SMART CONTRACT AUDIT REPORT

for

VALUE DEFI

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Hangzhou, China
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Contents

1 Introduction

Given the opportunity to review the design document and related smart contract source code of `Vaults` in the Value DeFi protocol, we in the report outline our systematic approach to evaluate potential security issues in the smart contract implementation, expose possible semantic inconsistencies between smart contract code and design document, and provide additional suggestions or recommendations for improvement. Our results show that the given version of smart contracts can be further improved due to the presence of several issues related to either security or performance. This document outlines our audit results.

1.1 About Value DeFi

The Value DeFi protocol is a platform containing a suite of products that aims to bring fairness, value, and innovation to DeFi. It operates on four core tenets: 1) increase accessibility to yield farming, 2) provide on-chain voting for governance, 3) reward our stakeholders with flexible, optimized and profitable vault strategies, and 4) protect the community's funds through the integration of an insurance treasury. The audited `Vaults` are yield aggregators that deploy your assets using multiple strategies to keep the returns as high as possible.

The basic information of the Vaults is as follows:

Table 1.1: Basic Information of Vaults

Item	Description
Issuer	Value DeFi
Website	https://valuedefi.io
Type	Ethereum Smart Contract
Platform	Solidity
Audit Method	Whitebox
Latest Audit Report	November 28, 2020

In the following, we show the Git repository of reviewed files and the commit hash value

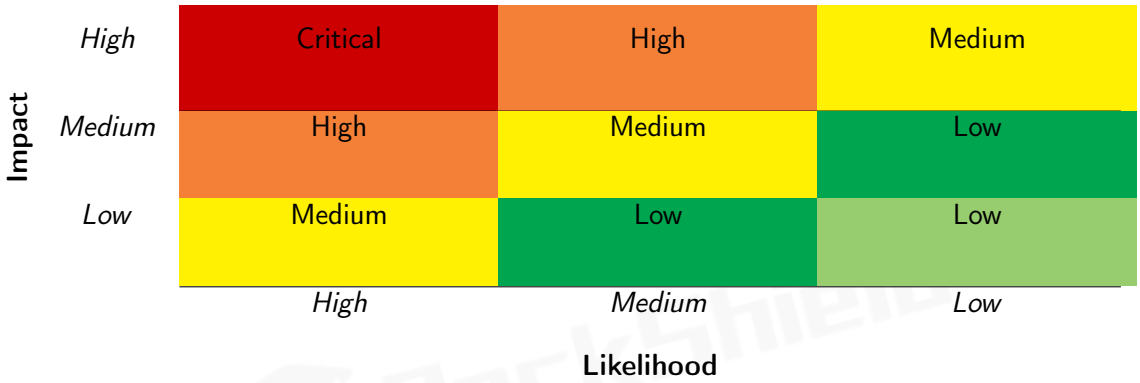
used in this audit. Note that the repository contains a number of contracts and sub-directories and this audit covers only the following ones: `ValueVaultMaster`, `ValueVaultBank`, `ValueVaultV2`, and `WETHMultiPoolStrategy`.

- https://github.com/valuedefi/vaults.git (dab536c)

1.2 About PeckShield

PeckShield Inc. [20] is a leading blockchain security company with the goal of elevating the security, privacy, and usability of current blockchain ecosystems by offering top-notch, industry-leading services and products (including the service of smart contract auditing). We are reachable at Telegram (https://t.me/peckshield), Twitter (http://twitter.com/peckshield), or Email (contact@peckshield.com).

Table 1.2: Vulnerability Severity Classification



1.3 Methodology

To standardize the evaluation, we define the following terminology based on OWASP Risk Rating Methodology [15]:

- Likelihood represents how likely a particular vulnerability is to be uncovered and exploited in the wild;
- Impact measures the technical loss and business damage of a successful attack;
- Severity demonstrates the overall criticality of the risk.

Likelihood and impact are categorized into three ratings: *H*, *M* and *L*, i.e., *high*, *medium* and *low* respectively. Severity is determined by likelihood and impact and can be classified into four categories accordingly, i.e., *Critical*, *High*, *Medium*, *Low* shown in Table 1.2.

Table 1.3: The Full List of Check Items

Category	Check Item
Basic Coding Bugs	Constructor Mismatch
	Ownership Takeover
	Redundant Fallback Function
	Overflows & Underflows
	Reentrancy
	Money-Giving Bug
	Blackhole
	Unauthorized Self-Destruct
	Revert DoS
	Unchecked External Call
	Gasless Send
	Send Instead Of Transfer
	Costly Loop
	(Unsafe) Use Of Untrusted Libraries
	(Unsafe) Use Of Predictable Variables
	Transaction Ordering Dependence
	Deprecated Uses
Semantic Consistency Checks	Semantic Consistency Checks
Advanced DeFi Scrutiny	Business Logics Review
	Functionality Checks
	Authentication Management
	Access Control & Authorization
	Oracle Security
	Digital Asset Escrow
	Kill-Switch Mechanism
	Operation Trails & Event Generation
	ERC20 Idiosyncrasies Handling
	Frontend-Contract Integration
	Deployment Consistency
	Holistic Risk Management
Additional Recommendations	Avoiding Use of Variadic Byte Array
	Using Fixed Compiler Version
	Making Visibility Level Explicit
	Making Type Inference Explicit
	Adhering To Function Declaration Strictly
	Following Other Best Practices

To evaluate the risk, we go through a list of check items and each would be labeled with a severity category. For one check item, if our tool or analysis does not identify any issue, the contract is considered safe regarding the check item. For any discovered issue, we might further deploy contracts on our private testnet and run tests to confirm the findings. If necessary, we would additionally build a PoC to demonstrate the possibility of exploitation. The concrete list of check items is shown in Table 1.3.

In particular, we perform the audit according to the following procedure:

- Basic Coding Bugs: We first statically analyze given smart contracts with our proprietary static code analyzer for known coding bugs, and then manually verify (reject or confirm) all the issues found by our tool.
- Semantic Consistency Checks: We then manually check the logic of implemented smart contracts and compare with the description in the white paper.
- Advanced DeFi Scrutiny: We further review business logics, examine system operations, and place DeFi-related aspects under scrutiny to uncover possible pitfalls and/or bugs.
- Additional Recommendations: We also provide additional suggestions regarding the coding and development of smart contracts from the perspective of proven programming practices.

To better describe each issue we identified, we categorize the findings with Common Weakness Enumeration (CWE-699) [14], which is a community-developed list of software weakness types to better delineate and organize weaknesses around concepts frequently encountered in software development. Though some categories used in CWE-699 may not be relevant in smart contracts, we use the CWE categories in Table 1.4 to classify our findings.

1.4 Disclaimer

Note that this audit does not give any warranties on finding all possible security issues of the given smart contract(s), i.e., the evaluation result does not guarantee the nonexistence of any further findings of security issues. As one audit-based assessment cannot be considered comprehensive, we always recommend proceeding with several independent audits and a public bug bounty program to ensure the security of smart contract(s). Last but not least, this security audit should not be used as investment advice.

Table 1.4: Common Weakness Enumeration (CWE) Classifications Used in This Audit

Category	Summary
Configuration	Weaknesses in this category are typically introduced during the configuration of the software.
Data Processing Issues	Weaknesses in this category are typically found in functionality that processes data.
Numeric Errors	Weaknesses in this category are related to improper calculation or conversion of numbers.
Security Features	Weaknesses in this category are concerned with topics like authentication, access control, confidentiality, cryptography, and privilege management. (Software security is not security software.)
Time and State	Weaknesses in this category are related to the improper management of time and state in an environment that supports simultaneous or near-simultaneous computation by multiple systems, processes, or threads.
Error Conditions, Return Values, Status Codes	Weaknesses in this category include weaknesses that occur if a function does not generate the correct return/status code, or if the application does not handle all possible return/status codes that could be generated by a function.
Resource Management	Weaknesses in this category are related to improper management of system resources.
Behavioral Issues	Weaknesses in this category are related to unexpected behaviors from code that an application uses.
Business Logics	Weaknesses in this category identify some of the underlying problems that commonly allow attackers to manipulate the business logic of an application. Errors in business logic can be devastating to an entire application.
Initialization and Cleanup	Weaknesses in this category occur in behaviors that are used for initialization and breakdown.
Arguments and Parameters	Weaknesses in this category are related to improper use of arguments or parameters within function calls.
Expression Issues	Weaknesses in this category are related to incorrectly written expressions within code.
Coding Practices	Weaknesses in this category are related to coding practices that are deemed unsafe and increase the chances that an exploitable vulnerability will be present in the application. They may not directly introduce a vulnerability, but indicate the product has not been carefully developed or maintained.

2 | Findings

2.1 Summary

Here is a summary of our findings after analyzing the design and implementation of Vaults. During the first phase of our audit, we study the smart contract source code and run our in-house static code analyzer through the codebase. The purpose here is to statically identify known coding bugs, and then manually verify (reject or confirm) issues reported by our tool. We further manually review business logics, examine system operations, and place DeFi-related aspects under scrutiny to uncover possible pitfalls and/or bugs.

Severity	# of Findings	
Critical	0	
High	0	
Medium	3	■■■
Low	5	■■■■■
Informational	1	■
Total	9	

We have so far identified a list of potential issues: some of them involve subtle corner cases that might not be previously thought of, while others refer to unusual interactions among multiple contracts. For each uncovered issue, we have therefore developed test cases for reasoning, reproduction, and/or verification. After further analysis and internal discussion, we determined a few issues of varying severities that need to be brought up and paid more attention to, which are categorized in the above table. More information can be found in the next subsection, and the detailed discussions of each of them are in Section 3.

2.2 Key Findings

Overall, these smart contracts are well-designed and engineered, though the implementation can be improved by resolving the identified issues (shown in Table 2.1), including 3 medium-severity vulnerabilities, 5 low-severity vulnerabilities, and 1 informational recommendation.

Table 2.1: Key Audit Findings of Vaults

ID	Severity	Title	Category
PVE-001	Medium	Revisited Assumption on Trusted Governance And Operator	Security Features
PVE-002	Low	Suggested Adherence of Checks-Effects-Interactions	Time and State
PVE-003	Informational	Incompatibility With Deflationary/Rebasing Tokens	Business Logic
PVE-004	Low	Improved Sanity Checks For System Parameters	Coding Practices
PVE-005	Low	Unused Code Removal	Coding Practices
PVE-006	Medium	Possible Sandwich/MEV Attack For Reduced Returns	Time and State
PVE-007	Low	Precise Conversion of WETH-USDC For Liquidity Addition	Business Logic
PVE-008	Medium	Improved claim() in WETHMultiPoolStrategy	Business Logic
PVE-009	Low	Improved Asset Consistency Among Bank And Strategies	Coding Practices

Besides recommending specific countermeasures to mitigate these issues, we also emphasize that it is always important to develop necessary risk-control mechanisms and make contingency plans, which may need to be exercised before the mainnet deployment. The risk-control mechanisms need to kick in at the very moment when the contracts are being deployed in mainnet. Please refer to Section 3 for details.

3 Detailed Results

3.1 Revisited Assumption on Trusted Governance And Operator

- ID: PVE-001
- Severity: Medium
- Likelihood: Medium
- Impact: Medium
- Target: `Multiple Contracts`
- Category: Security Features [9]
- CWE subcategory: CWE-287 [4]

Description

In Vaults, the governance/operator account plays a critical role in governing and regulating the system-wide operations (e.g., `vault`/`strategy` addition, reward adjustment, and parameter setting). It also has the privilege to control or govern the flow of assets for investment or full withdrawal among the three components, i.e., `vault`, `bank`, and `strategy`.

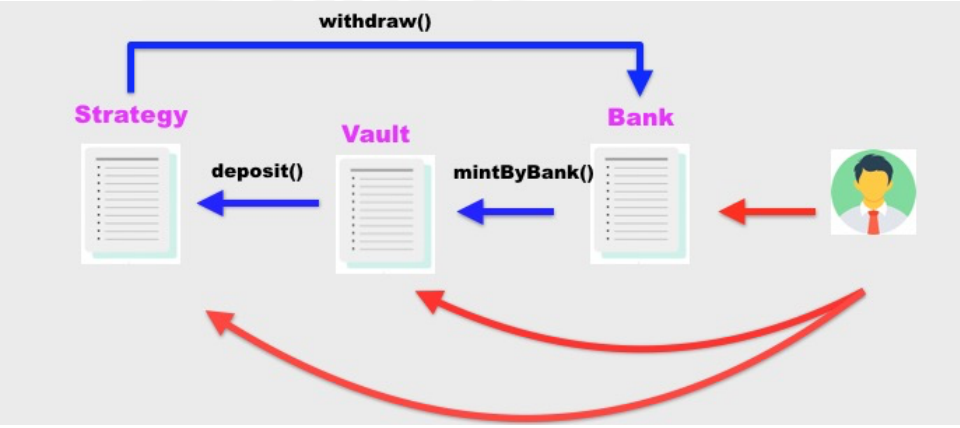


Figure 3.1: The Privilege Management Chain in Vaults

With great privilege comes great responsibility. Our analysis shows that the governance account is indeed privileged. In the following, we examine the current privilege management graph in the

Vaults protocol (Figure 3.1).

We emphasize that the privilege assignment among `bank`, `vault`, and `strategy` is properly administrated. However, it could be worrisome if `governance` is not governed by a `DAO`-like structure.

We point out that a compromised `governance` account would allow the attacker to add a malicious `strategy`, which directly undermines the assumption of the entire protocol.

Recommendation Promptly transfer the `governance` privilege to the intended `DAO`-like governance contract. And activate the normal on-chain community-based governance life-cycle and ensure the intended trustless nature and high-quality distributed governance.

3.2 Suggested Adherence of Checks-Effects-Interactions

- ID: PVE-002
- Severity: Low
- Likelihood: Low
- Impact: Low
- Target: `Multiple Contracts`
- Category: Time and State [12]
- CWE subcategory: CWE-663 [6]

Description

A common coding best practice in Solidity is the adherence of `checks-effects-interactions` principle. This principle is effective in mitigating a serious attack vector known as `re-entrancy`. Via this particular attack vector, a malicious contract can be reentering a vulnerable contract in a nested manner. Specifically, it first calls a function in the vulnerable contract, but before the first instance of the function call is finished, second call can be arranged to re-enter the vulnerable contract by invoking functions that should only be executed once. This attack was part of several most prominent hacks in Ethereum history, including the `DAO` [23] exploit, and the recent `Uniswap/Lendf.Me` hack [21].

We notice there are several occasions the `checks-effects-interactions` principle is violated. Using the `ValueVaultBank` as an example, the `emergencyWithdraw()` function (see the code snippet below) is provided to externally call a token contract to transfer assets. However, the invocation of an external contract requires extra care in avoiding the above `re-entrancy`.

Apparently, the interaction with the external contract (line 193) starts before effecting the update on internal states (lines 194 – 195), hence violating the principle. In this particular case, if the external contract has some hidden logic that may be capable of launching `re-entrancy` via the very same `emergencyWithdraw()` function.

```
190     // Withdraw without caring about rewards. EMERGENCY ONLY.
191     function emergencyWithdraw(uint256 _poolId) public {
192         uint256 amount = stakers[_poolId][msg.sender].stake;
193         poolMap[_poolId].token.safeTransfer(address(msg.sender), amount);
```

```
194         stakers[_poolId][msg.sender].stake = 0;
195         global[_poolId].total_stake = global[_poolId].total_stake.sub(amount);
196     }
```

Listing 3.1: ValueVaultBank.sol

Another similar violation can be found in the `make_profit()` routine within the same contract, the `deposit()` routine in `WETHSodaPoolStrategy`, and the `emergencyWithdraw()/depositOnBehalf()/withdrawOnBehalf()` routines in `ValueMinorPool`.

In the meantime, we should mention that the `UniswapV2`'s LP tokens implement rather standard ERC20 interfaces and their related token contracts are not vulnerable or exploitable for `re-entrancy`.

Recommendation Apply necessary reentrancy prevention by following the `checks-effects-interactions` best practice. The above `emergencyWithdraw()` can be revised as follows:

```
190     // Withdraw without caring about rewards. EMERGENCY ONLY.
191     function emergencyWithdraw(uint256 _poolId) public {
192         uint256 amount = stakers[_poolId][msg.sender].stake;
193         stakers[_poolId][msg.sender].stake = 0;
194         global[_poolId].total_stake = global[_poolId].total_stake.sub(amount);
195         poolMap[_poolId].token.safeTransfer(address(msg.sender), amount);
196     }
```

Listing 3.2: ValueVaultBank.sol (revised)

3.3 Incompatibility with Deflationary/Rebasing Tokens

- ID: PVE-003
- Severity: Informational
- Likelihood: N/A
- Impact: N/A
- Target: `ValueVaultBank`
- Category: Business Logics [11]
- CWE subcategory: CWE-841 [8]

Description

In `Vaults`, the `ValueVaultBank` contract is designed to be the main entry for interaction with farming users. In particular, one entry routine, i.e., `deposit()`, accepts user deposits of supported assets (e.g., `DAI`). Naturally, the contract implements a number of low-level helper routines to transfer assets into or out of the `ValueVaultBank` contract. These asset-transferring routines work as expected with standard ERC20 tokens: namely the vault's internal asset balances are always consistent with actual token balances maintained in individual ERC20 token contracts.

```
123     // Deposit tokens to Bank. If we have a strategy, then tokens will be moved there.
124     function deposit(uint256 _poolId, uint256 _amount, bool _farmMinorPool, address
            _referrer) public discountCHI {
```

```
125         PoolInfo storage pool = poolMap[_poolId];
126         require(now >= pool.startTime, "deposit: after startTime");
127         require(_amount > 0, "!_amount");
128         require(address(pool.vault) != address(0), "pool.vault = 0");
129         require(pool.individualCap == 0  stakers[_poolId][msg.sender].stake.add(_amount)
                <= pool.individualCap, "Exceed pool.individualCap");
130         require(pool.totalCap == 0  global[_poolId].total_stake.add(_amount) <= pool.
                totalCap, "Exceed pool.totalCap");
131
132         pool.token.safeTransferFrom(msg.sender, address(pool.vault), _amount);
133         pool.vault.mintByBank(pool.token, msg.sender, _amount);
134         if (_farmMinorPool && address(vaultMaster) != address(0)) {
135             address minorPool = vaultMaster.minorPool();
136             if (minorPool != address(0)) {
137                 IValueMinorPool(minorPool).depositOnBehalf(msg.sender, pool.minorPoolId,
                        pool.vault.balanceOf(msg.sender), _referrer);
138             }
139         }
140
141         _handleDepositStakeInfo(_poolId, _amount);
142         emit Deposit(msg.sender, _poolId, _amount);
143     }
```

Listing 3.3: ValueVaultBank.sol

However, there exist other ERC20 tokens that may make certain customizations to their ERC20 contracts. One type of these tokens is deflationary tokens that charge a certain fee for every `transfer()` or `transferFrom()`. (Another type is rebasing tokens such as `YAM`.) As a result, this may not meet the assumption behind these low-level asset-transferring routines. In other words, the above operations, such as `deposit()` and `withdraw()`, may introduce unexpected balance inconsistencies when comparing internal asset records with external ERC20 token contracts in the cases of deflationary/rebasing tokens.

One possible mitigation is to regulate the set of ERC20 tokens that are permitted into the `ValueVaultBank` contract. In our case, it is indeed possible to effectively regulate the set of tokens that can be supported. Keep in mind that there exist certain assets (e.g., `USDT`) that may have control switches that can be dynamically exercised to suddenly become one.

Recommendation If current codebase needs to support deflationary tokens, it is better to check the balance before and after the `transfer()/transferFrom()` call to ensure the book-keeping amount is accurate. This support may bring additional gas cost. Also, keep in mind that certain tokens may not be deflationary for the time being. However, they could have a control switch that can be exercised to turn them into deflationary tokens. One example is the widely-adopted `USDT`.

3.4 Improved Sanity Checks For System Parameters

- ID: PVE-004
- Severity: Low
- Likelihood: Low
- Impact: Low
- Target: `ValueVaultMaster`
- Category: Coding Practices [10]
- CWE subcategory: CWE-1126 [3]

Description

In `Vaults`, there are a number of home-made `strategy` contracts to invest farmers' assets (held in `ValueVaultBank`) and collect reward tokens. The distribution of reward tokens requires proper setup of certain fee parameters. The protocol also defines related risk parameters, e.g,. `gasFee` and `govVaultProfitShareFee`. The first parameter defines the deduction from the gains for gas reimbursement while the second parameter specifies the the deduction that is charged on the yields to the governance vault.

Our result shows the update logic on this fee parameter and other system-wide parameters can be improved by applying more rigorous sanity checks. Based on the current implementation, certain corner cases may lead to an undesirable consequence. For example, an unlikely mis-configuration of a large fee parameter (say more than 100%) will revert every `harvest()` operation.

To elaborate, we show below its code snippet of two related routines, i.e., `setGovVaultProfitShareFee()` and `setGasFee()`. These two functions update the percentages for governance profit and gas reimbursement respectively. However, they can be improved to validate that the given `govVaultProfitShareFee` (or `gasFee`) falls in an appropriate range.

```
134     function setGovVaultProfitShareFee(uint256 _govVaultProfitShareFee) public {
135         require(msg.sender == governance, "!governance");
136         govVaultProfitShareFee = _govVaultProfitShareFee;
137     }
138
139     function setGasFee(uint256 _gasFee) public {
140         require(msg.sender == governance, "!governance");
141         gasFee = _gasFee;
142     }
143
144     function setMinStakeTimeToClaimVaultReward(uint256 _minStakeTimeToClaimVaultReward)
            public {
145         require(msg.sender == governance, "!governance");
146         minStakeTimeToClaimVaultReward = _minStakeTimeToClaimVaultReward;
147     }
```

Listing 3.4: ValueVaultMaster.sol

Recommendation Validate any changes regarding these system-wide parameters to ensure they fall in an appropriate range. An example validation is shown below. Note the sanity checks can also be applied to other routines, such as `setMinStakeTimeToClaimVaultReward()`.

```
134     function setGovVaultProfitShareFee(uint256 _govVaultProfitShareFee) public {
135         require(msg.sender == governance, "!governance");
136         require(_govVaultProfitShareFee < FEE_DENOMINATOR, "!governance")
137         govVaultProfitShareFee = _govVaultProfitShareFee;
138     }
139
140     function setGasFee(uint256 _gasFee) public {
141         require(msg.sender == governance, "!governance");
142         require(_gasFee < FEE_DENOMINATOR, "!governance")
143         gasFee = _gasFee;
144     }
```

Listing 3.5: ValueVaultMaster.sol

3.5 Unused Code Removal

- ID: PVE-005
- Severity: Informational
- Likelihood: N/A
- Impact: N/A
- Target: `Multiple Contracts`
- Category: Coding Practices [10]
- CWE subcategory: CWE-563 [5]

Description

Vaults make good use of a number of reference contracts, such as `ERC20`, `SafeERC20`, `SafeMath`, `Context`, and `Ownable`, to facilitate its code implementation and organization. For example, the `ValueVaultBank` smart contract has so far imported at least four reference contracts. However, we observe the inclusion of certain unused code or the presence of unnecessary redundancies that can be safely removed.

For example, if we examine closely the `ValueVaultV2` contract, there is a state variable that is defined, but not used anymore: `lockedAmount`, This variable is apparently left behind from a deprecated feature.

```
19 contract ValueVaultV2 is IValueVault, ERC20 {
20     using SafeMath for uint256;
21
22     address public governance;
23
24     mapping (address => uint256) public lockedAmount;
25
26     IStrategyV2 public strategy;
```

```
27    ...
28 }
```

Listing 3.6: ValueVaultV2.sol

In addition, there are a number of unused state variables and these unused variables can be removed as well. Examples include `totalBalance` that is defined in various `strategies` under the `v2` sub-directory, `sodaVault` in `WETHSodaPoolStrategy`, and `discountCHI` in `ValueVaultBank`.

Recommendation Consider the removal of the unused code and the unused constants.

3.6 Possible Sandwich/MEV Attack For Reduced Returns

- ID: PVE-006
- Severity: Medium
- Likelihood: Medium
- Impact: Medium
- Target: `Strategies`
- Category: Time and State [13]
- CWE subcategory: CWE-682 [7]

Description

In Vaults, a number of different `strategy` contracts have been designed and implemented to invest farmers' assets (held in `ValueVaultBank`) and harvest growing yields. To elaborate, we show below the `harvest()` routine from the `Univ2ETHUSDCMultiPoolStrategy` strategy. By calling this routine, the strategy can collect any pending rewards and swap them to the designated `WETH` tokens for the next round of investment.

```
264     /**
265      * @dev See {IStrategyV2-harvest}.
266      */
267     function harvest(uint256 _bankPoolId, uint256 _poolId) external override {
268         address bank = valueVaultMaster.bank();
269         address _vault = msg.sender;
270         require(valueVaultMaster.isVault(_vault), "!vault"); // additional protection so
                we don't burn the funds
271
272         poolMap[_poolId].targetPool.getReward();
273         IERC20 targetToken = poolMap[_poolId].targetToken;
274         uint256 targetTokenBal = targetToken.balanceOf(address(this));
275
276         if (targetTokenBal < poolMap[_poolId].minHarvestForTakeProfit) return;
277
278         _swapTokens(address(targetToken), address(weth), targetTokenBal);
279         uint256 wethBal = weth.balanceOf(address(this));
280
281         ...
```

```
282
283     }
```

Listing 3.7: Univ2ETHUSDCMultiPoolStrategy.sol

We notice the collected yields are routed to `UniswapV2` in order to swap them to `WETH` as rewards. And the swap operation does not specify any restriction on possible slippage and is therefore vulnerable to possible front-running attacks, resulting in a smaller gain for this round of yielding. A similar issue also exists in the `harvest()` routine of other `strategies`.

Note that this is a common issue plaguing current AMM-based DEX solutions. Specifically, a large trade may be sandwiched by a preceding sell to reduce the market price, and a tailgating buy-back of the same amount plus the trade amount. Such sandwiching behavior unfortunately causes a loss and brings a smaller return as expected to the trading user or the `strategy` contract in our case (because the swap rate is lowered by the preceding sell). As a mitigation, we may consider specifying the restriction on possible slippage caused by the trade or referencing the `TWAP` or `time-weighted average price` of `UniswapV2`. Nevertheless, we need to acknowledge that this is largely inherent to current blockchain infrastructure and there is still a need to continue the search efforts for an effective defense.

Recommendation Develop an effective mitigation to the above sandwich attack to better protect the interests of farming users.

3.7 Precise Conversion of WETH-USDC For Liquidity Addition

- ID: PVE-007
- Severity: Low
- Likelihood: Low
- Impact:Low
- Target: `Univ2ETHUSDCMultiPoolStrategy`
- Category: Business Logic [11]
- CWE subcategory: CWE-841 [8]

Description

The Vaults protocol contains a strategy `Univ2ETHUSDCMultiPoolStrategy` that takes `Uniswap` LP tokens (e.g., `ETHUSDC_UNIv2`) and invests in specified reward pools. In the following, we show the code snippet of the `harvest()` routine.

The `harvest()` routine is used to collect possible yields and convert them into target tokens. Our analysis shows that the rewards (in `targetToken` - lines 272 – 275) are converted into `WETHs` as an intermediary token. The converted `WETHs` are used to pay `gasFee` and `govVaultProfitShareFee` and the remaining amount is further re-invested back for increased LP tokens (lines 298 – 299).

```
267     function harvest(uint256 _bankPoolId, uint256 _poolId) external override {
268         address bank = valueVaultMaster.bank();
269         address _vault = msg.sender;
270         require(valueVaultMaster.isVault(_vault), "!vault"); // additional protection so
                we don't burn the funds
271
272         poolMap[_poolId].targetPool.getReward();
273         IERC20 targetToken = poolMap[_poolId].targetToken;
274         uint256 targetTokenBal = targetToken.balanceOf(address(this));
275
276         if (targetTokenBal < poolMap[_poolId].minHarvestForTakeProfit) return;
277
278         _swapTokens(address(targetToken), address(weth), targetTokenBal);
279         uint256 wethBal = weth.balanceOf(address(this));
280
281         if (wethBal > 0) {
282             uint256 _reserved = 0;
283             uint256 _gasFee = 0;
284             uint256 _govVaultProfitShareFee = 0;
285
286             if (valueVaultMaster.gasFee() > 0) {
287                 _gasFee = wethBal.mul(valueVaultMaster.gasFee()).div(FEE_DENOMINATOR);
288                 _reserved = _reserved.add(_gasFee);
289             }
290
291             if (valueVaultMaster.govVaultProfitShareFee() > 0) {
292                 _govVaultProfitShareFee = wethBal.mul(valueVaultMaster.
                        govVaultProfitShareFee()).div(FEE_DENOMINATOR);
293                 _reserved = _reserved.add(_govVaultProfitShareFee);
294             }
295
296             uint256 wethToBuyTokenA = wethBal.sub(_reserved).div(2); // we have TokenB (
                    WETH) already, so use 1/2 bal to buy TokenA (USDC)
297
298         ...
299
300     }
```

Listing 3.8: Univ2ETHUSDCMultiPoolStrategy.sol

However, the current method in converting the remaining amount back to liquidity can be improved. The reason is that the current pool reserve may not be balanced in requiring the equally same value of `WETH` and `USDT`. A better approach is to make user of an external helper (deployed at `0x3AF045FD63Afc040aE9FD8C5b380d2DF2B804cfc`) to better maximize the liquidity return.

Recommendation Optimize the allocation of rewarded assets for maximized liquidity return. An example implementation is located in `0x3AF045FD63Afc040aE9FD8C5b380d2DF2B804cfc`.

3.8 Improved claim() in WETHMultiPoolStrategy

- ID: PVE-008
- Severity: Medium
- Likelihood: Medium
- Impact:Medium
- Target: `WETHMultiPoolStrategy`
- Category: Business Logic [11]
- CWE subcategory: CWE-841 [8]

Description

The Vaults protocol contains another strategy `WETHMultiPoolStrategy` that takes the `WETH` assets and invests in three different reward pools, i.e., `Golff.finance`, `ChickenSwap`, `Soda.finance`. This strategy exports the functionality to claim current rewards. To elaborate, we show below the related code snippet of the `claim()` routine.

```
287     /**
288      * @dev See {IStrategy-claim}.
289      */
290     function claim(address _vault) external override {
291         require(valueVaultMaster.isVault(_vault), "not vault");
292         require(poolPreferredIds.length > 0, "no pool");
293         for (uint256 i = 0; i < poolPreferredIds.length; ++i) {
294             uint256 _pid = poolPreferredIds[i];
295             if (poolMap[_pid].vault == _vault) {
296                 _claim(_pid);
297             }
298         }
299     }
300
301     /**
302      * @dev See {IStrategyV2-claim}.
303      */
304     function claim(uint256 _poolId) external override {
305         require(poolMap[_poolId].vault == msg.sender, "sender not vault");
306         _claim(_poolId);
307     }
308
309     function _claim(uint256 _poolId) internal {
310         if (poolMap[_poolId].poolType == 0) {
311             IStakingRewards(poolMap[_poolId].targetPool).getReward();
312         } else if (poolMap[_poolId].poolType == 1) {
313             ISushiPool(poolMap[_poolId].targetPool).deposit(poolMap[_poolId].
                    targetPoolId, 0);
314         } else {
315             ISodaPool(poolMap[_poolId].targetPool).claim(poolMap[_poolId].targetPoolId);
316         }
317     }
```

Listing 3.9: WETHMultiPoolStrategy.sol

Two `claim()` routines are publicly accessible while they both rely on an internal helpful routine, `_claim()`. It comes to our attention that the first `claim()` routine (lines $287-299$) essentially imposes no restriction on the caller, while the second `claim()` routine (lines $301-307$) requires the caller to be a known vault. Apparently, there is an inconsistency in enforcing who will be allowed to invoke the `claim()` functionality. Note that the `deposit()` functionality in the same contract shares a similar issue.

Recommendation Be consistent in applying sanity checks on both `claim()` and `deposit()` functionalities.

3.9 Asset Consistency Check Between Bank And Strategy

- ID: PVE-009
- Severity: Low
- Likelihood: Low
- Impact: Low
- Target: `Multiple Contracts`
- Category: Coding Practices [10]
- CWE subcategory: CWE-1099 [2]

Description

In the Vaults protocol, there is a one-to-one mapping between a `vault` and its `strategy`. To properly link a `vault` with its `strategy`, it is natural for the two to operate on the same underlying asset. For example, `ValueVaultV2` allows for `WETH`-based deposits and withdraws. The associated `strategy`, i.e., a `WETHMultiPoolStrategy`-based instance, naturally has `WETH` as the underlying asset. If these two have different underlying assets, the link should not be successful.

```
123     // Deposit tokens to Bank. If we have a strategy, then tokens will be moved there.
124     function deposit(uint256 _poolId, uint256 _amount, bool _farmMinorPool, address
            _referrer) public discountCHI {
125         PoolInfo storage pool = poolMap[_poolId];
126         require(now >= pool.startTime, "deposit: after startTime");
127         require(_amount > 0, "!_amount");
128         require(address(pool.vault) != address(0), "pool.vault = 0");
129         require(pool.individualCap == 0  stakers[_poolId][msg.sender].stake.add(_amount)
                <= pool.individualCap, "Exceed pool.individualCap");
130         require(pool.totalCap == 0  global[_poolId].total_stake.add(_amount) <= pool.
                totalCap, "Exceed pool.totalCap");
131
132         pool.token.safeTransferFrom(msg.sender, address(pool.vault), _amount);
133         pool.vault.mintByBank(pool.token, msg.sender, _amount);
134         if (_farmMinorPool && address(vaultMaster) != address(0)) {
135             address minorPool = vaultMaster.minorPool();
136             if (minorPool != address(0)) {
137                 IValueMinorPool(minorPool).depositOnBehalf(msg.sender, pool.minorPoolId,
                        pool.vault.balanceOf(msg.sender), _referrer);
```

```
138             }
139         }
140
141         _handleDepositStakeInfo(_poolId, _amount);
142         emit Deposit(msg.sender, _poolId, _amount);
143     }
```

Listing 3.10: ValueVaultBank.sol

For elaboration, we show above the `deposit()` routine of the `ValueVaultBank` contract. It is important to ensure the deposited asset is consistent with the expected asset in receiving strategies for investment. In other words, it is suggested to impose another requirement, i.e., `require(pool.vault.strategy.getLpToken()== pool.token)`. By doing so, we can ensure users may not mistakenly sent wrong assets for investment.

Recommendation Ensure the consistency of the underlying asset between the `bank` and its associated `strategies`.

4 Conclusion

In this audit, we have analyzed the design and implementation of Vaults in the Value DeFi protocol. The audited system presents a unique addition to current DeFi offerings in maximizing yields for users. Inspired from YFI, the Value DeFi protocol has been equipped with additional home-made strategies that work with different yield-generating pools. The current code base is clearly organized and those identified issues are promptly confirmed and fixed.

As a final precaution, we need to emphasize that smart contracts as a whole are still in an early, but exciting stage of development. To improve this report, we greatly appreciate any constructive feedbacks or suggestions, on our methodology, audit findings, or potential gaps in scope/coverage.

5 Appendix

5.1 Basic Coding Bugs

5.1.1 Constructor Mismatch

- Description: Whether the contract name and its constructor are not identical to each other.
- Result: Not found
- Severity: Critical

5.1.2 Ownership Takeover

- Description: Whether the set owner function is not protected.
- Result: Not found
- Severity: Critical

5.1.3 Redundant Fallback Function

- Description: Whether the contract has a redundant fallback function.
- Result: Not found
- Severity: Critical

5.1.4 Overflows & Underflows

- Description: Whether the contract has general overflow or underflow vulnerabilities [16, 17, 18, 19, 22].
- Result: Not found
- Severity: Critical

5.1.5 Reentrancy

- Description: Reentrancy [24] is an issue when code can call back into your contract and change state, such as withdrawing ETHs.
- Result: Not found
- Severity: Critical

5.1.6 Money-Giving Bug

- Description: Whether the contract returns funds to an arbitrary address.
- Result: Not found
- Severity: High

5.1.7 Blackhole

- Description: Whether the contract locks ETH indefinitely: merely in without out.
- Result: Not found
- Severity: High

5.1.8 Unauthorized Self-Destruct

- Description: Whether the contract can be killed by any arbitrary address.
- Result: Not found
- Severity: Medium

5.1.9 Revert DoS

- Description: Whether the contract is vulnerable to DoS attack because of unexpected `revert`.
- Result: Not found
- Severity: Medium

5.1.10 Unchecked External `Call`

- Description: Whether the contract has any external `call` without checking the return value.
- Result: Not found
- Severity: Medium

5.1.11 Gasless `Send`

- Description: Whether the contract is vulnerable to gasless `send`.
- Result: Not found
- Severity: Medium

5.1.12 `Send` Instead Of `Transfer`

- Description: Whether the contract uses `send` instead of `transfer`.
- Result: Not found
- Severity: Medium

5.1.13 Costly Loop

- Description: Whether the contract has any costly loop which may lead to `Out-Of-Gas` exception.
- Result: Not found
- Severity: Medium

5.1.14 (Unsafe) Use Of Untrusted Libraries

- Description: Whether the contract use any suspicious libraries.
- Result: Not found
- Severity: Medium

5.1.15 (Unsafe) Use Of Predictable Variables

- Description: Whether the contract contains any randomness variable, but its value can be predicated.
- Result: Not found
- Severity: Medium

5.1.16 Transaction Ordering Dependence

- Description: Whether the final state of the contract depends on the order of the transactions.
- Result: Not found
- Severity: Medium

5.1.17 Deprecated Uses

- Description: Whether the contract use the deprecated `tx.origin` to perform the authorization.
- Result: Not found
- Severity: Medium

5.2 Semantic Consistency Checks

- Description: Whether the semantic of the white paper is different from the implementation of the contract.
- Result: Not found
- Severity: Critical

5.3 Additional Recommendations

5.3.1 Avoid Use of Variadic Byte Array

- Description: Use fixed-size byte array is better than that of `byte[]`, as the latter is a waste of space.
- Result: Not found
- Severity: Low

5.3.2 Make Visibility Level Explicit

- Description: Assign explicit visibility specifiers for functions and state variables.
- Result: Not found
- Severity: Low

5.3.3 Make Type Inference Explicit

- Description: Do not use keyword `var` to specify the type, i.e., it asks the compiler to deduce the type, which is not safe especially in a loop.
- Result: Not found
- Severity: Low

5.3.4 Adhere To Function Declaration Strictly

- Description: Solidity compiler (version 0.4.23) enforces strict ABI length checks for return data from `calls()` [1], which may break the the execution if the function implementation does NOT follow its declaration (e.g., no return in implementing `transfer()` of ERC20 tokens).
- Result: Not found
- Severity: Low

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