



Security Assessment

bitbestdex

CertiK Assessed on Oct 9th, 2023





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bitbestdex

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

Executive Summary

TYPES

ERC-20

ECOSYSTEM

Ethereum (ETH)

METHODS

Formal Verification, Manual Review, Static Analysis

LANGUAGE

Solidity

TIMELINE

Delivered on 10/09/2023

KEY COMPONENTS

N/A

CODEBASE

<https://github.com/bitbestdex/bitbestdex/blob/main/contracts/BSTToken.sol>[View All in Codebase Page](#)

COMMITTS

- v1: 54ad6204061367eeabfb6c635bef47d2dbd7d1a
- v2: cfc5173b51cb9a13c8483b36c8c28abbd11686eb

[View All in Codebase Page](#)

Highlighted Centralization Risks

Initial owner token share is 100%

Vulnerability Summary



4

Total Findings

2

Resolved

0

Mitigated

0

Partially Resolved

2

Acknowledged

0

Declined

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.

2 Major

1 Resolved, 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.

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 Resolved



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.

TABLE OF CONTENTS | BITBESTDEX

I Summary

Executive Summary

Vulnerability Summary

Codebase

Audit Scope

Approach & Methods

I Findings

BST-02 : Lack of Token Minting Mechanism

BTT-01 : Initial Token Distribution

BST-01 : Missing Zero Address Validation

BSB-01 : Possibility of Replay Attack

I Formal Verification

Considered Functions And Scope

Verification Results

I Appendix

I Disclaimer

CODEBASE | BITBESTDEX

Repository



<https://github.com/bitbestdex/bitbestdex/blob/main/contracts/BSTToken.sol>

Commit

- v1: 54ad6204061367eeabbfb6c635bef47d2dbd7d1a
- v2: cfc5173b51cb9a13c8483b36c8c28abbd11686eb

AUDIT SCOPE | BITBESTDEX

2 files audited ● 2 files without findings

ID	File	SHA256 Checksum
● BST	 BSTToken.sol	31f80a1ac4da5af48ae9e832d692ad27501cd ce10c41d626c82e9808a110f1a7
● BTT	 BSTToken.sol	f6b99c2eb30c7de3d85afe39c8a21de74d6af6 9a5ecbff482bd3ac5091294109

APPROACH & METHODS | BITBESTDEX

This report has been prepared for bitbestdex to discover issues and vulnerabilities in the source code of the bitbestdex 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 | BITBESTDEX



4

Total Findings

0

Critical

2

Major

0

Medium

1

Minor

1

Informational

This report has been prepared to discover issues and vulnerabilities for bitbestdex. 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
BST-02	Lack Of Token Minting Mechanism	Design Issue	Major	● Resolved
BTT-01	Initial Token Distribution	Centralization	Major	● Acknowledged
BST-01	Missing Zero Address Validation	Volatile Code	Minor	● Resolved
BSB-01	Possibility Of Replay Attack	Volatile Code	Informational	● Acknowledged

BST-02 | LACK OF TOKEN MINTING MECHANISM

Category	Severity	Location	Status
Design Issue	● Major	BSTToken.sol (v1)	● Resolved

Description

The contract does not utilize or call the `_mint()` function. This means that the contract cannot distribute any tokens. For a token-based smart contract, this is a crucial oversight, as the inability to mint tokens renders the primary purpose of the contract ineffective.

Recommendation

It is recommended to utilize the `_mint()` function to mint tokens.

Alleviation

[bitbestdex Team, 10/06/2023]: The team heeded the advice and resolved the issue in commit [cfc5173b51cb9a13c8483b36c8c28abbd11686ebh](#).

BTT-01 | INITIAL TOKEN DISTRIBUTION

Category	Severity	Location	Status
Centralization	● Major	BSTToken.sol (v2): 31	● Acknowledged

Description

All of the BST-EX tokens are sent to the contract deployer. This is a centralization risk because the deployer can distribute tokens without obtaining the consensus of the community. Any compromise to the contract may allow a hacker to steal and sell tokens on the market, resulting in severe damage to the project.

Recommendation

It is recommended that the team be transparent regarding the initial token distribution process. The token distribution plan should be published in a public location that the community can access. The team should make efforts to restrict access to the private keys of the deployer account or EOAs. A multi-signature ($\frac{2}{3}$, $\frac{3}{5}$) wallet can be used to prevent a single point of failure due to a private key compromise. Additionally, the team can lock up a portion of tokens, release them with a vesting schedule for long-term success, and deanonymize the project team with a third-party KYC provider to create greater accountability.

Alleviation

[bitbestdex Team, 10/09/2023]: When the project starts, BST-EX is minted and distributed to community members. If community members do not obtain BST-EX, the project will not start.

BST-01 | MISSING ZERO ADDRESS VALIDATION

Category	Severity	Location	Status
Volatile Code	Minor	BSTToken.sol (v1): 56	Resolved

Description

The `to` parameter in the following functions is missing a check that it is not `address(0)` :

- `_transfer()` Function:** Without the `address(0)` check, tokens can be inadvertently transferred to the zero address. Since there's no way to retrieve tokens sent to this address, they would be lost forever, reducing the effective circulating supply while not adjusting the `totalSupply` .
- `_mint()` Function:** In the absence of this check, tokens could be minted directly to the zero address. This would increase the `totalSupply` counter without adding to the effective circulating supply, creating a discrepancy between the two.
- `_burn()` Function:** If tokens are burnt from the zero address without a corresponding mint having taken place, it could lead to the `totalSupply` being reduced more than the actual tokens being burnt, again leading to a discrepancy between the `totalSupply` and the effective circulating supply.

Recommendation

We recommend adding a check the `to` address is not `address(0)` to prevent unexpected errors.

Alleviation

[bitbestdex Team, 10/06/2023]: The team heeded the advice and resolved the issue in commit [cfc5173b51cb9a13c8483b36c8c28abbd11686ebh](#).

BSB-01 | POSSIBILITY OF REPLAY ATTACK

Category	Severity	Location	Status
Volatile Code	● Informational	source/contracts/BSTToken.sol (v1): 19	● Acknowledged

Description

The state variable `DOMAIN_SEPARATOR` that is used to calculate hash has a value of `chainId` that is derived only once in the constructor, which does not change after contract deployment. In the event of a fork cross-chain replay attacks can be executed.

The attack scenario is that if a fork happens and two different networks have id of say `1` and `9`. The `chainId` coded in `DOMAIN_SEPARATOR` will be the same on contracts residing in both of the forks. If the `chainId` of `1` is stored in the contract, then a signature for the chain with a `chainid` of `1` will be executable on both of the forks.

Recommendation

We recommend constructing the `DOMAIN_SEPARATOR` hash inside the function which utilizes the signature so the current `chainid` is fetched for each transaction.

FORMAL VERIFICATION | BITBESTDEX

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-self	<code>transfer</code> Succeeds on Admissible Self Transfers
erc20-transfer-succeed-normal	<code>transfer</code> Succeeds on Admissible Non-self Transfers
erc20-transfer-correct-amount-self	<code>transfer</code> Transfers the Correct Amount in 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-false	If <code>transfer</code> Returns <code>false</code> , the Contract State Is Not Changed
erc20-transfer-exceed-balance	<code>transfer</code> Fails if Requested Amount Exceeds Available Balance
erc20-transfer-never-return-false	<code>transfer</code> Never Returns <code>false</code>
erc20-transferfrom-revert-from-zero	<code>transferFrom</code> Fails for Transfers From the Zero Address

Property Name	Title
erc20-transferfrom-revert-to-zero	<code>transferFrom</code> Fails for Transfers To the Zero Address
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-succeed-normal	<code>transferFrom</code> Succeeds on Admissible Non-self Transfers
erc20-transferfrom-correct-amount	<code>transferFrom</code> Transfers the Correct Amount in Non-self Transfers
erc20-transferfrom-correct-allowance	<code>transferFrom</code> Updated the Allowance Correctly
erc20-transferfrom-fail-exceed-allowance	<code>transferFrom</code> Fails if the Requested Amount Exceeds the Available Allowance
erc20-transferfrom-fail-recipient-overflow	<code>transferFrom</code> Prevents Overflows in the Recipient's Balance
erc20-transferfrom-fail-exceed-balance	<code>transferFrom</code> Fails if the Requested Amount Exceeds the Available Balance
erc20-totalsupply-succeed-always	<code>totalSupply</code> Always Succeeds
erc20-transferfrom-false	If <code>transferFrom</code> Returns <code>false</code> , the Contract's State Is Unchanged
erc20-totalsupply-correct-value	<code>totalSupply</code> Returns the Value of the Corresponding State Variable
erc20-totalsupply-change-state	<code>totalSupply</code> Does Not Change the Contract's State
erc20-transferfrom-never-return-false	<code>transferFrom</code> Never Returns <code>false</code>
erc20-balanceof-succeed-always	<code>balanceOf</code> Always Succeeds
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
erc20-approve-succeed-normal	<code>approve</code> Succeeds for Admissible Inputs
erc20-approve-revert-zero	<code>approve</code> Prevents Approvals For the Zero Address

Property Name	Title
erc20-approve-correct-amount	<code>approve</code> Updates the Approval Mapping Correctly
erc20-approve-false	If <code>approve</code> Returns <code>false</code> , the Contract's State Is Unchanged
erc20-approve-never-return-false	<code>approve</code> Never Returns <code>false</code>

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 BSTToken (contracts/BSTToken.sol) In Commit 54ad6204061367eeabbfb6c635bef47d2dbd7d1a

Verification of ERC-20 Compliance

Detailed results for function `transfer`

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

APPENDIX | BITBESTDEX

Finding Categories

Categories	Description
Volatile Code	Volatile Code findings refer to segments of code that behave unexpectedly on certain edge cases and may result in vulnerabilities.
Centralization	Centralization findings detail the design choices of designating privileged roles or other centralized controls over the code.
Design Issue	Design Issue findings indicate general issues at the design level beyond program logic that are not covered by other finding categories.

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

Technical description

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.

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 of those functions. 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 as operations on the congruence classes arising from the bit-width of the underlying numeric 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 an ERC-20 token 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 definitions

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 steps. 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 to reason about the validity of 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 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 for ERC-20 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)))
```

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 <= type(uint256).max && _balances[to] >= 0
  && _balances[msg.sender] <= type(uint256).max)
  ==> <>(finished(contract.transfer(to, value), return)))
```

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] <= type(uint256).max)
  ==> <>(finished(contract.transfer(to, value), return)))
```

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:

```

[](willSucceed(contract.transfer(to, value), to != msg.sender
  && _balances[to] >= 0 && value >= 0
  && _balances[to] + value <= type(uint256).max
  && _balances[msg.sender] >= 0 && _balances[msg.sender] <= type(uint256).max)
  ==> <>(finished(contract.transfer(to, value), return
    ==> _balances[msg.sender] == old(_balances[msg.sender]) - value
    && _balances[to] == old(_balances[to]) + value)))

```

erc20-transfer-correct-amount-self

Function `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] <= type(uint256).max)
  ==> <>(finished(contract.transfer(to, value), return
    ==> _balances[to] == old(_balances[to]))))

```

erc20-transfer-change-state

Function `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
    ==> (_totalSupply == old(_totalSupply) && _allowances == old(_allowances)
    && _balances[p1] == old(_balances[p1]))))

```

erc20-transfer-exceed-balance

Function `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 <= type(uint256).max)
  ==> <>(reverted(contract.transfer) || finished(contract.transfer(to, value),
    !return)))

```

erc20-transfer-recipient-overflow

Function `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 > type(uint256).max
  && _balances[to] >= 0 && _balances[to] <= type(uint256).max
  && _balances[msg.sender] <= type(uint256).max
  && value > 0 && value <= _balances[msg.sender])
  ==> <>(reverted(contract.transfer) || finished(contract.transfer(to, value),
    !return) || finished(contract.transfer(to, value), _balances[to]
      > old(_balances[to]) + value - type(uint256).max - 1)))

```

erc20-transfer-false

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:

```

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

```

erc20-transfer-never-return-false

Function `transfe` Never Returns `false`.

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

Specification:

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

Properties for ERC-20 function `transferFrom`

erc20-transferfrom-revert-from-zero

Function `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)))
```

erc20-transferfrom-revert-to-zero

Function `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)))
```

erc20-transferfrom-succeed-normal

Function `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 <= type(uint256).max
  && value >= 0 && _balances[to] >= 0 && _balances[from] >= 0
  && _balances[from] <= type(uint256).max
  && _allowances[from][msg.sender] >= 0
  && _allowances[from][msg.sender] <= type(uint256).max)
  ==> <>(finished(contract.transferFrom(from, to, value), return)))

```

erc20-transferfrom-succeed-self

Function `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] <= type(uint256).max
  && _allowances[from][msg.sender] <= type(uint256).max)
  ==> <>(finished(contract.transferFrom(from, to, value), return)))

```

erc20-transferfrom-correct-amount

Function `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] <= type(uint256).max
  && _balances[to] >= 0 && _balances[to] + value <= type(uint256).max)
  ==> <>(finished(contract.transferFrom(from, to, value), return
    ==> _balances[from] == old(_balances[from]) - value
    && _balances[to] == old(_balances[to] + value))))

```

erc20-transferfrom-correct-amount-self

Function `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 <= type(uint256).max && _balances[from] >= 0
  && _balances[from] <= type(uint256).max)
  ==> <>(finished(contract.transferFrom(from, to, value), return
    ==> _balances[from] == old(_balances[from]))))]
```

erc20-transferfrom-correct-allowance

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:

```
[(willSucceed(contract.transferFrom(from, to, value), value >= 0
  && value <= type(uint256).max && _balances[from] >= 0
  && _balances[from] <= type(uint256).max && _balances[to] >= 0
  && _balances[to] <= type(uint256).max && _allowances[from][msg.sender] >= 0
  && _allowances[from][msg.sender] <= type(uint256).max)
  ==> <>(finished(contract.transferFrom(from, to, value), return
    ==> ((_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]
            == type(uint256).max)))))))]
```

erc20-transferfrom-change-state

Function `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
    ==> (_totalSupply == old(_totalSupply) && _balances[p1] == old(_balances[p1])
      && _allowances[p2][p3] == old(_allowances[p2][p3])  ))))

```

erc20-transferfrom-fail-exceed-balance

Function `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] <= type(uint256).max)
  ==> <>(reverted(contract.transferFrom)
    || finished(contract.transferFrom, !return)))

```

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:

```

[](started(contract.transferFrom(from, to, value), value > _allowances[from]
[msg.sender]
  && _allowances[from][msg.sender] >= 0 && value <= type(uint256).max)
  ==> <>(reverted(contract.transferFrom)
    || finished(contract.transferFrom(from, to, value), !return)
    || finished(contract.transferFrom(from, to, value), return
      && (msg.sender == from
        || _allowances[from][msg.sender] == type(uint256).max))))

```

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:

```

[] (started(contract.transferFrom(from, to, value), from != to
  && _balances[to] + value > type(uint256).max && value <= type(uint256).max
  && _balances[to] >= 0 && _balances[to] <= type(uint256).max)
  ==> <>(reverted(contract.transferFrom)
    || finished(contract.transferFrom(from, to, value), !return)
    || finished(contract.transferFrom(from, to, value), _balances[to]
      > old(_balances[to]) + value - type(uint256).max - 1)))

```

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.transfer(to, value))
  ==> <>(finished(contract.transfer(to, value), !return
  ==> (_balances == old(_balances) && _totalSupply == old(_totalSupply)
    && _allowances == old(_allowances) ))))

```

erc20-transferfrom-never-return-false

Function `transferFrom` Never Returns `false`.

The `transferFrom` function must never return `false`.

Specification:

```

[] (!(finished(contract.transferFrom, !return)))

```

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) )))
```

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) )))
```

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) )))
```

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)))
```

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)))
```

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 <= type(uint256).max)
  ==> <>(finished(contract.approve(spender, value), return
    ==> _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
        ==> _totalSupply == old(_totalSupply) && _balances == old(_balances)
        && _allowances[p1][p2] == old(_allowances[p1][p2]) )))

```

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
        ==> (_balances == old(_balances) && _totalSupply == old(_totalSupply)
        && _allowances == old(_allowances) ))))

```

erc20-approve-never-return-false

Function `approve` Never Returns `false`.

The function `approve` must never returns `false`.

Specification:

```

[] (! (finished(contract.approve, !return)))

```

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