EVP_SKEY: symmetric keys beyond raw bytes

Opaque symmetric keys in OpenSSL

OpenAlt conference
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Dmitry Belyavskiy, Principal Software Engineer, Red Hat

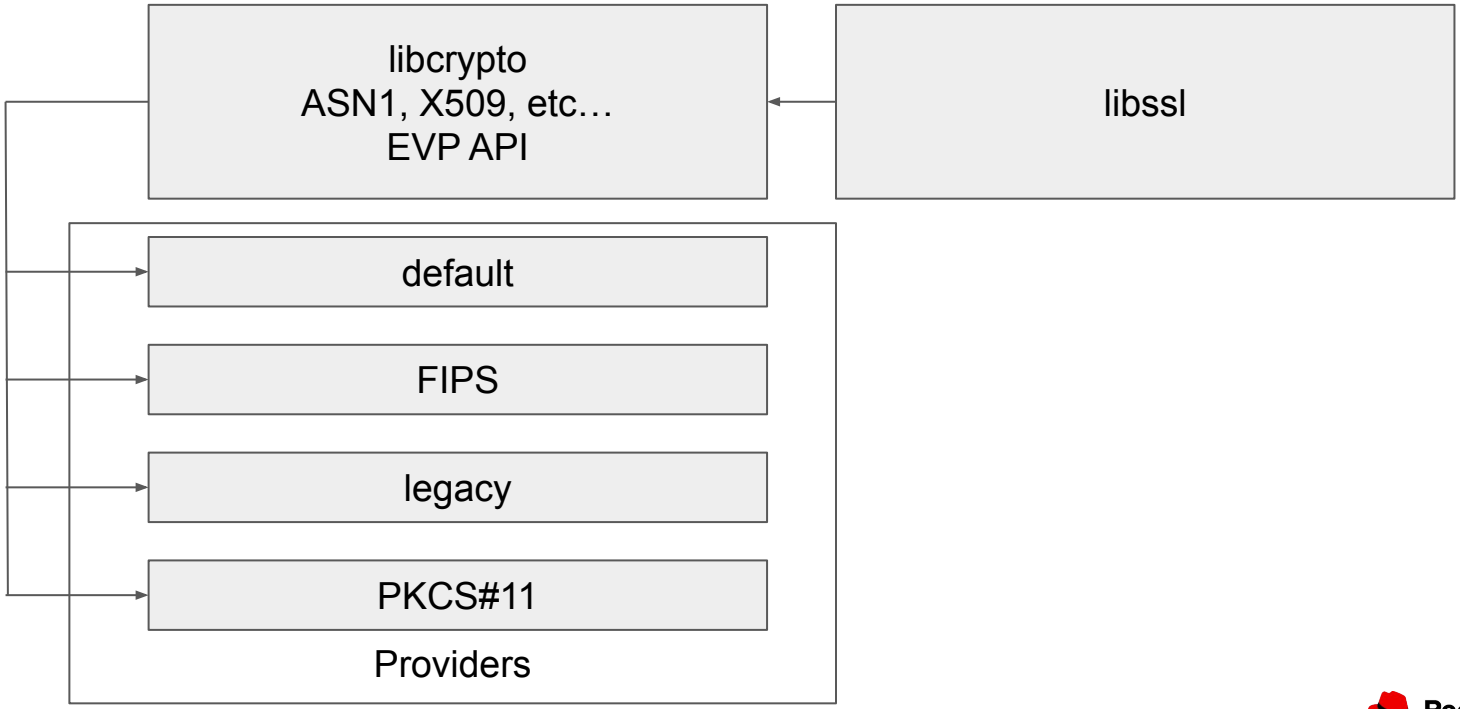
Red Hat

Who am I

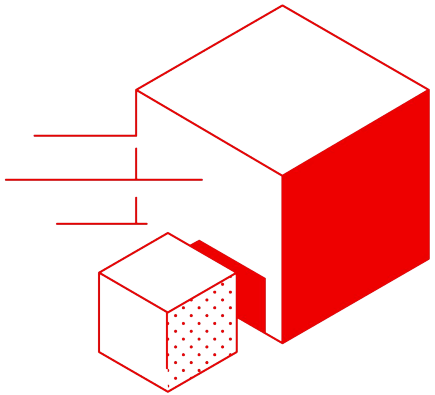
Dmitry Belyavskiy
Red Hat Principal Software Engineer
Maintain: OpenSSL, OpenSSH
Current work: Post-Quantum transition in Red Hat

OpenSSL experience
Hacking since 2004
OpenSSL Technical Committee member since 2021
OpenSSL TACs/BAC member

OpenSSL library architecture



Asymmetric and symmetric cryptography



Asymmetric crypto

Digital signature, key exchange, key encapsulation

ML-DSA, RSA, ECDSA, (EC)DH, ML-KEM...

Keys: structures/opaque pointers

EVP_PKEY API

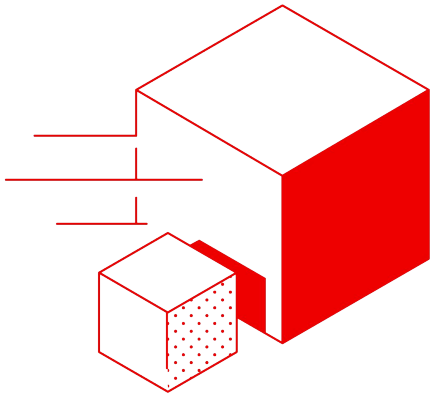
Symmetric crypto

Symmetric ciphers, MAC, etc

AES, ChaCha20, HMAC, CMAC...

Keys: raw byte arrays

Opaque symmetric keys – rationale



Hardware backed keys

PKCS#11, HSM, processor enclaves

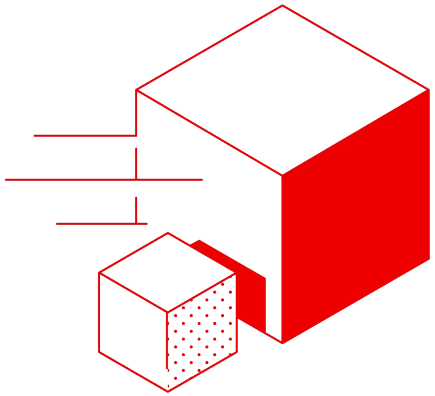
PKCS#11 provider

https://github.com/latchset/pkcs11-provider

Obfuscation/security

Key masking

Already implemented



Pre-3.5

Doable for EVP_CIPHER

Implementation-specific

OpenSSL 3.5

Support for symmetric ciphers and MACs

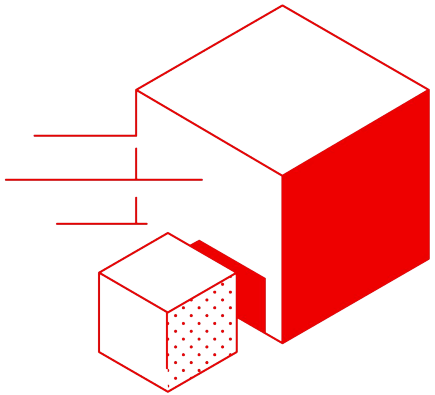
PR #26753, PR #26832

OpenSSL 3.6

EVP_SKEY derivation from KDFs and key exchange

PR #28369, PR #28486

Introducing EVP_SKEY structure

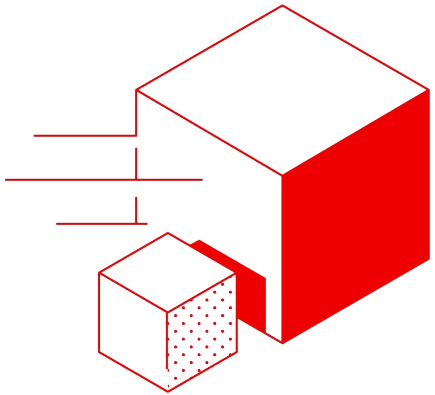


EVP_SKEY structure

```
struct evp_skey_st {
   /* == Common attributes == */
   CRYPTO_REF_COUNT references;
   CRYPTO_RWLOCK *lock;

   void *keydata; /* Alg-specific key data */
   EVP_SKEYMGMT *skeymgmt; /* Import, export, manage */
}; /* EVP_SKEY */
```

EVP_SKEY API



Man EVP_SKEY

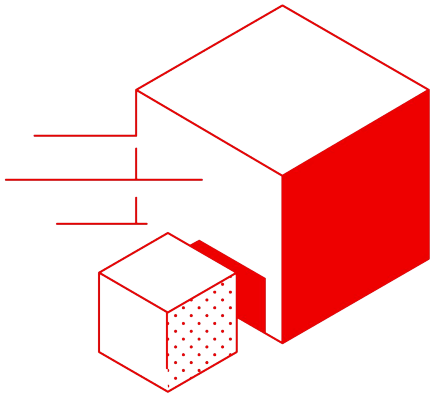
EVP_SKEY ***EVP_SKEY_generate**

EVP_SKEY *
EVP_SKEY_import, EVP_SKEY_import_raw_key,
EVP_SKEY_import_SKEYMGMT

EVP_SKEY ***EVP_SKEY_to_provider**

int **EVP_SKEY_export**
int **EVP_SKEY_get0_raw_key**

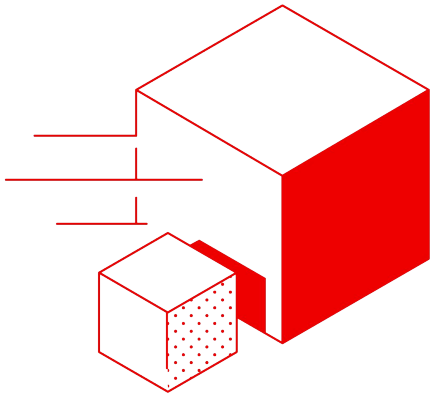
Introducing EVP_SKEYMGMT - I



EVP_SKEYMGMT structure

```
struct evp_skeymgmt_st {
    int name_id;
    char *type_name;
    const char *description;
    OSSL_PROVIDER *prov;
    CRYPTO_REF_COUNT refcnt;
...
     /* destructor */
    OSSL_FUNC_skeymgmt_free_fn *free;
} /* EVP_SKEYMGMT */;
```

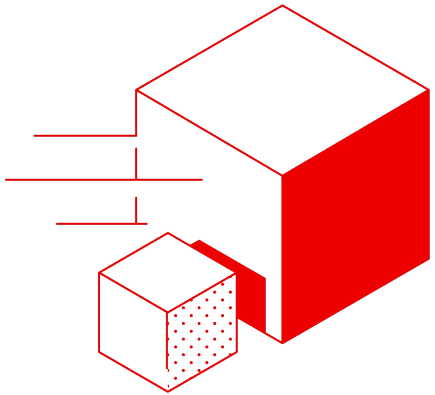
Introducing EVP_SKEYMGMT - II



EVP_SKEYMGMT structure

```
/* Import and export routines */
OSSL_FUNC_skeymgmt_imp_settable_params_fn *imp_params;
OSSL_FUNC_skeymgmt_import_fn *import;
OSSL_FUNC_skeymgmt_export_fn *export;
/* Key generation */
OSSL_FUNC_skeymgmt_gen_settable_params_fn *gen_params;
OSSL_FUNC_skeymgmt_generate_fn *generate;
/* Key identifier */
OSSL_FUNC_skeymgmt_get_key_id_fn *get_key_id;
```

EVP_SKEYMGMT API



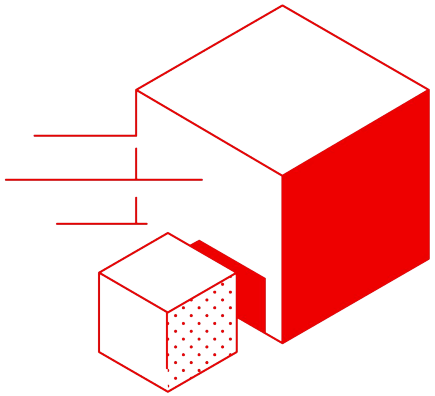
Man EVP_SKEYMGMT

EVP_SKEYMGMT_fetch, EVP_SKEYMGMT_up_ref,
EVP_SKEYMGMT_free

EVP_SKEYMGMT_get0_provider, EVP_SKEYMGMT_is_a,
EVP_SKEYMGMT_get0_name, EVP_SKEYMGMT_get0_description

EVP_SKEYMGMT_get0_gen_settable_params,
EVP_SKEYMGMT_get0_imp_settable_params

EVP_SKEYMGMT implementation guidelines



Some sort of “inheritance”

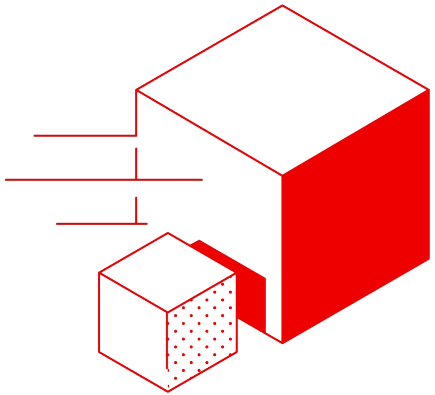
One parameterized EVP_SKEYMGMT (PKCS#11 provider)
GENERIC + AES (OpenSSL providers)
Support of raw bytes format for import

Export support

int EVP_SKEY_export(const EVP_SKEY *skey, int selection,
OSSL_CALLBACK *export_cb, void *export_cbarg)

define OSSL_SKEYMGMT_SELECT_PARAMETERS 0x01
define OSSL_SKEYMGMT_SELECT_SECRET_KEY 0x02

EVP_CIPHER an EVP_MAC API changes



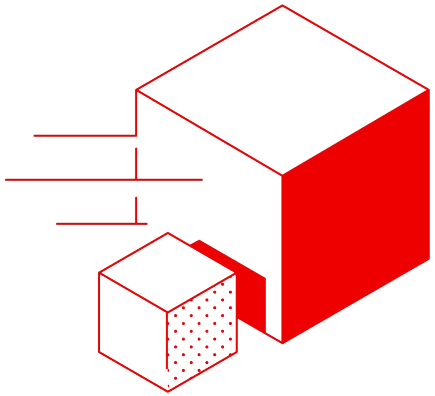
EVP_CIPHER API

int **EVP_CipherInit_SKEY**(EVP_CIPHER_CTX *ctx, const EVP_CIPHER *cipher, EVP_SKEY *skey, const unsigned char *iv, size_t iv_len, int enc, const OSSL_PARAM params[]);

EVP_MAC API

int **EVP_MAC_init_SKEY**(EVP_MAC_CTX *ctx, EVP_SKEY *skey, const OSSL_PARAM params[]);

EVP_CIPHER an EVP_MAC new callbacks



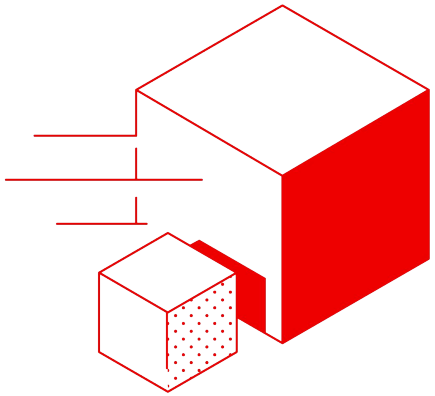
EVP_CIPHER callbacks

int **OSSL_FUNC_cipher_encrypt_skey_init**(void *cctx, void *skeydata, const unsigned char *iv, size_t ivlen, const OSSL_PARAM params[]);
... and the same for decrypt

EVP_MAC callbacks

int **OSSL_FUNC_mac_init_skey**(void *mctx, const void *key, const OSSL_PARAM params[]);

EVP_KDF an EVP_KEYEXCH API changes



EVP_KDF API

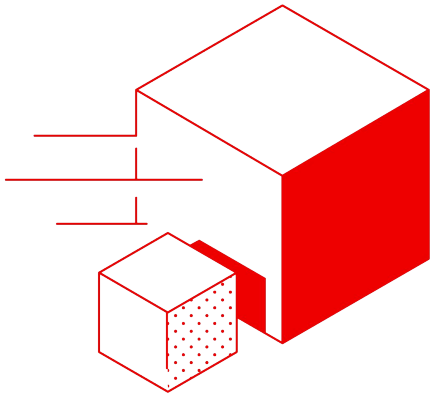
int **EVP_KDF_CTX_set_SKEY**(EVP_KDF_CTX *ctx, EVP_SKEY *key, const char *paramname);

EVP_SKEY ***EVP_KDF_derive_SKEY**(EVP_KDF_CTX *ctx, EVP_SKEYMGMT *mgmt, const char *key_type, const char *propquery, size_t keylen, const OSSL_PARAM params[]);

EVP_KEYEXCH API

EVP_SKEY ***EVP_PKEY_derive_SKEY**(EVP_PKEY_CTX *ctx, EVP_SKEYMGMT *mgmt, const char *key_type, const char *propquery, size_t keylen, const OSSL_PARAM params[]);

EVP_KDF an EVP_KEYEXCH API new callbacks



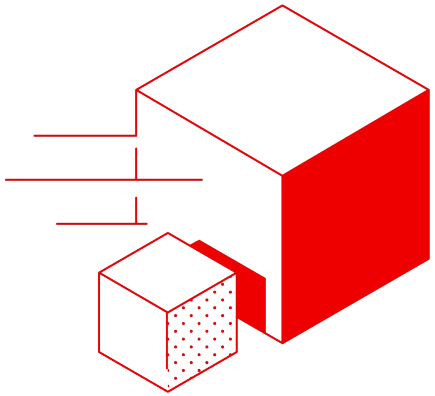
EVP_KDF API

int **OSSL_FUNC_kdf_set_skey**(void *kctx, void *skeydata, const char *paramname);
void ***OSSL_FUNC_kdf_derive_skey**(void *ctx, const char *key_type, void *provctx, OSSL_FUNC_skeymgmt_import_fn *import, size_t keylen, const OSSL_PARAM params[]);

EVP_KEYEXCH API

int **OSSL_FUNC_keyexch_derive_skey**(void *ctx, const char *key_type, void *provctx, OSSL_FUNC_skeymgmt_import_fn *import, size_t keylen, const OSSL_PARAM params[]);

Fallback mechanisms



Old implementations, new API

Not all calls work now

Internally use EVP_SKEY_get0_raw_key/EVP_SKEY_export

Needs grooming

For retrieving: EVP_SKEY_import

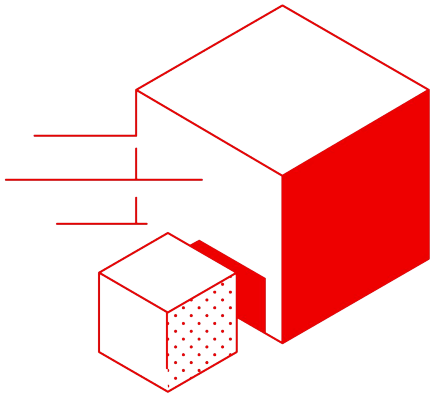
New implementations

Implement both callbacks (do_smth/do_smth_skey)

Providers mismatch

Export/import dance

Nearest step: STORE support



file: STORE

There is no format specification for symmetric keys

Ways forward: RFC 6031? PKCS#12?

Any sequence of bytes can be a symmetric key

Proposal: 2048 bytes max, request EVP_SKEY explicitly

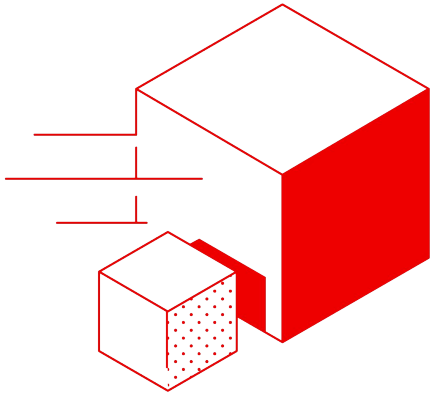
Special raw2obj decoder

PR#28278

pkcs11://uri

Just works out of box

Openssl command-line utilities



openssl list

-skey-managers

openssl skeyutl

-cipher, -skeymgmt, -skeyopt, -genkey

openssl enc

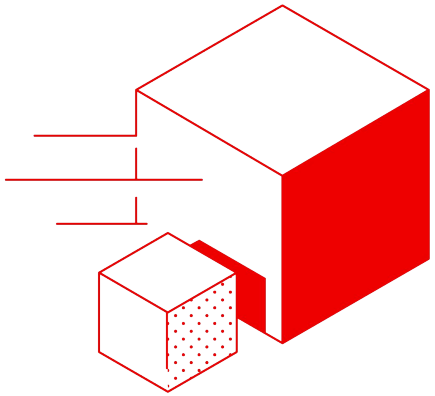
-skeymgmt, -skeyopt

After STORE changes land: -skeyuri, -storepass

openssl storeutl

After STORE changes land: -skeys

Known implementations



EVP_SKEYMGMT in OpenSSL providers

default (3.5), fips and legacy (3.6)
GENERIC-SECRET and AES
Support for test purposes: PBKDF1, ECDH KEX

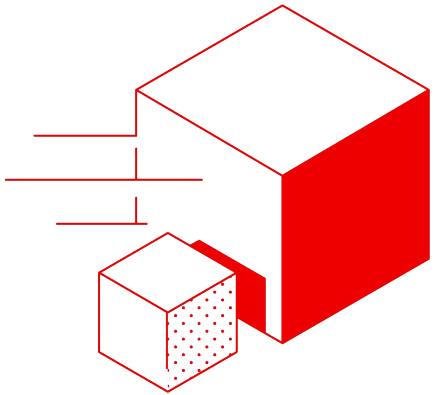
PKCS#11 provider

https://github.com/latchset/pkcs11-provider

OpenSSL conference presentations

Taking the OpenSSL into the PKCS#11 World and Vice Versa
Exploiting hardware-backed keys with the new EVP_SKEY API

To be done



OpenSSL 4.0?

EVP_SKEY store support (PR #28278)

Some future

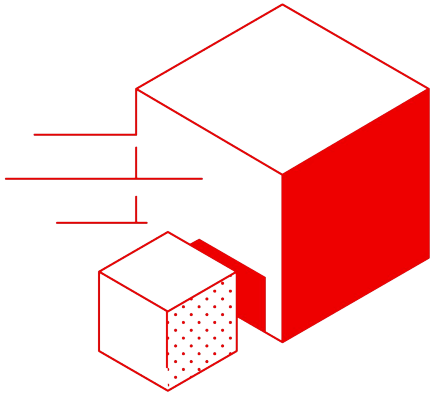
Encoders/decoders support

Simultaneous derivation of multiple keys (TLS)

Distant future

Use only opaque objects?

Let's cooperate



EVP_SKEY Special Interest Group

HSM vendors

HSM users

PKCS#11 vendors

Academics community

Thank you

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