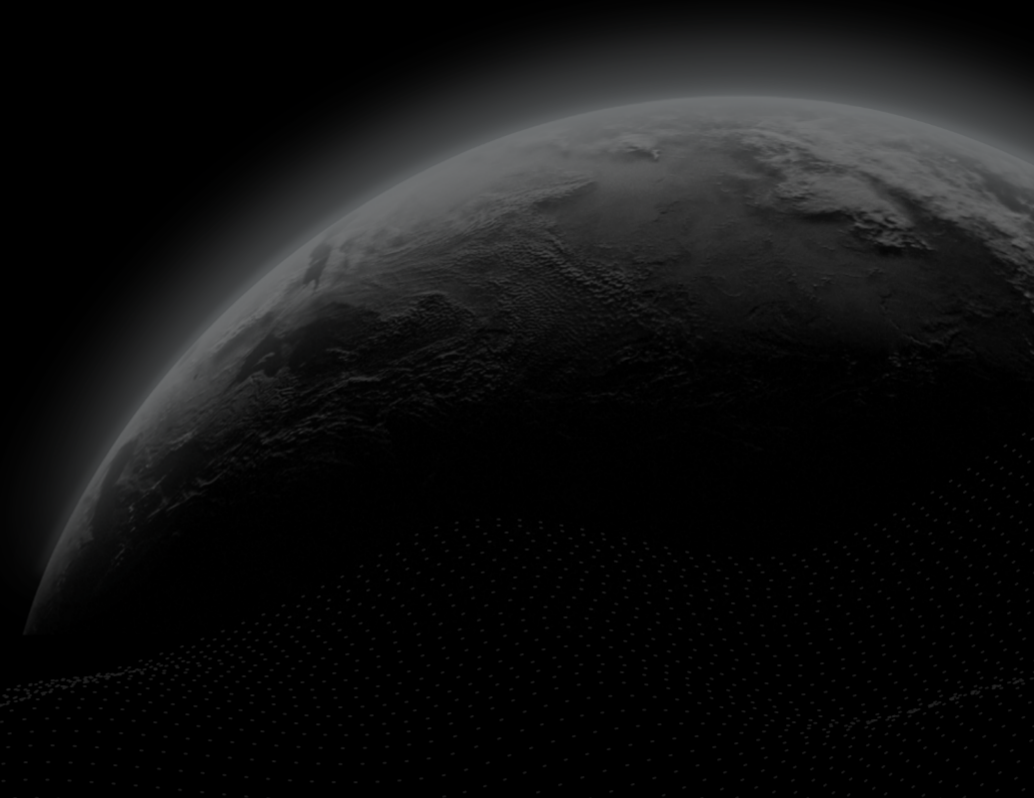
Economic Assessment

T.I.M.E. Dividend (TIME) - Ethereum

CertiK Verified on Mar 24th, 2023



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

Executive Summary

TYPES	ECOSYSTEM	METHODS
DeFi	Ethereum	Manual Review

LANGUAGE	TIMELINE	KEY COMPONENTS
Solidity	Delivered on 03/24/2023	TIMEDividend

CODEBASE

https://bitbucket.org/internet-money/wallet-contracts/src/master/contracts/TIMEDividend.sol

...View All

COMMITS

856179395047c7818b0b34ddae503089ba0c2969

...View All

Vulnerability Summary

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

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

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CODEBASE | T.I.M.E. DIVIDEND (TIME) - ETHEREUM

Repository

https://bitbucket.org/internet-money/wallet-contracts/src/master/contracts/TIMEDividend.sol

Commit

856179395047c7818b0b34ddae503089ba0c2969

AUDIT SCOPE | T.I.M.E. DIVIDEND (TIME) - ETHEREUM

1 file audited ● 1 file without findings

ID	File	SHA256 Checksum
TIM	TIMEDividend.sol	bb0400ff9b904a7de218ab0039e6eb169d1d18e72d485eecc8b7dda25b07f52a

APPROACH & METHODS | T.I.M.E. DIVIDEND (TIME) - ETHEREUM

This report has been prepared for T.I.M.E. Dividend to discover issues and vulnerabilities of the economic model of the T.I.M.E. Dividend (TIME) - Ethereum project, based on the source code of the T.I.M.E. Dividend (TIME) - Ethereum project. We treated the provided background information (Appendix) as design specifications. A comprehensive examination has been performed, utilizing Manual Review techniques.

The auditing process includes the following considerations:

- Conducting rigorous mathematical reasoning to analyze the economic model, with particular emphasis on discrete data types, to ensure accuracy and reliability.
- Assessing the compliance of the economic model with current industry standards and best practices to identify areas for improvement.
- Reviewing the economic model to ensure the preservation of semantics in comparison to the design documentation, and that no essential elements have been lost.
- Performing a meticulous manual line-by-line review of the codebase to confirm that the code implementation aligns with the economic model and satisfies all applicable standards and requirements.

INTRODUCTION | T.I.M.E. DIVIDEND (TIME) - ETHEREUM

The `TIMEDividend` contract allows for the distribution of dividends to token holders. The dividends are paid out in native coins (ETH), with the amount distributed based on the number of tokens held by each address after delta correction. The delta correction moves opposite to the token flow of token transferring, such that in general, the dividend distribution is aligned with the initial token holding status. Generally we do not recommend the token distribution to have more than half of the total supply held by one user, given that the initial token distribution takes place before the contract is ready and allowed to work.

The contract uses a unique approach to calculate dividends, where `magnifiedDividendPerShare` and `magnifiedDividendCorrections` of each address are to ensure that the dividend payouts/claims are maintained over time.

A core value of the calculation if the state variable `magnitude` , which is a constant value used to convert amounts to scaling magnitudes. It used to maintaining the resolution of payouts to be accurately calculated for very small amounts. It is hardcoded to 2^{128} in the contract.

The contract contains two key mappings, `cumulativeDividendClaimed` and `magnifiedDividendCorrections` . `cumulativeDividendClaimed` is used to track the cumulative amount of dividend claimed by each address, ensuring that double payouts are not made. `magnifiedDividendCorrections` is used to track corrections made to the magnified dividend per share as tokens are transferred between accounts.

The `receive()` function is aim to receive fees generated from the swap operations, which is not implemented in the TIMEDividend contract. In fact the `receive` function does not specify which address is the source of the fees, such that it allows any addresses to send native coin (ETH) to itself. The function requires that the minting process is complete and the ownership has been renounced, which can also be seen as a status that the whole contract is ready to start functioning.

PROTOCOL DESCRIPTION | T.I.M.E. DIVIDEND (TIME) - ETHEREUM

State Variables

```
uint256 public constant magnitude = 2**128;
uint256 public magnifiedDividendPerShare;

mapping(address => int256) public magnifiedDividendCorrections;
mapping(address => uint256) public cumulativeDividendClaimed;
```

Functions

receive()

Let a_b be the native coins (ETH) transfer amount, which is also known as `msg.value` in Solidity. For each function call, we have

$$magnifiedDividendPerShare += \frac{a_b}{totalSupply} \times magnitude$$

If the receive function is called for n times, we have

$$magnifiedDividendPerShare_n = \sum_{i=1}^{n} \frac{a_{bi}}{totalSupply} \times magnitude$$

$$\implies magnifiedDividendPerShare_n = 2^{128} * \sum_{i=1}^{n} \frac{a_{bi}}{totalSupply}$$

where `totalSupply` cannot be increased since the require statement of the `receive` function checks that the contract ownership is already renounced.

_beforeTokenTransfer()

Let's say there is a transfer transaction, where u_s is the sender's address, u_r is the recepient address, and a_t is the token transfer amount. Let `magnifiedDividendCorrections` be mdc. If this function is called for n times, we have

$$mdc[u_s] = \sum_{i=1}^{n} magnifiedDividendPerShare \times a_t$$

and

$$mdc[u_r] = -\sum_{i=1}^{n} magnifiedDividendPerShare \times a_t$$

divideFrom()

$$product = magDividendPerShare * balance + correction$$

$$return_1 = product/magnitude$$

$$\implies return_1 = (magDividendPerShare * balance + correction) \div magnitude$$

$$return_2 = product \mod magnitude$$

$$\implies return_2 = (magDividendPerShare * balance + correction) \mod magnitude$$

accumulativeDividendOf()

Let `magnifiedDividendCorrections` be mdc, and `account` be the input address. Also since there are two parts of the return value, let the former value be $return_1$ and the latter value be $return_2$.

$$return_1 = product/magnitude$$

$$\implies return_1 = (magDividendPerShare * balanceOf(account) + mdc[account]) \div magnitude$$

$$return_2 = product \mod magnitude$$

$$\implies return_2 = (magDividendPerShare * balanceOf(account) + mdc[account]) \mod magnitude$$

claimableDividendOf()

Let `magnifiedDividendCorrections` be mdc, `account` be the input address, and `cumulativeDividendClaimed` be cdc, we have

$$return = (return_1 \ of \ dividendFrom) - cdc[account]$$

$$\implies return = \frac{magDividendPerShare*balanceOf(account)+mdc[account]}{magnitude} - cdc[account]$$

claimDividend()

Let `magnifiedDividendCorrections` be mdc, and let `cumulativeDividendClaimed` be cdc.

$$claimable = \frac{magDividendPerShare*balanceOf(account)+mdc[account]}{magnitude} - cdc[account]_{old}$$

$$recipent \ balance \mathrel{+}= claimable \text{ , where currency is ETH}$$

$$cdc[account] \mathrel{+}= claimable$$

distributeAll()

This function is removed in commit hash `d6c89e5dac14b6db95f9dc67af54bd76103805fe`.

~~Called function `distributeAll()` from interface `IInternetMoneySwapRouter`. The function sends all fees, the input `amount` of native coins and/or WETH tokens, to the `destination` address defined in the contract behind the `IInternetMoneySwapRouter`.~~

PROTOCOL ANALYSIS | T.I.M.E. DIVIDEND (TIME) - ETHEREUM

The smart contract and its functions don't maintain any time-related variables, so the length of time a user holds TIME tokens doesn't affect the final dividend amount. We thoroughly examined the state and local variables of the TIMEDividend contract and found that it doesn't store or use any external data related to a locking time period. Therefore, the only variables that influence a user's dividend/reward are the `magnifiedDividendPerShare`, the amount of TIME tokens held by the user's address, and the `magnifiedDividendCorrections` (mdc) of the user's address.

Claimable Dividend

Within the four state variables, `magnitude` is declared to be `constant`.

`magnifiedDividendPerShare` is a variable that keeps track of the magnified dividend per share. It is calculated by dividing the total amount of dividend received by the `<total supply of tokens>`, and then multiplying by `magnitude` (2^{128}).

The `magnifiedDividendCorrections` mapping keeps track of the magnified dividend corrections for each account. Magnified dividend corrections are used to adjust the claimable dividend of an account based on its transfer history.

The `cumulativeDividendClaimed` mapping keeps track of the cumulative dividend claimed for each account. It is used to calculate the total claimable dividend for an account.

Here we would like to summarize a general math expression of the claimable dividend of a user. For the n-th time the function `claimDividend` is being called by an address, define the follow variables:

- `msg.sender`, the function caller address: u
- `magnifiedDividendPerShare`: `mdps`
- the previous claimed dividend summation: cdc_{n-1}
- the number of function calls of `claimDividend` before this call : n_c
- the number of function calls of `receive`: n_{nc}
    - the received native coin (ETH) amount of the i_{nc} time with the total n_{nc} time:$amount_{i_{nc}}$
- the number of function calls of `transfer` as a sender: n_{ts}
    - the sent token amount of the i_{ts} time with the total n_{ts} time: $amount_{i_{ts}}$
- the number of function calls of `transfer` as a receiver: n_{tr}
    - the received token amount of the i_{tr} time with the total n_{tr} time: $amount_{i_{tr}}$
- the number of function calls of `burn`: n_b
    - the burnt token amount of the i_b time with the total n_b time: $amount_{i_b}$
- initial token balance of the user: $initBal$

- current token balance of the user: $currBal$, at the n-th call of `claimDividend`

From the above function description, we have

$$claimable_n = \frac{magDividendPerShare_{n_{nc}} * balanceOf(account) + mdc[account]}{magnitude} - cdc_{old}$$

Here for the balance of u at the n-th call of `claimDividend` , the current token balance is

$$currBal = initBal - \text{<all sent amount>} + \text{<all received amount>} - \text{<all burnt amount>}$$

$$\implies currBal = initBal - \sum_{i_{ts}=1}^{n_{ts}} amount_{i_{tr}} + \sum_{i_{ts}=1}^{n_{tr}} amount_{i_{tr}} - \sum_{i_b=1}^{n_b} amount_{i_b}$$

Similarly, we have the `magnifiedDividendCorrections` be

$$mdc = mdps * (\text{<all sent amount>} - \text{<all received amount>} + \text{<all burnt amount>})$$

$$\implies mdc = mdps * (\sum_{i_{ts}=1}^{n_{ts}} amount_{i_{tr}} - \sum_{i_{ts}=1}^{n_{tr}} amount_{i_{tr}} + \sum_{i_b=1}^{n_b} amount_{i_b})$$

In the meanwhile, `magnifiedDividendPerShare` is monotonically increasing controlled by the `receive` function. From the above function description of `receive` , we have

$$magnifiedDividendPerShare_{n_{nc}} = \sum_{i_{nc}=1}^{n_{nc}} \frac{amount_{i_{nc}}}{totalSupply} \times magnitude$$

Also, for the previous claimed dividend summation, we have $cdc_{n-1} = \sum_{i=1}^{n-1} claimable_i$

Therefore, for $claimable_n$, we have

$$claimable_n = \frac{magDividendPerShare_{n_{nc}} * balanceOf(account) + mdc[account]}{magnitude} - cdc_{old}$$

Substitute the variable names and make them fit the latest definition in the analysis.

$$claimable_n = \frac{mdps_{n_{nc}} * currBal + mdc}{magnitude} - cdc_{n-1}$$

Since $mdc == mdps * (\text{<transfer amount delta>})$, we can extract $\frac{mdps}{magnitude}$, and then we have

$$claimable_n = \frac{mdps}{magnitude} * (currBal + \frac{mdc}{mdps}) - \sum_{i=1}^{n-1} claimable_i$$

Substitute $currBal$ and mdc, we have the expression with the detailed amount summation based on the times of different functions being called for the current `receiver` function caller.

$$\implies claimable_n = \frac{mdps}{magnitude} * (initBal - \sum_{i_{ts}=1}^{n_{ts}} amount_{i_{tr}} + \sum_{i_{ts}=1}^{n_{tr}} amount_{i_{tr}} - \sum_{i_b=1}^{n_b} amount_{i_b} + \sum_{i_{ts}=1}^{n_{ts}} amount_{i_{tr}} - \sum_{i_{ts}=1}^{n_{tr}} amount_{i_{tr}} + \sum_{i_b=1}^{n_b} amount_{i_b}) - \sum_{i=1}^{n-1} claimable_i$$

$$= \frac{mdps}{magnitude} * initBal - \sum_{i=1}^{n-1} claimable_i$$

$$= \frac{\sum_{i_{nc}=1}^{n_{nc}} \frac{amount_{i_{nc}}}{totalSupply} \times magnitude}{magnitude} - \sum_{i=1}^{n-1} claimable_i$$

$$= \sum_{i_{nc}=1}^{n_{nc}} \frac{amount_{i_{nc}}}{totalSupply} - \sum_{i=1}^{n-1} claimable_i$$

Here when $i = 1$, the base case gives that the $claimable_1 = 0$, and the first time claimable dividend is the sum of quotient of each native coin (ETH) deposit divided by the total supply at that time.

APPENDIX | T.I.M.E. DIVIDEND (TIME) - ETHEREUM

Initial Consultation

General overview of TIME.

(There are three cases to consider: Native to token, token to native, and token to token)

1&2. Swap occurs within in the wallet. A fee of .729% of the USD value of the asset being swapped out of is charged in the form of the native coin for that given chain. Example: $100 of USDC is being swapped to ETH. A fee of $0.729 will be charged. That fee will be paid in the form of ETH.

3&4. Fees are stored in the swap router contract until a user "sweeps" the fees. At which time, the fees are sent to and stored in the TIME contract. Holders of TIME are then credited their portion of fees, which they can claim as frequently as they desire. With no expiration date to claim.

Notes

If an address sells, burns or transfers its tokens, it is still entitled to claim the fees it has been credited in the TIME contract up until the point of sell, burn or transfer. If TIME is burned, new fees coming into the TIME contract will be equitably distributed to remaining TIME holders.

Detailed Notes

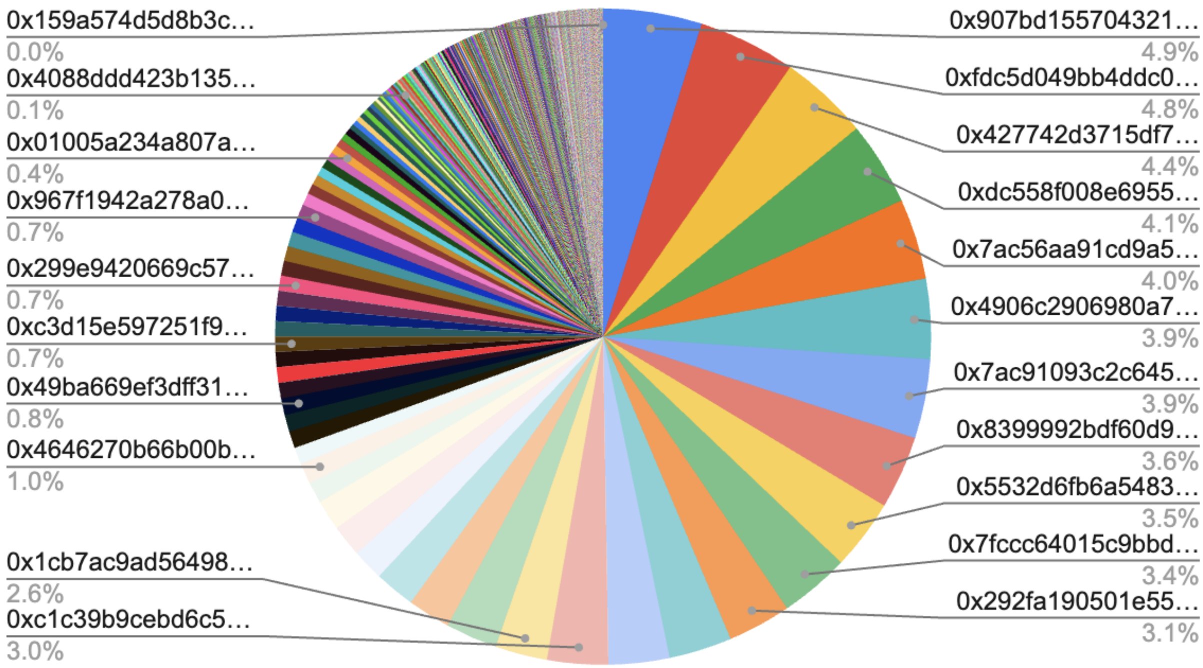
1. While the token has an owner no distribution occurs, only trading of magnified dividend corrections can occur.
2. When funds come into the TIME token contract, they increment a magnified share value which is used to derive a portion of ownership for each address that has a token balance at the time of the distribution. The distribution is additive and non destructive, as in it will provide an equitable share of the income to the contract that holds timedividend and that income will be accessible even if the holder trades away / transfers away their tokens.
3. Ensure there are no ways to extract more value out of the system than is equitable based on ownership during income events.
4. Address should still be able to claim their dividend events that they held after they burn or transfer tokens away. The remaining addresses should not have more or less available to them during the burn, only more after, proportional to their new % ownership of the total supply (% equity).
5. Rounding errors will occur at various points during the calculations - defining these more cleanly + systematically would be helpful.
6. A test is provided in the timedividend.test.ts file that has 3 addresses shifting funds around and burning while income is being distributed. I don't think our pathological cases need to cover less than 2 accounts with balances. A test has been provided that prints out a table that can be seen by running yarn run test:flow. Other pathological cases could include any combination of burning 99.99% percent of the supply, flow of funds being equivalent to the total supply of native token per day (pulsechain ~ 1_200_000x eth) both pulsechain, ethereum, or any other anomalous chains' total supply, perhaps xdai would be a good example.

Initial Distribution

As of Mar 24, 2023, the TIMEDividend contract is deployed to Ethereum Mainnet. The contract address is 0xd08481058399490B83a72676901d4e9dB70E75aC.

We have `0x907bd155704321d8c27d7ce8d9a51452e7eb22b6` to be the address that holds the most tokens. It holds 97178934 TIME, which is around 4.86% of the total distribution.

Below is the pie chart of all token holding addresses. We can see the distribution is sufficiently diverse.



Finding Categories

Categories	Description

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.

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