# Security Assessment

# Defrost Finance

Nov 10th, 2021

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# About

# Summary

This report has been prepared for Defrost Finance to discover issues and vulnerabilities in the source code of the Defrost Finance project as well as any contract dependencies that were not part of an officially recognized library. A comprehensive examination has been performed, utilizing Static Analysis and Manual Review techniques.

The auditing process pays special attention to the following considerations:

- Testing the smart contracts against both common and uncommon attack vectors.
- Assessing the codebase to ensure compliance with current best practices and industry standards.
- Ensuring contract logic meets the specifications and intentions of the client.
- Cross referencing contract structure and implementation against similar smart contracts produced by industry leaders.
- Thorough line-by-line manual review of the entire codebase by industry experts.

The security assessment resulted in findings that ranged from critical to informational. We recommend addressing these findings to ensure a high level of security standards and industry practices. We suggest recommendations that could better serve the project from the security perspective:

- Enhance general coding practices for better structures of source codes;
- Add enough unit tests to cover the possible use cases;
- Provide more comments per each function for readability, especially contracts that are verified in public;
- Provide more transparency on privileged activities once the protocol is live.

# Overview

## Project Summary

| | |
|---|---|
| Project Name | Defrost Finance |
| Platform | Avalanche C-chain |
| Language | Solidity |
| Codebase | https://github.com/DefrostFinance/defrost-finance-contract/tree/master/contracts/collateralVault<br>https://github.com/DefrostFinance/defrost-finance-contract/tree/master/contracts/systemCoin<br>https://github.com/DefrostFinance/defrost-finance-contract/blob/master/contracts/interestEngine/interestEngine.sol<br>https://github.com/DefrostFinance/defrost-finance-contract/blob/master/contracts/defrostFactory |
| Commit | 0b89aa6a7fd976145c2dee25c27d3f811acba9f5 |

## Audit Summary

| | |
|---|---|
| Delivery Date | Nov 10, 2021 |
| Audit Methodology | Static Analysis, Manual Review |
| Key Components | |

# Vulnerability Summary

| Vulnerability Level | Total | ⓘ Pending | ⊗ Declined | ⓘ Acknowledged | ⓘ Partially Resolved | ✓ Resolved |
|---|---|---|---|---|---|---|
| ● Critical | 1 | 0 | 0 | 0 | 0 | 1 |
| ● Major | 5 | 0 | 0 | 5 | 0 | 0 |
| ● Medium | 0 | 0 | 0 | 0 | 0 | 0 |
| ● Minor | 6 | 0 | 0 | 1 | 0 | 5 |
| ● Informational | 12 | 0 | 0 | 7 | 0 | 5 |
| ● Discussion | 0 | 0 | 0 | 0 | 0 | 0 |

## Audit Scope

| ID | File | SHA256 Checksum |
|---|---|---|
| VVD | collateralVault/collateralVault.sol | 031331248648ccd26aa50defd2f636243379f18660a5a0c226ef1d88f7e08360 |
| EVD | collateralVault/vaultEngine.sol | f6c310124f3038265b7543ab4d543bb576e4bea272203130e1d8826ad30f73ab |
| EDV | collateralVault/vaultEngineData.sol | f0b7c28c0b366b7a0dcf729c292e7be3ca2ea88d960cac82db2363b67e545708 |
| FFD | defrostFactory/defrostFactory.sol | 1d74bc60aff4d4d607c86a7a05685c342d63b885a357318cd2dea1596462221e |
| FDD | defrostFactory/defrostFactoryData.sol | 22f2d82799093e31c8be365a576ee33f339c539ed730f0d8d035ba885db8ab36 |
| EED | interestEngine/interestEngine.sol | 744521ba13fc15c502ba7ec20039fe49d494932e7f73f63b94d5d4a422c43e0e |
| CCD | systemCoin/Coin.sol | e169f22b8298eafc8b4fb76b7db7f6022209e59fe596665c4e4855c0a4aaee40 |

It should be noted that the system design includes a number of economic arguments and assumptions. These were explored to the extent that they clarified the intention of the code base, but we did not audit the mechanism design itself. Note that financial models of blockchain protocols need to be resilient to attacks. It needs to pass simulations and verifications to guarantee the security of the overall protocol. The correctness of the financial model is not in the scope of the audit.

Note that this audit only includes the contracts in the stated scope while the files outside the scope are treated as black boxes and are assumed to be functionally correct.

To bridge the trust gap between owner and users, the owner needs to express a sincere attitude with the consideration of the administrator team's anonymousness.

The owner has the responsibility to notify users with the following capability of the administrator:

- init contract through `initContract()`

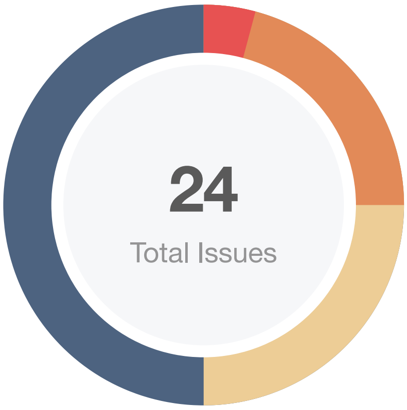
The origin has the responsibility to notify users with the following capability of the administrator:

- set emergency start time through `setEmergency()`
- set liquidation info through `setLiquidationInfo()`
- set pool asset limitation through `setPoolLimitation()`
- set stability fee through `setStabilityFee()`
- create vault through `createVault()`
- create system coins through `createSystemCoin()`

The authorized has the responsibility to notify users with the following capability of the administrator:

- maliciously add auth to an account through `addAuthorization()`
- maliciously remove auth from an account through `removeAuthorization()`
- maliciously mint new coins through `mint()`

# Findings



| | |
|---|---|
| 🟥 **Critical** | **1** (4.17%) |
| 🟧 **Major** | **5** (20.83%) |
| 🟨 **Medium** | **0** (0.00%) |
| 🟨 **Minor** | **6** (25.00%) |
| 🟦 **Informational** | **12** (50.00%) |
| 🟩 **Discussion** | **0** (0.00%) |

| ID | Title | Category | Severity | Status |
|---|---|---|---|---|
| GLOBAL-01 | Unlocked Compiler Version | Language Specific | ● Informational | ⓘ Acknowledged |
| CCD-01 | Lack of Zero Address Validation | Volatile Code | ● Minor | ✓ Resolved |
| CCD-02 | Function Visibility Optimization | Gas Optimization | ● Informational | ✓ Resolved |
| CCD-03 | Incorrect naming convention utilization | Coding Style | ● Informational | ⓘ Acknowledged |
| **CCD-04** | Centralization Risk | **Centralization / Privilege** | ● **Major** | ⓘ Acknowledged |
| CCD-05 | Set `constant` to Variables | Gas Optimization | ● Informational | ✓ Resolved |
| CCD-06 | Possibility of Replay Attack in `permit()` | Logical Issue | ● Minor | ✓ Resolved |
| CCD-07 | Susceptible to Signature Malleability | Volatile Code | ● Minor | ✓ Resolved |
| EED-01 | Function Visibility Optimization | Gas Optimization | ● Informational | ✓ Resolved |
| EED-02 | Incorrect naming convention utilization | Coding Style | ● Informational | ⓘ Acknowledged |
| EED-03 | Discussion For Function `getAssetBalance()` | Logical Issue | ● Informational | ⓘ Acknowledged |
| EED-04 | Visibility Specifiers Missing | Language Specific | ● Informational | ✓ Resolved |
| **EVD-01** | Centralization Risk | **Centralization / Privilege** | ● **Major** | ⓘ Acknowledged |
| FDD-01 | Incorrect naming convention utilization | Coding Style | ● Informational | ⓘ Acknowledged |

| ID | Title | Category | Severity | Status |
|---|---|---|---|---|
| FFD-01 | Lack of Zero Address Validation | Volatile Code | ● Minor | ✓ Resolved |
| **FFD-02** | Centralization Risk | **Centralization / Privilege** | ● **Major** | ⓘ Acknowledged |
| VVD-01 | Lack of Zero Address Validation | Volatile Code | ● Minor | ✓ Resolved |
| VVD-02 | Missing Emit Events | Gas Optimization | ● Informational | ✓ Resolved |
| **VVD-03** | Centralization Risk | **Centralization / Privilege** | ● **Major** | ⓘ Acknowledged |
| **VVD-04** | Centralization Risk | **Centralization / Privilege** | ● **Major** | ⓘ Acknowledged |
| VVD-05 | Incorrect `amount` Value | Logical Issue | ● Critical | ✓ Resolved |
| VVD-06 | Third Party Dependencies | Volatile Code | ● Minor | ⓘ Acknowledged |
| VVD-07 | Discussion For Function `setEmergency()` | Control Flow | ● Informational | ⓘ Acknowledged |
| VVD-08 | Discussion For Function `emergencyExit()` | Control Flow | ● Informational | ⓘ Acknowledged |

# GLOBAL-01 | Unlocked Compiler Version

| Category | Severity | Location | Status |
|---|---|---|---|
| Language Specific | ● Informational | Global | ⓘ Acknowledged |

## Description

The contract has an unlocked compiler version. An unlocked compiler version in the source code of the contract permits the user to compile it at or above a particular version. This, in turn, leads to differences in the generated bytecode between compilations due to differing compiler version numbers. This can lead to ambiguity when debugging as compiler-specific bugs may occur in the codebase that would be hard to identify over a span of multiple compiler versions rather than a specific one.

## Recommendation

It is a general practice to instead lock the compiler at a specific version rather than allow a range of compiler versions to be utilized to avoid compiler-specific bugs and be able to identify ones more easily. We recommend locking the compiler at the lowest possible version that supports all the capabilities wished by the codebase. This will ensure that the project utilizes a compiler version that has been in use for the longest time and as such is less likely to contain yet-undiscovered bugs.

## Alleviation

`[Client]`: Have set compiler version in range of 0.7.x.

# CCD-01 | Lack of Zero Address Validation

| Category | Severity | Location | Status |
|---|---|---|---|
| Volatile Code | ● Minor | systemCoin/Coin.sol: 128, 22, 14 | ✓ Resolved |

## Description

The zero address is not verified when calling the following function.

- `addAuthorization()`
- `removeAuthorization()`
- `mint()`
- `approve()`
- `constructor()`
- `exit()`
- `emergencyExit()`
- `_mintSystemCoin()`
- `_repaySystemCoin()`
- `constructor()`

## Recommendation

We advise the client to check that the aforementioned function's parameters are not zero address.

## Alleviation

`[Client]`: Have add modifier notZeroAddress

```
modifier notZeroAddress(address inputAddress) {
    require(inputAddress != address(0), "Coin : input zero address");
    _;
}
```

# CCD-02 | Function Visibility Optimization

| Category | Severity | Location | Status |
|---|---|---|---|
| Gas Optimization | ● Informational | systemCoin/Coin.sol: 138, 128, 99 | ✓ Resolved |

## Description

The following functions are declared as `public` and are not invoked in any of the contracts contained within the project's scope:

- `transfer()`
- `mint()`
- `burn()`
- `getInterestInfo()`

The functions that are never called internally within the contract should have external visibility.

## Recommendation

We advise that the functions' visibility specifiers are set to `external` and the array-based arguments change their data location from `memory` to `calldata`, optimizing the gas cost of the function.

## Alleviation

The client heeded our advice and resolved this issue.

# CCD-03 | Incorrect naming convention utilization

| Category | Severity | Location | Status |
|---|---|---|---|
| Coding Style | ● Informational | systemCoin/Coin.sol: 71 | ⓘ Acknowledged |

## Description

Naming conventions are powerful when adopted and used broadly. The use of different conventions can convey significant meta information that would otherwise not be immediately available.

Solidity defines a naming convention that should be followed.

- Contracts and libraries should be named using the CapWords style.
- Structs should be named using the CapWords style.
- Events should be named using the CapWords style.
- Functions should use mixedCase.
- Function arguments should use mixedCase.
- Local and State Variable Names should use mixedCase.
- Constants should be named with all capital letters with underscores separating words.
- Enums, in the style of simple type declarations, should be named using the CapWords style.

Reference: https://docs.soliditylang.org/en/latest/style-guide.html#naming-conventions

## Recommendation

We advise the client to follow the Solidity naming convention. The recommendations outlined here are intended to improve the readability, and thus they are not rules, but rather guidelines to try and help convey the most information through the names of things.

## Alleviation

`[Client]`: the contract's ABIs are already well used in many programs. It's hard to fix it.

## CCD-04 | Centralization Risk

| Category | Severity | Location | Status |
|---|---|---|---|
| **Centralization / Privilege** | ● **Major** | systemCoin/Coin.sol: 128, 22, 14 | ⓘ Acknowledged |

### Description

In the contract `Coin`, the role `authorized` has the authority over the following function:

- `addAuthorization()`
- `removeAuthorization()`
- `mint()`

Any compromise to the `authorized` account may allow the hacker to take advantage of this and:

- maliciously add auth to an account through `addAuthorization()`
- maliciously remove auth from an account through `removeAuthorization()`
- maliciously mint new coins through `mint()`

### Recommendation

We advise the client to carefully manage the `authorized` account's private key to avoid any potential risks of being hacked. In general, we strongly recommend centralized privileges or roles in the protocol to be improved via a decentralized mechanism or smart-contract-based accounts with enhanced security practices, e.g. Multisignature wallets.

Indicatively, here is some feasible suggestions that would also mitigate the potential risk at the different level in term of short-term and long-term:

- Time-lock with reasonable latency, e.g., 48 hours, for awareness on privileged operations;
- Assignment of privileged roles to multi-signature wallets to prevent a single point of failure due to the private key;
- Introduction of a DAO/governance/voting module to increase transparency and user involvement.

### Alleviation

`[Client]`: `Coin.sol` must be deployed by `defrostFactory.sol`, all authorized roles must be `defrostFactory.sol` and `collateralVault.sol`. So, Personal account cannot become an authorized role.

# CCD-05 | Set `constant` to Variables

| Category | Severity | Location | Status |
|---|---|---|---|
| Gas Optimization | ● Informational | systemCoin/Coin.sol: 40 | ✓ Resolved |

## Description

The variable `version` is unchanged throughout the contract.

## Recommendation

We advise the client to set `version` as `constant` variables.

## Alleviation

The client heeded our advice and resolved this issue.

# CCD-06 | Possibility of Replay Attack in `permit()`

| Category | Severity | Location | Status |
|---|---|---|---|
| Logical Issue | ● Minor | systemCoin/Coin.sol: 178 | ✓ Resolved |

## Description

The `permit` function performs the operation of deriving signer address from the signature values of `v`, `r` and `s`. The state variable `DOMAIN_SEPARATOR` that is used to calculate hash has a value of `chainid` that is derived only once in the constructor, which does not change after contract deployment. The issue arises in the event of fork when the cross-chain replay attacks can be executed. The attack scenario can be thought of as if a fork of Ethereum happens and two different networks have id of for example `1` and `9`. The `chainid` coded in `DOMAIN_SEPARATOR` will be the same on contracts residing in both of the forks. If the chainid `1` is stored in the contract then the `permit` transaction signed for chainid `1` will be executable on both of the forks.

## Recommendation

We advise to construct the `DOMAIN_SEPARATOR` hash inside the permit function so the current `chainid` could be fetched and only the transactions signed for current network could succeed.

## Alleviation

`[Client]`: Have removed function `permit()`.

# CCD-07 | Susceptible to Signature Malleability

| Category | Severity | Location | Status |
|---|---|---|---|
| Volatile Code | ● Minor | systemCoin/Coin.sol: 188 | ✓ Resolved |

## Description

The signature malleability is possible within the Elliptic Curve cryptographic system. An Elliptic Curve is symmetric on the X-axis, meaning two points can exist with the same `X` value. In the `r`, `s` and `v` representation this permits us to carefully adjust `s` to produce a second valid signature for the same `r`, thus breaking the assumption that a signature cannot be replayed in what is known as a replay-attack.

## Recommendation

We advise the client to utilize a `recover()` function similar to that of the `ECDSA.sol` implementation of OpenZeppelin.

## Alleviation

`[Client]`: Have removed function `permit()`.

# EED-01 | Function Visibility Optimization

| Category | Severity | Location | Status |
|---|---|---|---|
| Gas Optimization | ● Informational | interestEngine/interestEngine.sol: 42 | ✓ Resolved |

## Description

The following functions are declared as `public` and are not invoked in any of the contracts contained within the project's scope:

- `transfer()`
- `mint()`
- `burn()`
- `getInterestInfo()`

The functions that are never called internally within the contract should have external visibility.

## Recommendation

We advise that the functions' visibility specifiers are set to `external` and the array-based arguments change their data location from `memory` to `calldata`, optimizing the gas cost of the function.

## Alleviation

The client heeded our advice and resolved this issue.

# EED-02 | Incorrect naming convention utilization

| Category | Severity | Location | Status |
|---|---|---|---|
| Coding Style | ● Informational | interestEngine/interestEngine.sol: 13 | ⓘ Acknowledged |

## Description

Naming conventions are powerful when adopted and used broadly. The use of different conventions can convey significant meta information that would otherwise not be immediately available.

Solidity defines a naming convention that should be followed.

- Contracts and libraries should be named using the CapWords style.
- Structs should be named using the CapWords style.
- Events should be named using the CapWords style.
- Functions should use mixedCase.
- Function arguments should use mixedCase.
- Local and State Variable Names should use mixedCase.
- Constants should be named with all capital letters with underscores separating words.
- Enums, in the style of simple type declarations, should be named using the CapWords style.

Reference: https://docs.soliditylang.org/en/latest/style-guide.html#naming-conventions

## Recommendation

We advise the client to follow the Solidity naming convention. The recommendations outlined here are intended to improve the readability, and thus they are not rules, but rather guidelines to try and help convey the most information through the names of things.

## Alleviation

`[Client]`: the contract’s ABIs are already well used in many programs. It’s hard to fix it.

# EED-03 | Discussion For Function `getAssetBalance()`

| Category | Severity | Location | Status |
|---|---|---|---|
| Logical Issue | ● Informational | interestEngine/interestEngine.sol: 65 | ⓘ Acknowledged |

## Description

In the function `getAssetBalance()`, zero would be returned when either `interestRateOrigin` or `interestInterval` is equal to 0, instead of the `assetAndInterest`. We would like to inquire why it is the case.

## Alleviation

`[Client]`: If the user's `interestRateOrigin` is zero, he will not interact with this contract, his asset balance will be zero. If `interestInterval` Is zero, the contract will not start to work, all users' asset balance will be zero.

# EED-04 | Visibility Specifiers Missing

| Category | Severity | Location | Status |
|---|---|---|---|
| Language Specific | ● Informational | interestEngine/interestEngine.sol: 13 | ✓ Resolved |

## Description

The linked variable declarations do not have a visibility specifier explicitly set.

## Recommendation

Inconsistencies in the default visibility the Solidity compilers impose can cause issues in the functionality of the codebase. We advise that visibility specifiers for the linked variables are explicitly set.

## Alleviation

`[Client]`: uint256 constant internal rayDecimals = 1e27;

# EVD-01 | Centralization Risk

| Category | Severity | Location | Status |
|---|---|---|---|
| **Centralization / Privilege** | ● **Major** | collateralVault/vaultEngine.sol: 19 | ⓘ Acknowledged |

## Description

In the contract `collateralVault`、 `vaultEngine` and `defrostFactory`, the role `origin` has the authority over the following function:

- `setEmergency()`
- `setLiquidationInfo()`
- `setPoolLimitation()`
- `setStabilityFee()`
- `createVault()`
- `createSystemCoin()`

Any compromise to the `origin` account may allow the hacker to take advantage of this and:

- set emergency start time through `setEmergency()`
- set liquidation info through `setLiquidationInfo()`
- set pool asset limitation through `setPoolLimitation()`
- set stability fee through `setStabilityFee()`
- create vault through `createVault()`
- create system coins through `createSystemCoin()`

## Recommendation

We advise the client to carefully manage the `origin` account's private key to avoid any potential risks of being hacked. In general, we strongly recommend centralized privileges or roles in the protocol to be improved via a decentralized mechanism or smart-contract-based accounts with enhanced security practices, e.g. Multisignature wallets.

Indicatively, here is some feasible suggestions that would also mitigate the potential risk at the different level in term of short-term and long-term:

- Time-lock with reasonable latency, e.g., 48 hours, for awareness on privileged operations;
- Assignment of privileged roles to multi-signature wallets to prevent a single point of failure due to the private key;

- Introduction of a DAO/governance/voting module to increase transparency and user involvement.

## Alleviation

`[Client]`: onlyOrigin is a multiple signature authorized check. The accounts origin0 and origin1 have the property to create an invoked application, multiple signature will signature this application.

```
    modifier onlyOrigin() {
        require (isOrigin(),"proxyOwner: caller is not the tx origin!");
        checkMultiSignature();
        _;
    }
    function checkMultiSignature() internal {
        uint256 value;
        assembly {
            value := callvalue()
        }
        bytes32 msgHash = keccak256(abi.encodePacked(msg.sender,
address(this),value,msg.data));
        address multiSign = getMultiSignatureAddress();
        uint256 index = getValue(uint256(msgHash));
        uint256 newIndex = IMultiSignature(multiSign).getValidSignature(msgHash,index);
        require(newIndex > index, "multiSignatureClient : This tx is not aprroved");
        saveValue(uint256(msgHash),newIndex);
    }
```

# FDD-01 | Incorrect naming convention utilization

| Category | Severity | Location | Status |
|---|---|---|---|
| Coding Style | ● Informational | defrostFactory/defrostFactoryData.sol: 5 | ⓘ Acknowledged |

## Description

Naming conventions are powerful when adopted and used broadly. The use of different conventions can convey significant meta information that would otherwise not be immediately available.

Solidity defines a naming convention that should be followed.

- Contracts and libraries should be named using the CapWords style.
- Structs should be named using the CapWords style.
- Events should be named using the CapWords style.
- Functions should use mixedCase.
- Function arguments should use mixedCase.
- Local and State Variable Names should use mixedCase.
- Constants should be named with all capital letters with underscores separating words.
- Enums, in the style of simple type declarations, should be named using the CapWords style.

Reference: https://docs.soliditylang.org/en/latest/style-guide.html#naming-conventions

## Recommendation

We advise the client to follow the Solidity naming convention. The recommendations outlined here are intended to improve the readability, and thus they are not rules, but rather guidelines to try and help convey the most information through the names of things.

## Alleviation

`[Client]`: the contract’s ABIs are already well used in many programs. It’s hard to fix it.

# FFD-01 | Lack of Zero Address Validation

| Category | Severity | Location | Status |
|---|---|---|---|
| Volatile Code | ● Minor | defrostFactory/defrostFactory.sol: 13 | ✓ Resolved |

## Description

The zero address is not verified when calling the following function.

- `addAuthorization()`
- `removeAuthorization()`
- `mint()`
- `approve()`
- `constructor()`
- `exit()`
- `emergencyExit()`
- `_mintSystemCoin()`
- `_repaySystemCoin()`
- `constructor()`

## Recommendation

We advise the client to check that the aforementioned function's parameters are not zero address.

## Alleviation

`[Client]`: Have add modifier notZeroAddress

```
modifier notZeroAddress(address inputAddress) {
    require(inputAddress != address(0), "Coin : input zero address");
    _;
}
```

# FFD-02 | Centralization Risk

| Category | Severity | Location | Status |
|---|---|---|---|
| **Centralization / Privilege** | ● **Major** | defrostFactory/defrostFactory.sol: 43, 18 | ⓘ Acknowledged |

## Description

In the contract `collateralVault`、 `vaultEngine` and `defrostFactory`, the role `origin` has the authority over the following function:

- `setEmergency()`
- `setLiquidationInfo()`
- `setPoolLimitation()`
- `setStabilityFee()`
- `createVault()`
- `createSystemCoin()`

Any compromise to the `origin` account may allow the hacker to take advantage of this and:

- set emergency start time through `setEmergency()`
- set liquidation info through `setLiquidationInfo()`
- set pool asset limitation through `setPoolLimitation()`
- set stability fee through `setStabilityFee()`
- create vault through `createVault()`
- create system coins through `createSystemCoin()`

## Recommendation

We advise the client to carefully manage the `origin` account's private key to avoid any potential risks of being hacked. In general, we strongly recommend centralized privileges or roles in the protocol to be improved via a decentralized mechanism or smart-contract-based accounts with enhanced security practices, e.g. Multisignature wallets.

Indicatively, here is some feasible suggestions that would also mitigate the potential risk at the different level in term of short-term and long-term:

- Time-lock with reasonable latency, e.g., 48 hours, for awareness on privileged operations;
- Assignment of privileged roles to multi-signature wallets to prevent a single point of failure due to the private key;

- Introduction of a DAO/governance/voting module to increase transparency and user involvement.

## Alleviation

`[Client]`: onlyOrigin is a multiple signature authorized check. The accounts origin0 and origin1 have the property to create an invoked application, multiple signature will signature this application.

```
    modifier onlyOrigin() {
        require (isOrigin(),"proxyOwner: caller is not the tx origin!");
        checkMultiSignature();
        _;
    }
    function checkMultiSignature() internal {
        uint256 value;
        assembly {
            value := callvalue()
        }
        bytes32 msgHash = keccak256(abi.encodePacked(msg.sender,
address(this),value,msg.data));
        address multiSign = getMultiSignatureAddress();
        uint256 index = getValue(uint256(msgHash));
        uint256 newIndex = IMultiSignature(multiSign).getValidSignature(msgHash,index);
        require(newIndex > index, "multiSignatureClient : This tx is not aprroved");
        saveValue(uint256(msgHash),newIndex);
    }
```

# VVD-01 | Lack of Zero Address Validation

| Category | Severity | Location | Status |
|---|---|---|---|
| Volatile Code | ● Minor | collateralVault/collateralVault.sol: 116, 97, 78, 72, 7 | ✓ Resolved |

## Description

The zero address is not verified when calling the following function.

- `addAuthorization()`
- `removeAuthorization()`
- `mint()`
- `approve()`
- `constructor()`
- `exit()`
- `emergencyExit()`
- `_mintSystemCoin()`
- `_repaySystemCoin()`
- `constructor()`

## Recommendation

We advise the client to check that the aforementioned function's parameters are not zero address.

## Alleviation

`[Client]`: Have add modifier notZeroAddress

```
modifier notZeroAddress(address inputAddress) {
    require(inputAddress != address(0), "Coin : input zero address");
    _;
}
```

# VVD-02 | Missing Emit Events

| Category | Severity | Location | Status |
|---|---|---|---|
| Gas Optimization | ● Informational | collateralVault/collateralVault.sol: 16 | ✓ Resolved |

## Description

Functions that affect the status of sensitive variables should be able to emit events as notifications to customers.

- `initContract()`

## Recommendation

We advise the client to add events for sensitive actions and emit them in the function.

## Alleviation

The client heeded our advice and resolved this issue.

# VVD-03 | Centralization Risk

| Category | Severity | Location | Status |
|---|---|---|---|
| **Centralization / Privilege** | ● **Major** | collateralVault/collateralVault.sol: 16 | ⓘ Acknowledged |

## Description

In the contract `collateralVault`, the role `owner` has the authority over the following function:

- `initContract()`

Any compromise to the `owner` account may allow the hacker to take advantage of this and:

- init contract through `initContract()`

## Recommendation

We advise the client to carefully manage the `owner` account's private key to avoid any potential risks of being hacked. In general, we strongly recommend centralized privileges or roles in the protocol to be improved via a decentralized mechanism or smart-contract-based accounts with enhanced security practices, e.g. Multisignature wallets.

Indicatively, here is some feasible suggestions that would also mitigate the potential risk at the different level in term of short-term and long-term:

- Time-lock with reasonable latency, e.g., 48 hours, for awareness on privileged operations;
- Assignment of privileged roles to multi-signature wallets to prevent a single point of failure due to the private key;
- Introduction of a DAO/governance/voting module to increase transparency and user involvement.

## Alleviation

`[Client]`: Owner must be contract. In this case, owner is `defrostFactory.sol`.

```
function isOwner() public view returns (bool) {
    return msg.sender == owner() && isContract(msg.sender);
}
```

# VVD-04 | Centralization Risk

| Category | Severity | Location | Status |
|---|---|---|---|
| **Centralization / Privilege** | ● **Major** | collateralVault/collateralVault.sol: 42, 32, 27 | ⓘ Acknowledged |

## Description

In the contract `collateralVault`、`vaultEngine` and `defrostFactory`, the role `origin` has the authority over the following function:

- `setEmergency()`
- `setLiquidationInfo()`
- `setPoolLimitation()`
- `setStabilityFee()`
- `createVault()`
- `createSystemCoin()`

Any compromise to the `origin` account may allow the hacker to take advantage of this and:

- set emergency start time through `setEmergency()`
- set liquidation info through `setLiquidationInfo()`
- set pool asset limitation through `setPoolLimitation()`
- set stability fee through `setStabilityFee()`
- create vault through `createVault()`
- create system coins through `createSystemCoin()`

## Recommendation

We advise the client to carefully manage the `origin` account's private key to avoid any potential risks of being hacked. In general, we strongly recommend centralized privileges or roles in the protocol to be improved via a decentralized mechanism or smart-contract-based accounts with enhanced security practices, e.g. Multisignature wallets.

Indicatively, here is some feasible suggestions that would also mitigate the potential risk at the different level in term of short-term and long-term:

- Time-lock with reasonable latency, e.g., 48 hours, for awareness on privileged operations;
- Assignment of privileged roles to multi-signature wallets to prevent a single point of failure due to the private key;

- Introduction of a DAO/governance/voting module to increase transparency and user involvement.

## Alleviation

`[Client]`: onlyOrigin is a multiple signature authorized check. The accounts origin0 and origin1 have the property to create an invoked application, multiple signature will signature this application.

```
    modifier onlyOrigin() {
        require (isOrigin(),"proxyOwner: caller is not the tx origin!");
        checkMultiSignature();
        _;
    }
    function checkMultiSignature() internal {
        uint256 value;
        assembly {
            value := callvalue()
        }
        bytes32 msgHash = keccak256(abi.encodePacked(msg.sender,
address(this),value,msg.data));
        address multiSign = getMultiSignatureAddress();
        uint256 index = getValue(uint256(msgHash));
        uint256 newIndex = IMultiSignature(multiSign).getValidSignature(msgHash,index);
        require(newIndex > index, "multiSignatureClient : This tx is not aprroved");
        saveValue(uint256(msgHash),newIndex);
    }
```

# VVD-05 | Incorrect `amount` Value

| Category | Severity | Location | Status |
|---|---|---|---|
| Logical Issue | ● Critical | collateralVault/collateralVault.sol: 60~61 | ✓ Resolved |

## Description

In the function `_join()`, the `getPayableAmount()` is to transfer the user's assets to the contract which can take the forms of either ETH or other erc20 tokens. If the user transfers ETH, the variable `collateralBalances[account]` needs to increase by `msg.value`, not `amount`. The aforementioned line of code is inconsistent with the actual underlying asset transfer.

## Recommendation

We advise the client to recheck the functions.

## Alleviation

The client heeded our advice and resolved this issue in commit : 07b70dc35bbd876768dbc98faae6e4530a75a9cf.

# VVD-06 | Third Party Dependencies

| Category | Severity | Location | Status |
|---|---|---|---|
| Volatile Code | ● Minor | collateralVault/collateralVault.sol: 14 | ⓘ Acknowledged |

## Description

The contract is serving as the underlying entity to interact with third-party protocols. The scope of the audit would treat those 3rd party entities as black boxes and assume their functional correctness. However, in the real world, 3rd parties may be compromised and lead to assets being lost or stolen.

## Recommendation

We understand that the implementation of `collateralVault.sol` requires interaction with `oraclePrice()`. We encourage the team to carefully review this function for any security vulnerabilities, and constantly monitor the statuses of 3rd parties to mitigate the side effects when unexpected activities are observed.

## Alleviation

`[Client]`: We will use a bridge contract which will be connected with ChainLink oracle.

# VVD-07 | Discussion For Function `setEmergency()`

| Category | Severity | Location | Status |
|---|---|---|---|
| Control Flow | ● Informational | collateralVault/collateralVault.sol: 27 | ⓘ Acknowledged |

## Description

When the contract is halted, the function `setEmergency()` can only be called once. We would like to know if it Is consistent with project design?

## Alleviation

`[Client]`: The definition of the emergency time: When havoc will be happened, this economic system will be stopped, Users will emergency exit from the system.

# VVD-08 | Discussion For Function `emergencyExit()`

| Category | Severity | Location | Status |
|---|---|---|---|
| Control Flow | ● Informational | collateralVault/collateralVault.sol: 78 | ⓘ Acknowledged |

## Description

In the function `emergencyExit()`, all the collateral of the user can be refunded. We would like to know why the user's loan is not settled along with the collateral and if the code logic is consistent with project design?

## Alleviation

`[Client]`: The definition of the emergency time: When havoc will be happened, this economic system will be stopped, Users will emergency exit from the system.

# Appendix

## Finding Categories

### Centralization / Privilege

Centralization / Privilege findings refer to either feature logic or implementation of components that act against the nature of decentralization, such as explicit ownership or specialized access roles in combination with a mechanism to relocate funds.

### Gas Optimization

Gas Optimization findings do not affect the functionality of the code but generate different, more optimal EVM opcodes resulting in a reduction on the total gas cost of a transaction.

### Logical Issue

Logical Issue findings detail a fault in the logic of the linked code, such as an incorrect notion on how block.timestamp works.

### Control Flow

Control Flow findings concern the access control imposed on functions, such as owner-only functions being invoke-able by anyone under certain circumstances.

### Volatile Code

Volatile Code findings refer to segments of code that behave unexpectedly on certain edge cases that may result in a vulnerability.

### Language Specific

Language Specific findings are issues that would only arise within Solidity, i.e. incorrect usage of private or delete.

### Coding Style

Coding Style findings usually do not affect the generated byte-code but rather comment on how to make the codebase more legible and, as a result, easily maintainable.

## Checksum Calculation Method

The "Checksum" field in the "Audit Scope" section is calculated as the SHA-256 (Secure Hash Algorithm 2 with digest size of 256 bits) digest of the content of each file hosted in the listed source repository under the specified commit.

The result is hexadecimal encoded and is the same as the output of the Linux "sha256sum" command against the target file.

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