

Happy Key: HPKE implementation (draft-irtf-cfrg-hpke)

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Chapter 1

Data Structure Index

1.1 Data Structures

Here are the data structures with brief descriptions:

hpke_aead_info_t	Info about an AEAD	5
hpke_kdf_info_t	Info about a KDF	5
hpke_kem_info_t	Info about a KEM	6
hpke_suite_t	Ciphersuite combination	6
hpke_tv_encs_t	Encryption(s) Test Vector structure using field names from published JSON file	7
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Chapter 2

File Index

2.1 File List

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

hpke.c	An OpenSSL-based HPKE implementation following draft-irtf-cfrg-hpke	11
hpke.h	This has the data structures and prototypes (both internal and external) for an OpenSSL-based HPKE implementation following draft-irtf-cfrg-hpke	24
hpketv.c	Implementation related to test vectors for HPKE	30
hpketv.h	Header file related to test vectors for HPKE	33

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
- 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
- int [groupid](#)
NID of KEM.
- size_t [Nenc](#)
length of encapsulated key
- size_t [Npk](#)
length of public 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](#)
Authenticated Encryption with Associated Data 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 * [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:

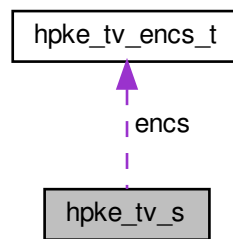
- [hpketv.h](#)

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 **kdfID**
- uint16_t **aeadID**
- uint16_t **kemID**
- const char * **context**
- const char * **skI**
- const char * **pkI**
- const char * **zz**
- const char * **secret**
- const char * **enc**
- const char * **info**
- const char * **pskID**
- const char * **nonce**
- const char * **key**
- const char * **pkR**
- const char * **pkE**
- const char * **skR**
- const char * **skE**
- 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 following draft-irtf-cfrg-hpke.

```
#include <stddef.h>
#include <stdint.h>
#include <string.h>
#include <ctype.h>
#include <openssl/ssl.h>
#include <openssl/rand.h>
#include <openssl/kdf.h>
#include <openssl/evp.h>
#include <openssl/params.h>
#include "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 [CHECK_HPKE_CTX](#) if ((cp->context)>*contextlen) { erv=__LINE__; goto err; }
make it easier to do repetitive code
- #define [ISAUTHMODE](#)(xxmode) (xxmode==[HPKE_MODE_AUTH](#) || xxmode==[HPKE_MODE_PSKAUTH](#))
- #define [ISPSKMODE](#)(xxmode) (xxmode==[HPKE_MODE_PSK](#) || xxmode==[HPKE_MODE_PSKAUTH](#))

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_pbuf](#) (FILE *fout, char *msg, unsigned char *buf, size_t blen)
for odd/occasional debugging
- static int [hpke_suite_check](#) (hpke_suite_t suite)
Check if ciphersuite is ok/known to us.
- static size_t [figure_contextlen](#) (hpke_suite_t suite)
return the length of the context for this suite
- 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](#) (hpke_suite_t suite, const unsigned char *salt, const size_t saltlen, const unsigned char *zz, const size_t zzlen, unsigned char **secret, const size_t secretlen)
- static int [hpke_expand](#) (hpke_suite_t suite, unsigned char *secret, size_t secretlen, char *label, unsigned char *context, size_t contextlen, unsigned char **out, size_t outlen)
- static int [hpke_do_kem](#) (EVP_PKEY *key1, EVP_PKEY *key2, unsigned char **zz, size_t *zzlen)
run the KEM with two keys
- static int [hpke_make_context](#) (int mode, hpke_suite_t suite, const unsigned char *enc, const size_t encenclen, const unsigned char *pub, const size_t publen, const unsigned char *pk1_hash, const size_t pk1_hashlen, const char *pskid, const unsigned char *info, const size_t infolen, unsigned char **context, size_t *contextlen)
Create context for input to extract/expand.
- 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 EVP_PKEY * [hpke_EVP_PKEY_new_raw_nist_private_key](#) (int curve, unsigned char *buf, size_t buflen)
hpke wrapper to import NIST curve private key as easily as x25519/x448
- 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 privlen, unsigned char *priv, size_t clearlen, unsigned char *clear, size_t aadlen, unsigned char *aad, size_t infolen, unsigned char *info, size_t *senderpublen, unsigned char *senderpub, size_t *cipherlen, unsigned char *cipher)
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, size_t encenclen, unsigned char *enc, size_t cipherlen, unsigned char *cipher, size_t aadlen, unsigned char *aad, size_t infolen, unsigned char *info, 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

Variables

- `hpke_aead_info_t hpke_aead_tab []`
table of AEADs
- `hpke_kem_info_t hpke_kem_tab []`
table of KEMs
- `hpke_kdf_info_t hpke_kdf_tab []`
table of KDFs
- static const unsigned char `zero_buf` [SHA512_DIGEST_LENGTH]
handy thing to have :-)

4.1.1 Detailed Description

An OpenSSL-based HPKE implementation following draft-irtf-cfrg-hpke.

I plan to use this for my ESNI-enabled OpenSSL build (<https://github.com/sftcd/openssl>) when the time is right.

4.1.2 Function Documentation

4.1.2.1 figure_contextlen()

```
static size_t figure_contextlen (
    hpke_suite_t suite ) [static]
```

return the length of the context for this suite

Parameters

<i>suite</i>	is the ciphersuite to use
--------------	---------------------------

Returns

the length (in octets) of the context

4.1.2.2 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

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

Returns

1 for good otherwise bad

4.1.2.3 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

<i>suite</i>	is the ciphersuite
<i>key</i>	is the secret
<i>keylen</i>	is the length of the secret
<i>iv</i>	is the initialisation vector

Parameters

<i>ivlen</i>	is the length of the iv
<i>aad</i>	is the additional authenticated data
<i>aadlen</i>	is the length of the aad
<i>plain</i>	is an output
<i>plainlen</i>	is the length of plain
<i>cipher</i>	is an output
<i>cipherlen</i>	is an input/output, better be big enough on input, exact on output

Returns

1 for good otherwise bad

4.1.2.4 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

Bash command line hashing starting from ascii hex example:

```
$ echo -e "4f6465206f6e2061204772656369616e2055726e" | xxd -r -p | openssl sha256 (stdin)= 55c4040629c64c5efec2f7230407d6
```

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)= e3b0c44298fc1c149afb4c8996fb92427ae41e4649b934ca495991b7852b855` Or if you'd like to re-calculate 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

<i>ahlen</i>	is the ascii hex string length
<i>ah</i>	is the ascii hex string
<i>blen</i>	is a pointer to the returned binary length
<i>buf</i>	is a pointer to the internally allocated binary buffer

Returns

1 for good otherwise bad

4.1.2.5 hpke_dec()

```
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,
    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 * clearlen,
    unsigned char * clear )
```

HPKE single-shot decryption function.

Parameters

<i>mode</i>	is the HPKE mode
<i>suite</i>	is the ciphersuite
<i>pskid</i>	is the pskid string for a PSK mode (can be NULL)
<i>psklen</i>	is the psk length
<i>psk</i>	is the psk
<i>publen</i>	is the length of the public (authentication) key
<i>pub</i>	is the encoded public (authentication) key
<i>privlen</i>	is the length of the private key
<i>priv</i>	is the encoded private key
<i>enclen</i>	is the length of the peer's public value
<i>enc</i>	is the peer's public value
<i>cipherlen</i>	is the length of the ciphertext
<i>cipher</i>	is the ciphertext
<i>aadlen</i>	is the length of the additional data
<i>aad</i>	is the encoded additional data
<i>infolen</i>	is the length of the info data (can be zero)
<i>info</i>	is the encoded info data (can be NULL)
<i>clearlen</i>	is the length of the input buffer for cleartext (octets used on output)
<i>clear</i>	is the encoded cleartext

Returns

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

4.1.2.6 hpke_do_kem()

```
static int hpke_do_kem (
    EVP_PKEY * key1,
    EVP_PKEY * key2,
    unsigned char ** zz,
    size_t * zzlen ) [static]
```

run the KEM with two keys

Parameters

<i>key1</i>	is the first key, for which we have the private value
<i>key2</i>	is the peer's key
<i>zz</i>	is (a pointer to) the buffer for the result
<i>zzlen</i>	is the size of the buffer (octets-used on exit)

Returns

1 for good, not-1 for not good

4.1.2.7 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 privlen,
    unsigned char * priv,
    size_t clearlen,
    unsigned char * clear,
    size_t aadlen,
    unsigned char * aad,
    size_t infolen,
    unsigned char * info,
    size_t * senderpublen,
    unsigned char * senderpub,
    size_t * cipherlen,
    unsigned char * cipher )
```

HPKE single-shot encryption function.

Parameters

<i>mode</i>	is the HPKE mode
<i>suite</i>	is the ciphersuite to use
<i>pskid</i>	is the pskid string fpr a PSK mode (can be NULL)

Parameters

<i>psklen</i>	is the psk length
<i>psk</i>	is the psk
<i>publen</i>	is the length of the recipient public key
<i>pub</i>	is the encoded recipient public key
<i>privlen</i>	is the length of the private (authentication) key
<i>priv</i>	is the encoded private (authentication) key
<i>clearlen</i>	is the length of the cleartext
<i>clear</i>	is the encoded cleartext
<i>aadlen</i>	is the lenght of the additional data (can be zero)
<i>aad</i>	is the encoded additional data (can be NULL)
<i>info</i>	is the lenght of the info data (can be zero)
<i>info</i>	is the encoded info data (can be NULL)
<i>senderpublen</i>	is the length of the input buffer for the sender's public key (length used on output)
<i>senderpub</i>	is the input buffer for ciphertext
<i>cipherlen</i>	is the length of the input buffer for ciphertext (length used on output)
<i>cipher</i>	is the input buffer for ciphertext

Returns

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

4.1.2.8 hpke_EVP_PKEY_new_raw_nist_private_key()

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

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

Parameters

<i>curve</i>	is the curve NID
<i>buf</i>	is the binary buffer with the private value
<i>buflen</i>	is the length of the private key buffer

Returns

a working EVP_PKEY * or NULL

Loads a malarkey required as it turns out You gotta: 1) name group 2) import private 3) then manually re-calc public key before 4) make an EVP_PKEY

4.1.2.9 hpke_expand()

```
static int hpke_expand (
    hpke_suite_t suite,
    unsigned char * secret,
    size_t secretlen,
    char * label,
    unsigned char * context,
    size_t contextlen,
    unsigned char ** out,
    size_t outlen ) [static]
```

brief RFC5869 HKDF-Expand

Parameters

<i>suite</i>	is the ciphersuite
<i>secret</i>	- the initial key material (IKM)
<i>secretlen</i>	- length of above
<i>label</i>	- label to prepend to info
<i>context</i>	- the info
<i>contextlen</i>	- length of above
<i>out</i>	- the result of expansion (allocated inside)
<i>outlen</i>	- an input only!

Returns

1 for good otherwise bad

4.1.2.10 hpke_extract()

```
static int hpke_extract (
    hpke_suite_t suite,
    const unsigned char * salt,
    const size_t saltlen,
    const unsigned char * zz,
    const size_t zzlen,
    unsigned char ** secret,
    const size_t secretlen ) [static]
```

brief RFC5869 HKDF-Extract

Parameters

<i>suite</i>	is the ciphersuite
<i>salt</i>	- surprisingly this is the salt;-)
<i>saltlen</i>	- length of above
<i>zz</i>	- the initial key material (IKM)
<i>zzlen</i>	- length of above
<i>secret</i>	- the result of extraction (allocated inside)
<i>secretlen</i>	- an input only!

Returns

1 for good otherwise bad

4.1.2.11 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

<i>mode</i>	is the mode (currently unused)
<i>suite</i>	is the ciphersuite (currently unused)
<i>publen</i>	is the size of the public key buffer (exact length on output)
<i>pub</i>	is the public value
<i>privlen</i>	is the size of the private key buffer (exact length on output)
<i>priv</i>	is the private key

Returns

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

4.1.2.12 hpke_make_context()

```
static int hpke_make_context (
    int mode,
    hpke_suite_t suite,
    const unsigned char * enc,
    const size_t enclen,
    const unsigned char * pub,
    const size_t publen,
    const unsigned char * pkI_hash,
    const size_t pkI_hashlen,
    const char * pskid,
    const unsigned char * info,
    const size_t infolen,
    unsigned char ** context,
    size_t * contextlen ) [static]
```

Create context for input to extract/expand.

Parameters

<i>mode</i>	is the HPKE mode
<i>suite</i>	is the ciphersuite to use
<i>enc</i>	is the sender public key
<i>enclen</i>	is the length of the sender public key
<i>pub</i>	is the encoded recipient public key
<i>publen</i>	is the length of the recipient public key
<i>pkl_hash</i>	is the hash of the sender's authentication key (or NULL)
<i>pkl_hashlen</i>	is the length of the pkl_hash
<i>pskid</i>	is a PSK ID string (can be NULL)
<i>info</i>	is buffer of info to bind
<i>infoLen</i>	is the length of the buffer of info
<i>context</i>	is a buffer for the resulting context
<i>contextlen</i>	is the size of the buffer and octets-used on exit

Returns

1 for good, not 1 otherwise

4.1.2.13 hpke_mode_check()

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

check mode is in-range and supported

Parameters

<i>mode</i>	is the caller's chosen mode
-------------	-----------------------------

Returns

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

4.1.2.14 hpke_pbuf()

```
static int hpke_pbuf (
    FILE * fout,
    char * msg,
    unsigned char * buf,
    size_t blen ) [static]
```

for odd/occasional debugging

Parameters

<i>fout</i>	is a FILE * to use
<i>msg</i>	is prepended to print
<i>buf</i>	is the buffer to print
<i>blen</i>	is the length of the buffer

Returns

1 for success

4.1.2.15 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

<i>mode</i>	is the mode in use
<i>pskid</i>	PSK identifier
<i>psklen</i>	length of PSK
<i>psk</i>	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.

4.1.2.16 hpke_suite_check()

```
static int hpke_suite_check (
    hpke_suite_t suite ) [static]
```

Check if ciphersuite is ok/known to us.

Parameters

<i>suite</i>	is the externally supplied cipheruite
--------------	---------------------------------------

Returns

1 for good, not-1 for error

For now, we only recognise HPKE_SUITE_DEFAULT

4.1.3 Variable Documentation**4.1.3.1 hpke_aead_tab**

```
hpke_aead_info_t hpke_aead_tab[]
```

Initial value:

```
={
    { 0, NULL, 0, 0, 0 },
    { HPKE_AEAD_ID_AES_GCM_128, EVP_aes_128_gcm, 16, 16, 12 },
    { HPKE_AEAD_ID_AES_GCM_256, EVP_aes_256_gcm, 16, 32, 12 },
    { HPKE_AEAD_ID_CHACHA_POLY1305, EVP_chacha20_poly1305, 16, 32, 12 }
}
```

table of AEADs

4.1.3.2 hpke_kdf_tab

```
hpke_kdf_info_t hpke_kdf_tab[]
```

Initial value:

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

table of KDFs

4.1.3.3 hpke_kem_tab

```
hpke_kem_info_t hpke_kem_tab[]
```

Initial value:

```
={
    { 0, 0, 0, 0 },
    { HPKE_KEM_ID_P256, NID_X9_62_prime256v1, 65, 65 },
    { HPKE_KEM_ID_25519, EVP_PKEY_X25519, 32, 32 },
    { HPKE_KEM_ID_P521, NID_secp521r1, 133, 133 },
    { HPKE_KEM_ID_448, EVP_PKEY_X448, 56, 56 }
}
```

table of KEMs

4.1.3.4 zero_buf

```
const unsigned char zero_buf[SHA512_DIGEST_LENGTH] [static]
```

Initial value:

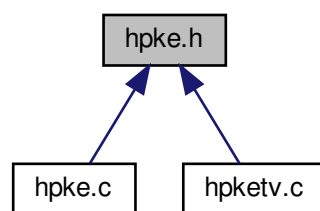
```
= {
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00 }
```

handy thing to have :-)

4.2 hpke.h File Reference

This has the data structures and prototypes (both internal and external) for an OpenSSL-based HPKE implementation following draft-irtf-cfrg-hpke.

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



Data Structures

- struct [hpke_suite_t](#)
ciphersuite combination

Macros

- #define **HPKE_MAXSIZE** (640*1024)
640k is more than enough for anyone (using this program:-)
- #define **HPKE_MODE_BASE** 0
Base mode (all that we support for now)
- #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** 0x0001
NIST P-256.
- #define **HPKE_KEM_ID_25519** 0x0002
Curve25519.
- #define **HPKE_KEM_ID_P521** 0x0003
NIST P-521.
- #define **HPKE_KEM_ID_448** 0x0004
Curve448.
- #define **HPKE_KEM_ID_MAX** 0x0004
Curve448.
- #define **HPKE_KDF_ID_RESERVED** 0x0000
not used
- #define **HPKE_KDF_ID_HKDF_SHA256** 0x0001
HKDF-SHA256.
- #define **HPKE_KDF_ID_HKDF_SHA512** 0x0002
HKDF-SHA512.
- #define **HPKE_KDF_ID_MAX** 0x0002
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_SUITE_DEFAULT** { **HPKE_KEM_ID_25519**, **HPKE_KDF_ID_HKDF_SHA256**, **HPKE_AEAD_ID_AES_GCM_128** }
- #define **HPKE_SUITE_TURNITUPTO11** { **HPKE_KEM_ID_448**, **HPKE_KDF_ID_HKDF_SHA512**, **HPKE_AEAD_ID_CHACHA_POLY1305** }
- #define **HPKE_A2B**(__c__)
Map ascii to binary - utility macro used in > 1 place.

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 privlen, unsigned char *priv, size_t clearlen, unsigned char *clear, size_t aadlen, unsigned char *aad, size_t infolen, unsigned char *info, size_t *senderpublen, unsigned char *senderpub, size_t *cipherlen, unsigned char *cipher)
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, 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 *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_ah_decode](#) (size_t ahlen, const char *ah, size_t *blen, unsigned char **buf)
decode ascii hex to a binary buffer

4.2.1 Detailed Description

This has the data structures and prototypes (both internal and external) for an OpenSSL-based HPKE implementation following draft-irtf-cfrg-hpke.

I plan to use this for my ESNI-enabled OpenSSL build when the time is right, that's: <https://github.com/sftcd/openssl>

4.2.2 Macro Definition Documentation

4.2.2.1 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.

4.2.2.2 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

<i>ahlen</i>	is the ascii hex string length
<i>ah</i>	is the ascii hex string
<i>blen</i>	is a pointer to the returned binary length
<i>buf</i>	is a pointer to the internally allocated binary buffer

Returns

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

Bash command line hashing starting from ascii hex example:

```
$ echo -e "4f6465206f6e2061204772656369616e2055726e" | xxd -r -p | openssl sha256 (stdin)= 55c4040629c64c5efec2f7230407d6
```

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-calculate 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

<i>ahlen</i>	is the ascii hex string length
<i>ah</i>	is the ascii hex string
<i>blen</i>	is a pointer to the returned binary length
<i>buf</i>	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 publen,
    unsigned char * pub,
    size_t privlen,
    unsigned char * priv,
    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 * clearlen,
    unsigned char * clear )
```

HPKE single-shot decryption function.

Parameters

<i>mode</i>	is the HPKE mode
<i>suite</i>	is the ciphersuite
<i>pskid</i>	is the pskid string for a PSK mode (can be NULL)
<i>psklen</i>	is the psk length
<i>psk</i>	is the psk
<i>publen</i>	is the length of the public (authentication) key
<i>pub</i>	is the encoded public (authentication) key
<i>privlen</i>	is the length of the private key
<i>priv</i>	is the encoded private key
<i>enclen</i>	is the length of the peer's public value
<i>enc</i>	is the peer's public value
<i>cipherlen</i>	is the length of the ciphertext
<i>cipher</i>	is the ciphertext
<i>aadlen</i>	is the length of the additional data
<i>aad</i>	is the encoded additional data
<i>infolen</i>	is the length of the info data (can be zero)
<i>info</i>	is the encoded info data (can be NULL)
<i>clearlen</i>	is the length of the input buffer for cleartext (octets used on output)
<i>clear</i>	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 privlen,
    unsigned char * priv,
    size_t clearlen,
    unsigned char * clear,
    size_t aadlen,
    unsigned char * aad,
    size_t infolen,
    unsigned char * info,
    size_t * senderpublen,
    unsigned char * senderpub,
    size_t * cipherlen,
    unsigned char * cipher )
```

HPKE single-shot encryption function.

Parameters

<i>mode</i>	is the HPKE mode
<i>suite</i>	is the ciphersuite to use
<i>pskid</i>	is the pskid string fpr a PSK mode (can be NULL)
<i>psklen</i>	is the psk length
<i>psk</i>	is the psk
<i>publen</i>	is the length of the recipient public key
<i>pub</i>	is the encoded recipient public key
<i>privlen</i>	is the length of the private (authentication) key
<i>priv</i>	is the encoded private (authentication) key
<i>clearlen</i>	is the length of the cleartext
<i>clear</i>	is the encoded cleartext
<i>aadlen</i>	is the lenght of the additional data (can be zero)
<i>aad</i>	is the encoded additional data (can be NULL)
<i>infolen</i>	is the lenght of the info data (can be zero)
<i>info</i>	is the encoded info data (can be NULL)
<i>senderpublen</i>	is the length of the input buffer for the sender's public key (length used on output)
<i>senderpub</i>	is the input buffer for ciphertext
<i>cipherlen</i>	is the length of the input buffer for ciphertext (length used on output)
<i>cipher</i>	is the input buffer for ciphertext

Returns

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

4.2.3.4 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

<i>mode</i>	is the mode (currently unused)
<i>suite</i>	is the ciphersuite (currently unused)
<i>publen</i>	is the size of the public key buffer (exact length on output)
<i>pub</i>	is the public value
<i>privlen</i>	is the size of the private key buffer (exact length on output)
<i>priv</i>	is the private key

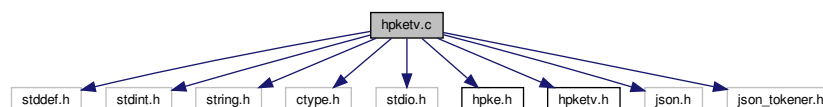
Returns

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

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_tokenener.h>
Include dependency graph for hpketv.c:
```



Macros

- `#define FAIL2BUILD(x) int x;`
- `#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/test_vectors.json A copy from 20191126 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.

4.3.3 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

<i>nelems</i>	is the number of array elements
<i>array</i>	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

<i>fname</i>	is the json file
<i>nelems</i>	returns with the number of array elements
<i>array</i>	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

<i>mode</i>	is the selected mode
<i>suite</i>	is the ciphersuite
<i>nelems</i>	is the number of array elements
<i>arr</i>	is the elements
<i>tv</i>	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

<i>nelems</i>	is the number of array elements
<i>array</i>	is the elements

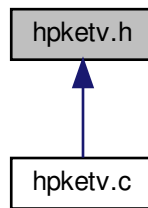
Returns

1 for good, other for bad

4.4 hpke_tv.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/test_vectors.json A copy from 20191126 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

<i>nelems</i>	is the number of array elements
<i>array</i>	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

<i>fname</i>	is the json file
<i>nelems</i>	returns with the number of array elements
<i>array</i>	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

<i>mode</i>	is the selected mode
<i>suite</i>	is the ciphersuite
<i>nelems</i>	is the number of array elements
<i>arr</i>	is the elements
<i>tv</i>	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

<i>nelems</i>	is the number of array elements
<i>array</i>	is the elements

Returns

1 for good, other for bad

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