



AAVE

# **Aave v3.0.1 Contract Review**

*Version: 1.0*

**December, 2022**

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## Introduction

Sigma Prime was commercially engaged to perform a time-boxed security review of the Aave smart contracts. The review focused solely on the security aspects of the Solidity implementation of the contract, though general recommendations and informational comments are also provided.

## Disclaimer

Sigma Prime makes all effort but holds no responsibility for the findings of this security review. Sigma Prime does not provide any guarantees relating to the function of the smart contract. Sigma Prime makes no judgements on, or provides any security review, regarding the underlying business model or the individuals involved in the project.

## Document Structure

The first section provides an overview of the functionality of the Aave smart contracts contained within the scope of the security review. A summary followed by a detailed review of the discovered vulnerabilities is then given which assigns each vulnerability a severity rating (see [Vulnerability Severity Classification](#)), an *open/closed/resolved* status and a recommendation. Additionally, findings which do not have direct security implications (but are potentially of interest) are marked as *informational*.

Outputs of automated testing that were developed during this assessment are also included for reference (in the Appendix: [Test Suite](#)).

The appendix provides additional documentation, including the severity matrix used to classify vulnerabilities within the Aave smart contracts.

## Overview

Aave `v3.0.1` is an update to the [aave-v3-core](#) repository. The following are a list of changes implemented in `v3.0.1`:

- ATokens transfer events have been updated to be ERC20 compliant.
- Patch to prevent reentrancy on withdrawals and liquidations, only applies to reentrant tokens (e.g. ERC777).
- Allows borrows and repays to occur in the same block.
- Adds a return value for `backUnbacked()`.
- Adds a configuration parameter to a reserve to disable flash loans for a collateral.
- Fix edge case for liquidations if protocol fee is greater than user balance.
- Patches a bug when reserve factor is 100%.
- Optimises state updates if the timestamp is unchanged.

## Security Assessment Summary

This review was conducted on the files hosted on the [aave-v3-core repository](#) and assessed updates from v3.0.0 to v3.0.1 as seen in PR [#701 @ 84b900c](#).

*Note: the OpenZeppelin libraries and dependencies were excluded from the scope of this assessment.*

The manual code review section of the report is focused on identifying any and all issues/vulnerabilities associated with the business logic implementation of the contracts. This includes their internal interactions, intended functionality and correct implementation with respect to the underlying functionality of the Ethereum Virtual Machine (for example, verifying correct storage/memory layout). Additionally, the manual review process focused on all known Solidity anti-patterns and attack vectors. These include, but are not limited to, the following vectors: re-entrancy, front-running, integer overflow/underflow and correct visibility specifiers. For a more thorough, but non-exhaustive list of examined vectors, see [\[1, 2\]](#).

To support this review, the testing team used the following automated testing tools:

- Mythril: <https://github.com/ConsenSys/mythril>
- Slither: <https://github.com/trailofbits/slither>
- Surya: <https://github.com/ConsenSys/surya>

Output for these automated tools is available upon request.

## Findings Summary

The testing team identified a total of 2 issues during this assessment. Categorised by their severity:

- Informational: 2 issues.

## Detailed Findings

This section provides a detailed description of the vulnerabilities identified within the Aave smart contracts. Each vulnerability has a severity classification which is determined from the likelihood and impact of each issue by the matrix given in the Appendix: [Vulnerability Severity Classification](#).

A number of additional properties of the contracts, including gas optimisations, are also described in this section and are labelled as “informational”.

Each vulnerability is also assigned a **status**:

- **Open:** the issue has not been addressed by the project team.
- **Resolved:** the issue was acknowledged by the project team and updates to the affected contract(s) have been made to mitigate the related risk.
- **Closed:** the issue was acknowledged by the project team but no further actions have been taken.

# Summary of Findings

ID	Description	Severity	Status
AV301-01	Mint Event Is Emitted When Zero Value Is Minted	Informational	Resolved
AV301-02	Miscellaneous General Comments	Informational	Resolved

<b>AV301-01</b>	Mint Event Is Emitted When Zero Value Is Minted
Asset	ScaledBalanceTokenBase.sol
Status	<b>Resolved:</b> See <a href="#">Resolution</a>
Rating	Informational

## Description

Scaled balance tokens such as `aTokens` accrue interest and increase in value. When these tokens are transferred both the sender's and receiver's balances are checked for a balance increase. `Mint` events are always emitted for the sender and only for the receiver if there has been a balance increase.

```

138 function _transfer(
139     address sender,
140     address recipient,
141     uint256 amount,
142     uint256 index
143 ) internal {
144     uint256 senderScaledBalance = super.balanceOf(sender);
145     uint256 senderBalanceIncrease = senderScaledBalance.rayMul(index) -
146         senderScaledBalance.rayMul(_userState[sender].additionalData);
147     uint256 recipientScaledBalance = super.balanceOf(recipient);
148     uint256 recipientBalanceIncrease = recipientScaledBalance.rayMul(index) -
149         recipientScaledBalance.rayMul(_userState[recipient].additionalData);
150     _userState[sender].additionalData = index.toUint128();
151     _userState[recipient].additionalData = index.toUint128();
152
153     super._transfer(sender, recipient, amount.rayDiv(index).toUint128());
154
155     emit Transfer(address(0), sender, senderBalanceIncrease);
156     emit Mint(_msgSender(), sender, senderBalanceIncrease, senderBalanceIncrease, index);
157
158     if (recipientBalanceIncrease > 0) {
159         emit Transfer(address(0), recipient, recipientBalanceIncrease);
160         emit Mint(_msgSender(), recipient, recipientBalanceIncrease, recipientBalanceIncrease, index);
161     }

```

It is expected for the case where `senderBalanceIncrease = 0` to occur if a sender makes multiple actions in the same block. One example is making two transfers as the first transfer will update the `_userState[sender].additionalData` to the current `index`. The second transfer will then have `_userState[sender].additionalData = index` and hence `senderBalanceIncrease` will be zero.

The impact of the issue is informational. Emitting zero value events will increase gas costs and increase the load of processing events off-chain. There are no funds at risk and the events will always display the correct values.

## Recommendations

The issue may be resolved by only emitting the `Mint` event if the `senderBalanceIncrease` is non-zero.

## Resolution

The issue is resolved in PR [#745](#) by adding the following check.

```
if (senderBalanceIncrease > 0) {  
    emit Transfer(address(0), sender, senderBalanceIncrease);  
    emit Mint(msgSender(), sender, senderBalanceIncrease, senderBalanceIncrease, index);  
}
```



<b>AV301-02</b>	Miscellaneous General Comments
Asset	contracts/*
Status	<b>Resolved:</b> See <a href="#">Resolution</a>
Rating	Informational

## Description

This section details miscellaneous findings discovered by the testing team that do not have direct security implications:

### 1. `ReserveCache.currLiquidityIndex` is no longer necessary.

The variable `currLiquidityIndex` is cached in `ReserveCache` to help minimise storage load operations. This variable is only ever used in `_updateIndexes()`. It is safe to remove this variable and instead use `nextLiquidityIndex` during `_updateIndexes()`.

### 2. Camel Case inconsistencies in the use of `flashLoan` and `flashloan`.

Consider updating the the following types to have an upper-case "L":

- `ValidationLogic.validateFlashloanSimple()`
- `DataTypes.FlashloanSimpleParams`
- `ValidationLogic.validateFlashloan()`
- `DataTypes.FlashloanParams`
- `Pool.updateFlashloanPremiums()` and `IPool.updateFlashloanPremiumTotal()`
- `IPoolConfigurator.FlashloanPremiumTotalUpdated` event and parameters `oldFlashloanPremiumTotal` and `newFlashloanPremiumTotal`
- `IPoolConfigurator.FlashloanPremiumToProtocolUpdated` event and parameters `oldFlashloanPremiumTotal` and `newFlashloanPremiumTotal`
- `IPoolConfigurator` and `PoolConfigurator` function `updateFlashloanPremiumTotal()` function (also parameters and local variables for this function)
- `IPoolConfigurator` and `PoolConfigurator` function `updateFlashloanPremiumToProtocol()` function (also parameters and local variables for this function)

## Recommendations

Ensure that the comments are understood and acknowledged, and consider implementing the suggestions above.

## Resolution

The development team have opted not to remove `currLiquidityIndex`. The reason is that the current logic matches `currVariableBorrowIndex` and `nextVariableBorrowIndex`, modifying `currLiquidityIndex` will cause inconsistencies between these two variables and complicate the code base.

The discrepancies between `flashloan` and `flashLoan` require changes to interfaces which impact users of the smart contracts. Changes will not be made in a minor patch and will be implemented in a future update.

## Appendix A Test Suite

A non-exhaustive list of tests were constructed to aid this security review and are provided alongside this document. The `brownie` framework was used to perform these tests and the output is given below.

test_borrow	PASSED	[0%]
test_borrow_isolation_mode	PASSED	[1%]
test_repay	PASSED	[2%]
test_repay_isolation_mode	PASSED	[2%]
test_rebalance_stable_borrow_rate	PASSED	[3%]
test_swap_borrow_rate_mode_stable	PASSED	[4%]
test_swap_borrow_rate_mode_variable	PASSED	[4%]
test_mint_unbacked	PASSED	[5%]
test_mint_unbacked_supply_and_borrows	PASSED	[6%]
test_mint_unbacked_cap	PASSED	[6%]
test_mint_unbacked_zero	PASSED	[7%]
test_only_bridge_modifier	PASSED	[8%]
test_back_unbacked	PASSED	[8%]
test_back_unbacked_erc20_fails	PASSED	[9%]
test_set_user_emode	PASSED	[10%]
test_flashloan_repay	PASSED	[11%]
test_flashloan_borrow	PASSED	[11%]
test_flashloan_simple	PASSED	[12%]
test_liquidation_call	PASSED	[13%]
test_linear_interest	PASSED	[13%]
test_linear_interest_one_year	PASSED	[14%]
test_linear_interest_max_values	PASSED	[15%]
test_linear_interest_zero	PASSED	[15%]
test_compound_interest	PASSED	[16%]
test_compound_interest_overflows	PASSED	[17%]
test_compound_interest_zero	PASSED	[17%]
test_percent_mul	PASSED	[18%]
test_percent_mul_zero	PASSED	[19%]
test_percent_mul_overflow	PASSED	[20%]
test_percent_div	PASSED	[20%]
test_percent_div_zero	PASSED	[21%]
test_percent_div_overflow	PASSED	[22%]
test_init_reserves	PASSED	[22%]
test_drop_reserve	PASSED	[23%]
test_update_atoken	PASSED	[24%]
test_update_stable_debt_token	PASSED	[24%]
test_update_variable_debt_token	PASSED	[25%]
test_set_reserve_borrowing	PASSED	[26%]
test_configure_reserve_as_collateral	PASSED	[26%]
test_configure_reserve_as_collateral_large_ltv	PASSED	[27%]
test_configure_reserve_as_collateral_non_zero_bonus	PASSED	[28%]
test_configure_reserve_as_collateral_excessive_bonus	PASSED	[28%]
test_configure_reserve_as_collateral_small_bonus	PASSED	[29%]
test_configure_reserve_as_collateral_supply	PASSED	[30%]
test_set_reserve_stable_rate_borrowing	PASSED	[31%]
test_set_reserve_active	PASSED	[31%]
test_set_reserve_active_atokens	PASSED	[32%]
test_set_reserve_freeze	PASSED	[33%]
test_set_borrowable_in_isolation	PASSED	[33%]
test_set_reserve_pause	PASSED	[34%]
test_set_reserve_factor	PASSED	[35%]
test_set_debt_ceiling	PASSED	[35%]
test_set_borrow_cap	PASSED	[36%]
test_set_supply_cap	PASSED	[37%]
test_set_liquidation_protocol_fee	PASSED	[37%]
test_set_emode_category	PASSED	[38%]
test_set_emode_category_invalid_cases	PASSED	[39%]
test_set_emode_category_below_asset	PASSED	[40%]
test_set_asset_emode_category	PASSED	[40%]
test_set_asset_emode_category_invalid_threshold	PASSED	[41%]
test_set_unbacked_mint_cap	PASSED	[42%]

test_set_pool_paused	PASSED	[42%]
test_update_bridge_protocol_fee	PASSED	[43%]
test_update_flash_loan_premium_total	PASSED	[44%]
test_update_flash_loan_premium_to_protocol	PASSED	[44%]
test_only_pool_admin	PASSED	[45%]
test_only_emergency_admin	PASSED	[46%]
test_only_emergency_or_pool_admin	PASSED	[46%]
test_only_asset_listing_or_pool_admins	PASSED	[47%]
test_only_risk_or_pool_admins	PASSED	[48%]
test_supply	PASSED	[48%]
test_withdraw	PASSED	[49%]
test_withdraw_bad_hf	PASSED	[50%]
test_finalize_transfer	PASSED	[51%]
test_finalize_transfer_bad_hf	PASSED	[51%]
test_set_user_use_reserve_as_collateral	PASSED	[52%]
test_set_user_use_reserve_as_collateral_bad_hf	PASSED	[53%]
test_set_user_use_reserve_as_collateral_twice	PASSED	[53%]
test_set_user_use_reserve_as_collateral_isolation_mode	PASSED	[54%]
test_validate_supply_paused	PASSED	[55%]
test_validate_supply_frozen	PASSED	[55%]
test_validate_supply_active	PASSED	[56%]
test_validate_supply_amount_zero	PASSED	[57%]
test_validate_supply_cap	PASSED	[57%]
test_validate_withdraw_paused	PASSED	[58%]
test_validate_withdraw_frozen	PASSED	[59%]
test_validate_withdraw_amount_zero	PASSED	[60%]
test_validate_withdraw_insufficient_balance	PASSED	[60%]
test_validate_borrow_paused	PASSED	[61%]
test_validate_borrow_frozen	PASSED	[62%]
test_validate_borrow_amount_zero	PASSED	[62%]
test_validate_borrow_borrowing_disabled	PASSED	[63%]
test_validate_borrow_price_oracle_sentinel_disallowed	PASSED	[64%]
test_validate_borrow_interest_rate_mode	PASSED	[64%]
test_validate_borrow_borrow_cap	PASSED	[65%]
test_validate_borrow_isolation_not_borrowable	PASSED	[66%]
test_validate_borrow_isolation_debt_ceiling	PASSED	[66%]
test_validate_borrow_emode_category	PASSED	[67%]
test_validate_borrow_zero_collateral	PASSED	[68%]
test_validate_borrow_bad_hf	PASSED	[68%]
test_validate_borrow_insufficient_collateral	PASSED	[69%]
test_validate_borrow_stable_disabled	PASSED	[70%]
test_validate_borrow_collateral_currency	PASSED	[71%]
test_validate_borrow_stable_max_size	PASSED	[71%]
test_validate_repay_paused	PASSED	[72%]
test_validate_repay_amount_zero	PASSED	[73%]
test_validate_repay_same_block_stable	PASSED	[73%]
test_validate_repay_same_block_variable	PASSED	[74%]
test_validate_repay_no_debt	PASSED	[75%]
test_validate_repay_max_on_behalf_of	PASSED	[75%]
test_validate_swap_rate_mode_paused	PASSED	[76%]
test_validate_swap_rate_mode_frozen	PASSED	[77%]
test_validate_swap_rate_mode_no_stable_debt	PASSED	[77%]
test_validate_swap_rate_mode_no_variable_debt	PASSED	[78%]
test_validate_swap_rate_mode_stable_disabled	PASSED	[79%]
test_validate_swap_rate_mode_stable_collateral	PASSED	[80%]
test_validate_rebalance_stable_borrow_rate_paused	PASSED	[80%]
test_validate_rebalance_stable_borrow_rate_criteria	PASSED	[81%]
test_validate_set_use_reserve_as_collateral_paused	PASSED	[82%]
test_validate_set_use_reserve_as_collateral_no_balance	PASSED	[82%]
test_validate_flash_loan_paused	PASSED	[83%]
test_validate_flash_loan_simple_paused	PASSED	[84%]
test_validate_flash_loan_disabled	PASSED	[84%]
test_validate_liquidation_call_paused	PASSED	[85%]
test_validate_liquidation_call_sentinel	PASSED	[86%]
test_validate_liquidation_call_health_factor	PASSED	[86%]
test_validate_liquidation_call_collateral_not_enabled	PASSED	[87%]
test_validate_liquidation_call_no_debt	PASSED	[88%]
test_validate_health_factor	PASSED	[88%]
test_validate_hf_and_ltv	PASSED	[89%]
test_validate_transfer	PASSED	[90%]

test_validate_drop_reserve_zero_address	PASSED	[91%]
test_validate_drop_reserve_invalid_asset	PASSED	[91%]
test_validate_drop_reserve_atoken	PASSED	[92%]
test_validate_drop_reserve_stable	PASSED	[93%]
test_validate_drop_reserve_variable	PASSED	[93%]
test_validate_set_user_emode_invalid_category	PASSED	[94%]
test_validate_set_user_emode_category_match_borrowings	PASSED	[95%]
test_getters	PASSED	[95%]
test_wad_mul	PASSED	[96%]
test_wad_div	PASSED	[97%]
test_ray_mul	PASSED	[97%]
test_ray_div	PASSED	[98%]
test_ray_to_wad	PASSED	[99%]
test_ray_mul_div_rounding	PASSED	[100%]

## Appendix B Vulnerability Severity Classification

This security review classifies vulnerabilities based on their potential impact and likelihood of occurrence. The total severity of a vulnerability is derived from these two metrics based on the following matrix.

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

Table 1: Severity Matrix - How the severity of a vulnerability is given based on the *impact* and the *likelihood* of a vulnerability.

## References

- [1] Sigma Prime. Solidity Security. Blog, 2018, Available: <https://blog.sigmaprime.io/solidity-security.html>. [Accessed 2018].
- [2] NCC Group. DASP - Top 10. Website, 2018, Available: <http://www.dasp.co/>. [Accessed 2018].

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