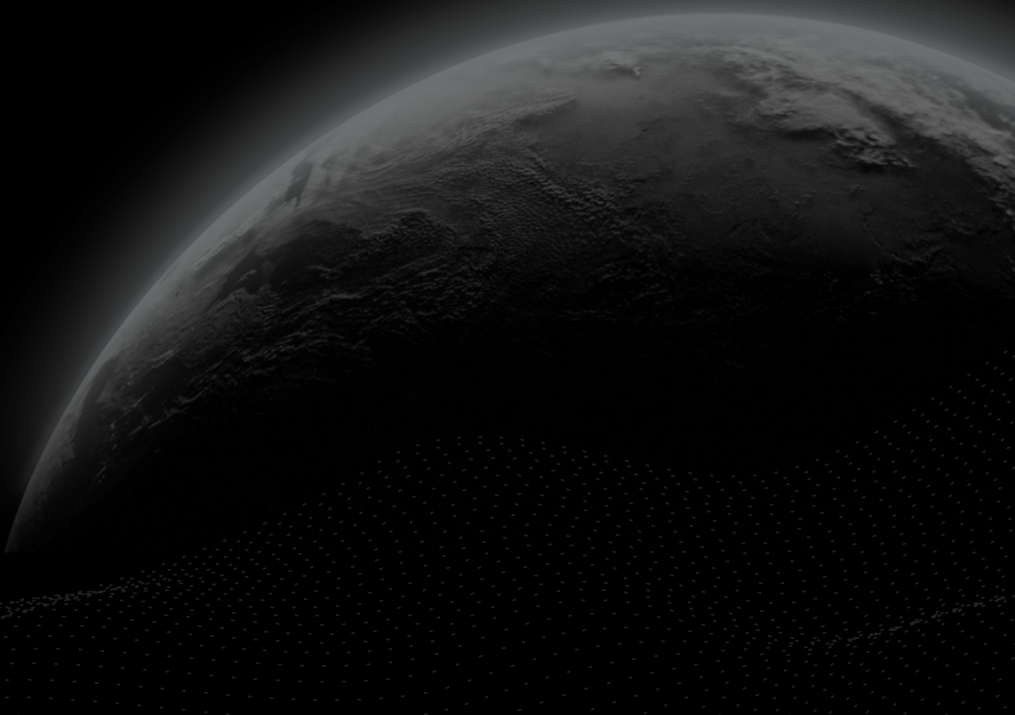




Security Assessment

Privateum Global

CertiK Verified on Apr 7th, 2023





Certik Verified on Apr 7th, 2023

Privateum Global

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

Executive Summary

TYPES

DeFi

ECOSYSTEM

Binance Smart Chain
(BSC)

METHODS

Formal Verification, Manual Review, Static Analysis

LANGUAGE

Solidity

TIMELINE

Delivered on 04/07/2023

KEY COMPONENTS

N/A

CODEBASE

[https://bscscan.com/address/0xb10be3f4c7e1f870d86ed6cfd412fed661](https://bscscan.com/address/0xb10be3f4c7e1f870d86ed6cfd412fed6615feb6f)[5feb6f](#)[...View All](#)

Vulnerability Summary



1

Total Findings

1

Resolved

0

Mitigated

0

Partially Resolved

0

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.



0

Minor

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.



0

Informational

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 | PRIVATEUM GLOBAL

Repository

<https://bscscan.com/address/0xb10be3f4c7e1f870d86ed6cfd412fed6615feb6f>

AUDIT SCOPE


|

PRIVATEUM GLOBAL

1 file audited

●

1 file with Resolved findings

ID	File	SHA256 Checksum
● BEP	<div>  <div>BEP20.sol</div> </div>	<div>f77b69c02c209b7075d01d0f6ef9fc672fceb0a</div> <div>7fe9af1eca393669cd908e23b</div>

APPROACH & METHODS | PRIVATEUM GLOBAL

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

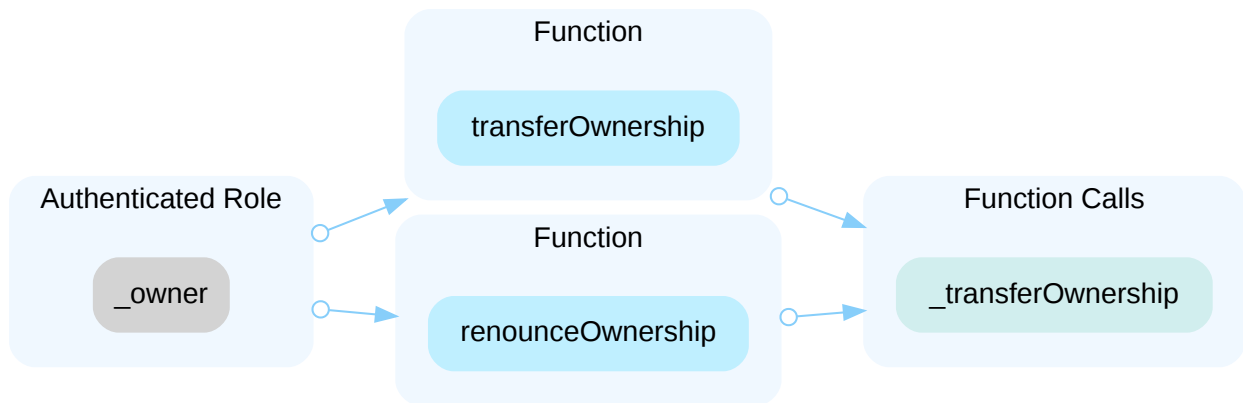
The security assessment resulted in findings that ranged from critical to informational. We recommend addressing these findings to ensure a high level of security standards and industry practices. We suggest recommendations that could better serve the project from the security perspective:

- 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.

DECENTRALIZATION EFFORTS | PRIVATEUM GLOBAL

Description

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



Any compromise to the `_owner` account may allow the hacker to take advantage of this authority.

Recommendations

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 ($\frac{2}{3}$, $\frac{3}{5}$) 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

The team acknowledged the description and recommendations.

FINDINGS | PRIVATEUM GLOBAL

**1**

Total Findings

0

Critical

1

Major

0

Medium

0

Minor

0

Informational

This report has been prepared to discover issues and vulnerabilities for Privateum Global. Through this audit, we have uncovered 1 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
BEP-01	Initial Token Distribution	Centralization / Privilege	Major	● Resolved

BEP-01 | INITIAL TOKEN DISTRIBUTION

Category	Severity	Location	Status
Centralization / Privilege	● Major	BEP20.sol: 567	● Resolved

Description

All `PRI` tokens are sent to the contract deployer when deploying the contract. This is a potential centralization risk as the deployer can distribute `PRI` tokens without the consensus of the community.

Recommendation

We recommend transparency through providing a breakdown of the intended initial token distribution in a public location. We also recommend the team make an effort to restrict the access of the corresponding private key.

Alleviation

[Privateum Global]:

Token Supply:

The total supply of PRI Token is 80 million. This number will remain fixed, as there will be no further issuance or creation of new tokens beyond this initial supply.

Token Allocation:

The 80 million PRI Tokens will be allocated as follows:

- Team: 30.4 million PRI Tokens (38%)
- Development: 23.2 million PRI Tokens (29%)
- Marketing: 16 million PRI Tokens (20%)
- Angel Investors: 10.4 million PRI Tokens (13%)

FORMAL VERIFICATION | PRIVATEUM GLOBAL

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

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

Property Name	Title	
erc20-approve-revert-zero	<code>approve</code>	Prevents Approvals For the Zero Address
erc20-approve-correct-amount	<code>approve</code>	Updates the Approval Mapping Correctly
erc20-approve-succeed-normal	<code>approve</code>	Succeeds for Admissible Inputs
erc20-approve-change-state	<code>approve</code>	Has No Unexpected State Changes
erc20-approve-never-return-false	<code>approve</code>	Never Returns <code>false</code>
erc20-approve-false	If <code>approve</code> Returns <code>false</code> , the Contract's State Is Unchanged	

Verification Results

For the following contracts, model checking established that each of the properties that were in scope of this audit (see scope) are valid:

Detailed Results For Contract ERC20 (BEP20.sol) In Commit 0xb10be3f4c7e1f870d86ed6cfd412fed6615feb6f

Verification of ERC-20 Compliance

Detailed results for function `transfer`

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

Detailed results for function `transferFrom`

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

Detailed Results For Contract BEP20 (BEP20.sol) In Commit
0xb10be3f4c7e1f870d86ed6cfd412fed6615feb6f

Verification of ERC-20 Compliance

Detailed results for function `transfer`

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

Detailed results for function `transferFrom`

Property Name	Final Result	Remarks
erc20-transferfrom-revert-to-zero	● True	
erc20-transferfrom-revert-from-zero	● True	
erc20-transferfrom-succeed-normal	● True	
erc20-transferfrom-succeed-self	● True	
erc20-transferfrom-correct-amount	● True	
erc20-transferfrom-correct-amount-self	● True	
erc20-transferfrom-change-state	● True	
erc20-transferfrom-correct-allowance	● True	
erc20-transferfrom-fail-exceed-balance	● True	
erc20-transferfrom-fail-exceed-allowance	● True	
erc20-transferfrom-fail-recipient-overflow	● True	
erc20-transferfrom-false	● True	
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	● 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-revert-zero	● True	
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	

APPENDIX | PRIVATEUM GLOBAL

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.

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] <
    0x1000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(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 <
    0x1000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(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:

erc20-transfer-false

erc20-transfer-never-return-false

Properties related to function `transferFrom`

`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:

`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 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] <  
        0x1000000000000000000000000000000000000000000000000000000000000000) ==>  
<>(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:

[illegible]

`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:

erc20-transferfrom-false

erc20-transferfrom-never-return-false

erc20-totalsupply-succeed-always

erc20-totalsupply-correct-value

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 <
  0x1000000000000000000000000000000000000000000000000000000000000000) ==>
  <>(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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