arr* | is the elements |
| *tv* | is the chosen test vector (doesn't need to be freed) |

**Returns**

1 for good, other for bad

This function will randomly pick a matching test vector that matches the specified criteria.

The string to use is like "0,1,1,2" specifying the mode and suite in the (sorta:-) obvious manner. < array of pointers to matching vectors

### 4.4.3.4 hpke_tv_print()

```
void hpke_tv_print (
            int nelems,
            hpke_tv_t * array )
```

print test vectors

**Parameters**

| | |
|---|---|
| *nelems* | is the number of array elements |
| *array* | is the elements |

**Returns**

1 for good, other for bad

# Index