

# Contract State Encryption

## Encryption at deployment of contract

When a contract is executed on chain the state of the contracts needs to be encrypted so that observers can not see the computation that is initialized. The contract should be able to call certain functions inside the enclave and store the contract state on-chain.

A contract can call 3 different functions: `write_db(field_name, value)`, `read_db(field_name)`, and `remove_db(field_name)`. It is important that the `field_name` remains constant between contract calls.

We will go over the different steps associated with the encryption of the contract state.

### 1. Create `contract_key`

The `contract_key` is the encryption key for the contract state and is a combination of two values: `signer_id` || `authenticated_contract_key`. Every contract has its own unforgeable encryption key. The concatenation of the values is what makes every unique and this is important for several reasons

1. Make sure the state of two contracts with the same code is different
2. Make sure a malicious node runner won't be able to locally encrypt transactions with its own encryption key, and then decrypt the resulting state with the fake key
- 3.

so to reiterate, every contract on Secret Network has its own unique and unforgeable encryption key `contract_key`

This process of creating `contract_key` is started when the Secret contract is deployed on-chain. First `authentication_key` is generated using HDKF-SHA256 inside the enclave from the following values:

- `consensus_state_ikm`
- HDK-salt
- `signer_id`
- 

...

```
Copy signer_id = sha256(concat(msg_sender, block_height));
```

```
authentication_key = hkdf({ salt: hkdf_salt, info: "contract_key", ikm: concat(consensus_state_ikm, signer_id), });
```

...

From the `authentication_key` create `authenticated_contract_key` by calling the hmac-SHA256 hash function with the `contractcode_hash` as hashing data.

This step makes sure the key is unique for every contracts with different code.

...

```
Copy authenticated_contract_key = hmac_sha256({ key: authentication_key, data: code_hash, });
```

...

Lastly concat the `signer_id` and `authenticated_contract_key` to create `contract_key`. This step makes it so the key is unforgeable as the key can only be recreated with the current `signer_id`

...

```
Copy contract_key = concat(signer_id, authenticated_contract_key);
```

...

### 1. At execution share `contract_key` with enclave

Every time a contract execution is called, `contract_key` should be sent to the enclave. In the enclave, the following verification needs to happen to proof a genuine `contract_key`

...

```
Copy signer_id = contract_key.slice(0, 32); expected_contract_key = contract_key.slice(32, 64);
```

```

authentication_key = hkdf({ salt: hkdf_salt, info: "contract_key", ikm: concat(consensus_state_ikm, signer_id), });
calculated_contract_key = hmac_sha256({ key: authentication_key, data: code_hash, });
assert(calculated_contract_key == expected_contract_key);
...

```

#### 1. Callback function logic

```

write_db(field_name, value)
...

```

```

Copy encryption_key = hkdf({ salt: hkdf_salt, ikm: concat(consensus_state_ikm, field_name, contract_key), });
encrypted_field_name = aes_128_siv_encrypt({ key: encryption_key, data: field_name, });
current_state_ciphertext = internal_read_db(encrypted_field_name);

if (current_state_ciphertext == null) { // field_name doesn't yet initialized in state ad = sha256(encrypted_field_name); } else {
// read previous_ad, verify it, calculate new ad previous_ad = current_state_ciphertext.slice(0, 32); // first 32 bytes/256 bits
current_state_ciphertext = current_state_ciphertext.slice(32); // skip first 32 bytes

aes_128_siv_decrypt({ key: encryption_key, data: current_state_ciphertext, ad: previous_ad, }); // just to authenticate
previous_ad ad = sha256(previous_ad); }

new_state_ciphertext = aes_128_siv_encrypt({ key: encryption_key, data: value, ad: ad, });
new_state = concat(ad, new_state_ciphertext);
internal_write_db(encrypted_field_name, new_state);
...

```

```

read_db(field_name)
...

```

```

Copy encryption_key=hkdf({ salt:hkdf_salt, ikm:concat(consensus_state_ikm,field_name,contract_key), });
encrypted_field_name=aes_128_siv_encrypt({ key:encryption_key, data:field_name, });
current_state_ciphertext=internal_read_db(encrypted_field_name);

if(current_state_ciphertext==null) { // field_name doesn't yet initialized in state returnnull; }

// read ad, verify it ad=current_state_ciphertext.slice(0,32);// first 32 bytes/256 bits
current_state_ciphertext=current_state_ciphertext.slice(32);// skip first 32 bytes
current_state_plaintext=aes_128_siv_decrypt({ key:encryption_key, data:current_state_ciphertext, ad:ad, });

returncurrent_state_plaintext;
...

```

```

remove_db(field_name)

```

Very similar to read\_db .

```

...

```

```

Copy encryption_key=hkdf({ salt:hkdf_salt, ikm:concat(consensus_state_ikm,field_name,contract_key), });
encrypted_field_name=aes_128_siv_encrypt({ key:encryption_key, data:field_name, });
internal_remove_db(encrypted_field_name);
...

```

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