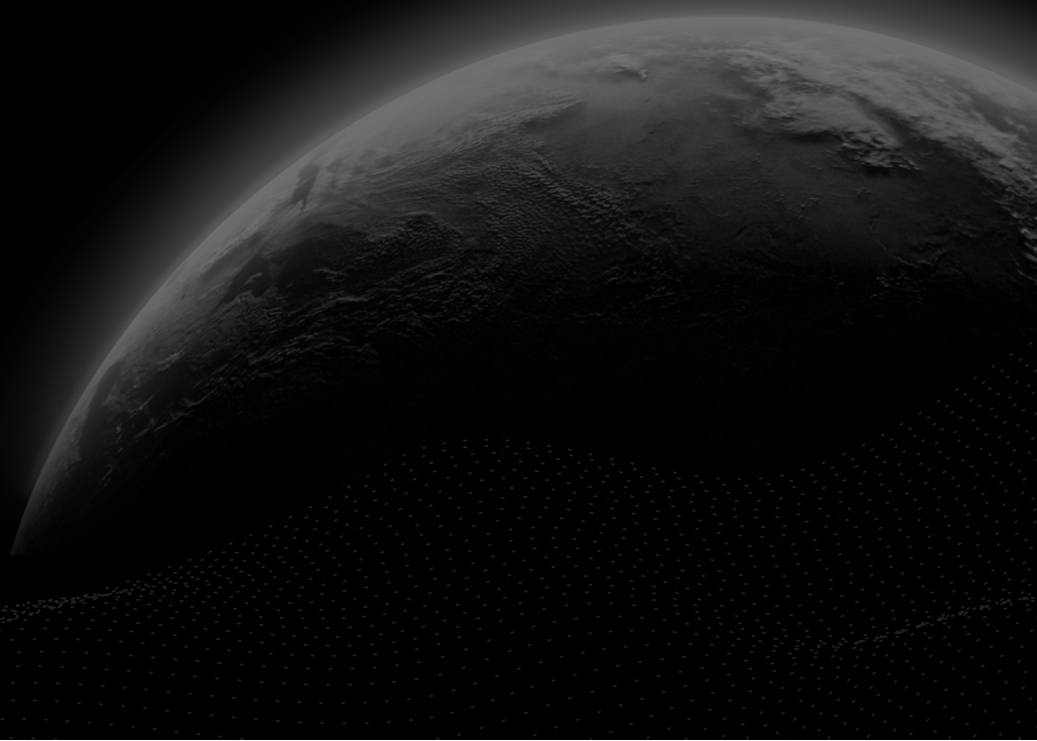
CERTIK

Security Assessment

DettoFinance - Audit

CertiK Assessed on Dec 12th, 2023



CertiK Assessed on Dec 12th, 2023

DettoFinance - Audit

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

Executive Summary

TYPES	ECOSYSTEM	METHODS
ERC-20	Ethereum (ETH)	Formal Verification, Manual Review, Static Analysis

LANGUAGE	TIMELINE	KEY COMPONENTS
Solidity	Delivered on 12/12/2023	N/A

CODEBASE

detto

Basescan

View All in Codebase Page

COMMITS

Audit Version:

fc5d8c4bdf0e534fe2bd1342a2a5407bea3c0329

Remediation Version:

View All in Codebase Page

Vulnerability Summary

5	3	2	0	0	0
Total Findings	Resolved	Mitigated	Partially Resolved	Acknowledged	Declined

1	Critical	1 Resolved	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.
3	Major	1 Resolved, 2 Mitigated	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.
1	Informational	1 Resolved	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 | DETTOFINANCE - AUDIT

Repository

detto

Basescan

Commit

Audit Version:

fc5d8c4bdf0e534fe2bd1342a2a5407bea3c0329

Remediation Version:

fa4104559bdbf226b41320a22a412499d246b40c

Base | 0x7bc401227777f173ff871993b198a8632741b9bb

AUDIT SCOPE | DETTOFINANCE - AUDIT

2 files audited ● 1 file with Mitigated findings ● 1 file with Resolved findings

ID	Repo	File	SHA256 Checksum
● TOK	DettoFinance/detto	Token.sol	b7955f808a55a2ec7baf501008d9524ad8bffde57ec4073a6ad605b5723d4998
● TDF	DettoFinance/detto	Token.sol	cb21e92c8f2666f62eefddb502478e1ac0726d7d47080f46110f54d96a3465df

APPROACH & METHODS | DETTOFINANCE - AUDIT

This report has been prepared for DettoFinance to discover issues and vulnerabilities in the source code of the DettoFinance - Audit project as well as any contract dependencies that were not part of an officially recognized library. A comprehensive examination has been performed, utilizing Manual Review and Static Analysis 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.

REVIEW NOTES | DETTOFINANCE - AUDIT

Overview

The `DettoFinance` is a standard ERC20 token project with burn functionality. The focus of this audit is the token contract.

External Dependencies

The following are external contracts referred to in the contracts. The contract mainly uses OpenZeppelin contracts and libraries for the templates and setup of contracts:

- `ERC20` & `Ownable`.

Since the OpenZeppelin contracts are actively developed, we recommend the team continuously monitor the library change to avoid unexpected failure.

The following are external addresses used within the contracts:

Token.sol

- `_owner` - Owner account of the contract.
- `minter` - Minter account of the contract.

It is assumed that these contracts and libraries are valid and are implemented properly within the current project.

Privileged Functions

In the `DettoFinance` project, multiple roles are adopted to ensure the dynamic runtime updates of the project, which were specified in the findings *TOK-01*.

The advantage of this privileged role in the codebase is that the client reserves the ability to adjust the protocol according to the runtime required to best serve the community. It is also worth of note the potential drawbacks of these functions, which should be clearly stated through the client's action/plan. Additionally, if the private key of the privileged account is compromised, it could lead to devastating consequences for the project.

To improve the trustworthiness of the project, dynamic runtime updates in the project should be notified to the community. Any plan to invoke the aforementioned functions should be also considered to move to the execution queue of the `Timelock` contract.

FINDINGS | DETTOFINANCE - AUDIT

5	1	3	0	0	1
Total Findings	Critical	Major	Medium	Minor	Informational

This report has been prepared to discover issues and vulnerabilities for DettoFinance - Audit. Through this audit, we have uncovered 5 issues ranging from different severity levels. Utilizing the techniques of Manual Review & Static Analysis to complement rigorous manual code reviews, we discovered the following findings:

ID	Title	Category	Severity	Status
TDF-02	Missing Access Control On Burn Function	Logical Issue	Critical	Resolved
TDF-03	**Centralized Balance Manipulation**	**Centralization**	**Major**	**Resolved**
TOK-01	**Centralization Risks In Token.Sol**	**Centralization**	**Major**	**Mitigated**
TOK-02	**Initial Token Distribution**	**Centralization**	**Major**	**Mitigated**
TDF-01	Token Is Not Capped By Total Supply	Logical Issue	Informational	Resolved

TDF-02 | MISSING ACCESS CONTROL ON BURN FUNCTION

Category	Severity	Location	Status
Logical Issue	Critical	Token.sol (fc5d8c4bdf0e534fe2bd1342a2a5407bea3c0329): 21~23	Resolved

Description

The current implementation of the `burn()` function permits unrestricted access, allowing any user to initiate the burning of tokens from arbitrary addresses. This flaw can be exploited in several harmful ways.

```
function burn(address _from, uint256 _amount) public {
    _burn(_from, _amount);
}
```

Scenario

An attacker could leverage this vulnerability in Automated Market Maker (AMM) environments. For instance, if the token is traded on platforms like Uniswap, an attacker could burn tokens directly from the Uniswap pair contract. This action could artificially inflate the token's price, leading to the potential drainage of assets from the pair contract.

Recommendation

We recommend adding corresponding access control on the `burn` function.

Alleviation

[DettoFinance Team, 12/04/2023]: The team resolved this issue by adding corresponding access control on the `burn` function in the updated version fa4104559bdbf226b41320a22a412499d246b40c.

TDF-03 | CENTRALIZED BALANCE MANIPULATION

Category	Severity	Location	Status
Centralization	**Major**	**Token.sol (fc5d8c4bdf0e534fe2bd1342a2a5407bea3c0329): 17**	**Resolved**

Description

In the contract `Token.sol` , the role owner has the authority to update the token balance of an arbitrary account without sanity restriction.

```
function mint(address _to, uint256 _amount) public onlyOwner {
    _mint(_to, _amount);
}
```

Any compromise to the owner account may allow a hacker to take advantage of this authority and manipulate users' balances. The attacker can mint tokens and sell the tokens for profit. It could lead to the price drop of the token and thus cause heavy losses for the token holders.

Recommendation

We recommend the team makes efforts to restrict access to the private key of the privileged account. A strategy of multi-signature (⅔, ⅗) wallet can be used to prevent a single point of failure due to a private key compromise. In addition, the team should be transparent and notify the community in advance whenever they plan to mint more tokens or engage in similar balance-related operations.
Here are some feasible short-term and long-term suggestions that would mitigate the potential risk to a different level and suggestions that would permanently *fully* resolve the risk:

Short Term:

A multi signature (⅔, ⅗) wallet *mitigate* the risk by avoiding a single point of key management failure.

- Assignment of privileged roles to multi-signature wallets to prevent a single point of failure due to a private key compromised;
  AND
- A medium/blog link for sharing the time-lock contract and multi-signers' addresses information with the community.

For remediation and mitigated status, please provide the following information:

- Provide the **gnosis** address with **ALL** the multi-signer addresses for the verification process.
- Provide a link to the **medium/blog** with all of the above information included.

Long Term:

A DAO for controlling the operation *mitigate* the risk by applying transparency and decentralization.

- Introduction of a DAO, governance, or voting module to increase decentralization, transparency, and user involvement;
  AND
- A medium/blog link for sharing the multi-signers' addresses, and DAO information with the community.

For remediation and mitigated status, please provide the following information:

- Provide the **gnosis** address with **ALL** the multi-signer addresses for the verification process.
- Provide a link to the **medium/blog** with all of the above information included.

Permanent:

The following actions can *fully* resolve the risk:

- Renounce the ownership and never claim back the privileged role.
  OR
- Remove the risky functionality.
  OR
- Add minting logic (such as a vesting schedule) to the contract instead of allowing the owner account to call the sensitive function directly.

Note: we recommend the project team consider the long-term solution or the permanent solution. The project team shall make a decision based on the current state of their project, timeline, and project resources.

Alleviation

[DettoFinance Team, 12/04/2023]: The team resolved this issue by removing the `mint()` function in the updated version fa4104559bdbf226b41320a22a412499d246b40c.

TOK-01 | CENTRALIZATION RISKS IN TOKEN.SOL

Category	Severity	Location	Status
Centralization	**Major**	**Token.sol (12/04-fa4104): 20, 24**	**Mitigated**

Description

In the contract `Token` the role `_owner` has authority over the functions listed below.

- transferOwnership(): transfer ownership to a specified address.
- renounceOwnership(): renounce the ownership of the contract.
- setMinter(): set the `minter` role of the contract.

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

In the contract `Token` the role `minter` has authority over the functions listed below.

- burn(): burn any tokens from an arbitrary address.

Any compromise to the `minter` account may allow the hacker to take advantage of this authority and burn assets.

Notes

It is noted that the `minter` role has the authority to burn the tokens of an arbitrary account without sanity restriction. Any compromise to the `minter` account may allow a hacker to take advantage of this authority and manipulate users' balances.

Recommendation

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

Short Term:

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

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

Long Term:

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

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

Permanent:

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

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

Alleviation

[CertiK, 12/04/2023]: This finding relates to the updated version fa4104559bdbf226b41320a22a412499d246b40c.

[DettoFinance, 12/08/2023]: The team has deployed the contract to the address Base | 0x7bc401227777f173ff871993b198a8632741b9bb. The team adopted Timelock and Multi sign combination to mitigate this issue.

Timelock address: 0xACA88A24944EEC339069D55200F9947ed6b4A669, has a delay of 48 hours. The admin of this timelock contract is the multisig address 0x345b276Da99520A792070A8BA529833108b854a6.

Multisig address: 0x345b276Da99520A792070A8BA529833108b854a6, requires 2 out of 3 owners.

Signer 1: 0x8BF597b3569b1872690866157D414A820d9c0fEf

Signer 2: 0x19cEbEb25f6B15fcb466b967e9E24E29615829AD

Signer 3: 0x94274b2063707d99456C78e2110e7edcba9726df

[CertiK, 12/08/2023]: The current contract adopts two roles `_owner` and `minter` to implement the functionality. It is noted that the `_owner` role can update the `minter` role and the `minter` role can be used to burn tokens from users. The `minter` role of the deployed contract is set to an unverified proxy contract 0x187e9Bb88b3619ffa96D6884E6eD7f10780eF45F.

While this strategy has indeed reduced the risk, it's crucial to note that it has not completely eliminated it. CertiK strongly encourages the project team periodically revisit the private key security management of all above-listed addresses.

TOK-02 | INITIAL TOKEN DISTRIBUTION

Category	Severity	Location	Status
Centralization	**Major**	**Token.sol (12/04-fa4104): 17**	**Mitigated**

Description

All of the `DETO` tokens are sent to the contract deployer or one or several externally-owned account (EOA) addresses. This is a centralization risk because the deployer or the owner(s) of the EOAs can distribute tokens without obtaining the consensus of the community. Any compromise to these addresses 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 (⅔, ⅗) 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

[CertiK, 12/04/2023]: This finding relates to the updated version fa4104559bdbf226b41320a22a412499d246b40c.

[DettoFinance, 12/06/2023]: The team has deployed the contract to the address Base | 0x7bc401227777f173ff871993b198a8632741b9bb. The team also shared a public link to the token distribution plan: https://docs.detto.finance/deto-token/tokenomics and stated they have issued multi-signature wallet for the undeployed DETO tokens.

Multi-sig wallet address: 0x345b276Da99520A792070A8BA529833108b854a6, requires 2 out of 3 owners.

Signer 1: 0x8BF597b3569b1872690866157D414A820d9c0fEf

Signer 2: 0x19cEbEb25f6B15fcb466b967e9E24E29615829AD

Signer 3: 0x94274b2063707d99456C78e2110e7edcba9726df

[CertiK, 12/06/2023]: As of December 6th, 2023, 22,225,000 tokens are held in the multisig wallet. While this strategy has indeed reduced the risk, it's crucial to note that it has not completely eliminated it. CertiK strongly encourages the project team periodically revisit the private key security management of all above-listed addresses.

TDF-01 | TOKEN IS NOT CAPPED BY TOTAL SUPPLY

Category	Severity	Location	Status
Logical Issue	Informational	Token.sol (fc5d8c4bdf0e534fe2bd1342a2a5407bea3c0329): 9	Resolved

Description

The contract defines an `INITIAL_SUPPLY` constant, setting the initial token supply to 100,000,000 tokens. However, there is no initial supply minted in the `constructor()`.

We would like to discuss with the team if it is the intended design. What is the intended design of the `INITIAL_SUPPLY`?

Recommendation

We would like to discuss with the team if it is the intended design.

Alleviation

[DettoFinance Team, 12/04/2023]: The team resolved this issue by minting `INITIAL_SUPPLY` tokens in the `constructor()` function in the updated version fa4104559bdbf226b41320a22a412499d246b40c.

FORMAL VERIFICATION | DETTOFINANCE - AUDIT

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 formal verification to prove that important functions in the smart contracts adhere to their expected behaviors.

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-approve-succeed-normal	`approve` Succeeds for Admissible Inputs
erc20-totalsupply-change-state	`totalSupply` Does Not Change the Contract's State
erc20-transferfrom-correct-amount-self	`transferFrom` Performs Self Transfers Correctly
erc20-transferfrom-revert-from-zero	`transferFrom` Fails for Transfers From the Zero Address
erc20-transferfrom-correct-amount	`transferFrom` Transfers the Correct Amount in Non-self Transfers
erc20-transfer-exceed-balance	`transfer` Fails if Requested Amount Exceeds Available Balance
erc20-allowance-succeed-always	`allowance` Always Succeeds
erc20-approve-never-return-false	`approve` Never Returns `false`
erc20-transferfrom-succeed-self	`transferFrom` Succeeds on Admissible Self Transfers
erc20-allowance-change-state	`allowance` Does Not Change the Contract's State
erc20-balanceof-change-state	`balanceOf` Does Not Change the Contract's State

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

Property Name	Title
erc20-transferfrom-fail-exceed-balance	`transferFrom` Fails if the Requested Amount Exceeds the Available Balance
erc20-approve-correct-amount	`approve` Updates the Approval Mapping Correctly

Verification Results

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

Detailed Results For Contract Token (Token.sol) In Commit fa4104559bdbf226b41320a22a412499d246b40c

Verification of ERC-20 Compliance

Detailed Results for Function `approve`

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

Detailed Results for Function `totalSupply`

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

Detailed Results for Function `transferFrom`

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

Detailed Results for Function `transfer`

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

Detailed Results for Function `allowance`

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

Detailed Results for Function `balanceOf`

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

Detailed Results For Contract Token (Token.sol) In Commit fc5d8c4bdf0e534fe2bd1342a2a5407bea3c0329

Verification of ERC-20 Compliance

Detailed Results for Function `transfer`

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

Detailed Results for Function `transferFrom`

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

Detailed Results for Function `approve`

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

Detailed Results for Function `totalSupply`

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

Detailed Results for Function `allowance`

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

Detailed Results for Function `balanceOf`

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

APPENDIX | DETTOFINANCE - AUDIT

Finding Categories

Categories	Description
Logical Issue	Logical Issue findings indicate general implementation issues related to the program logic.
Centralization	Centralization findings detail the design choices of designating privileged roles or other centralized controls over the code.

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. Each such contract was compiled into a mathematical model that 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 following assumptions and simplifications apply to our model:

- 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 specifications

All properties are expressed in a behavioral interface specification language that CertiK has developed for Solidity, which allows us to specify the behavior of each function in terms of the contract state and its parameters and return values, as well as contract properties that are maintained by every observable state transition. Observable state transitions occur when the contract's external interface is invoked and the invocation does not revert, and when the contract's Ether balance is changed by the EVM due to another contract's "self-destruct" invocation. The specification language has the usual Boolean connectives, as well as the operator `\old` (used to denote the state of a variable before a state transition), and several types of specification clause:

Apart from the Boolean connectives and the modal operators "always" (written `[]`) and "eventually" (written `<>`), 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:

- `requires [cond]` - the condition `cond`, which refers to a function's parameters, return values, and contract state variables, must hold when a function is invoked in order for it to exhibit a specified behavior.
- `ensures [cond]` - the condition `cond`, which refers to a function's parameters, return values, and both `\old` and current contract state variables, is guaranteed to hold when a function returns if the corresponding requires condition held when it was invoked.
- `invariant [cond]` - the condition `cond`, which refers only to contract state variables, is guaranteed to hold at every observable contract state.
- `constraint [cond]` - the condition `cond`, which refers to both `\old` and current contract state variables, is guaranteed to hold at every observable contract state except for the initial state after construction (because there is no previous state); constraints are used to restrict how contract state can change over time.

Description of the Analyzed ERC-20 Properties

Properties related to function `approve`

erc20-approve-correct-amount

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:

```
requires spender != address(0);
ensures \result ==> allowance(msg.sender, \old(spender)) == \old(amount);
```

erc20-approve-correct-amount

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:

```
requires spender != address(0);
ensures \result ==> allowance(msg.sender, \old(spender)) == \old(amount);
```

erc20-approve-false

If function `approve` returns `false` to signal a failure, it must undo all state changes that it incurred before returning to the caller.

Specification:

```
ensures !\result ==> \assigned (\nothing);
```

erc20-approve-false

If function `approve` returns `false` to signal a failure, it must undo all state changes that it incurred before returning to the caller.

Specification:

```
ensures !\result ==> \assigned (\nothing);
```

erc20-approve-never-return-false

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

Specification:

```
ensures \result;
```

erc20-approve-never-return-false

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

Specification:

```
ensures \result;
```

erc20-approve-revert-zero

All calls of the form `approve(spender, amount)` must fail if the address in `spender` is the zero address.

Specification:

```
ensures \old(spender) == address(0) ==> !\result;
```

erc20-approve-revert-zero

All calls of the form `approve(spender, amount)` must fail if the address in `spender` is the zero address.

Specification:

```
ensures \old(spender) == address(0) ==> !\result;
```

erc20-approve-succeed-normal

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:

```
requires spender != address(0);
ensures \result;
reverts_only_when false;
```

erc20-approve-succeed-normal

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:

```
requires spender != address(0);
ensures \result;
reverts_only_when false;
```

Properties related to function `totalSupply`

erc20-totalsupply-change-state

The `totalSupply` function in contract Token must not change any state variables.

Specification:

```
assignable \nothing;
```

erc20-totalsupply-change-state

The `totalSupply` function in contract Token must not change any state variables.

Specification:

```
assignable \nothing;
```

erc20-totalsupply-correct-value

The `totalSupply` function must return the value that is held in the corresponding state variable of contract Token.

Specification:

```
ensures \result == totalSupply();
```

erc20-totalsupply-correct-value

The `totalSupply` function must return the value that is held in the corresponding state variable of contract Token.

Specification:

```
ensures \result == totalSupply();
```

erc20-totalsupply-succeed-always

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

Specification:

```
reverts_only_when false;
```

erc20-totalsupply-succeed-always

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

Specification:

```
reverts_only_when false;
```

Properties related to function `transferFrom`

erc20-transferfrom-correct-allowance

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:

```
ensures \result ==> allowance(\old(sender), msg.sender) == \old(allowance(sender,
msg.sender)) - \old(amount)
                || (allowance(\old(sender), msg.sender) == \old(allowance(sender,
msg.sender)) && \old(allowance(sender, msg.sender)) == type(uint256).max);
```

erc20-transferfrom-correct-allowance

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:

```
ensures \result ==> allowance(\old(sender), msg.sender) == \old(allowance(sender,
msg.sender)) - \old(amount)
                || (allowance(\old(sender), msg.sender) == \old(allowance(sender,
msg.sender)) && \old(allowance(sender, msg.sender)) == type(uint256).max);
```

erc20-transferfrom-correct-amount

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:

```
requires recipient != sender;
requires balanceOf(recipient) + amount <= type(uint256).max;
ensures \result ==> balanceOf(\old(recipient)) == \old(balanceOf(recipient) +
amount)
                  && balanceOf(\old(sender)) == \old(balanceOf(sender) - amount);
```

erc20-transferfrom-correct-amount

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`.

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```
requires recipient != sender;
requires balanceOf(recipient) + amount <= type(uint256).max;
ensures \result ==> balanceOf(\old(recipient)) == \old(balanceOf(recipient) +
amount)
                  && balanceOf(\old(sender)) == \old(balanceOf(sender) - amount);
```

erc20-transferfrom-correct-amount-self

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:

```
requires recipient == sender;
ensures \result ==> balanceOf(\old(recipient)) == \old(balanceOf(recipient));
```

erc20-transferfrom-correct-amount-self

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:

```
requires recipient == sender;
ensures \result ==> balanceOf(\old(recipient)) == \old(balanceOf(recipient));
```

erc20-transferfrom-fail-exceed-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:

```
requires msg.sender != sender;
requires amount > allowance(sender, msg.sender);
ensures !\result;
```

erc20-transferfrom-fail-exceed-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:

```
requires msg.sender != sender;
requires amount > allowance(sender, msg.sender);
ensures !\result;
```

erc20-transferfrom-fail-exceed-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:

```
requires amount > balanceOf(sender);
ensures !\result;
```

erc20-transferfrom-fail-exceed-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:

```
requires amount > balanceOf(sender);
ensures !\result;
```

erc20-transferfrom-fail-recipient-overflow

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:

```
requires recipient != sender;
requires balanceOf(recipient) + amount > type(uint256).max;
ensures !\result;
```

erc20-transferfrom-fail-recipient-overflow

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:

```
requires recipient != sender;
requires balanceOf(recipient) + amount > type(uint256).max;
ensures !\result;
```

erc20-transferfrom-false

If `transferFrom` returns `false` to signal a failure, it must undo all incurred state changes before returning to the caller.

Specification:

```
ensures !\result ==> \assigned (\nothing);
```

erc20-transferfrom-false

If `transferFrom` returns `false` to signal a failure, it must undo all incurred state changes before returning to the caller.

Specification:

```
ensures !\result ==> \assigned (\nothing);
```

erc20-transferfrom-never-return-false

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

Specification:

```
ensures \result;
```

erc20-transferfrom-never-return-false

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

Specification:

```
ensures \result;
```

erc20-transferfrom-revert-from-zero

All calls of the form `transferFrom(from, dest, amount)` where the `from` address is zero, must fail.

Specification:

```
ensures \old(sender) == address(0) ==> !\result;
```

erc20-transferfrom-revert-from-zero

All calls of the form `transferFrom(from, dest, amount)` where the `from` address is zero, must fail.

Specification:

```
ensures \old(sender) == address(0) ==> !\result;
```

erc20-transferfrom-revert-to-zero

All calls of the form `transferFrom(from, dest, amount)` where the `dest` address is zero, must fail.

Specification:

```
ensures \old(recipient) == address(0) ==> !\result;
```

erc20-transferfrom-revert-to-zero

All calls of the form `transferFrom(from, dest, amount)` where the `dest` address is zero, must fail.

Specification:

```
ensures \old(recipient) == address(0) ==> !\result;
```

erc20-transferfrom-succeed-normal

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:

```
requires recipient != address(0) && sender != address(0) && recipient != sender;
requires amount <= balanceOf(sender);
requires amount <= allowance(sender, msg.sender);
requires balanceOf(recipient) + amount <= type(uint256).max;
ensures \result;
reverts_only_when false;
```

erc20-transferfrom-succeed-normal

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:

```
requires recipient != address(0) && sender != address(0) && recipient != sender;
requires amount <= balanceOf(sender);
requires amount <= allowance(sender, msg.sender);
requires balanceOf(recipient) + amount <= type(uint256).max;
ensures \result;
reverts_only_when false;
```

erc20-transferfrom-succeed-self

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:

```
requires recipient != address(0) && recipient == sender;
requires amount <= balanceOf(sender);
requires amount <= allowance(sender, msg.sender);
ensures \result;
reverts_only_when false;
```

erc20-transferfrom-succeed-self

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:

```
requires recipient != address(0) && recipient == sender;
requires amount <= balanceOf(sender);
requires amount <= allowance(sender, msg.sender);
ensures \result;
reverts_only_when false;
```

Properties related to function `transfer`

erc20-transfer-correct-amount

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:

```
requires recipient != msg.sender;
requires balanceOf(recipient) + amount <= type(uint256).max;
ensures \result ==> balanceOf(recipient) == \old(balanceOf(recipient) + amount)
&& balanceOf(msg.sender) == \old(balanceOf(msg.sender) - amount);
```

erc20-transfer-correct-amount

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:

```
requires recipient != msg.sender;
requires balanceOf(recipient) + amount <= type(uint256).max;
ensures \result ==> balanceOf(recipient) == \old(balanceOf(recipient) + amount)
&& balanceOf(msg.sender) == \old(balanceOf(msg.sender) - amount);
```

erc20-transfer-correct-amount-self

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:

```
requires recipient == msg.sender;
ensures \result ==> balanceOf(msg.sender) == \old(balanceOf(msg.sender));
```

erc20-transfer-correct-amount-self

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:

```
requires recipient == msg.sender;
ensures \result ==> balanceOf(msg.sender) == \old(balanceOf(msg.sender));
```

erc20-transfer-exceed-balance

Any transfer of an amount of tokens that exceeds the balance of `msg.sender` must fail.

Specification:

```
requires amount > balanceOf(msg.sender);
ensures !\result;
```

erc20-transfer-exceed-balance

Any transfer of an amount of tokens that exceeds the balance of `msg.sender` must fail.

Specification:

```
requires amount > balanceOf(msg.sender);
ensures !\result;
```

erc20-transfer-false

If the `transfer` function in contract `Token` fails by returning `false`, it must undo all state changes it incurred before returning to the caller.

Specification:

```
ensures !\result ==> \assigned (\nothing);
```

erc20-transfer-false

If the `transfer` function in contract `Token` fails by returning `false`, it must undo all state changes it incurred before returning to the caller.

Specification:

```
ensures !\result ==> \assigned (\nothing);
```

erc20-transfer-never-return-false

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

Specification:

```
ensures \result;
```

erc20-transfer-never-return-false

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

Specification:

```
ensures \result;
```

erc20-transfer-recipient-overflow

Any invocation of `transfer(recipient, amount)` must fail if it causes the balance of the `recipient` address to overflow.

Specification:

```
requires recipient != msg.sender;
requires balanceOf(recipient) + amount > type(uint256).max;
ensures !\result;
```

erc20-transfer-recipient-overflow

Any invocation of `transfer(recipient, amount)` must fail if it causes the balance of the `recipient` address to overflow.

Specification:

```
requires recipient != msg.sender;
requires balanceOf(recipient) + amount > type(uint256).max;
ensures !\result;
```

erc20-transfer-revert-zero

Any call of the form `transfer(recipient, amount)` must fail if the recipient address is the zero address.

Specification:

```
ensures \old(recipient) == address(0) ==> !\result;
```

erc20-transfer-revert-zero

Any call of the form `transfer(recipient, amount)` must fail if the recipient address is the zero address.

Specification:

```
ensures \old(recipient) == address(0) ==> !\result;
```

erc20-transfer-succeed-normal

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:

```
requires recipient != address(0) && recipient != msg.sender;
requires amount <= balanceOf(msg.sender);
requires balanceOf(recipient) + amount <= type(uint256).max;
ensures \result;
reverts_only_when false;
```

erc20-transfer-succeed-normal

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:

```
requires recipient != address(0) && recipient != msg.sender;
requires amount <= balanceOf(msg.sender);
requires balanceOf(recipient) + amount <= type(uint256).max;
ensures \result;
reverts_only_when false;
```

erc20-transfer-succeed-self

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:

```
requires recipient == msg.sender;
requires amount <= balanceOf(msg.sender);
ensures \result;
reverts_only_when false;
```

erc20-transfer-succeed-self

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:

```
requires recipient == msg.sender;
requires amount <= balanceOf(msg.sender);
ensures \result;
reverts_only_when false;
```

Properties related to function `allowance`

erc20-allowance-change-state

Function `allowance` must not change any of the contract's state variables.

Specification:

```
assignable \nothing;
```

erc20-allowance-change-state

Function `allowance` must not change any of the contract's state variables.

Specification:

```
assignable \nothing;
```

erc20-allowance-correct-value

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

Specification:

```
ensures \result == allowance(\old(owner), \old(spender));
```

erc20-allowance-correct-value

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

Specification:

```
ensures \result == allowance(\old(owner), \old(spender));
```

erc20-allowance-succeed-always

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

Specification:

```
reverts_only_when false;
```

erc20-allowance-succeed-always

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

Specification:

```
reverts_only_when false;
```

Properties related to function `balanceOf`

erc20-balanceof-change-state

Function `balanceOf` must not change any of the contract's state variables.

Specification:

```
assignable \nothing;
```

erc20-balanceof-change-state

Function `balanceOf` must not change any of the contract's state variables.

Specification:

```
assignable \nothing;
```

erc20-balanceof-correct-value

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

Specification:

```
ensures \result == balanceOf(\old(account));
```

erc20-balanceof-correct-value

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

Specification:

```
ensures \result == balanceOf(\old(account));
```

erc20-balanceof-succeed-always

Function `balanceOf` must always succeed if it does not run out of gas.

Specification:

```
reverts_only_when false;
```

erc20-balanceof-succeed-always

Function `balanceOf` must always succeed if it does not run out of gas.

Specification:

```
reverts_only_when false;
```

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