
Thunder Loan Protocol Audit Report

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Contents

Table of Contents	3
Protocol Summary	3
Disclaimer	3
Risk Classification	4
Audit Details	4
Scope	4
Protocol Summary	4
Roles	5
Executive Summary	5
Issues found	5
Findings	5
High	5
[H-1] Mixing up variable location causes storage collisions in ThunderLoan::s_flashLoanFee and ThunderLoan::s_currentlyFlashLoaning	5
[H-2] Unnecessary updateExchangeRate in deposit function incorrectly updates exchangeRate preventing withdraws and unfairly changing reward distribution	7
[H-3] By calling a flashloan and then ThunderLoan::deposit instead of ThunderLoan::repay users can steal all funds from the protocol	7
[H-4] getPriceOfOnePoolTokenInWeth uses the TSwap price which doesn't account for decimals, also fee precision is 18 decimals	7
Medium	7
[M-1] Centralization risk for trusted owners	7
[M-2] Using TSwap as price oracle leads to price and oracle manipulation attacks	8
[M-4] Fee on transfer, rebase, etc	9
Low	9
[L-1] Empty Function Body - Consider commenting why	9
[L-2] Initializers could be front-run	9
[L-3] Missing critical event emissions	9
Informational	10
[I-1] Poor Test Coverage	10

[I-2] Not using <code>__gap [50]</code> for future storage collision mitigation	10
[I-3] Different decimals may cause confusion. ie: AssetToken has 18, but asset has 6 . .	10
[I-4] Doesn't follow https://eips.ethereum.org/EIPS/eip-3156	10
Gas	11
[GAS-1] Using bools for storage incurs overhead	11
[GAS-2] Using <code>private</code> rather than <code>public</code> for constants, saves gas	11
[GAS-3] Unnecessary SLOAD when logging new exchange rate	11

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Table of Contents

- Table of Contents
- Protocol Summary
- Disclaimer
- Risk Classification
- Audit Details
 - Scope
 - Roles
- Executive Summary
 - Issues found
- Findings
- High
- Informational

Protocol Summary

A flash loan is a loan that exists for exactly 1 transaction. A user can borrow any amount of assets from the protocol as long as they pay it back in the same transaction. If they don't pay it back, the transaction reverts and the loan is cancelled.

Users additionally have to pay a small fee to the protocol depending on how much money they borrow. To calculate the fee, we're using the famous on-chain TSwap price oracle.

Disclaimer

The Linxun team makes all effort to find as many vulnerabilities in the code in the given time period, but holds no responsibilities for the findings provided in this document. A security audit by the team is not an endorsement of the underlying business or product. The audit was time-boxed and the review of the code was solely on the security aspects of the Solidity implementation of the contracts.

Risk Classification

		Impact		
		High	Medium	Low
Likelihood	High	H	H/M	M
	Medium	H/M	M	M/L
	Low	M	M/L	L

We use the CodeHawks severity matrix to determine severity. See the documentation for more details.

Audit Details

The findings described in this document correspond the following commit hash:

```
1 8803f851f6b37e99eab2e94b4690c8b70e26b3f6
```

Scope

```
1  |-- interfaces
2  |   |-- IFlashLoanReceiver.sol
3  |   |-- IPoolFactory.sol
4  |   |-- ISwapPool.sol
5  |   |-- IThunderLoan.sol
6  |-- protocol
7  |   |-- AssetToken.sol
8  |   |-- OracleUpgradeable.sol
9  |   |-- ThunderLoan.sol
10 |-- upgradedProtocol
11    |-- ThunderLoanUpgraded.sol
```

Protocol Summary

A flash loan is a loan that exists for exactly 1 transaction. A user can borrow any amount of assets from the protocol as long as they pay it back in the same transaction. If they don't pay it back, the transaction reverts and the loan is cancelled.

Users additionally have to pay a small fee to the protocol depending on how much money they borrow. To calculate the fee, we're using the famous on-chain TSwap price oracle.

Roles

- Owner: The owner of the protocol who has the power to upgrade the implementation.
- Liquidity Provider: A user who deposits assets into the protocol to earn interest.
- User: A user who takes out flash loans from the protocol.

Executive Summary

Issues found

Severity	Number of issues found
High	4
Medium	3
Low	3
Info	4
Gas Optimizations	2
Total	16

Findings

High

[H-1] Mixing up variable location causes storage collisions in `ThunderLoan::s_flashLoanFee` and `ThunderLoan::s_currentlyFlashLoaning`

Description: `ThunderLoan.sol` has two variables in the following order:

```
1     uint256 private s_feePrecision;  
2     uint256 private s_flashLoanFee; // 0.3% ETH fee
```

However, the expected upgraded contract `ThunderLoanUpgraded.sol` has them in a different order.

```
1      uint256 private s_flashLoanFee; // 0.3% ETH fee
2      uint256 public constant FEE_PRECISION = 1e18;
```

Due to how Solidity storage works, after the upgrade, the `s_flashLoanFee` will have the value of `s_feePrecision`. You cannot adjust the positions of storage variables when working with upgradeable contracts.

Impact: After upgrade, the `s_flashLoanFee` will have the value of `s_feePrecision`. This means that users who take out flash loans right after an upgrade will be charged the wrong fee. Additionally the `s_currentlyFlashLoaning` mapping will start on the wrong storage slot.

Proof of Code:

Code

Add the following code to the `ThunderLoanTest.t.sol` file.

```
1 // You'll need to import `ThunderLoanUpgraded` as well
2 import { ThunderLoanUpgraded } from "../../src/upgradedProtocol/
   ThunderLoanUpgraded.sol";
3
4 function testUpgradeBreaks() public {
5     uint256 feeBeforeUpgrade = thunderLoan.getFee();
6     vm.startPrank(thunderLoan.owner());
7     ThunderLoanUpgraded upgraded = new ThunderLoanUpgraded();
8     thunderLoan.upgradeTo(address(upgraded));
9     uint256 feeAfterUpgrade = thunderLoan.getFee();
10
11     assert(feeBeforeUpgrade != feeAfterUpgrade);
12 }
```

You can also see the storage layout difference by running `forge inspect ThunderLoan storage` and `forge inspect ThunderLoanUpgraded storage`

Recommended Mitigation: Do not switch the positions of the storage variables on upgrade, and leave a blank if you're going to replace a storage variable with a constant. In `ThunderLoanUpgraded.sol`:

```
1 -      uint256 private s_flashLoanFee; // 0.3% ETH fee
2 -      uint256 public constant FEE_PRECISION = 1e18;
3 +      uint256 private s_blank;
4 +      uint256 private s_flashLoanFee;
5 +      uint256 public constant FEE_PRECISION = 1e18;
```

[H-2] Unnecessary updateExchangeRate in deposit function incorrectly updates exchangeRate preventing withdraws and unfairly changing reward distribution**Description:**

```
1      function deposit(IERC20 token, uint256 amount) external
2          revertIfZero(amount) revertIfNotAllowedToken(token) {
3          AssetToken assetToken = s_tokenToAssetToken[token];
4          uint256 exchangeRate = assetToken.getExchangeRate();
5          uint256 mintAmount = (amount * assetToken.
6              EXCHANGE_RATE_PRECISION()) / exchangeRate;
7          emit Deposit(msg.sender, token, amount);
8          assetToken.mint(msg.sender, mintAmount);
9          uint256 calculatedFee = getCalculatedFee(token, amount);
10         assetToken.updateExchangeRate(calculatedFee);
11         token.safeTransferFrom(msg.sender, address(assetToken), amount)
12         ;
13     }
```

Impact:**Proof of Concept:****Recommended Mitigation:****[H-3] By calling a flashloan and then ThunderLoan::deposit instead of ThunderLoan::repay users can steal all funds from the protocol****[H-4] getPriceOfOnePoolTokenInWeth uses the TSwap price which doesn't account for decimals, also fee precision is 18 decimals****Medium****[M-1] Centralization risk for trusted owners**

Impact: Contracts have owners with privileged rights to perform admin tasks and need to be trusted to not perform malicious updates or drain funds.

Instances (2):

```
1 File: src/protocol/ThunderLoan.sol
2
3 223:     function setAllowedToken(IERC20 token, bool allowed) external
4         onlyOwner returns (AssetToken) {
5
6 261:     function _authorizeUpgrade(address newImplementation) internal
7         override onlyOwner { }
```


Contralized owners can brick redemptions by disapproving of a specific token**[M-2] Using TSwap as price oracle leads to price and oracle manipulation attacks**

Description: The TSwap protocol is a constant product formula based AMM (automated market maker). The price of a token is determined by how many reserves are on either side of the pool. Because of this, it is easy for malicious users to manipulate the price of a token by buying or selling a large amount of the token in the same transaction, essentially ignoring protocol fees.

Impact: Liquidity providers will drastically reduced fees for providing liquidity.

Proof of Concept:

The following all happens in 1 transaction.

1. User takes a flash loan from [ThunderLoan](#) for 1000 [tokenA](#). They are charged the original fee [fee1](#). During the flash loan, they do the following:
 1. User sells 1000 [tokenA](#), tanking the price.
 2. Instead of repaying right away, the user takes out another flash loan for another 1000 [tokenA](#).
 1. Due to the fact that the way [ThunderLoan](#) calculates price based on the [TSwapPool](#) this second flash loan is substantially cheaper.
3. The user then repays the first flash loan, and then repays the second flash loan.

I have created a proof of code located in my [audit-data](#) folder. It is too large to include here.

Recommended Mitigation: Consider using a different price oracle mechanism, like a Chainlink price feed with a Uniswap TWAP fallback oracle.

[M-4] Fee on transfer, rebase, etc**Low****[L-1] Empty Function Body - Consider commenting why***Instances (1):*

```
1 File: src/protocol/ThunderLoan.sol
2
3 261:     function _authorizeUpgrade(address newImplementation) internal
      override onlyOwner { }
```

[L-2] Initializers could be front-run

Initializers could be front-run, allowing an attacker to either set their own values, take ownership of the contract, and in the best case forcing a re-deployment

Instances (6):

```
1 File: src/protocol/OracleUpgradeable.sol
2
3 11:     function __Oracle_init(address poolFactoryAddress) internal
      onlyInitializing { }
```

```
1 File: src/protocol/ThunderLoan.sol
2
3 138:     function initialize(address tswapAddress) external initializer
      {
4
5 138:     function initialize(address tswapAddress) external initializer
      {
6
7 139:         __Ownable_init();
8
9 140:         __UUPSUpgradeable_init();
10
11 141:         __Oracle_init(tswapAddress);
```

[L-3] Missing critical event emissions

Description: When the `ThunderLoan::s_flashLoanFee` is updated, there is no event emitted.

Recommended Mitigation: Emit an event when the `ThunderLoan::s_flashLoanFee` is updated.

```

1 +   event FlashLoanFeeUpdated(uint256 newFee);
2   .
3   .
4   .
5   function updateFlashLoanFee(uint256 newFee) external onlyOwner {
6       if (newFee > s_feePrecision) {
7           revert ThunderLoan__BadNewFee();
8       }
9       s_flashLoanFee = newFee;
10 +   emit FlashLoanFeeUpdated(newFee);
11   }

```

Informational

[I-1] Poor Test Coverage

1 Running tests...				
2	File		% Lines	% Statements
3	% Branches	% Funcs		
3	-----	-----	-----	-----
4	src/protocol/AssetToken.sol		70.00% (7/10)	76.92% (10/13)
	50.00% (1/2)	66.67% (4/6)		
5	src/protocol/OracleUpgradeable.sol		100.00% (6/6)	100.00% (9/9)
	100.00% (0/0)	80.00% (4/5)		
6	src/protocol/ThunderLoan.sol		64.52% (40/62)	68.35% (54/79)
	37.50% (6/16)	71.43% (10/14)		

[I-2] Not using `__gap[50]` for future storage collision mitigation

[I-3] Different decimals may cause confusion. ie: AssetToken has 18, but asset has 6

[I-4] Doesn't follow <https://eips.ethereum.org/EIPS/eip-3156>

Recommended Mitigation: Aim to get test coverage up to over 90% for all files.

Gas

[GAS-1] Using bools for storage incurs overhead

Use `uint256(1)` and `uint256(2)` for true/false to avoid a `Gwarmaccess` (100 gas), and to avoid `Gs-set` (20000 gas) when changing from 'false' to 'true', after having been 'true' in the past. See source.

Instances (1):

```
1 File: src/protocol/ThunderLoan.sol
2
3 98:      mapping(IERC20 token => bool currentlyFlashLoaning) private
         s_currentlyFlashLoaning;
```

[GAS-2] Using private rather than public for constants, saves gas

If needed, the values can be read from the verified contract source code, or if there are multiple values there can be a single getter function that returns a tuple of the values of all currently-public constants. Saves **3406-3606 gas** in deployment gas due to the compiler not having to create non-payable getter functions for deployment calldata, not having to store the bytes of the value outside of where it's used, and not adding another entry to the method ID table

Instances (3):

```
1 File: src/protocol/AssetToken.sol
2
3 25:      uint256 public constant EXCHANGE_RATE_PRECISION = 1e18;
```

```
1 File: src/protocol/ThunderLoan.sol
2
3 95:      uint256 public constant FLASH_LOAN_FEE = 3e15; // 0.3% ETH fee
4
5 96:      uint256 public constant FEE_PRECISION = 1e18;
```

[GAS-3] Unnecessary SLOAD when logging new exchange rate

In `AssetToken::updateExchangeRate`, after writing the `newExchangeRate` to storage, the function reads the value from storage again to log it in the `ExchangeRateUpdated` event.

To avoid the unnecessary SLOAD, you can log the value of `newExchangeRate`.

```
1 s_exchangeRate = newExchangeRate;
2 - emit ExchangeRateUpdated(s_exchangeRate);
3 + emit ExchangeRateUpdated(newExchangeRate);
```