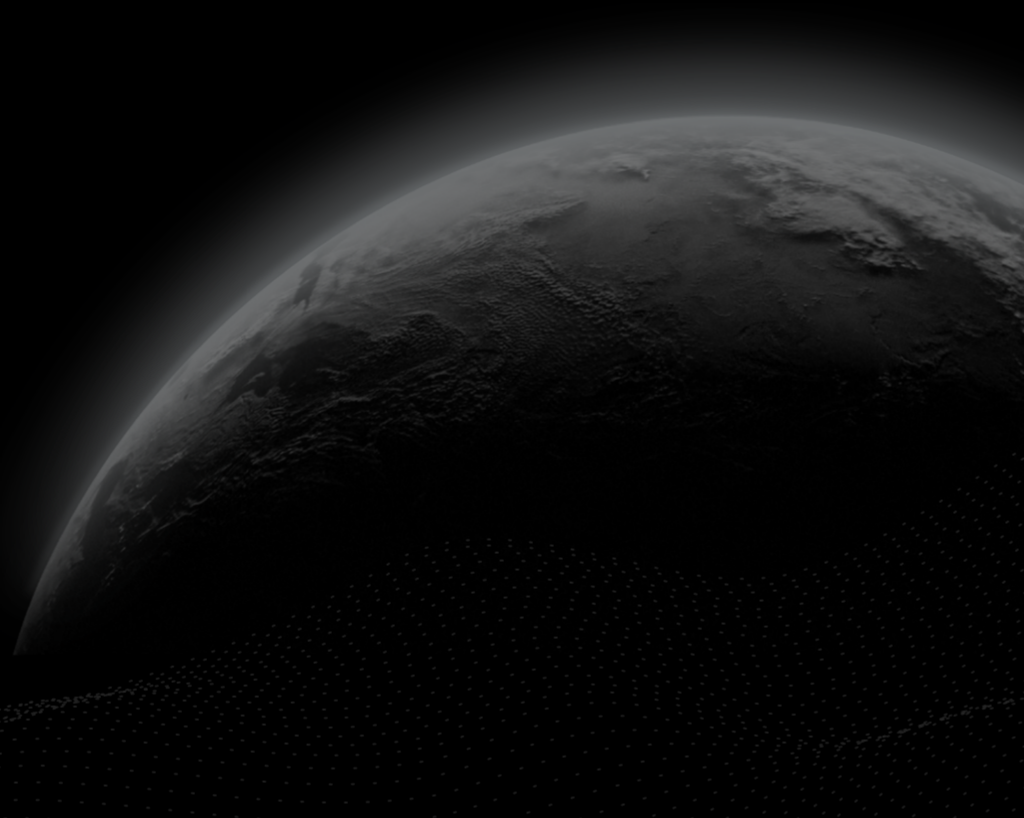
CERTIK

Preliminary Comments

STFX - V2 Staking

CertiK Verified on May 9th, 2023



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STFX - V2 Staking

These preliminary comments were prepared by CertiK, the leader in Web3.0 security.

Executive Summary

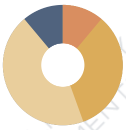
TYPES	ECOSYSTEM	METHODS
DeFi, Staking	Ethereum (ETH)	Formal Verification, Manual Review, Static Analysis

LANGUAGE	TIMELINE	KEY COMPONENTS
Solidity	Delivered on 05/09/2023	N/A

CODEBASE
https://github.com/STFX-IO/contracts-v2/tree/6abbb72e994862c912996b042addd26c8c4510c2
...View All

COMMITS
6abbb72e994862c912996b042addd26c8c4510c2
...View All

Vulnerability Summary



9	0	0	0	9	0	0
Total Findings	Resolved	Mitigated	Partially Resolved	Acknowledged	Declined	Unresolved

0	Critical		Critical risks are those that impact the safe functioning of a platform and must be addressed before launch. Users should not invest in any project with outstanding critical risks.
1	Major	1 Acknowledged	Major risks can include centralization issues and logical errors. Under specific circumstances, these major risks can lead to loss of funds and/or control of the project.
3	Medium	3 Acknowledged	Medium risks may not pose a direct risk to users' funds, but they can affect the overall functioning of a platform.
4	Minor	4 Acknowledged	Minor risks can be any of the above, but on a smaller scale. They generally do not compromise the overall integrity of the project, but they may be less efficient than other solutions.
1	Informational	1 Acknowledged	Informational errors are often recommendations to improve the style of the code or certain operations to fall within industry best practices. They usually do not affect the overall functioning of the code.
0	Discussion		The impact of the issue is yet to be determined, hence requires further clarifications from the project team.

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CODEBASE | STFX - V2 STAKING

Repository

https://github.com/STFX-IO/contracts-v2/tree/6abbb72e994862c912996b042addd26c8c4510c2

Commit

6abbb72e994862c912996b042addd26c8c4510c2

AUDIT SCOPE | STFX - V2 STAKING

1 file audited ● 1 file with Acknowledged findings

ID	File	SHA256 Checksum
● SST	src/Stake.sol	983b98a6063225e82fc7d282ed855ddc366b63be3bb2b833ec58c869182edf7e

APPROACH & METHODS | STFX - V2 STAKING

This report has been prepared for STFX to discover issues and vulnerabilities in the source code of the STFX - V2 Staking 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:

- Testing the smart contracts against both common and uncommon attack vectors;
- 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.

FINANCIAL MODELS | STFX - V2 STAKING

The audited contract is a staking protocol. The users can stake tokens and claim tokens as rewards, the interest rate depends on the staking period. Unstaking prematurely will be punished to burn tokens. The project owner should manually maintain sufficient rewards by transferring necessary tokens.

Financial models of blockchain protocols need to be resilient to attacks. They need to pass simulations and verifications to guarantee the security of the overall protocol. The financial model of this protocol is not in the scope of this audit.

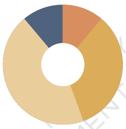
THIRD-PARTY DEPENDENCY | STFX - V2 STAKING

The contract is serving as the underlying entity to interact with one or more third-party protocols. The scope of the audit treats third-party entities as black boxes and assumes their functional correctness. However, in the real world, third parties can be compromised and this may lead to lost or stolen assets.

```
address public token;
```

We understand that business logic requires interaction with third parties. We encourage the team to constantly monitor the statuses of third parties to mitigate the side effects when unexpected activities are observed.

FINDINGS | STFX - V2 STAKING



9	0	1	3	4	1	0
Total Findings	Critical	Major	Medium	Minor	Informational	Discussion

This report has been prepared to discover issues and vulnerabilities for STFX - V2 Staking. Through this audit, we have uncovered 9 issues ranging from different severity levels. Utilizing the techniques of Static Analysis & Manual Review to complement rigorous manual code reviews, we discovered the following findings:

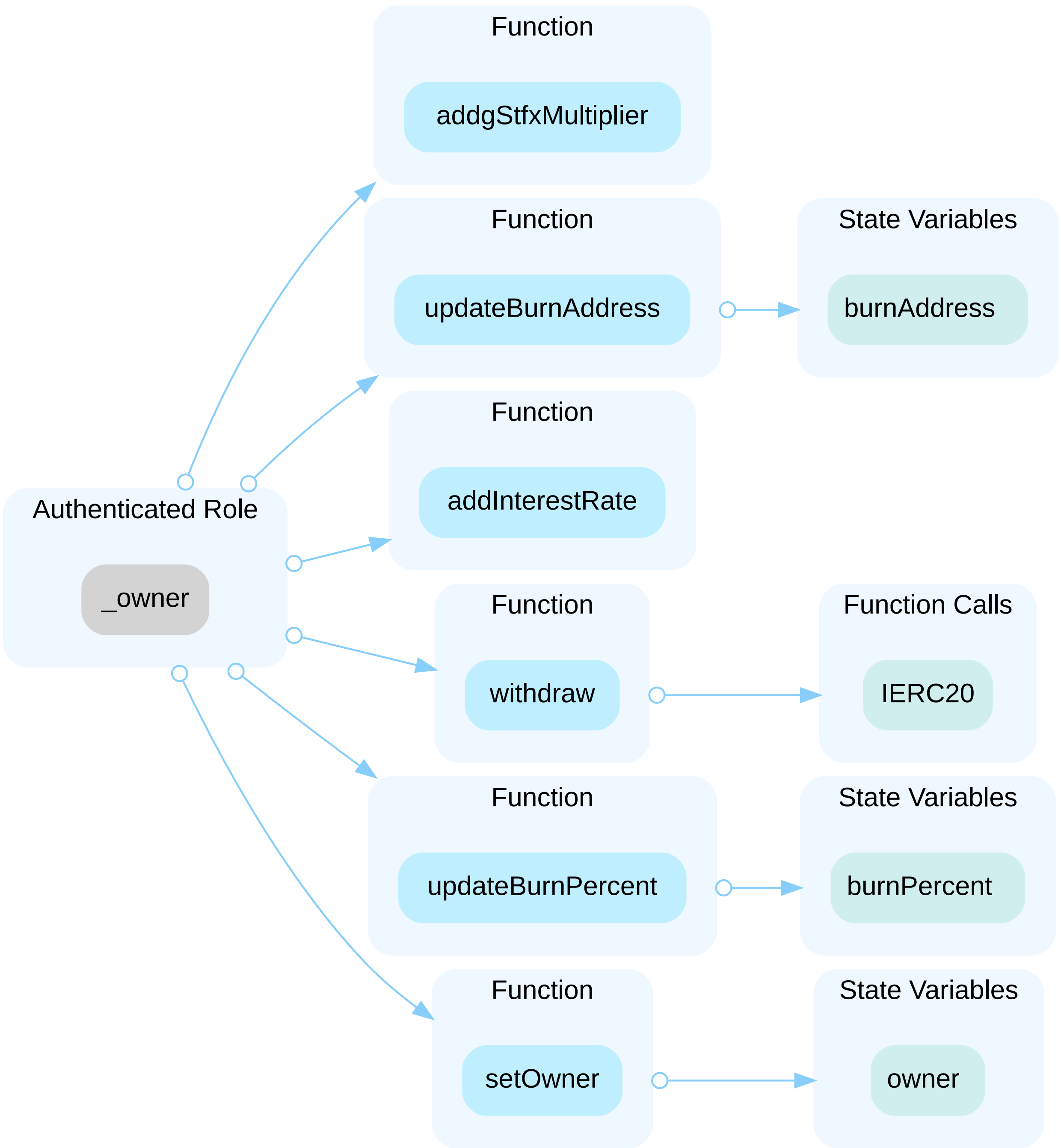
ID	Title	Category	Severity	Status
SST-01	**Centralization Risks In Stake.Sol**	**Centralization / Privilege**	**Major**	**Acknowledged**
SST-02	Incompatibility With Deflationary Tokens	Logical Issue	Medium	Acknowledged
SST-07	TotalStaked Not Deducted In Unstake And Claim	Logical Issue	Medium	Acknowledged
SST-08	Logical Issues In Withdraw Function	Logical Issue	Medium	Acknowledged
SST-03	Missing Zero Address Validation	Volatile Code	Minor	Acknowledged
SST-04	Unsafe Integer Cast	Logical Issue	Minor	Acknowledged
SST-06	Incorrect Checking For The Period	Logical Issue	Minor	Acknowledged
SST-09	Unchecked ERC-20 `transfer()` / `transferFrom()` Call	Volatile Code	Minor	Acknowledged
SST-05	Decimal Of InterestRate	Logical Issue	Informational	Acknowledged

SST-01 | CENTRALIZATION RISKS IN STAKE.SOL

Category	Severity	Location	Status
Centralization / Privilege	Major	src/Stake.sol: 269, 275, 281, 287, 293, 491	Acknowledged

Description

In the contract `Stake` the role `_owner` has authority over the functions shown in the diagram below.



This centralization risk may lead to a single point of failure and gives the owner significant control over the contract's behavior:

1. `setOwner(address newOwner)` - Allows the owner to change the contract ownership to a new address.
2. `addInterestRate(StakingPeriod period, uint96 rate)` - Allows the owner to add interest rates for different staking periods.
3. `addgStfxMultiplier(StakingPeriod period, uint32 multiplier)` - Allows the owner to add gStfx multipliers for different staking periods.
4. `updateBurnPercent(uint32 percent)` - Allows the owner to update the `burnPercent` without reasonable limitations, which affects how many tokens will be sent to the `burnAddress` when `unstake` the deposit prematurely
5. `updateBurnAddress(address burn)` - Allows the owner to update the `burnAddress`, which is not transparent because tokens will not actually be burned if the `_owner` change the `burnAddress` to a working address under the control of the `_owner`.
6. `withdraw(address tokenAddress)` - Allows the owner to withdraw all tokens from the contract.

Any compromise to the `_owner` account may allow the hacker to take advantage of this authority and change `owner`, `interestRate`, `gStfxMultiplier`, `burnPercent`, `burnAddress` and transfer all types of ERC20 tokens to the owner.

Recommendation

The risk describes the current project design and potentially makes iterations to improve in the security operation and level of decentralization, which in most cases cannot be resolved entirely at the present stage. We advise the client to carefully manage the privileged account's private key to avoid any potential risks of being hacked. In general, we strongly recommend centralized privileges or roles in the protocol be improved via a decentralized mechanism or smart-contract-based accounts with enhanced security practices, e.g., multisignature wallets. Indicatively, here are some feasible suggestions that would also mitigate the potential risk at a different level in terms of short-term, long-term and permanent:

Short Term:

Timelock and Multi sign (⅔, ⅗) combination *mitigate* by delaying the sensitive operation and avoiding a single point of key management failure.

- Time-lock with reasonable latency, e.g., 48 hours, for awareness on privileged operations;
  AND
- Assignment of privileged roles to multi-signature wallets to prevent a single point of failure due to the private key compromised;
  AND
- A medium/blog link for sharing the timelock contract and multi-signers addresses information with the public audience.

Long Term:

Timelock and DAO, the combination, *mitigate* by applying decentralization and transparency.

- Time-lock with reasonable latency, e.g., 48 hours, for awareness on privileged operations;
  AND
- Introduction of a DAO/governance/voting module to increase transparency and user involvement.
  AND
- A medium/blog link for sharing the timelock contract, multi-signers addresses, and DAO information with the public audience.

Permanent:

Renouncing the ownership or removing the function can be considered *fully resolved*.

- Renounce the ownership and never claim back the privileged roles.
  OR
- Remove the risky functionality.

Alleviation

`[STFX]` : yes, we are aware of the centralisation risk and are planning to use our multisig as the `owner` for the near future, which will reduce a little bit of the risk.

SST-02 | INCOMPATIBILITY WITH DEFLATIONARY TOKENS

Category	Severity	Location	Status
Logical Issue	Medium	src/Stake.sol: 341, 345	Acknowledged

Description

When transferring deflationary ERC20 tokens, the input amount may not be equal to the received amount due to the charged transaction fee. For example, if a user sends 100 deflationary tokens (with a 10% transaction fee), only 90 tokens actually arrived to the contract. However, a failure to discount such fees may allow the same user to withdraw 100 tokens from the contract, which causes the contract to lose 10 tokens in such a transaction.

Reference: https://thoreum-finance.medium.com/what-exploit-happened-today-for-gocerberus-and-garuda-also-for-lokum-ybear-piggy-caramelswap-3943ee23a39f

```
345         IERC20(token).transferFrom(msg.sender, address(this), amount);
```

- Transferring tokens by `amount`.

```
341         totalStaked += amount;
```

- The `amount` appears to be used for bookkeeping purposes without compensating the potential transfer fees.

Recommendation

We advise the client to regulate the set of tokens supported and add necessary mitigation mechanisms to keep track of accurate balances if there is a need to support deflationary tokens.

Alleviation

`[STFX]` : since we are only going to use our token for staking and would not use any other token, we believe this issue would not be a significant risk.

SST-07 | TOTALSTAKED NOT DEDUCTED IN UNSTAKE AND CLAIM

Category	Severity	Location	Status
Logical Issue	Medium	src/Stake.sol: 381, 424	Acknowledged

Description

The `totalStaked` state variable is used to track the total amount of tokens staked in the project. While the stake amount is added to `totalStaked` in functions such as `stake()` and `restake()`, it appears that the stake amount is not deducted from `totalStaked` in functions like `unstake()` and `claim()`.

Recommendation

We recommend the team modify the functions `unstake()` and `claim()` to deduct the correct amount:

One of options could be like:

```
405  stakingInfo[msg.sender][n[i]].isCompleted = true;
406  totalStaked -= (s.amount - burnAmount);
```

Alleviation

`[STFX]`: Issue acknowledged. I will fix the issue in the future, which will not be included in this audit engagement.

SST-08 | LOGICAL ISSUES IN WITHDRAW FUNCTION

Category	Severity	Location	Status
Logical Issue	Medium	src/Stake.sol: 491	Acknowledged

Description

The function `withdraw()` can be called by the owner to drain all types of ERC20 tokens in the contract. This is both a centralization issue and a logical issue.

Recommendation

We recommend the team add more restrictions to the function like the below:

```
function withdraw(address tokenAddress) external onlyOwner {
    require(tokenAddress!= token,'INVALID_TOKEN');
    uint256 balance = IERC20(tokenAddress).balanceOf(address(this));
    IERC20(tokenAddress).transfer(owner, balance);
    emit Withdraw(tokenAddress, balance);
}
```

Alleviation

`[STFX]` : this was intended to make sure if someone transfers any other erc20 token by mistake, it would be easier for our team to get it back as opposed to getting the tokens stuck in the contract.

SST-03 | MISSING ZERO ADDRESS VALIDATION

Category	Severity	Location	Status
Volatile Code	Minor	src/Stake.sol: 90, 294	Acknowledged

Description

Addresses should be checked before assignment or external call to make sure they are not zero addresses.

```
90          token = _token;
```

- `_token` is not zero-checked before being used.

```
294         burnAddress = burn;
```

- `burn` is not zero-checked before being used.

Recommendation

We advise adding a zero-check for the passed-in address value to prevent unexpected errors.

Alleviation

`[STFX]` : Issue acknowledged. I won't make any changes for the current version.

SST-04 | UNSAFE INTEGER CAST

Category	Severity	Location	Status
Logical Issue	Minor	src/Stake.sol: 189~192, 219~222, 304, 306, 308, 310, 312, 321, 324	Acknowledged

Description

```
189                    burnAmount += uint96(
190                        (uint256(burnPercent) * s.amount * (s.expiryTime - block.timestamp))
191                            / (uint256(s.expiryTime - s.startTime) * 100000)
192                    );
```

- The type conversion `uint96((uint256(burnPercent) * s.amount * (s.expiryTime - block.timestamp)) / (uint256(s.expiryTime - s.startTime) * 100000))` from larger type uint256 to smaller type uint96 may truncate data.

```
219                burnAmount = uint96(
220                    (uint256(burnPercent) * s.amount * (s.expiryTime - block.timestamp))
221                        / (uint256(s.expiryTime - s.startTime) * 100000)
222                );
```

- The type conversion `uint96((uint256(burnPercent) * s.amount * (s.expiryTime - block.timestamp)) / (uint256(s.expiryTime - s.startTime) * 100000))` from larger type uint256 to smaller type uint96 may truncate data.

```
304                expiryTime = uint40(block.timestamp + 30 days);
```

- The type conversion `uint40(block.timestamp + 2592000)` from larger type uint256 to smaller type uint40 may truncate data.

```
306                expiryTime = uint40(block.timestamp + 90 days);
```

- The type conversion `uint40(block.timestamp + 7776000)` from larger type uint256 to smaller type uint40 may truncate data.

```
308                 expiryTime = uint40(block.timestamp + 180 days);
```

- The type conversion `uint40(block.timestamp + 15552000)` from larger type uint256 to smaller type uint40 may truncate data.

```
310                 expiryTime = uint40(block.timestamp + 365 days);
```

- The type conversion `uint40(block.timestamp + 31536000)` from larger type uint256 to smaller type uint40 may truncate data.

```
312                 expiryTime = uint40(block.timestamp + 730 days);
```

- The type conversion `uint40(block.timestamp + 63072000)` from larger type uint256 to smaller type uint40 may truncate data.

```
321             s.expiryAmount = uint96(((uint256(amount) *
uint256(interestRate[uint8(period)])) / 100e18) + uint256(amount));
```

- The type conversion `uint96(((uint256(amount) * uint256(interestRate[uint8(period)])) / 100e18) + uint256(amount))` from larger type uint256 to smaller type uint96 may truncate data.

```
324             s.gStfxAmount = uint96((uint256(gStfxMultiplier[uint8(period)]) *
uint256(s.amount)) / 1000);
```

- The type conversion `uint96((uint256(gStfxMultiplier[uint8(period)]) * uint256(s.amount)) / 1000)` from larger type uint256 to smaller type uint96 may truncate data.

Recommendation

We advise checking the bounds of integer values before casting, so the values will not be truncated or flip the sign. Alternatively, the SafeCast library from OpenZeppelin can be used in place of type casting.

Reference: https://github.com/OpenZeppelin/openzeppelin-contracts/blob/71aaca2d9db4655602137403920 44b2cd3853a3b/contracts/utils/math/SafeCast.sol

Alleviation

`[STFX]` : Issue acknowledged. I will fix the issue in the future, which will not be included in this audit engagement.

SST-06 | INCORRECT CHECKING FOR THE PERIOD

Category	Severity	Location	Status
Logical Issue	Minor	src/Stake.sol: 359	Acknowledged

Description

In the function `restake()` , the new period has to be more than the existing stake period according to the code comments.

```
359     if (uint8(period) < uint8(s.period)) revert StakingPeriodMismatch();
```

However, the above checking allows the period to equal the existing period.

Recommendation

We recommend the team modify the condition as the below or modify the code comments:

```
359     if (uint8(period) <= uint8(s.period)) revert StakingPeriodMismatch();
```

Alleviation

`[STFX]` : yes, this is also intended. the comments should've mentioned greater than or equal to the existing stake period. will change the comment.

SST-09 | UNCHECKED ERC-20 `transfer()` / `transferFrom()` CALL

Category	Severity	Location	Status
Volatile Code	Minor	src/Stake.sol: 345, 415, 416, 455, 486, 493	Acknowledged

Description

The return value of the transfer()/transferFrom() call is not checked.

```
345         IERC20(token).transferFrom(msg.sender, address(this), amount);
```

```
415         IERC20(token).transfer(msg.sender, totalTransferAmount);
```

```
416         IERC20(token).transfer(burnAddress, totalBurnAmount);
```

```
455         IERC20(token).transfer(msg.sender, transferAmount);
```

```
486         IERC20(token).transfer(msg.sender, transferAmount);
```

```
493         IERC20(tokenAddress).transfer(owner, balance);
```

Recommendation

Since some ERC-20 tokens return no values and others return a `bool` value, they should be handled with care. We advise using the OpenZeppelin's `SafeERC20.sol` implementation to interact with the `transfer()` and `transferFrom()` functions of external ERC-20 tokens. The OpenZeppelin implementation checks for the existence of a return value and reverts if `false` is returned, making it compatible with all ERC-20 token implementations.

Alleviation

`[STFX]` : Issue acknowledged. I will fix the issue in the future, which will not be included in this audit engagement.

SST-05 | DECIMAL OF INTERESTRATE

Category	Severity	Location	Status
Logical Issue	● Informational	src/Stake.sol: 275, 321	● Acknowledged

Description

The `addInterestRate()` function can set the `interestRate`. According to the below logic, the decimal of the `interestRate` must be 18.

```
321     s.expiryAmount = uint96(((uint256(amount) *
uint256(interestRate[uint8(period)])) / 100e18) + uint256(amount));
```

Recommendation

We recommend the team modify the restriction as the below:

```
    function addInterestRate(StakingPeriod period, uint96 rate) external onlyOwner {
        if (rate < 1e18) revert ZeroAmount();
        interestRate[uint8(period)] = rate;
        emit AddInterestRate(uint8(period), rate);
    }
```

OPTIMIZATIONS | STFX - V2 STAKING

ID	Title	Category	Severity	Status
SST-10	Variable That Could Be Declared As Immutable	Gas Optimization	Optimization	Acknowledged

SST-10 | VARIABLE THAT COULD BE DECLARED AS IMMUTABLE

Category	Severity	Location	Status
Gas Optimization	Optimization	src/Stake.sol: 66	Acknowledged

Description

The `token` variable assigned in the constructor can be declared as `immutable`. Immutable state variables can be assigned during contract creation but will remain constant throughout the lifetime of a deployed contract. A big advantage of immutable variables is that reading them is significantly cheaper than reading from regular state variables since they will not be stored in storage.

Recommendation

We recommend declaring these variables as immutable. Please note that the `immutable` keyword only works in Solidity version `v0.6.5` and up.

FORMAL VERIFICATION | STFX - V2 STAKING

Formal guarantees about the behavior of smart contracts can be obtained by reasoning about properties relating to the entire contract (e.g. contract invariants) or to specific functions of the contract. Once such properties are proven to be valid, they guarantee that the contract behaves as specified by the property. As part of this audit, we applied automated formal verification (symbolic model checking) to prove that well-known functions in the smart contracts adhere to their expected behavior.

Considered Functions And Scope

In the following, we provide a description of the properties that have been used in this audit. They are grouped according to the type of contract they apply to.

Verification of ERC-20 Compliance

We verified properties of the public interface of those token contracts that implement the ERC-20 interface. This covers

- Functions `transfer` and `transferFrom` that are widely used for token transfers,
- functions `approve` and `allowance` that enable the owner of an account to delegate a certain subset of her tokens to another account (i.e. to grant an allowance), and
- the functions `balanceOf` and `totalSupply` , which are verified to correctly reflect the internal state of the contract.

The properties that were considered within the scope of this audit are as follows:

Property Name	Title
erc20-transfer-succeed-self	`transfer` Succeeds on Admissible Self Transfers
erc20-transfer-revert-zero	`transfer` Prevents Transfers to the Zero Address
erc20-transfer-correct-amount	`transfer` Transfers the Correct Amount in Non-self Transfers
erc20-transfer-succeed-normal	`transfer` Succeeds on Admissible Non-self Transfers
erc20-transfer-correct-amount-self	`transfer` Transfers the Correct Amount in Self Transfers
erc20-transfer-recipient-overflow	`transfer` Prevents Overflows in the Recipient's Balance
erc20-transfer-change-state	`transfer` Has No Unexpected State Changes
erc20-transfer-exceed-balance	`transfer` Fails if Requested Amount Exceeds Available Balance
erc20-transfer-false	If `transfer` Returns `false` , the Contract State Is Not Changed
erc20-transferfrom-revert-to-zero	`transferFrom` Fails for Transfers To the Zero Address

Property Name	Title
erc20-transferfrom-revert-from-zero	`transferFrom` Fails for Transfers From the Zero Address
erc20-transfer-never-return-false	`transfer` Never Returns `false`
erc20-transferfrom-succeed-normal	`transferFrom` Succeeds on Admissible Non-self Transfers
erc20-transferfrom-succeed-self	`transferFrom` Succeeds on Admissible Self Transfers
erc20-transferfrom-correct-amount	`transferFrom` Transfers the Correct Amount in Non-self Transfers
erc20-transferfrom-correct-amount-self	`transferFrom` Performs Self Transfers Correctly
erc20-transferfrom-correct-allowance	`transferFrom` Updated the Allowance Correctly
erc20-transferfrom-fail-exceed-balance	`transferFrom` Fails if the Requested Amount Exceeds the Available Balance
erc20-transferfrom-change-state	`transferFrom` Has No Unexpected State Changes
erc20-transferfrom-fail-exceed-allowance	`transferFrom` Fails if the Requested Amount Exceeds the Available Allowance
erc20-transferfrom-fail-recipient-overflow	`transferFrom` Prevents Overflows in the Recipient's Balance
erc20-transferfrom-false	If `transferFrom` Returns `false` , the Contract's State Is Unchanged
erc20-transferfrom-never-return-false	`transferFrom` Never Returns `false`
erc20-totalsupply-succeed-always	`totalSupply` Always Succeeds
erc20-totalsupply-correct-value	`totalSupply` Returns the Value of the Corresponding State Variable
erc20-totalsupply-change-state	`totalSupply` Does Not Change the Contract's State
erc20-balanceof-succeed-always	`balanceOf` Always Succeeds
erc20-balanceof-correct-value	`balanceOf` Returns the Correct Value
erc20-balanceof-change-state	`balanceOf` Does Not Change the Contract's State
erc20-allowance-succeed-always	`allowance` Always Succeeds
erc20-allowance-change-state	`allowance` Does Not Change the Contract's State
erc20-approve-revert-zero	`approve` Prevents Approvals For the Zero Address

Property Name	Title
erc20-allowance-correct-value	`allowance` Returns Correct Value
erc20-approve-succeed-normal	`approve` Succeeds for Admissible Inputs
erc20-approve-correct-amount	`approve` Updates the Approval Mapping Correctly
erc20-approve-false	If `approve` Returns `false` , the Contract's State Is Unchanged
erc20-approve-change-state	`approve` Has No Unexpected State Changes
erc20-approve-never-return-false	`approve` Never Returns `false`

Verification Results

In the remainder of this section, we list all contracts where model checking of at least one property was not successful. There are several reasons why this could happen:

- Model checking reports a counterexample that violates the property. Depending on the counterexample,this occurs if
  - The specification of the property is too generic and does not accurately capture the intended behavior of the smart contract. In that case, the counterexample does not indicate a problem in the underlying smart contract. We report such instances as being "inapplicable".
  - The property is applicable to the smart contract. In that case, the counterexample showcases a problem in the smart contract and a correspond finding is reported separately in the Findings section of this report. In the following tables, we report such instances as "invalid". The distinction between spurious and actual counterexamples is done manually by the auditors.
- The model checking result is inconclusive. Such a result does not indicate a problem in the underlying smart contract. An inconclusive result may occur if
  - The model checking engine fails to construct a proof. This can happen if the logical deductions necessary are beyond the capabilities of the automated reasoning tool. It is a technical limitation of all proof engines and cannot be avoided in general.
  - The model checking engine runs out of time or memory and did not produce a result. This can happen if automatic abstraction techniques are ineffective or of the state space is too big.

Detailed Results For Contract Stake (src/Stake.sol) In Commit 6abbb72e994862c912996b042addd26c8c4510c2

Verification of ERC-20 Compliance

Detailed results for function `transfer`

Property Name	Final Result	Remarks
erc20-transfer-succeed-self	Inconclusive	
erc20-transfer-revert-zero	Inconclusive	
erc20-transfer-correct-amount	Inconclusive	
erc20-transfer-succeed-normal	Inconclusive	
erc20-transfer-correct-amount-self	Inconclusive	
erc20-transfer-recipient-overflow	Inconclusive	
erc20-transfer-change-state	Inconclusive	
erc20-transfer-exceed-balance	Inconclusive	
erc20-transfer-false	Inconclusive	
erc20-transfer-never-return-false	True	

Detailed results for function `transferFrom`

Property Name	Final Result	Remarks
erc20-transferfrom-revert-to-zero	Inconclusive	
erc20-transferfrom-revert-from-zero	Inconclusive	
erc20-transferfrom-succeed-normal	Inconclusive	
erc20-transferfrom-succeed-self	Inconclusive	
erc20-transferfrom-correct-amount	Inconclusive	
erc20-transferfrom-correct-amount-self	Inconclusive	
erc20-transferfrom-correct-allowance	Inconclusive	
erc20-transferfrom-fail-exceed-balance	Inconclusive	
erc20-transferfrom-change-state	Inconclusive	
erc20-transferfrom-fail-exceed-allowance	Inconclusive	
erc20-transferfrom-fail-recipient-overflow	Inconclusive	
erc20-transferfrom-false	Inconclusive	
erc20-transferfrom-never-return-false	True	

Detailed results for function `totalSupply`

Property Name	Final Result	Remarks
erc20-totalsupply-succeed-always	True	
erc20-totalsupply-correct-value	True	
erc20-totalsupply-change-state	Inconclusive	

Detailed results for function `balanceOf`

Property Name	Final Result	Remarks
erc20-balanceof-succeed-always	True	
erc20-balanceof-correct-value	True	
erc20-balanceof-change-state	Inconclusive	

Detailed results for function `allowance`

Property Name	Final Result	Remarks
erc20-allowance-succeed-always	True	
erc20-allowance-change-state	Inconclusive	
erc20-allowance-correct-value	True	

Detailed results for function `approve`

Property Name	Final Result	Remarks
erc20-approve-revert-zero	Inconclusive	
erc20-approve-succeed-normal	Inconclusive	
erc20-approve-correct-amount	Inconclusive	
erc20-approve-false	Inconclusive	
erc20-approve-change-state	Inconclusive	
erc20-approve-never-return-false	True	

APPENDIX | STFX - V2 STAKING

Finding Categories

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

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.

Details on Formal Verification

Some Solidity smart contracts from this project have been formally verified using symbolic model checking. Each such contract was compiled into a mathematical model which reflects all its possible behaviors with respect to the property. The model takes into account the semantics of the Solidity instructions found in the contract. All verification results that we report are based on that model.

Technical Description

The model also formalizes a simplified execution environment of the Ethereum blockchain and a verification harness that performs the initialization of the contract and all possible interactions with the contract. Initially, the contract state is initialized non-deterministically (i.e. by arbitrary values) and over-approximates the reachable state space of the contract throughout any actual deployment on chain. All valid results thus carry over to the contract's behavior in arbitrary states after it has been deployed.

Assumptions and Simplifications

The following assumptions and simplifications apply to our model:

- Gas consumption is not taken into account, i.e. we assume that executions do not terminate prematurely because they run out of gas.
- The contract's state variables are non-deterministically initialized before invocation of any function. That ignores contract invariants and may lead to false positives. It is, however, a safe over-approximation.
- The verification engine reasons about unbounded integers. Machine arithmetic is modeled using modular arithmetic based on the bit-width of the underlying numeric Solidity type. This ensures that over- and underflow characteristics are faithfully represented.
- Certain low-level calls and inline assembly are not supported and may lead to a contract not being formally verified.
- We model the semantics of the Solidity source code and not the semantics of the EVM bytecode in a compiled contract.

Formalism for Property Specification

All properties are expressed in linear temporal logic (LTL). For that matter, we treat each invocation of and each return from a public or an external function as a discrete time step. Our analysis reasons about the contract's state upon entering and upon leaving public or external functions.

Apart from the Boolean connectives and the modal operators "always" (written `[]`) and "eventually" (written `<>`), we use the following predicates as atomic propositions. They are evaluated on the contract's state whenever a discrete time step occurs:

- `started(f, [cond])` Indicates an invocation of contract function `f` within a state satisfying formula `cond` .
- `willSucceed(f, [cond])` Indicates an invocation of contract function `f` within a state satisfying formula `cond` and considers only those executions that do not revert.
- `finished(f, [cond])` Indicates that execution returns from contract function `f` in a state satisfying formula `cond` . Here, formula `cond` may refer to the contract's state variables and to the value they had upon entering the function (using the `old` function).
- `reverted(f, [cond])` Indicates that execution of contract function `f` was interrupted by an exception in a contract state satisfying formula `cond` .

The verification performed in this audit operates on a harness that non-deterministically invokes a function of the contract's public or external interface. All formulas are analyzed w.r.t. the trace that corresponds to this function invocation.

Description of the Analyzed ERC-20 Properties

The specifications are designed such that they capture the desired and admissible behaviors of the ERC-20 functions `transfer` , `transferFrom` , `approve` , `allowance` , `balanceOf` , and `totalSupply` . In the following, we list those property specifications.

Properties related to function `transfer`

erc20-transfer-revert-zero

`transfer` Prevents Transfers to the Zero Address. Any call of the form `transfer(recipient, amount)` must fail if the recipient address is the zero address. Specification:

```
[](started(contract.transfer(to, value), to == address(0)) ==>
  <>(reverted(contract.transfer) || finished(contract.transfer(to, value), return
    == false)))
```

erc20-transfer-succeed-normal

`transfer` Succeeds on Admissible Non-self Transfers. All invocations of the form `transfer(recipient, amount)` must succeed and return `true` if

- the `recipient` address is not the zero address,
- `amount` does not exceed the balance of address `msg.sender`,
- transferring `amount` to the `recipient` address does not lead to an overflow of the recipient's balance, and
- the supplied gas suffices to complete the call. Specification:

```
[](started(contract.transfer(to, value), to != address(0) && to != msg.sender &&
    value >= 0 && value <= _balances[msg.sender] && _balances[to] + value <
    0x10000000000000000000000000000000000000000000000000000000000000000 &&
    _balances[to] >= 0 && _balances[msg.sender] <
    0x10000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(finished(contract.transfer(to, value), return == true)))
```

erc20-transfer-succeed-self

`transfer` Succeeds on Admissible Self Transfers. All self-transfers, i.e. invocations of the form `transfer(recipient, amount)` where the `recipient` address equals the address in `msg.sender` must succeed and return `true` if

- the value in `amount` does not exceed the balance of `msg.sender` and
- the supplied gas suffices to complete the call. Specification:

```
[](started(contract.transfer(to, value), to != address(0) && to == msg.sender &&
    value >= 0 && value <= _balances[msg.sender] && _balances[msg.sender] >= 0 &&
    _balances[msg.sender] <
    0x10000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(finished(contract.transfer(to, value), return == true)))
```

erc20-transfer-correct-amount

`transfer` Transfers the Correct Amount in Non-self Transfers. All non-reverting invocations of `transfer(recipient, amount)` that return `true` must subtract the value in `amount` from the balance of `msg.sender` and add the same value to the balance of the `recipient` address. Specification:

```
[](willSucceed(contract.transfer(to, value), to != msg.sender && _balances[to] >= 0
    && value >= 0 && _balances[to] + value <
    0x10000000000000000000000000000000000000000000000000000000000000000 &&
    _balances[msg.sender] >= 0 && _balances[msg.sender] <
    0x10000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(finished(contract.transfer(to, value), return == true ==>
      _balances[msg.sender] == old(_balances[msg.sender]) - value && _balances[to]
      == old(_balances[to]) + value)))
```

erc20-transfer-correct-amount-self

`transfer` Transfers the Correct Amount in Self Transfers. All non-reverting invocations of `transfer(recipient, amount)` that return `true` and where the `recipient` address equals `msg.sender` (i.e. self-transfers) must not change the balance of address `msg.sender`. Specification:

```
[](willSucceed(contract.transfer(to, value), to == msg.sender && _balances[to] >= 0
    && _balances[to] <
    0x10000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(finished(contract.transfer(to, value), return == true ==> _balances[to] ==
      old(_balances[to]))))
```

erc20-transfer-change-state

`transfer` Has No Unexpected State Changes. All non-reverting invocations of `transfer(recipient, amount)` that return `true` must only modify the balance entries of the `msg.sender` and the `recipient` addresses. Specification:

```
[](willSucceed(contract.transfer(to, value), p1 != msg.sender && p1 != to) ==>
  <>(finished(contract.transfer(to, value), return == true ==> (_totalSupply ==
        old(_totalSupply) && _allowances == old(_allowances) && _balances[p1] ==
        old(_balances[p1]) && other_state_variables ==
        old(other_state_variables)))))
```

erc20-transfer-exceed-balance

`transfer` Fails if Requested Amount Exceeds Available Balance. Any transfer of an amount of tokens that exceeds the balance of `msg.sender` must fail. Specification:

```
[](started(contract.transfer(to, value), value > _balances[msg.sender] &&
    _balances[msg.sender] >= 0 && value <
    0x10000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(reverted(contract.transfer) || finished(contract.transfer(to, value), return
      == false)))
```

erc20-transfer-recipient-overflow

`transfer` Prevents Overflows in the Recipient's Balance. Any invocation of `transfer(recipient, amount)` must fail if it causes the balance of the `recipient` address to overflow. Specification:

```
[](started(contract.transfer(to, value), to != msg.sender && _balances[to] + value
    >= 0x10000000000000000000000000000000000000000000000000000000000000000 &&
    _balances[to] >= 0 && _balances[to] <
    0x10000000000000000000000000000000000000000000000000000000000000000 &&
    _balances[msg.sender] <
    0x10000000000000000000000000000000000000000000000000000000000000000 && value >
    0 && value <= _balances[msg.sender]) ==> <>(reverted(contract.transfer) ||
    finished(contract.transfer(to, value), return == false) ||
    finished(contract.transfer(to, value), _balances[to] > old(_balances[to]) +
      value -
      0x10000000000000000000000000000000000000000000000000000000000000000)))
```

erc20-transfer-false

If `transfer` Returns `false`, the Contract State Is Not Changed. If the `transfer` function in contract `contract` fails by returning `false`, it must undo all state changes it incurred before returning to the caller. Specification:

```
[](willSucceed(contract.transfer(to, value)) ==> <>(finished(contract.transfer(to,
        value), return == false ==> (_balances == old(_balances) && _totalSupply ==
        old(_totalSupply) && _allowances == old(_allowances) &&
        other_state_variables == old(other_state_variables)))))
```

erc20-transfer-never-return-false

`transfer` Never Returns `false`. The transfer function must never return `false` to signal a failure. Specification:

```
[](!(finished(contract.transfer, return == false)))
```

Properties related to function `transferFrom`

erc20-transferfrom-revert-from-zero

`transferFrom` Fails for Transfers From the Zero Address. All calls of the form `transferFrom(from, dest, amount)` where the `from` address is zero, must fail. Specification:

```
[](started(contract.transferFrom(from, to, value), from == address(0)) ==>
  <>(reverted(contract.transferFrom) || finished(contract.transferFrom, return ==
      false)))
```

erc20-transferfrom-revert-to-zero

`transferFrom` Fails for Transfers To the Zero Address. All calls of the form `transferFrom(from, dest, amount)` where the `dest` address is zero, must fail. Specification:

```
[](started(contract.transferFrom(from, to, value), to == address(0)) ==>
  <>(reverted(contract.transferFrom) || finished(contract.transferFrom, return ==
      false)))
```

erc20-transferfrom-succeed-normal

`transferFrom` Succeeds on Admissible Non-self Transfers. All invocations of `transferFrom(from, dest, amount)` must succeed and return `true` if

- the value of `amount` does not exceed the balance of address `from` ,
- the value of `amount` does not exceed the allowance of `msg.sender` for address `from` ,
- transferring a value of `amount` to the address in `dest` does not lead to an overflow of the recipient's balance, and
- the supplied gas suffices to complete the call. Specification:

```
[](started(contract.transferFrom(from, to, value), from != address(0) && to !=
    address(0) && from != to && value <= _balances[from] && value <=
    _allowances[from][msg.sender] && _balances[to] + value <
    0x10000000000000000000000000000000000000000000000000000000000000000 && value >=
    0 && _balances[to] >= 0 && _balances[from] >= 0 && _balances[from] <
    0x10000000000000000000000000000000000000000000000000000000000000000 &&
    _allowances[from][msg.sender] >= 0 && _allowances[from][msg.sender] <
    0x10000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(finished(contract.transferFrom(from, to, value), return == true)))
```

erc20-transferfrom-succeed-self

`transferFrom` Succeeds on Admissible Self Transfers. All invocations of `transferFrom(from, dest, amount)` where the `dest` address equals the `from` address (i.e. self-transfers) must succeed and return `true` if:

- The value of `amount` does not exceed the balance of address `from` ,
- the value of `amount` does not exceed the allowance of `msg.sender` for address `from` , and
- the supplied gas suffices to complete the call. Specification:

```
[](started(contract.transferFrom(from, to, value), from != address(0) && from == to
    && value <= _balances[from] && value <= _allowances[from][msg.sender] && value
    >= 0 && _balances[from] <
    0x10000000000000000000000000000000000000000000000000000000000000000 &&
    _allowances[from][msg.sender] <
    0x10000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(finished(contract.transferFrom(from, to, value), return == true)))
```

erc20-transferfrom-correct-amount

`transferFrom` Transfers the Correct Amount in Non-self Transfers. All invocations of `transferFrom(from, dest, amount)` that succeed and that return `true` subtract the value in `amount` from the balance of address `from` and add the same value to the balance of address `dest`. Specification:

```
[](willSucceed(contract.transferFrom(from, to, value), from != to && value >= 0 &&
    _balances[from] >= 0 && _balances[from] <
    0x10000000000000000000000000000000000000000000000000000000000000000 &&
    _balances[to] >= 0 && _balances[to] + value <
    0x10000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(finished(contract.transferFrom(from, to, value), return == true ==>
      _balances[from] == old(_balances[from]) - value && _balances[to] ==
      old(_balances[to] + value))))
```

erc20-transferfrom-correct-amount-self

`transferFrom` Performs Self Transfers Correctly. All non-reverting invocations of `transferFrom(from, dest, amount)` that return `true` and where the address in `from` equals the address in `dest` (i.e. self-transfers) do not change the balance entry of the `from` address (which equals `dest`). Specification:

```
[](willSucceed(contract.transferFrom(from, to, value), from == to && value >= 0 &&
    value < 0x10000000000000000000000000000000000000000000000000000000000000000 &&
    _balances[from] >= 0 && _balances[from] <
    0x10000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(finished(contract.transferFrom(from, to, value), return == true ==>
      _balances[from] == old(_balances[from]))))
```

erc20-transferfrom-correct-allowance

`transferFrom` Updated the Allowance Correctly. All non-reverting invocations of `transferFrom(from, dest, amount)` that return `true` must decrease the allowance for address `msg.sender` over address `from` by the value in `amount`. Specification:

```
[](willSucceed(contract.transferFrom(from, to, value), value >= 0 && value <
    0x10000000000000000000000000000000000000000000000000000000000000000 &&
    _balances[from] >= 0 && _balances[from] <
    0x10000000000000000000000000000000000000000000000000000000000000000 &&
    _balances[to] >= 0 && _balances[to] <
    0x10000000000000000000000000000000000000000000000000000000000000000 &&
    _allowances[from][msg.sender] >= 0 && _allowances[from][msg.sender] <
    0x10000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(finished(contract.transferFrom(from, to, value), return == true ==>
      ((_allowances[from][msg.sender] == old(_allowances[from][msg.sender]) -
      value) || (_allowances[from][msg.sender] ==
      old(_allowances[from][msg.sender]) && (from == msg.sender ||
        old(_allowances[from][msg.sender]) ==
        0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF))))))
```

erc20-transferfrom-change-state

`transferFrom` Has No Unexpected State Changes. All non-reverting invocations of `transferFrom(from, dest, amount)` that return `true` may only modify the following state variables:

- The balance entry for the address in `dest` ,
- The balance entry for the address in `from` ,
- The allowance for the address in `msg.sender` for the address in `from` . Specification:

```
[](willSucceed(contract.transferFrom(from, to, amount), p1 != from && p1 != to &&
    (p2 != from || p3 != msg.sender)) ==> <>(finished(contract.transferFrom(from,
      to, amount), return == true ==> (_totalSupply == old(_totalSupply) &&
      _balances[p1] == old(_balances[p1]) && _allowances[p2][p3] ==
      old(_allowances[p2][p3]) && other_state_variables ==
      old(other_state_variables)))))
```

erc20-transferfrom-fail-exceed-balance

`transferFrom` Fails if the Requested Amount Exceeds the Available Balance. Any call of the form `transferFrom(from, dest, amount)` with a value for `amount` that exceeds the balance of address `from` must fail. Specification:

```
[](started(contract.transferFrom(from, to, value), value > _balances[from] &&
    _balances[from] >= 0 && _balances[from] <
    0x10000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(reverted(contract.transferFrom) || finished(contract.transferFrom, return ==
      false)))
```

erc20-transferfrom-fail-exceed-allowance

`transferFrom` Fails if the Requested Amount Exceeds the Available Allowance. Any call of the form `transferFrom(from, dest, amount)` with a value for `amount` that exceeds the allowance of address `msg.sender` must fail. Specification:

```
[](started(contract.transferFrom(from, to, value), msg.sender != from && value >
    _allowances[from][msg.sender] && _allowances[from][msg.sender] >= 0 && value <
    0x10000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(reverted(contract.transferFrom) || finished(contract.transferFrom(from, to,
        value), return == false)))
```

erc20-transferfrom-fail-recipient-overflow

`transferFrom` Prevents Overflows in the Recipient's Balance. Any call of `transferFrom(from, dest, amount)` with a value in `amount` whose transfer would cause an overflow of the balance of address `dest` must fail. Specification:

```
[](started(contract.transferFrom(from, to, value), from != to && _balances[to] +
    value >= 0x10000000000000000000000000000000000000000000000000000000000000000 &&
    value < 0x10000000000000000000000000000000000000000000000000000000000000000 &&
    _balances[to] >= 0 && _balances[to] <
    0x10000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(reverted(contract.transferFrom) || finished(contract.transferFrom(from, to,
        value), return == false) || finished(contract.transferFrom(from, to,
        value), _balances[to] > old(_balances[to]) + value -
      0x10000000000000000000000000000000000000000000000000000000000000000)))
```

erc20-transferfrom-false

If `transferFrom` Returns `false`, the Contract's State Is Unchanged. If `transferFrom` returns `false` to signal a failure, it must undo all incurred state changes before returning to the caller. Specification:

```
[](willSucceed(contract.transferFrom(from, to, value)) ==>
  <>(finished(contract.transferFrom(from, to, value), return == false ==>
    (_balances == old(_balances) && _totalSupply == old(_totalSupply) &&
    _allowances == old(_allowances) && other_state_variables ==
    old(other_state_variables)))))
```

erc20-transferfrom-never-return-false

`transferFrom` Never Returns `false`. The `transferFrom` function must never return `false`. Specification:

```
[](!(finished(contract.transferFrom, return == false)))
```

Properties related to function `totalSupply`

erc20-totalsupply-succeed-always

`totalSupply` Always Succeeds. The function `totalSupply` must always succeeds, assuming that its execution does not run out of gas. Specification:

```
[](started(contract.totalSupply) ==> <>(finished(contract.totalSupply)))
```

erc20-totalsupply-correct-value

`totalSupply` Returns the Value of the Corresponding State Variable. The `totalSupply` function must return the value that is held in the corresponding state variable of contract contract. Specification:

```
[](willSucceed(contract.totalSupply) ==> <>(finished(contract.totalSupply, return
      == _totalSupply)))
```

erc20-totalsupply-change-state

`totalSupply` Does Not Change the Contract's State. The `totalSupply` function in contract contract must not change any state variables. Specification:

```
[](willSucceed(contract.totalSupply) ==> <>(finished(contract.totalSupply,
      _totalSupply == old(_totalSupply) && _balances == old(_balances) &&
      _allowances == old(_allowances) && other_state_variables ==
      old(other_state_variables))))
```

Properties related to function `balanceOf`

erc20-balanceof-succeed-always

`balanceOf` Always Succeeds. Function `balanceOf` must always succeed if it does not run out of gas. Specification:

```
[](started(contract.balanceOf) ==> <>(finished(contract.balanceOf)))
```

erc20-balanceof-correct-value

`balanceOf` Returns the Correct Value. Invocations of `balanceOf(owner)` must return the value that is held in the contract's balance mapping for address `owner`. Specification:

```
[](willSucceed(contract.balanceOf) ==> <>(finished(contract.balanceOf(owner),
      return == _balances[owner])))
```

erc20-balanceof-change-state

`balanceOf` Does Not Change the Contract's State. Function `balanceOf` must not change any of the contract's state variables. Specification:

```
[](willSucceed(contract.balanceOf) ==> <>(finished(contract.balanceOf(owner),
      _totalSupply == old(_totalSupply) && _balances == old(_balances) &&
      _allowances == old(_allowances) && other_state_variables ==
      old(other_state_variables))))
```

Properties related to function `allowance`

erc20-allowance-succeed-always

`allowance` Always Succeeds. Function `allowance` must always succeed, assuming that its execution does not run out of gas. Specification:

```
[](started(contract.allowance) ==> <>(finished(contract.allowance)))
```

erc20-allowance-correct-value

`allowance` Returns Correct Value. Invocations of `allowance(owner, spender)` must return the allowance that address `spender` has over tokens held by address `owner`. Specification:

```
[](willSucceed(contract.allowance(owner, spender)) ==>
  <>(finished(contract.allowance(owner, spender), return ==
    _allowances[owner][spender])))
```

erc20-allowance-change-state

`allowance` Does Not Change the Contract's State. Function `allowance` must not change any of the contract's state variables. Specification:

```
[](willSucceed(contract.allowance(owner, spender)) ==>
  <>(finished(contract.allowance(owner, spender), _totalSupply == old(_totalSupply)
    && _balances == old(_balances) && _allowances == old(_allowances) &&
    other_state_variables == old(other_state_variables))))
```

Properties related to function `approve`

erc20-approve-revert-zero

`approve` Prevents Approvals For the Zero Address. All calls of the form `approve(spender, amount)` must fail if the address in `spender` is the zero address. Specification:

```
[](started(contract.approve(spender, value), spender == address(0)) ==>
  <>(reverted(contract.approve) || finished(contract.approve(spender, value),
    return == false)))
```

erc20-approve-succeed-normal

`approve` Succeeds for Admissible Inputs. All calls of the form `approve(spender, amount)` must succeed, if

- the address in `spender` is not the zero address and
- the execution does not run out of gas. Specification:

```
[](started(contract.approve(spender, value), spender != address(0)) ==>
  <>(finished(contract.approve(spender, value), return == true)))
```

erc20-approve-correct-amount

`approve` Updates the Approval Mapping Correctly. All non-reverting calls of the form `approve(spender, amount)` that return `true` must correctly update the allowance mapping according to the address `msg.sender` and the values of `spender` and `amount`. Specification:

```
[](willSucceed(contract.approve(spender, value), spender != address(0) && value >=
    0 && value <
    0x10000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(finished(contract.approve(spender, value), return == true ==>
      _allowances[msg.sender][spender] == value)))
```

erc20-approve-change-state

`approve` Has No Unexpected State Changes. All calls of the form `approve(spender, amount)` must only update the allowance mapping according to the address `msg.sender` and the values of `spender` and `amount` and incur no other state changes. Specification:

```
[](willSucceed(contract.approve(spender, value), spender != address(0) && (p1 !=
      msg.sender || p2 != spender)) ==> <>(finished(contract.approve(spender,
        value), return == true ==> _totalSupply == old(_totalSupply) && _balances
      == old(_balances) && _allowances[p1][p2] == old(_allowances[p1][p2]) &&
      other_state_variables == old(other_state_variables))))
```

erc20-approve-false

If `approve` Returns `false` , the Contract's State Is Unchanged. If function `approve` returns `false` to signal a failure, it must undo all state changes that it incurred before returning to the caller. Specification:

```
[](willSucceed(contract.approve(spender, value)) ==>
  <>(finished(contract.approve(spender, value), return == false ==> (_balances ==
      old(_balances) && _totalSupply == old(_totalSupply) && _allowances ==
      old(_allowances) && other_state_variables == old(other_state_variables)))))
```

erc20-approve-never-return-false

`approve` Never Returns `false` . The function `approve` must never returns `false` . Specification:

```
[](!(finished(contract.approve, return == false)))
```

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