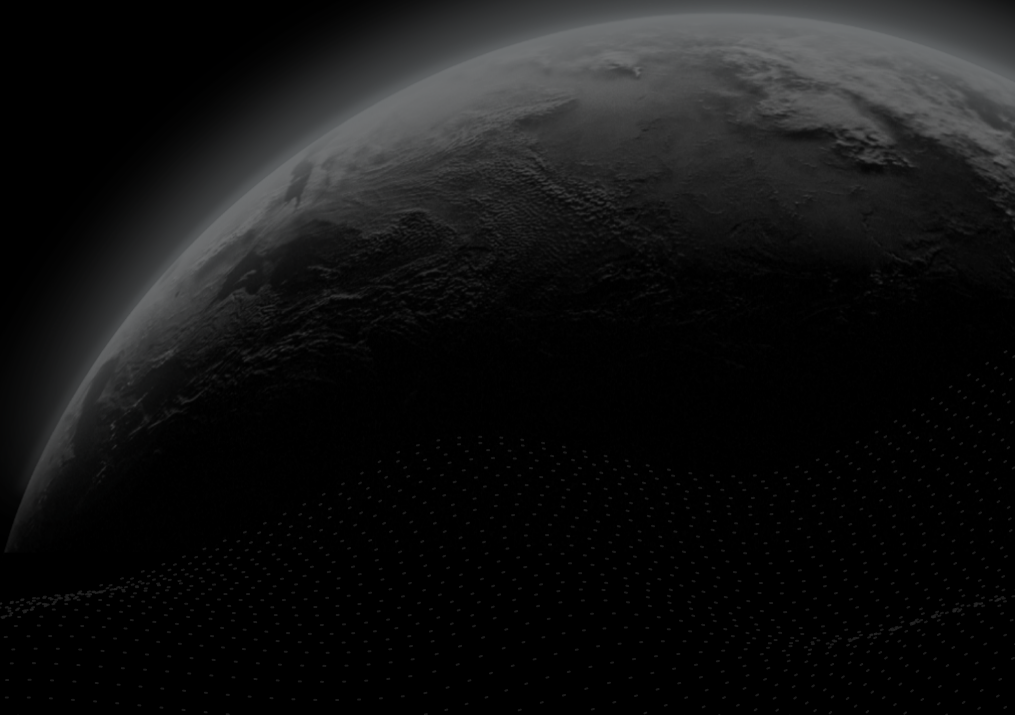




Security Assessment

OxAI

CertiK Verified on Feb 20th, 2023





Certik Verified on Feb 20th, 2023

OxAI

The security assessment was prepared by Certik, the leader in Web3.0 security.

Executive Summary

TYPES

ERC-20

ECOSYSTEM

Ethereum

METHODS

Formal Verification, Manual Review, Static Analysis

LANGUAGE

Solidity

TIMELINE

Delivered on 02/20/2023

KEY COMPONENTS

N/A

CODEBASE

<https://etherscan.io/address/0x428dca9537116148616a5a3e44035af17238fe9d>
[...View All](#)

Vulnerability Summary



4

Total Findings

1

Resolved

0

Mitigated

0

Partially Resolved

3

Acknowledged

0

Declined

0

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 Resolved



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.

■ 0 Medium

Medium risks may not pose a direct risk to users' funds, but they can affect the overall functioning of a platform.

■ 1 Minor

1 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.

■ 2 Informational

2 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.

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CODEBASE | OXAI

Repository

<https://etherscan.io/address/0x428dca9537116148616a5a3e44035af17238fe9d>

AUDIT SCOPE | OXAI

2 files audited ● 2 files with Acknowledged findings

ID	File	SHA256 Checksum
● OXA	 OXAI.sol	1d9b3a21ea30a4870ff77d9757b28540c2242 5875e46946f0817483f50617c67
● ERC	 solmate/tokens/ERC20.sol	a3a7e839f42762ef24623581542a916e838f3c 7c0bef647963d1fdad0f9d208a

APPROACH & METHODS | OXAI

This report has been prepared for OxAI to discover issues and vulnerabilities in the source code of the OxAI 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.

FINDINGS | OXAI



4

Total Findings

0

Critical

1

Major

0

Medium

1

Minor

2

Informational

This report has been prepared to discover issues and vulnerabilities for OxAI. Through this audit, we have uncovered 4 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
OXA-01	Centralization Related Risks	Centralization / Privilege	Major	● Resolved
CKP-01	Missing Zero Address Validation	Volatile Code	Minor	● Acknowledged
CKP-02	Different Solidity Versions	Language Specific	Informational	● Acknowledged
OXA-02	Missing Emit Events	Coding Style	Informational	● Acknowledged

OXA-01 | CENTRALIZATION RELATED RISKS

Category	Severity	Location	Status
Centralization / Privilege	● Major	OXAI.sol: 15, 22	● Resolved

Description

In the contract `OXAI`, the role `minter` has authority over the following functions:

- `mint()`: mint `OXAI` tokens to any account
- `transferMinter()`: transfer the minter role to other account

Any compromise to the minter account may allow a hacker to take advantage of this authority and mint OXAI tokens indefinitely.

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 recommend carefully managing 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., multi-signature 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 ($\frac{2}{3}$, $\frac{3}{5}$) 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.

I Alleviation

[Certik]: The `minter` role has been transferred to the contract `OXAIFairLaunch` and cannot be transferred anymore. According to the configuration of the `OXAIFairLaunch` contract, `OXAI` cannot be minted by the `OXAIFairLaunch` contract after the `launchTime(2023/2/7 00:00:00 GMT+0800)`, the issue has been resolved.

CKP-01 | MISSING ZERO ADDRESS VALIDATION

Category	Severity	Location	Status
Volatile Code	Minor	OXAI.sol: 26; solmate/tokens/ERC20.sol: 82, 104	Acknowledged

Description

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

```
26         minter = _newMinter;
```

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

```
82         balanceOf[to] += amount;
```

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

```
104        balanceOf[to] += amount;
```

- `to` 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

[OXAI]: Issue acknowledged.

CKP-02 | DIFFERENT SOLIDITY VERSIONS

Category	Severity	Location	Status
Language Specific	● Informational	OXAI.sol: 2; solmate/tokens/ERC20.sol: 2	● Acknowledged

Description

Multiple Solidity versions may be used in the codebase. The solidity version in the `OXAI.sol` may not be the same as `ERC20.sol`.

`^0.8.18` is used in the OXAI.sol file.

```
2 pragma solidity ^0.8.18;
```

`>=0.8.0` is used in the ERC20.sol file.

```
2 pragma solidity >=0.8.0;
```

Recommendation

We recommend using one Solidity version.

Alleviation

[OXAI]: Issue acknowledged.

OXA-02 | MISSING EMIT EVENTS

Category	Severity	Location	Status
Coding Style	● Informational	OXAI.sol: 22	● Acknowledged

Description

Functions that update state variables should emit relevant events as notifications.

Recommendation

We advise adding events for state-changing actions, and emitting them in their relevant functions.

Alleviation

[`OXAI`]: Issue acknowledged.

FORMAL VERIFICATION | OXAI

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-normal	Function <code>transfer</code> Succeeds on Admissible Non-self Transfers
erc20-transfer-succeed-self	Function <code>transfer</code> Succeeds on Admissible Self Transfers
erc20-transfer-correct-amount	Function <code>transfer</code> Transfers the Correct Amount in Non-self Transfers
erc20-transfer-correct-amount-self	Function <code>transfer</code> Transfers the Correct Amount in Self Transfers
erc20-transfer-change-state	Function <code>transfer</code> Has No Unexpected State Changes
erc20-transfer-false	If Function <code>transfer</code> Returns <code>false</code> , the Contract State Has Not Been Changed
erc20-transfer-never-return-false	Function <code>transfer</code> Never Returns <code>false</code>
erc20-transferfrom-succeed-normal	Function <code>transferFrom</code> Succeeds on Admissible Non-self Transfers
erc20-transferfrom-succeed-self	Function <code>transferFrom</code> Succeeds on Admissible Self Transfers

Property Name	Title	
erc20-transferfrom-correct-amount	Function <code>transferFrom</code>	Transfers the Correct Amount in Non-self Transfers
erc20-transferfrom-correct-amount-self	Function <code>transferFrom</code>	Performs Self Transfers Correctly
erc20-transferfrom-correct-allowance	Function <code>transferFrom</code>	Updated the Allowance Correctly
erc20-transferfrom-change-state	Function <code>transferFrom</code>	Has No Unexpected State Changes
erc20-transferfrom-fail-exceed-allowance	Function <code>transferFrom</code>	Fails if the Requested Amount Exceeds the Available Allowance
erc20-transferfrom-false	If Function <code>transferFrom</code> Returns <code>false</code> , the Contract's State Has Not Been Changed	
erc20-transferfrom-never-return-false	Function <code>transferFrom</code>	Never Returns <code>false</code>
erc20-totalsupply-succeed-always	Function <code>totalSupply</code>	Always Succeeds
erc20-totalsupply-correct-value	Function <code>totalSupply</code>	Returns the Value of the Corresponding State Variable
erc20-totalsupply-change-state	Function <code>totalSupply</code>	Does Not Change the Contract's State
erc20-balanceof-succeed-always	Function <code>balanceOf</code>	Always Succeeds
erc20-balanceof-correct-value	Function <code>balanceOf</code>	Returns the Correct Value
erc20-balanceof-change-state	Function <code>balanceOf</code>	Does Not Change the Contract's State
erc20-allowance-succeed-always	Function <code>allowance</code>	Always Succeeds
erc20-allowance-correct-value	Function <code>allowance</code>	Returns Correct Value
erc20-allowance-change-state	Function <code>allowance</code>	Does Not Change the Contract's State
erc20-approve-succeed-normal	Function <code>approve</code>	Succeeds for Admissible Inputs
erc20-approve-correct-amount	Function <code>approve</code>	Updates the Approval Mapping Correctly
erc20-approve-change-state	Function <code>approve</code>	Has No Unexpected State Changes
erc20-approve-false	If Function <code>approve</code> Returns <code>false</code> , the Contract's State Has Not Been Changed	
erc20-approve-never-return-false	Function <code>approve</code>	Never Returns <code>false</code>

Property Name	Title	
erc20-transfer-revert-zero	Function	<code>transfer</code> Prevents Transfers to the Zero Address
erc20-transfer-exceed-balance	Function	<code>transfer</code> Fails if Requested Amount Exceeds Available Balance
erc20-transfer-recipient-overflow	Function	<code>transfer</code> Prevents Overflows in the Recipient's Balance
erc20-transferfrom-revert-from-zero	Function	<code>transferFrom</code> Fails for Transfers From the Zero Address
erc20-transferfrom-revert-to-zero	Function	<code>transferFrom</code> Fails for Transfers To the Zero Address
erc20-transferfrom-fail-exceed-balance	Function	<code>transferFrom</code> Fails if the Requested Amount Exceeds the Available Balance
erc20-transferfrom-fail-recipient-overflow	Function	<code>transferFrom</code> Prevents Overflows in the Recipient's Balance
erc20-approve-revert-zero	Function	<code>approve</code> Prevents Giving Approvals For the Zero Address

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 OXAI (OXAI.sol)

Verification of ERC-20 Compliance

Detailed results for function `transfer`

Property Name	Final Result	Remarks
erc20-transfer-succeed-normal	● True	
erc20-transfer-succeed-self	● True	
erc20-transfer-correct-amount	● True	
erc20-transfer-correct-amount-self	● True	
erc20-transfer-change-state	● True	
erc20-transfer-false	● True	
erc20-transfer-never-return-false	● True	
erc20-transfer-revert-zero	● False	
erc20-transfer-exceed-balance	● Inapplicable	Inapplicable
erc20-transfer-recipient-overflow	● Inapplicable	Context not considered

Detailed results for function `transferFrom`

Property Name	Final Result	Remarks
erc20-transferfrom-succeed-normal	● True	
erc20-transferfrom-succeed-self	● True	
erc20-transferfrom-correct-amount	● True	
erc20-transferfrom-correct-amount-self	● True	
erc20-transferfrom-correct-allowance	● True	
erc20-transferfrom-change-state	● True	
erc20-transferfrom-fail-exceed-allowance	● True	
erc20-transferfrom-false	● True	
erc20-transferfrom-never-return-false	● True	
erc20-transferfrom-revert-from-zero	● Inapplicable	Inapplicable
erc20-transferfrom-revert-to-zero	● False	
erc20-transferfrom-fail-exceed-balance	● Inapplicable	Inapplicable
erc20-transferfrom-fail-recipient-overflow	● Inapplicable	Context not considered

Detailed results for function `totalSupply`

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

Detailed results for function `balanceOf`

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

Detailed results for function `allowance`

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

Detailed results for function `approve`

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

APPENDIX | OXAI

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.
Volatile Code	Volatile Code findings refer to segments of code that behave unexpectedly on certain edge cases that may result in a vulnerability.
Language Specific	Language Specific findings are issues that would only arise within Solidity, i.e. incorrect usage of private or delete.
Coding Style	Coding Style findings usually do not affect the generated byte-code but rather comment on how to make the codebase more legible and, as a result, easily maintainable.

Checksum Calculation Method

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

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

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 \Box) and "eventually" (written \Diamond), 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`

Function `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

Function `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

Function `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

Function `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:

erc20-transfer-correct-amount-self

erc20-transfer-change-state

erc20-transfer-exceed-balance

erc20-transfer-recipient-overflow

[illegible]

If Function `transfer` Returns `false` , the Contract State Has Not Been 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:

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

Specification:

erc20-transferfrom-revert-from-zero

```

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

```

```

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

```

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

- ```

[](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 <
 0x100 && value >=
 0 && _balances[to] >= 0 && _balances[from] >= 0 && _balances[from] <
 0x100 &&
 _allowances[from][msg.sender] >= 0 && _allowances[from][msg.sender] <
 0x100) ==>
<=>(finished(contract.transferFrom(from, to, value), return == true)))

```

- 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] <
 0x100 &&
 _allowances[from][msg.sender] <
 0x1000) ==>
 <>(finished(contract.transferFrom(from, to, value), return == true)))
```



Function `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:

erc20-transferfrom-change-state

- 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:

erc20-transferfrom-fail-exceed-balance

erc20-transferfrom-fail-exceed-allowance

Function `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:

[illegible]

## erc20-transferfrom-fail-recipient-overflow

Function `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:

[illegible]

## erc20-transferfrom-false

If Function `transferFrom` Returns `false` , the Contract's State Has Not Been Changed. 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

Function `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

Function `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

Function `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

Function `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

Function `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

Function `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

Function `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

Function `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

Function `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

Function `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

Function `approve` Prevents Giving 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

Function `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

Function `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 <
 0x100) ==>
 <>(finished(contract.approve(spender, value), return == true ==>
 _allowances[msg.sender][spender] == value)))

```

#### erc20-approve-change-state

Function `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 Function `approve` Returns `false`, the Contract's State Has Not Been Changed. 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

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

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

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