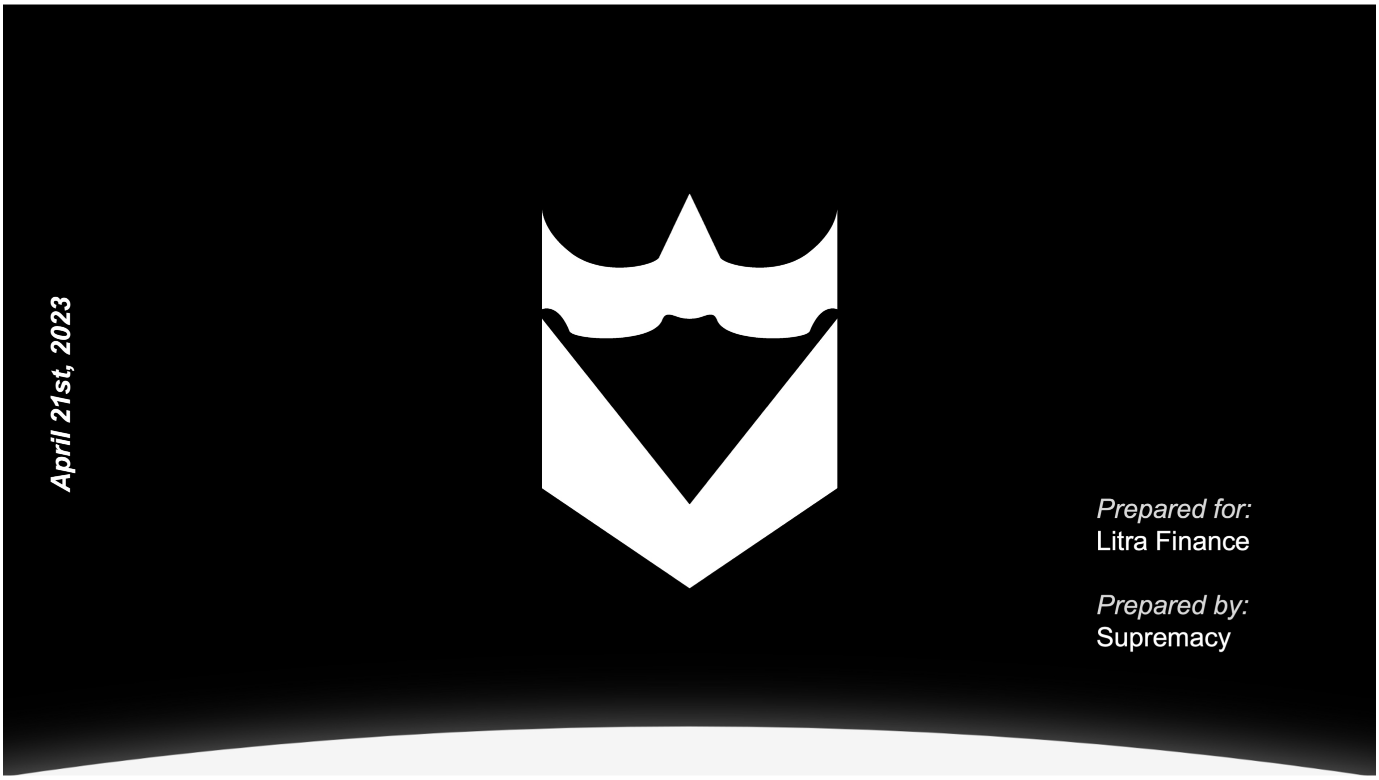
Litra Finance Security Audit



April 21st, 2023

Prepared for:
Litra Finance

Prepared by:
Supremacy

Contents

Introduction

Given the opportunity to review the design document and related source code of the Litra protocol, we outline in the report our systematic approach to evaluate potential security issues in the smart contract(s) implementation, and provide additional suggestions or recommendations for improvement. Our results show that the given version of smart contracts can be further improved due to the presence of several issues related to either security or performance. This document outlines our audit results.

About Client

Litra Finance is an NFT liquidity protocol that wraps NFT into fungible ERC20 tokens to improve trading accuracy and provide more basic liquidity targets. Combining an automated centralized liquidity AMM with a customized curve provides traders with the ultimate trading experience with low slippage, while reducing impermanent losses for liquidity providers. The introduction of the veToken model encourages liquidity providers to actively and consistently provide liquidity for greater returns, which also aligns the interests of all parties.

Item	Description
Client	Litra Finance
Website	https://litra.finance/
Type	Smart Contract
Languages	Solidity
Platform	EVM-compatible

Audit Scope

The codebase is delivered to us in a compressed file called litra-contracts.rar. This security audit was performed for checksum of `0a3e607cfff4605d061e95a8fac91786cba7d92d399bfb4019b0dc4ce1b929d8`.

Below are the files in scope for this security audit and their corresponding SHA256 hashes.

Filename	SHA256
./dao/admin/EmergencyAdminManaged.sol	c1673836bea9343a262747c4df381fa44c9f02cf579f0d78e7faea6272cca0a9
./dao/admin/OwnershipAdminManaged.sol	6cdd35621608154eae6e9fc07460e411fc3a879220aeb97a9a3e1448c429b145
./dao/admin/ParameterAdminManaged.sol	625636c12957e5a15d41807b0d37474d77a2f33247b16bb1273c0fbf85454a5e
./dao/admin/Stoppable.sol	fa47ef841e4558d14b6a67865043469018c599a04631bb60a0b40ee727dc902d
./dao/FeeManager.sol	0a04c5f40c77682e06312082204139cf1d790c11c7bea5dd7f0771877518314a
./tokenize/NFTVault.sol	b18c08f1f24c05e4b9eb1515b88a3496de13c5c72af4dab627ebf2b980b6b973
./tokenize/WrappedNFT.sol	c6fde303290d72aea41b389a54f964850c8e1349bac30b3d1d5fdc60fa44a968

This is the checksum after all fixes for the issues found in the audit have been checked in: `9303970128295bc8c223712bfbd56f92826d3821b4f51798eca9a38f97643b5b`

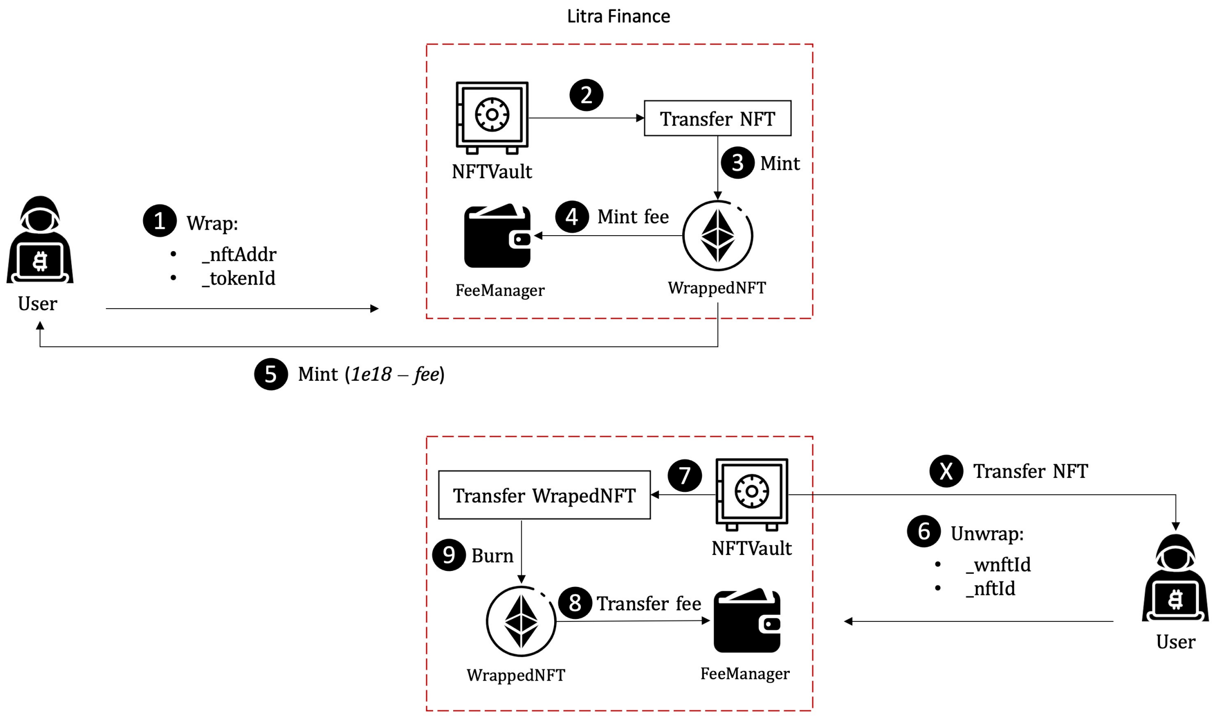
And the files in scope and their SHA256 hashes after this security audit issue has been fixed.

Filename	SHA256
./dao/admin/EmergencyAdminManaged.sol	493960567fea3e9e5e3aa0b52e5730540642a669e48add8a1012607e8cb4dcb5
./dao/admin/OwnershipAdminManaged.sol	972be6bd2fd8656c6f7ab3dbf7cf0b2067bd0c5621fa15632d831e9b04554abd
./dao/admin/ParameterAdminManaged.sol	6dd0b26eb7891129aa1a8c99f060a181df6c21ed5e0a07f68422e83f325943df
./dao/admin/Stoppable.sol	fa47ef841e4558d14b6a67865043469018c599a04631bb60a0b40ee727dc902d
./dao/FeeManager.sol	5bf86ec90832c50728952f4a570d4637009137ccac2ca95642180ad7ea4220f2
./tokenize/NFTVault.sol	c1e1b30ea88b062e12e3a04fb369eb2539be17f22fa451c7012b59219c8872e9
./tokenize/WrappedNFT.sol	c6fde303290d72aea41b389a54f964850c8e1349bac30b3d1d5fdc60fa44a968

Changelog

Version	Date	Description
0.1	April 07, 2023	Initial Draft
0.2	April 08, 2023	Release Candidate #1
1.0	April 21, 2023	Final Report

Threat Model



Litra Finance is an NFT liquidity protocol, and within the scope of observable security audits its main functions are the components NFTVault, FeeManager and Admin.

As shown above, this involves multiple interactions between a user who (wraps) his NFT into a WrappedNFT via Litra Finance and a user who (unwraps) his WrappedNFT into an NFT via Litra Finance. **During the audit, we assume the user could be malicious, which means all messages sent to Litra Finance are untrusted.**

We enumerated the attack surface based on this assumption.

About Us

Supremacy is a leading blockchain security agency, composed of industry hackers and academic researchers, providing clients with a one-stop security solution for the whole life cycle with our technology precipitation and innovative research.

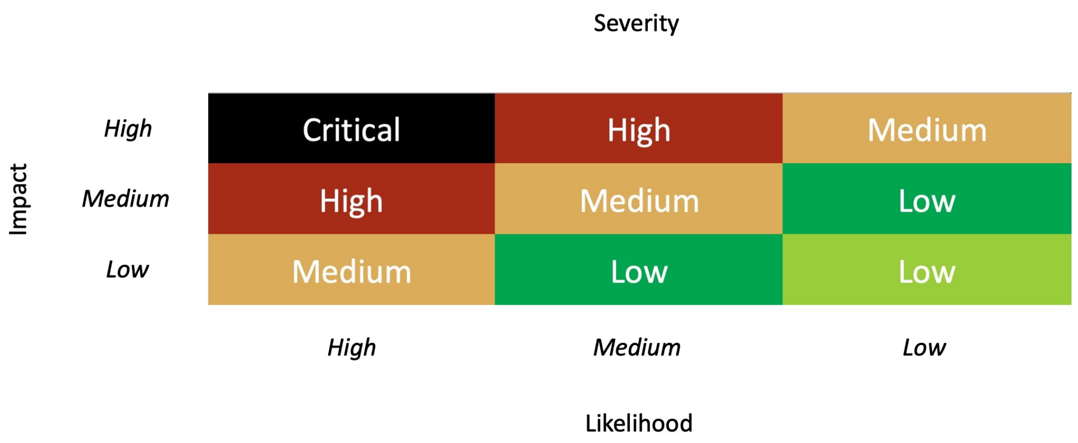
We are reachable at Telegram (https://t.me/SupremacyInc), Twitter (https://twitter.com/Supremacy_CA), or Email (contact@supremacy.email).

Terminology

For the purpose of this assessment, we adopt the following terminology. To classify the severity of our findings, we determine the likelihood and impact (according to the CVSS risk rating methodology).

- Likelihood represents the likelihood of a finding to be triggered or exploited in practice
- Impact specifies the technical and business-related consequences of a finding
- Severity is derived based on the likelihood and the impact

We categorize the findings into four distinct categories, depending on their severity. These severities are derived from the likelihood and the impact using the following table, following a standard risk assessment procedure.



Severity

		High	Medium	Low
Impact	High	Critical	High	Medium
	Medium	High	Medium	Low
	Low	Medium	Low	Low

Likelihood

As seen in the table above, findings that have both a high likelihood and a high impact are classified as critical. Intuitively, such findings are likely to be triggered and cause significant disruption. Overall, the severity correlates with the associated risk. However, every finding's risk should always be closely checked, regardless of severity.

Findings

The table below summarizes the findings of the audit, including status and severity details.

ID	Severity	Description	Status
1	Critical	`WrappedNFT forcible minting`	`Fixed`
2	Critical	`Theft of any user's NFT`	`Fixed`
3	Medium	`Potential fee loss`	`Fixed`
4	Medium	`Centralization risk`	`Confirmed`
5	Low	`Unchecked zero-address`	`Fixed`
6	Low	`Unchecked return values`	`Fixed`
7	Informational	`Missing event records`	`Fixed`
8	Informational	`Best Practices`	`Fixed`
9	Informational	`Best Practices`	`Fixed`

Critical

1. WrappedNFT forcible minting **[Critical]**

- **Severity**: Critical
- **Likelihood**: High
- **Impact**: High
- **Status**: Fixed

Description: `NFTVault::wrap()` is a function that converts ERC721 (NFT) to ERC20 (WrappedNFT). However, since #L90 assigns wnftId to `wnftIds[WrappedNFT]` and `_nftAddr` is controllable, resulting in WrappedNFT being arbitrarily mint.

1. The hacker selects an already existing **WrappedNFT** series and calls `NFTVault::wrap(WrappedNFT, 0)`
2. Then #L56 of `wrap()` will call `WrappedNFT::transferFrom()` externally, and since WrappedNFT is a standard ERC20 Token, it can be executed normally, but without actually transferring the Token, because `_value` is `0`

3. Since **WrappedNFT** can obtain `wnftId` through #L61, it will not enter the `CREATE` procedure, but the `else` condition, and the `wnft` obtained through #L94 is WrappedNFT itself, so the subsequent procedure, will be directly for the `caller` Mint **WrappedNFT**

```
    /**
        @notice Wrap a NFT(IERC721) into a ERC20 token.
        @param _nftAddr address of NFT contract
        @param _tokenId token id of the NFT
     */
    function wrap (
        address _nftAddr,
        uint256 _tokenId
    ) external payable nonReentrant {
        IERC721(_nftAddr).transferFrom(msg.sender, address(this), _tokenId);
        // Save nft record
        uint256 recordId = wrappedNfts.length;
        wrappedNfts.push(WrappedNFTInfo(_nftAddr, _tokenId, true));
        // Get FT Info
        uint256 wnftId = wnftIds[_nftAddr];
        address wnft;
        if(wnftId == 0) {
            // Create a new FT
            string memory wnftName;
            string memory wnftSymbol;
            (bool succeed, bytes memory result) =
_nftAddr.call(abi.encodeWithSignature("name()"));
            if(succeed) {
                string memory nftName = abi.decode(result, (string));
                wnftName = string(abi.encodePacked(nftName, " Wrapped NFT"));
            } else {
                wnftName = string(abi.encodePacked("Litra FT#", wnftId));
            }
            (succeed, result) = _nftAddr.call(abi.encodeWithSignature("symbol()"));
            if(succeed) {
                string memory nftSymbol = abi.decode(result, (string));
                wnftSymbol = string(abi.encodePacked(nftSymbol, "wnft"));
            } else {
                wnftSymbol = string(abi.encodePacked("LWNFT#", wnftId));
            }
            wnft = address(new WrappedNFT(wnftName, wnftSymbol));
            // get ftId
            uint256 _nextWnftId = nextWnftId;
            wnftId = _nextWnftId;
            _nextWnftId ++;
            nextWnftId = _nextWnftId;
            // storage
            wnfts[wnftId] = WNFTInfo(_nftAddr, wnft);
            wnftIds[_nftAddr] = wnftId;
            wnftIds[wnft] = wnftId;

            emit CreateWrappedNFT(_nftAddr, wnftId, wnft);
        } else {
            wnft = wnfts[wnftId].wnftAddr;
        }
        // bound FT and NFT
        _nfts[wnftId].add(recordId);
        // mint and charge fee
        uint256 fee;
        if(address(feeManager) != address(0)) {
            fee = feeManager.wrapFee(wnft);
        }
        if(fee > 0) {
            WrappedNFT(wnft).mint(address(feeManager), fee);
        }
        WrappedNFT(wnft).mint(msg.sender, 1e18 - fee);

        emit Wrap(msg.sender, wnftId, recordId);
    }
```

NFTVault.sol

Recommendation: Delete #L90 from `NFTVault.sol`

```
-    wnftIds[wnft] = wnftId;
```

NFTVault.sol

---

2. Theft of any user's NFT **[Critical]**

- **Severity**: Critical
- **Likelihood**: High
- **Impact**: High
- **Status**: Fixed

Description: Based on the premise of **Critical-1**, a hacker can force the minting of any number of WrappedNFTs under a certain NFT series. however, in the `NFTVault::unwrap()` function, it allows the user to submit `1e18` WrappedNFTs and redeem the NFTs of that series. thus, the hacker can premeditatedly obtain all the deposited NFTVault in NFTVault and thus theft all users' NFTs by calling `NFTVault::unwrap()`.

```
    /**
        @notice Redeem nft from vault and burn one FT
        @param _wnftId index of fts
        @param _nftId Greate than or equal 0 to redeem a designated nft with a more fees
                        Less than 0 to redeem a recent fungiblized nft with a normal fee
     */
    function unwrap(uint256 _wnftId, uint256 _nftId) external payable nonReentrant {
        WNFTInfo memory ftInfo = wnfts[_wnftId];
        require(ftInfo.nftAddr != address(0), "Invalid FT");
        require(WrappedNFT(ftInfo.wnftAddr).balanceOf(msg.sender) >= 1e18, "Insufficient
ft");
        require(_nfts[_wnftId].length() > 0, "No NFT in vault");
        require(_nfts[_wnftId].contains(uint256(_nftId)), "Invalid nftId");
        // burn ft and charge fee
        uint256 fee;
        if(address(feeManager) != address(0)) {
            fee = feeManager.unwrapFee(ftInfo.wnftAddr);
        }
        if(fee > 0) {
            WrappedNFT(ftInfo.wnftAddr).transferFrom(msg.sender, address(feeManager),
fee);
        }
        WrappedNFT(ftInfo.wnftAddr).transferFrom(msg.sender, address(this), 1e18);
        WrappedNFT(ftInfo.wnftAddr).burn(1e18);
        // return nft
        WrappedNFTInfo memory nftInfo = wrappedNfts[_nftId];
        wrappedNfts[_nftId].inVault = false;
        _nfts[_wnftId].remove(_nftId);
        IERC721(nftInfo.nftAddr).safeTransferFrom(address(this), msg.sender,
nftInfo.tokenId);
```

```
        emit Unwrap(msg.sender, _wnftId, _nftId);
    }
```

NFTVault.sol

Recommendation: Refer to the first recommendation.

Medium

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3. Potential fee loss **[Medium]**

- **Severity**: Medium
- **Likelihood**: High
- **Impact**: Low
- **Status**: Fixed

Description: It is not recommended to leave the initial fee to the user to set, because due to the atomic nature of the transaction, it is not possible to charge a fee for WrappedNFTs created within a single transaction anyway. If the user sets both `Wrap` and `Unwrap` fees to `0` after the WrappedNFT is created, no fee will be charged during the window until the parameterAdmin sets the fee again, thus, causing some financial loss.

```
    /**
        @notice Set fee for wrapping.
        Anyone can make the first setting,but generally the first maker will be creator of wnft.
        After first setting, only parameter admin can change
     */
    function setWrapFee(address _wnft, uint256 _fee) external {
        Fee memory fee = _wrapFee[_wnft];
        require(!fee.initialized || msg.sender == parameterAdmin, "! parameter admin");
        _wrapFee[_wnft] = Fee(true, _fee);
    }

    /**
        @notice Set fee for unwrapping.
        Anyone can make the first setting,but generally the first maker will be creator of wnft.
        After first setting, only parameter admin can change
     */
    function setUnwrapFee(address _wnft, uint256 _fee) external {
        Fee memory fee = _unwrapFee[_wnft];
        require(!fee.initialized || msg.sender == parameterAdmin, "! parameter admin");
        _unwrapFee[_wnft] = Fee(true, _fee);
    }
```

FeeManager.sol

Recommendation: When the user calls `NFTVault::Wrap()` or `NFTVault::Unwrap()`, call `FeeManager::setWrapFee()` externally to set the fee instantly before NFTVault transfers the fee (need to add access control in FeeManager).

```
-    require(!fee.initialized || msg.sender == parameterAdmin, "! parameter admin");
+    require(msg.sender == nftVault || msg.sender == parameterAdmin, "! parameter admin");
```

FeeManager.sol

---

4. Centralization risk **[Medium]**

- **Severity**: Medium
- **Likelihood**: Low
- **Impact**: High
- **Status**: Confirmed

Description: In the Litra Finance protocol, privileged accounts exist that play a key role in managing and regulating the operation of the entire system (e.g., configuring various parameters and setting stopped parameters). It also has the privilege of controlling or managing the flow of assets managed by the protocol.

Our analysis shows that privileged accounts need to be scrutinized. In the following, we will examine privileged accounts and the associated privileged access in the current contract.

Note that if the privileged owner account is a plain EOA, this may be worrisome and pose counter-party risk to the protocol users. A multi-sig account could greatly alleviate this concern, though it is still far from perfect. Specifically, a better approach is to eliminate the administration key concern by transferring the role to a community-governed DAO. In the meantime, a timelock-based mechanism can also be considered as mitigation.

```
contract OwnershipAdminManaged {
    address public ownershipAdmin;
    address public futureOwnershipAdmin;

    constructor(address _o) {
        ownershipAdmin = _o;
    }

    modifier onlyOwnershipAdmin {
        require(msg.sender == ownershipAdmin, "! ownership admin");
        _;
    }

    function commitOwnershipAdmin(address _o) external onlyOwnershipAdmin {
        futureOwnershipAdmin = _o;
    }

    function applyOwnershipAdmin() external {
        require(msg.sender == futureOwnershipAdmin, "Access denied!");
        ownershipAdmin = futureOwnershipAdmin;
    }
}
```

OwnershipAdminManaged.sol

```
pragma solidity ^0.8.0;

import "./OwnershipAdminManaged.sol";

abstract contract EmergencyAdminManaged is OwnershipAdminManaged {
    address public emergencyAdmin;
    address public futureEmergencyAdmin;

    constructor(address _e) {
        emergencyAdmin = _e;
    }

    modifier onlyEmergencyAdmin {
        require(msg.sender == emergencyAdmin, "! emergency admin");
        _;
    }

    function commitEmergencyAdmin(address _e) external onlyEmergencyAdmin {
        futureEmergencyAdmin = _e;
    }

    function applyEmergencyAdmin() external {
        require(msg.sender == futureEmergencyAdmin, "! emergency admin");
        emergencyAdmin = futureEmergencyAdmin;
    }
}
```

EmergencyAdminManaged.sol

```
pragma solidity ^0.8.0;

import "./OwnershipAdminManaged.sol";

abstract contract ParameterAdminManaged is OwnershipAdminManaged {
    address public parameterAdmin;
    address public futureParameterAdmin;

    constructor(address _e) {
        parameterAdmin = _e;
    }

    modifier onlyParameterAdmin {
        require(msg.sender == parameterAdmin, "! parameter admin");
        _;
    }

    function commitParameterAdmin(address _p) external onlyOwnershipAdmin {
        futureParameterAdmin = _p;
    }

    function applyParameterAdmin() external {
        require(msg.sender == futureParameterAdmin, "Access denied!");
        parameterAdmin = futureParameterAdmin;
    }
}
```

ParameterAdminManaged.sol

Recommendation: Initially onboarding could can use multisign wallets or timelocks to initially mitigate centralization risks, but as a long-running protocol, we recommend eventually transfer the privileged account to the intended DAO-like governance contract. All changed to privileged operations may need to be mediated with necessary timelocks.

Eventually, activate the normal on-chain community-based governance life-cycle and ensure the intended trustless nature and high-quality distributed governance.

Low

5. Unchecked zero-address **[Low]**

    - **Severity**: Low
    - **Likelihood**: Low
    - **Impact**: Low
    - **Status**: Fixed

Description: Adding the requirement for non-zero address to target.

> EmergencyAdminManaged::commitEmergencyAdmin()
> OwnershipAdminManaged::commitOwnershipAdmin()
> ParameterAdminManaged::commitParameterAdmin()

Recommendation: Add the code.

```
    function commitEmergencyAdmin(address _e) external onlyEmergencyAdmin {
+       require(_e != address(0));
        futureEmergencyAdmin = _e;
    }
```

EmergencyAdminManaged.sol

---

6. Unchecked return values **[Low]**

- **Severity**: Low
- **Likelihood**: Low
- **Impact**: Low
- **Status**: Fixed

Description: The NFTVault contract uses the EnumerableSet library to `add` and `remove` values to the set. Both functions return boolean values when they're called:

```
    /**
        @notice Wrap a NFT(IERC721) into a ERC20 token.
        @param _nftAddr address of NFT contract
        @param _tokenId token id of the NFT
     */
    function wrap (
        address _nftAddr,
        uint256 _tokenId
    ) external payable nonReentrant {
        IERC721(_nftAddr).transferFrom(msg.sender, address(this), _tokenId);
        // Save nft record
        uint256 recordId = wrappedNfts.length;
        wrappedNfts.push(WrappedNFTInfo(_nftAddr, _tokenId, true));
        // Get FT Info
        uint256 wnftId = wnftIds[_nftAddr];
        address wnft;
        if(wnftId == 0) {
            // Create a new FT
            string memory wnftName;
            string memory wnftSymbol;
            (bool succeed, bytes memory result) =
_nftAddr.call(abi.encodeWithSignature("name()"));
            if(succeed) {
                string memory nftName = abi.decode(result, (string));
                wnftName = string(abi.encodePacked(nftName, " Wrapped NFT"));
            } else {
                wnftName = string(abi.encodePacked("Litra FT#", wnftId));
            }
            (succeed, result) = _nftAddr.call(abi.encodeWithSignature("symbol()"));
            if(succeed) {
                string memory nftSymbol = abi.decode(result, (string));
                wnftSymbol = string(abi.encodePacked(nftSymbol, "wnft"));
            } else {
                wnftSymbol = string(abi.encodePacked("LWNFT#", wnftId));
            }
            wnft = address(new WrappedNFT(wnftName, wnftSymbol));
            // get ftId
            uint256 _nextWnftId = nextWnftId;
            wnftId = _nextWnftId;
            _nextWnftId ++;
            nextWnftId = _nextWnftId;
            // storage
            wnfts[wnftId] = WNFTInfo(_nftAddr, wnft);
            wnftIds[_nftAddr] = wnftId;
            wnftIds[wnft] = wnftId;

            emit CreateWrappedNFT(_nftAddr, wnftId, wnft);
        } else {
            wnft = wnfts[wnftId].wnftAddr;
        }
        // bound FT and NFT
        _nfts[wnftId].add(recordId);
        // mint and charge fee
        uint256 fee;
        if(address(feeManager) != address(0)) {
            fee = feeManager.wrapFee(wnft);
        }
        if(fee > 0) {
            WrappedNFT(wnft).mint(address(feeManager), fee);
        }
        WrappedNFT(wnft).mint(msg.sender, 1e18 - fee);

        emit Wrap(msg.sender, wnftId, recordId);
    }
```

NFTVault.sol

```
    /**
        @notice Redeem nft from vault and burn one FT
        @param _wnftId index of fts
        @param _nftId Greate than or equal 0 to redeem a designated nft with a more fees
                        Less than 0 to redeem a recent fungiblized nft with a normal fee
     */
    function unwrap(uint256 _wnftId, uint256 _nftId) external payable nonReentrant {
        WNFTInfo memory ftInfo = wnfts[_wnftId];
        require(ftInfo.nftAddr != address(0), "Invalid FT");
        require(WrappedNFT(ftInfo.wnftAddr).balanceOf(msg.sender) >= 1e18, "Insufficient
ft");
        require(_nfts[_wnftId].length() > 0, "No NFT in vault");
        require(_nfts[_wnftId].contains(uint256(_nftId)), "Invalid nftId");
        // burn ft and charge fee
        uint256 fee;
        if(address(feeManager) != address(0)) {
            fee = feeManager.unwrapFee(ftInfo.wnftAddr);
        }
        if(fee > 0) {
            WrappedNFT(ftInfo.wnftAddr).transferFrom(msg.sender, address(feeManager),
fee);
        }
        WrappedNFT(ftInfo.wnftAddr).transferFrom(msg.sender, address(this), 1e18);
        WrappedNFT(ftInfo.wnftAddr).burn(1e18);
        // return nft
        WrappedNFTInfo memory nftInfo = wrappedNfts[_nftId];
        wrappedNfts[_nftId].inVault = false;
        _nfts[_wnftId].remove(_nftId);
        IERC721(nftInfo.nftAddr).safeTransferFrom(address(this), msg.sender,
nftInfo.tokenId);

        emit Unwrap(msg.sender, _wnftId, _nftId);
    }
```

NFTVault.sol

Therefore, there should be a check to validate that the addition or removal from the set was correct. Otherwise, every time the function is called, the owner will have to check using getter functions.

Recommendation: Check the return values using either assert() or require() statements.

```
-        _nfts[wnftId].add(recordId);
+        require(_nfts[wnftId].add(recordId));
```

NFTVault.sol

Informational

7. Missing event records **[Informational]**

   Status: Fixed

   Description: In the `EmergencyAdminManaged`, `OwnershipAdminManaged`, `ParameterAdminManaged`, and `Stoppable` contracts, privileged accounts can set Admin privileges and `stopped` status through privileged functions respectively, but no event logging is performed. And, in `FeeManager` contract, user will call `setWrapFee()` & `setUnwrapFee()` to change the status, but no event logging.

```
pragma solidity ^0.8.0;

import "./OwnershipAdminManaged.sol";

abstract contract EmergencyAdminManaged is OwnershipAdminManaged {
    address public emergencyAdmin;
    address public futureEmergencyAdmin;

    constructor(address _e) {
        emergencyAdmin = _e;
    }

    modifier onlyEmergencyAdmin {
        require(msg.sender == emergencyAdmin, "! emergency admin");
        _;
    }

    function commitEmergencyAdmin(address _e) external onlyEmergencyAdmin {
        futureEmergencyAdmin = _e;
    }

    function applyEmergencyAdmin() external {
        require(msg.sender == futureEmergencyAdmin, "! emergency admin");
        emergencyAdmin = futureEmergencyAdmin;
    }
}
```

EmergencyAdminManaged.sol

Events are important because off-chain monitoring tools rely on them to index important state changes to the smart contract(s).

Recommendation: Consider emitting events when state changes are performed in the `EmergencyAdminManaged`, `OwnershipAdminManaged`, `ParameterAdminManaged`, `Stoppable` and `FeeManager` contract.

---

8. Best Practices **[Informational]**

    Status: Fixed

    Description: Some storage variables should be immutable Marking these as immutable (as they never change outside the constructor) would avoid them taking space in the storage.

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.8.0;

import "./admin/Stoppable.sol";
import "../interfaces/IBurner.sol";
import "../interfaces/IFeeManager.sol";
import "./admin/ParameterAdminManaged.sol";

import "@openzeppelin/contracts/token/ERC20/IERC20.sol";

contract FeeManager is IFeeManager, Stoppable, ParameterAdminManaged {
    struct Fee {
        bool initialized;
        uint256 value;
    }

    address public vault;
    ...
```

FeeManager.sol

Recommendation: Change the code in #L17.

```
-    address public vault;
+    address public immutable vault;
```

FeeManager.sol

9. Best Practices **[Informational]**

    Status: Fixed

    Description: In the `EmergencyAdminManaged`, `OwnershipAdminManaged` and `ParameterAdminManaged` contracts, privileged accounts can each set administrative privileges via privileged functions, where a transition account `future` exists so that the `future` account in the future can be upgraded to administrator by calling the applyAdmin() privilege function.

    However, the call to applyAdmin() does not reset `future`, making the calling account both `Admin` and `future`.

```
pragma solidity ^0.8.0;
```

```
import "./OwnershipAdminManaged.sol";

abstract contract EmergencyAdminManaged is OwnershipAdminManaged {
    address public emergencyAdmin;
    address public futureEmergencyAdmin;

    constructor(address _e) {
        emergencyAdmin = _e;
    }

    modifier onlyEmergencyAdmin {
        require(msg.sender == emergencyAdmin, "! emergency admin");
        _;
    }

    function commitEmergencyAdmin(address _e) external onlyEmergencyAdmin {
        futureEmergencyAdmin = _e;
    }

    function applyEmergencyAdmin() external {
        require(msg.sender == futureEmergencyAdmin, "! emergency admin");
        emergencyAdmin = futureEmergencyAdmin;
    }
}
```

EmergencyAdminManaged.sol

Recommendation: Add the code.

```
    function applyEmergencyAdmin() external {
        require(msg.sender == futureEmergencyAdmin, "! emergency admin");
        emergencyAdmin = futureEmergencyAdmin;
+       futureEmergencyAdmin = address(0);
    }
```

EmergencyAdminManaged.sol

Disclaimer

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