SecureDapp

DApp Developers and Smart Contract Auditors

SMART CONTRACT SECURITY AUDIT

of

INDEXX.AI 500 CONTRACTS

Smart Contract Audit of INDEXX.AI 500

October 12th, 2022 | v. 1.0

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AUDIT INTRODUCTION

Auditing Firm	Secure DApp Auditors
Audit Architecture	Secure DApp Auditing Standard
Language	Solidity
Client Firm	INDEXX.AI 500
Website	https://indexx.ai/
Report Date	October 12, 2022

About Index.ai

A Blockchain-enabled platform aimed at disrupting the conventional financial system with a more updated approach to money.

AUDIT DOCUMENT

Name	Smart Contract Code Review and Security Analysis Report for Indexx.ai
Approved By	Himanshu Gautam | CTO at SecureDApp
Type	Defi Token Launch
Platform	EVM (Binance)
Language	Solidity
Changelog	04.10.2022 – Initial Review | 12.10.2022 - Second Review

AUDIT SCOPE

The scope of this report is to audit the smart contract source code of Indexx.ai.
Our client provided us with three smart contracts.

- Indexx500.sol
- Timelock.sol
- ICO.sol

All contracts were written in Solidity and based on the OpenZeppelin library.
Both of the smart contracts were to be deployed to the BSC network. The first contract was to launch Index 500 Token based on BEP-20 standards, second contract was for managing the pre-ICO and ICO launch of Token to users based on multiple payment options - USDT, BUSD and BNB and the third contract was to implement the vesting schedule for ICO.

After initial research, we agreed to perform the following tests and analyses as part of our well-rounded audit:

- Smart contract behavioral consistency analysis
- Test coverage analysis
- Penetration testing: checking against our database of vulnerabilities and simulating manual attacks against the contracts
- Static analysis
- Manual code review and evaluation of code quality
- Analysis of GAS usage
- Contract analysis with regards to the host network

Initial Review Scope

Repository	https://github.com/himang305/Indexx_all
Commit	F9BFE4A932D0414BF07B10EC1F1A5CF2
Functional Requirements	Full documentation provided. README.md
Technical Requirements	Partial documentation provided. README.md
Contracts Addresses	Not Yet Deployed
Contracts	File: ./contracts/Indexx500.sol SHA3: 07DE0D6F269B696466CEFDD2C6D6DE3FA8376C4DD313FD847BE9D433D File: ./contracts/ICO.sol SHA3: 90D4AFCF348556A0B201EBFF84E56F269BF4AF675E755948A44AA592E04 File: ./contracts/Timelock.sol SHA3: 8DCBB98DA8EB4A2EE3B1BEDD69A81A59A5591993813FC58D607F3D39F

Second Review Scope

Repository	https://github.com/himang305/Indexx_all
Commit	7857F418CD4446387A9BB0BB69A38594
Functional Requirements	Full documentation provided. README.md
Technical Requirements	Partial documentation provided. README.md
Contracts Addresses(BSC)	Indexx500 Contract: 0xf58e5644a650C0e4db0d6831664CF1Cb6A3B005A ICO Contract: 0x8bA9A63cac81B09509360d0A027dCE14F90F6779 Timelock Contract: 0x94C6156Da5DF99b3A529b47b54C6ff480c1440bb

Severity Definitions

Risk Level	Description
Critical	Critical vulnerabilities are usually straightforward to exploit and can lead to asset loss or data manipulations.
High	High-level vulnerabilities are difficult to exploit; however, they also have a significant impact on smart contract execution, e.g., public access to crucial functions.
Medium	Medium-level vulnerabilities are important to fix; however, they cannot lead to asset loss or data manipulations.
Low	Low-level vulnerabilities are mostly related to outdated, unused, etc. code snippets that cannot have a significant impact on execution.
Informational	Issue listed to improve understanding, readability and quality of code

All statuses which are identified in the audit report are categorized here for the reader to review:

Status Type	Definition
Open	Risks are open.
Acknowledged	Risks are acknowledged, but not fixed.
Resolved	Risks are acknowledged and fixed.

AUDIT SUMMARY

The Secure DApp team has performed a line-by-line manual analysis and automated review of smart contracts. Smart contracts were analyzed mainly for common contract vulnerabilities, exploits, and manipulation hacks. According to the audit:

Status	Critical	High	Medium	Low	Informative
Open	0	0	0	0	0
Acknowledged	3	2	5	4	6
Resolved	0	0	0	0	0

AUDIT METHODOLOGY

SecureDApp scans contracts and reviews codes for common vulnerabilities, exploits, hacks and back- doors. Mentioned are the steps used by SecureDApp to audit smart contracts:

a. Smart contract source code reviewal:
    i. Review of the specifications, sources, and instructions provided to SecureDApp to make sure we understand the audit scope, intended business behavior, overall architecture, and project's goal.
    ii. Manual review of code, which is the process of reading source code line-by-line to identify potential vulnerabilities.
b. Test coverage analysis: (Unit testing)
    i. Test coverage analysis is the process of determining whether the test cases are covering the code and how much code is exercised when we run those test cases.
c. Static analysis:
    i. Run a suite of vulnerability detectors to find security concerns in smart contracts with different impact levels.
d. Symbolically executed tests: (SMTChecker testing) (Taint analysis)
    i. Symbolic execution is analyzing a program to determine what inputs cause each part of a program to execute.
    ii. Check for security vulnerabilities using static and dynamic analysis
e. Property based analysis (Fuzz tests)(Invariant testing)
    i. Run the execution flow multiple times by generating random sequences of calls to the contract.
    ii. Asserts that all the invariants hold true for all scenarios.
f. Best practices review, which is a review of the smart contracts to improve efficiency, effectiveness, clarify, maintainability, security, and control based on the established industry and academic practices, recommendations, and research.
g. Specific, itemized, actionable recommendations to help you take steps to secure your smart contracts.

Automated 5S frameworks used to assess the smart contract vulnerabilities

- Consensys Tools
- SWC Registry
- Solidity Coverage
- Open Zeppelin Code Analyzer
- Solidity Code Compiler

We have audited the smart contracts for commonly known and more specific vulnerabilities.
Below is the list of smart contract tests, vulnerabilities, exploits, and hacks:

ID	Description	Status
EEA 3.3	Oracle Manipulation	Passed
EEA 3.3	Bad Randomness - VRF	N/A
S60	Assembly Usage	Passed
S59	Dangerous usage of block.timestamp	Passed
EEA 3.7	Front-Running Attacks	N/A
EEA 3.7	Back-Running Attacks	N/A
EEA 3.7	Sandwich Attacks	N/A
DASP	Gas Griefing Attacks	Passed
DASP	Force Feeding	Passed
SCSVS V2	Access Control	Passed
DASP	Short Address Attack	Passed
DASP	Checks Effects Interactions	Passed
EEA 4.1	No Self-destruct	Passed
SCSVS V14	Decentralized Finance Checks	Passed

Slither Tests	Checks for ERC's conformance	Passed
Coverage	Unit tests with 100% coverage	Passed
Gas Reporter	Gas usage & limitations	Passed
Echidna Tests	Malicious input handling	Passed
SWC-101	Integer Overflow and Underflow	Passed
SWC-102	Outdated Compiler Version	Passed
SWC-103	Floating Pragma	Passed
SWC-104	Unchecked Call Return Value	Passed
SWC-105	Unprotected Ether Withdrawal	Passed
SWC-106	Unprotected SELF-DESTRUCT Instruction	Passed
SWC-107	Re-entrancy	Passed
SWC-108	State Variable Default Visibility	Passed
SWC-109	Uninitialized Storage Pointer	Passed
SWC-110	Assert Violation	Passed
SWC-111	Use of Deprecated Solidity Functions	Passed
SWC-112	Delegate Call to Untrusted Callee	Passed

SWC-113	DoS with Failed Call	**Passed**
SWC-114	Transaction Order Dependence	**Passed**
SWC-115	Authorization through tx.origin	**Passed**
SWC-116	Block values as a proxy for time	**Passed**
SWC-117	Signature Malleability	**Passed**
SWC-134	Message call with the hardcoded gas amount	**Passed**
SWC-135	Code With No Effects (Irrelevant/Dead Code)	**Informational**
SWC-136/SCSVS V3	Unencrypted Private Data On-Chain	**Passed**

SYSTEM OVERVIEW

Indexx500 stock tokens (INXS) pioneered the stock index token model and are the world first traded. Indexx500 tokens offer the low risk, Secured and simplicity of S&P 500 stock index coupled with the innovative nature of blockchain technology, representing a perfect combination of both worlds

System architect uses three core contracts. Indexx500 contract is a BEP-20 Wrapper Contract with AntiBot Trading mechanism. TimeLock contract represent the vesting schedule for Index500 token Pre-ICO and ICO phases.

ICO contract allows users to purchase Indexx500 tokens using BTC, ETH, BUSD and BNB. It uses chainlink feed to get the real time prices for determining the payments. The scope of the audit is Indexx500.sol, ICO.sol and TimeLock.sol contracts.

Privileged roles

1. DEFAULT_ADMIN_ROLE:
    a. Control PAUSER_ROLE, MINTER_ROLE
2. ORACLE_ROLE:
    a. Providing real time prices of Onchain Payment Tokens (BTC, ETH, BUSD, BNB)
3. ICO_ADMIN_ROLE:
    a. Schedule Sale, Set Prices and Discounts

Risk

1. The impact of ORACLE_ROLE being compromised would have a huge impact on the protocol.
2. Centralization risk is the most common cause of cryptography asset loss
3. Compromising the DEFAULT_ADMIN_ROLE or ICO_ADMIN_ROLE may lead to all user's asset loss.

FINDINGS

Centralization Risk

Centralization risk is the most common cause of dapp's hacks. When a smart contract has an active contract ownership, the risk related to centralization is elevated. There are some well-intended reasons to be an active contract owner, such as:

- Contract owners can be granted the power to pause() or lock() the contract in case of an external attack.
- Contract owners can use functions like, include(), and exclude() to add or remove wallets from fees, swap checks, and transaction limits. This is useful to run a presale, and to list on an exchange.

Authorizing a full centralized power to a single body can be dangerous. Unfortunately, centralization related risks are higher than common smart contract vulnerabilities. Centralization of ownership creates a risk of rug pull scams, where owners cash out tokens in such quantities that they become valueless. Most important question to ask here is, how to mitigate centralization risk? Here's SecureDApp's recommendation to lower the risks related to centralization hacks:

- Smart contract owner's private key must be carefully secured to avoid any potential hack.
- Smart contract ownership should be shared by multi-signature (multi-sig) wallets.
- Smart contract ownership can be locked in a contract, user voting, or community DAO can be introduced to unlock the ownership.

Indexx500's Centralization Status

- Indexx's smart contract has DEFAULT_ADMIN_ROLE, ICO_ADMIN_ROLE and TimeLock_ADMIN roles without any backup mechanism in place to resolve centralisation concerns.

STATIC ANALYSIS REPORT

| Symbol | Meaning |

|:--------:|-----------|

| 🛑 | Function can modify state |

| 💵 | Function is payable |

| Contract | Type | Bases |

Function Name | **Visibility** | **Mutability** | **Modifiers** |

| **Indexx500** | Implementation | ERC20, ERC20Burnable, Pausable, AccessControl |||

| └ | <Constructor> | Public ❗ | 🛑 | ERC20 |

| └ | changeFeeAdmin | External ❗ | 🛑 | onlyRole |

| └ | changeFeeStatus | External ❗ | 🛑 | onlyRole |

| └ | pause | Public ❗ | 🛑 | onlyRole |

| └ | unpause | Public ❗ | 🛑 | onlyRole |

| └ | mint | Public ❗ | 🛑 | onlyRole |

| └ | _beforeTokenTransfer | Internal 🔒 | 🛑 | whenNotPaused |

| └ | transfer | Public ❗ | 🛑 |NO ❗ |

| └ | transferFrom | Public ❗ | 🛑 |NO ❗ |

||||||

||||||

| **ICO** | Implementation | ChainlinkDataFeed |||

| └ | <Constructor> | Public ❗ | 🛑 |NO ❗ |

| └ | <Receive Ether> | External ❗ | 💵 |NO ❗ |

| └ | <Fallback> | External ❗ | 💵 |NO ❗ |

| └ | scheduleSale | External ❗ | 🛑 | onlyIcoAdmin |

| └ | changeDiscount | External ❗ | 🛑 | onlyIcoAdmin |

| └ | changeIcoAdmin | External ❗ | 🛑 | onlyIcoAdmin |

| └ | buyIndexxFromAnyBEP20 | External ❗ | 🛑 | onlyWhileOpen |

| └ | buyIndexxFromBNB | Public ❗ | 💵 | onlyWhileOpen |

| └ | hasClosed | Public ❗ | |NO ❗ |

| └ | _transferPayment | Internal 🔒 | 🛑 | |

| └ | _preValidateTokenPurchase | Internal 🔒 | | |

| └ | _preValidatePurchase | Internal 🔒 | | |

| └ | _deliverTokens | Internal 🔒 | 🛑 | |

| └ | _processPurchase | Internal 🔒 | 🛑 | |

| └ | _updatePurchasingState | Internal 🔒 | 🛑 | |

| └ | _getTokenAmount | Internal 🔒 | | |

| | | | | |

| | | | | |

| **TimeLock** | Implementation | | | |

| └ | <Constructor> | Public ❗ | 🛑 | NO ❗ |

| └ | changeLockers | External ❗ | 🛑 | NO ❗ |

| └ | changeAdmin | External ❗ | 🛑 | NO ❗ |

| └ | initiateTokenLock | Public ❗ | 🛑 | onlyLockers |

| └ | releaseTokens | Public ❗ | 🛑 | NO ❗ |

| └ | changeWithdrawalStatus | External ❗ | 🛑 | NO ❗ |

| | | | | |

| | | | | |

| **ChainlinkDataFeed** | Implementation | | | |

| └ | <Constructor> | Public ❗ | 🛑 | NO ❗ |

| └ | getSp500LatestPrice | Internal 🔒 | | |

| └ | getBnbLatestPrice | Internal 🔒 | | |

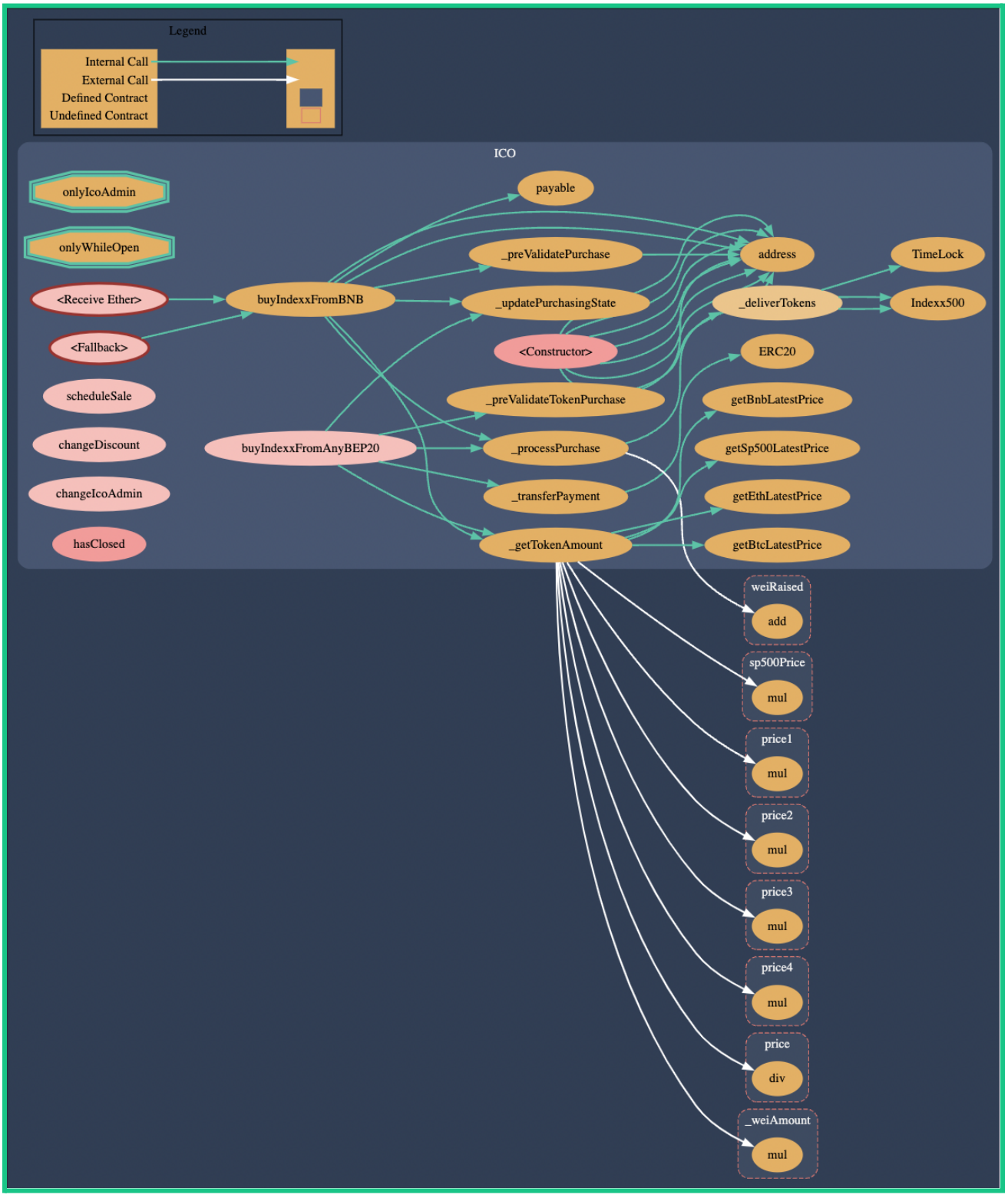
| └ | getBtcLatestPrice | Internal 🔒 | | |

| └ | getEthLatestPrice | Internal 🔒 | | |

| | | | | |

DYNAMIC TEST REPORT

INHERITANCE GRAPH - CALL GRAPH



MANUAL REVIEW

Identifier	Definition	Severity
CRI-01	Centralization privileges of Admins	High

Centralized privileges are listed below:

INDEXX500.sol

- DEFAULT_ADMIN_ROLE
- PAUSER_ROLE
- MINTER_ROLE

ICO.sol

- ICO_ADMIN

TIMELOCK.sol

- TIMELOCK_ADMIN

RECOMMENDATION

Deployer, contract owner, role, and access control privileges must be authenticated and their private keys should be secured carefully. Please refer to CENTRALIZED PRIVILEGES for a detailed understanding.

Status: Acknowledged

According to the project team, Multi-sig wallet plans are on the roadmap to lower centralization related risks.

Identifier	Definition	Severity
CRI-02	Reentrancy Attack vulnerability detected in two contracts	Critical

ICO.sol

- Reentrancy in ICO.buyIndexxFromAnyBEP20 (#139-154)
- Reentrancy in ICO.buyIndexxFromBNB (#160-184)

TIMELOCK.sol

- Reentrancy in TimeLock.releaseTokens (#89-105)

RECOMMENDATION

Implement Openzeppelin ReentrancyGuard control in both the contracts and add modifiers in all vulnerable functions OR Apply check-effects-interactions pattern in logic.

Status: RESOLVED

According to the project team, Developers have integrated the reentrancy guard.

Identifier	Definition	Severity
HIG-01	Unchecked Transfer	High

ICO.sol

- ICO.transferPayment ignores return value by ERC20().transferFrom (#199-209)

TimeLock.sol

- TimeLock.releaseTokens ignores return value by ERC20().transfer()) (#89-105)

RECOMMENDATION

Use SafeERC20, or ensure that the transfer/transferFrom return value is checked.

Status: Resolved

Revised commit: 099142e81032c0345673d4dad6b5520803141a99

Identifier	Definition	Severity
MED-01	Missing zero address validation	MEDIUM

ICO.sol

- ICO.changeIcoAdmin() (#129) lacks a zero-check.

Indexx500.sol

- Indexx500.changeFeeAdmin() (#37) lacks a zero-check.

TimeLock.sol

- TimeLock.constructor() (#41) lacks a zero-check.
- TimeLock.changeLockers() (#56) lacks a zero-check.
- TimeLock.changeAdmin() (#65) lacks a zero-check.

RECOMMENDATION

Check that the address is not zero.

Status: Resolved

Revised commit: 099142e81032c0345673d4dad6b5520803141a99

Identifier	Definition	Severity
LOW-01	Events-access - difficult to track off-chain changes	Low

ICO.sol

- ICO.changeIcoAdmin() (#129-131) should emit an event.
- ICO.scheduleSale() (#105-115) should emit an event.
- ICO.changeDiscount() (#121-123) should emit an event.

TimeLock.sol

- TimeLock.changeLockers() (#56-59) should emit an event.

RECOMMENDATION

Emit an event for critical parameter changes.

Status: Resolved

Revised commit: 099142e81032c0345673d4dad6b5520803141a99

Identifier	Definition	Severity
INF-01	Constant and Immutable States	Informational

ICO.sol

- ICO.investorMinCap (#33) should be immutable
- ICO.reserveWallet (#18) should be immutable
- ICO.timelockContract (#24) should be immutable
- ICO.token (#20) should be immutable

TimeLock.sol

- TimeLock.token (#19) should be immutable

RECOMMENDATION

State variables that are not updated following deployment should be declared immutable to save gas.

Status: Acknowledged

Revised commit: 099142e81032c0345673d4dad6b5520803141a99

Identifier	Definition	Severity
INF-02	Conformance to Solidity naming conventions	Informational

- Function/Parameters not in mixedCase
    - ICO.schedulesale
    - ICO.changediscount
    - ICO.buyindexxFromBNB
    - ICO.buyIndexxFromanyBEP20
    - TimeLock.initiateTokenlock
    - TimeLock.changewithdrawalStatus
    - Indexx500.changefeeAdmin

RECOMMENDATION

Apply the Solidity Naming Conventions

Status: Resolved

Revised commit: 099142e81032c0345673d4dad6b5520803141a99

UNIT TEST REPORT

```
Indexx_500_Testing
  ✔ Contracts Deployed Successfully
  ✔ Mint Indexx500 Tokens
  ✔ Burn Indexx500 Tokens
  ✔ Transfer Indexx500 Tokens
  ✔ Transfer Indexx500 Tokens with transfer fee added
  ✔ Check Indexx500 Access Controls
 Indexx_ICO_Testing
  ✔ Schedule Sale in ICO
  ✔ Change ICO-ADMIN
  ✔ Purchase Index500 using BUSD, BNB and BTC
 Indexx_TimeLock_Testing
  ✔ Check vesting schedules locks
  ✔ Change ICO sale status
  ✔ Withdraw Vested Token after 1 month
  ✔ Withdraw Vested Token after 1 year
 13 passing (4ms)
```

DISCLAIMER

SecureDApp Auditors provides the easy-to-understand audit of solidity source codes (commonly known as smart contracts).

The smart contract for this particular audit was analyzed for common contract vulnerabilities, and centralization exploits. This audit report makes no statements or warranties on the security of the code. This audit report does not provide any warranty or guarantee regarding the absolute bug-free nature of the smart contract analyzed, nor do they provide any indication of the client's business, business model or legal compliance. This audit report does not extend to the compiler layer, any other areas beyond the programming language, or other programming aspects that could present security risks. Cryptographic tokens are emergent technologies, they carry high levels of technical risks and uncertainty. You agree that your access and/or use, including but not limited to any services, reports, and materials, will be at your sole risk on an as-is, where-is, and as-available basis. This audit report could include false positives, false negatives, and other unpredictable results.

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SecureDApp is built by a decentralized team of UI experts, contributors, engineers, and enthusiasts from all over the world. Our team currently consists of 6+ core team members, and 10+ casual contributors. SecureDApp provides manual, static, and automatic smart contract analysis, to ensure that the project is checked against known attacks and potential vulnerabilities.

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