1inch

Cumulative Merkle Drop

SMART CONTRACT AUDIT

06.09.2021

Made in Germany by Chainsulting.de

Table of contents

1. Disclaimer

The audit makes no statements or warrantees about utility of the code, safety of the code, suitability of the business model, investment advice, endorsement of the platform or its products, regulatory regime for the business model, or any other statements about fitness of the contracts to purpose, or their bug free status. The audit documentation is for discussion purposes only.

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Major Versions / Date	Description
0.1 (04.09.2021)	Layout
0.5 (04.09.2021)	Manual & Automated Security Testing
0.6 (05.09.2021)	Testing SWC Checks
0.7 (05.09.2021)	Verify Claims
0.9 (06.09.2021)	Summary and Recommendation
1.0 (06.09.2021)	Final document
1.1 (TBA)	Added deployed contract addresses

2. About the Project and Company

Company address:

1Inch Limited
Quijano Chambers, P.O. Box 3159, Road Town
Tortola, British Virgin Islands

Sergej Kunz Co-Founder & Chief Executive Officer
Anton Bukov Co-Founder & Chief Technology Officer

Discord: https://discord.gg/FZADkCZ

Blog: https://blog.1inch.io

Medium: https://medium.com/@1inch.exchange

Website: https://app.1inch.io

Twitter: https://twitter.com/1inchExchange

Reddit: https://www.reddit.com/r/1inch_exchange

Telegram: https://t.me/OneInchExchange

Forum: https://gov.1inch.io

2.1 Project Overview

The 1inch Network unites decentralized protocols whose synergy enables the most lucrative, fastest and protected operations in the DeFi space. The initial protocol of the 1inch Network is a DEX aggregator solution that searches deals across multiple liquidity sources, offering users better rates than any individual exchange.

This protocol incorporates the Pathfinder algorithm which finds the best paths among different markets over 50+ liquidity sources on Ethereum, 20+ liquidity sources on Binance Smart Chain and 8+ liquidity sources on Polygon. In just two years the 1inch DEX aggregator surpassed $50B in overall volume on the Ethereum network alone. The 1inch Aggregation Protocol facilitates cost-efficient and secure swap transactions across multiple liquidity sources.

The 1inch Liquidity Protocol is a next-generation automated market maker that protects users from front-running attacks and offers attractive opportunities to liquidity providers. The 1inch Limit Order Protocol facilitates the most innovative and flexible limit order swap opportunities in DeFi. The protocol's features, such as dynamic pricing, conditional orders and extra RFQ support, power various implementations, including stop-loss and trailing stop orders, as well as auctions.

1inch limit order protocol is a set of smart contracts, that can work on any EVM based blockchains (Ethereum, Binance Smart Chain, Polygon, etc.). Key features of the protocol is extreme flexibility and high gas efficiency that achieved by using two different order types - regular Limit Order and RFQ Order. Smart Contract allows users to place limit orders and RFQ Orders, that later could be filled on-chain. Both type of orders is a data structure created off-chain and signed according to EIP-712.

3. Vulnerability & Risk Level

Risk represents the probability that a certain source-threat will exploit vulnerability, and the impact of that event on the organization or system. Risk Level is computed based on CVSS version 3.0.

Level	Value	Vulnerability	Risk (Required Action)
Critical	9 – 10	A vulnerability that can disrupt the contract functioning in a number of scenarios, or creates a risk that the contract may be broken.	Immediate action to reduce risk level.
High	7 – 8.9	A vulnerability that affects the desired outcome when using a contract, or provides the opportunity to use a contract in an unintended way.	Implementation of corrective actions as soon as possible.
Medium	4 – 6.9	A vulnerability that could affect the desired outcome of executing the contract in a specific scenario.	Implementation of corrective actions in a certain period.
Low	2 – 3.9	A vulnerability that does not have a significant impact on possible scenarios for the use of the contract and is probably subjective.	Implementation of certain corrective actions or accepting the risk.
Informational	0 – 1.9	A vulnerability that have informational character but is not effecting any of the code.	An observation that does not determine a level of risk

4. Auditing Strategy and Techniques Applied

Throughout the review process, care was taken to evaluate the repository for security-related issues, code quality, and adherence to specification and best practices. To do so, reviewed line-by-line by our team of expert pentesters and smart contract developers, documenting any issues as there were discovered.

4.1 Methodology

The auditing process follows a routine series of steps:

1. Code review that includes the following:
   i. Review of the specifications, sources, and instructions provided to Chainsulting to make sure we understand the size, scope, and functionality of the smart contract.
   ii. Manual review of code, which is the process of reading source code line-by-line in an attempt to identify potential vulnerabilities.
   iii. Comparison to specification, which is the process of checking whether the code does what the specifications, sources, and instructions provided to Chainsulting describe.
2. Testing and automated analysis that includes the following:
   i. Test coverage analysis, which is the process of determining whether the test cases are actually covering the code and how much code is exercised when we run those test cases.
   ii. Symbolic execution, which is analysing a program to determine what inputs causes each part of a program to execute.
3. 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.
4. Specific, itemized, actionable recommendations to help you take steps to secure your smart contracts.

4.2 Used Code from other Frameworks/Smart Contracts (direct imports)

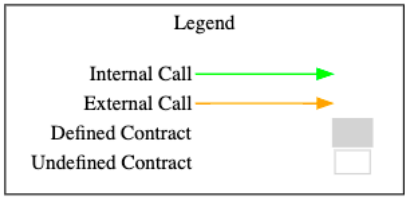
Dependency / Import Path	Source
@openzeppelin/contracts/access/Ownable.sol	https://github.com/OpenZeppelin/openzeppelin-contracts/blob/v4.3.1/contracts/access/Ownable.sol
@openzeppelin/contracts/token/ERC20/IERC20.sol	https://github.com/OpenZeppelin/openzeppelin-contracts/blob/v4.3.1/contracts/token/ERC20/IERC20.sol
@openzeppelin/contracts/token/ERC20/utils/SafeERC20.sol	https://github.com/OpenZeppelin/openzeppelin-contracts/blob/v4.3.1/contracts/token/ERC20/utils/SafeERC20.sol

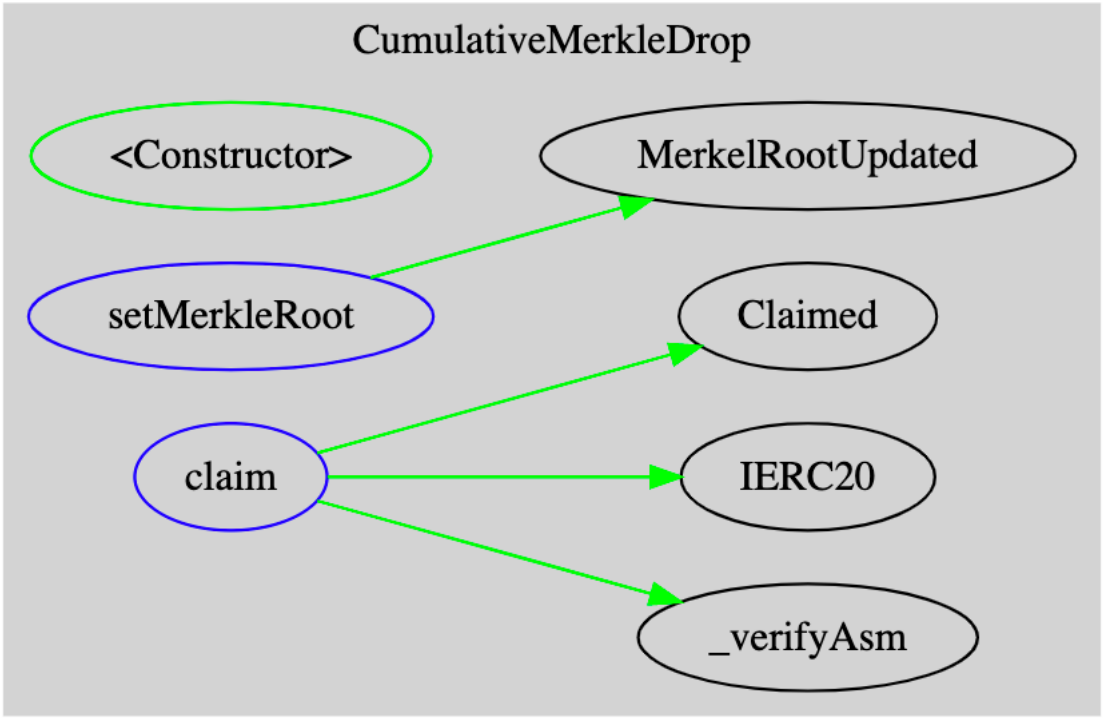
4.3 Tested Contract Files

The following are the MD5 hashes of the reviewed files. A file with a different MD5 hash has been modified, intentionally or otherwise, after the security review. You are cautioned that a different MD5 hash could be (but is not necessarily) an indication of a changed condition or potential vulnerability that was not within the scope of the review

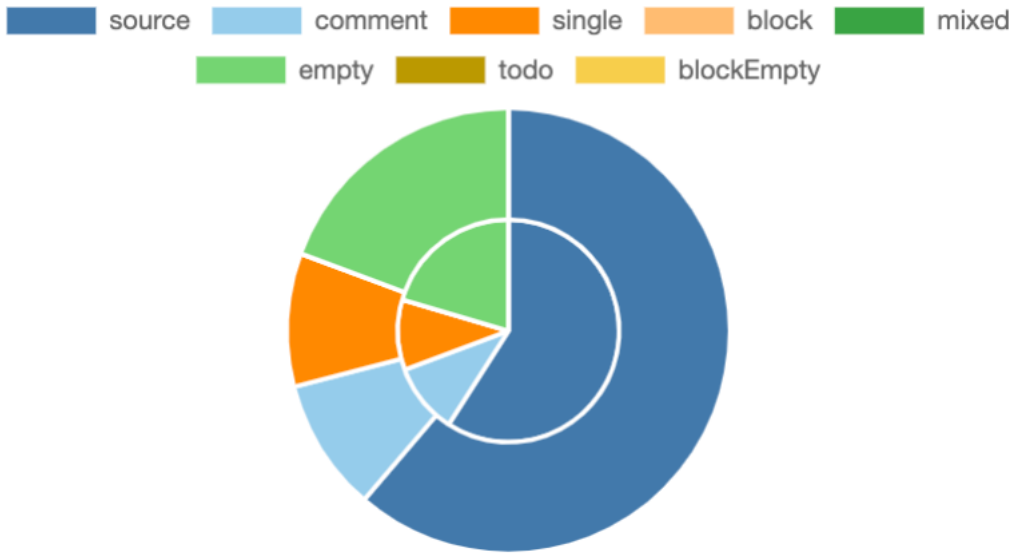
File	Fingerprint (MD5)
CumulativeMerkleDrop.sol	a2c729770bdcd1bad737db5a95541f6f

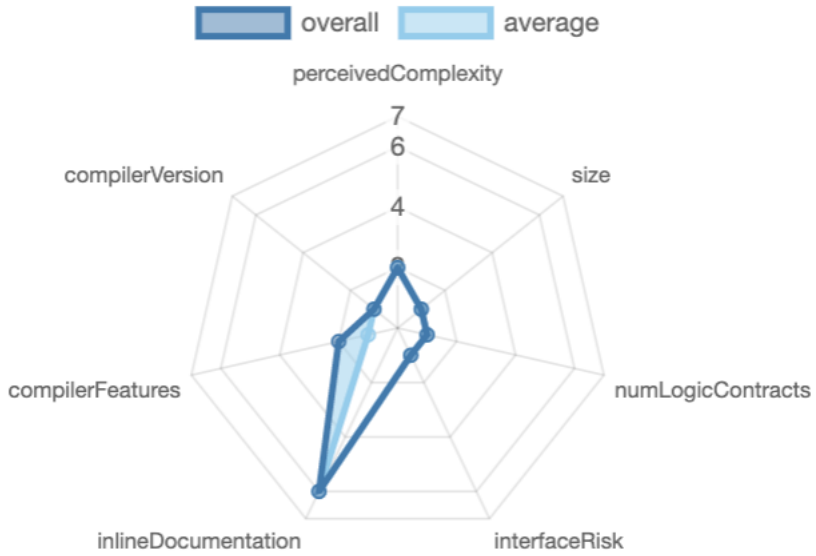
4.4 Metrics / CallGraph





4.5 Metrics / Source Lines & Risk





4.6 Metrics / Capabilities

Solidity Versions observed	Experimental Features	Can Receive Funds	Uses Assembly	Has Destroyable Contracts
`^0.8.6`			`yes` (1 asm blocks)	

Transfers ETH	Low-Level Calls	DelegateCall	Uses Hash Functions	ECRecover	New/Create/Create2
			`yes`		

Exposed Functions

This section lists functions that are explicitly declared public or payable. Please note that getter methods for public stateVars are not included.

Public	Payable
2	0

External	Internal	Private	Pure	View
2	3	1	1	0

StateVariables

Total	Public
3	3

4.7 Metrics / Source Unites in Scope

Type	File	Logic Contracts	Interfaces	Lines	nLines	nSLOC	Comment Lines	Complex. Score	Capabilities
	contracts/CumulativeMerkleDrop.sol	1		84	79	52	9	97	
	Totals	**1**		**84**	**79**	**52**	**9**	**97**	

Legend: [-]

- **Lines**: total lines of the source unit
- **nLines**: normalized lines of the source unit (e.g. normalizes functions spanning multiple lines)
- **nSLOC**: normalized source lines of code (only source-code lines; no comments, no blank lines)
- **Comment Lines**: lines containing single or block comments
- **Complexity Score**: a custom complexity score derived from code statements that are known to introduce code complexity (branches, loops, calls, external interfaces, ...)

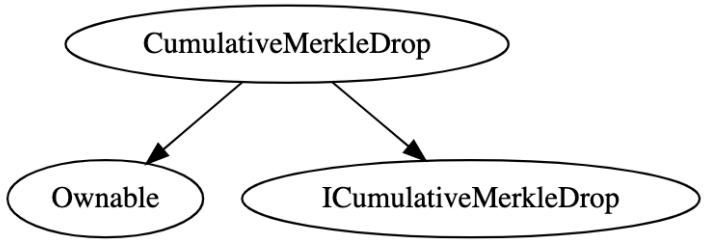
5. Scope of Work

The 1inch Team provided us with the files that needs to be tested. The scope of the audit is the cumulative merkle drop contract.

The team put forward the following assumptions regarding the security, usage of the contracts:

- The smart contract is coded according to the newest standards and in a secure way
- The smart contract is coded gas efficient
- Each next Merkle Tree root replaces previous one and should contain cumulative balances of all the participants
- Cumulative claimed amount is used as invalidation for every participant

The main goal of this audit was to verify these claims. The auditors can provide additional feedback on the code upon the client's request.



5.1 Manual and Automated Vulnerability Test

CRITICAL ISSUES
During the audit, Chainsulting's experts found **no Critical issues** in the code of the smart contract.

HIGH ISSUES
During the audit, Chainsulting's experts found **no High issues** in the code of the smart contract.

MEDIUM ISSUES
During the audit, Chainsulting's experts found **no Medium issues** in the code of the smart contract

LOW ISSUES
During the audit, Chainsulting's experts found **no Low issues** in the code of the smart contract

INFORMATIONAL ISSUES
During the audit, Chainsulting's experts found **no Informational issues** in the code of the smart contract

5.2. SWC Attacks

ID	Title	Relationships	Test Result
SWC-131	Presence of unused variables	CWE-1164: Irrelevant Code	✅
SWC-130	Right-To-Left-Override control character (U+202E)	CWE-451: User Interface (UI) Misrepresentation of Critical Information	✅
SWC-129	Typographical Error	CWE-480: Use of Incorrect Operator	✅
SWC-128	DoS With Block Gas Limit	CWE-400: Uncontrolled Resource Consumption	✅
SWC-127	Arbitrary Jump with Function Type Variable	CWE-695: Use of Low-Level Functionality	✅
SWC-125	Incorrect Inheritance Order	CWE-696: Incorrect Behavior Order	✅
SWC-124	Write to Arbitrary Storage Location	CWE-123: Write-what-where Condition	✅
SWC-123	Requirement Violation	CWE-573: Improper Following of Specification by Caller	✅

ID	Title	Relationships	Test Result
SWC-122	Lack of Proper Signature Verification	CWE-345: Insufficient Verification of Data Authenticity	✅
SWC-121	Missing Protection against Signature Replay Attacks	CWE-347: Improper Verification of Cryptographic Signature	✅
SWC-120	Weak Sources of Randomness from Chain Attributes	CWE-330: Use of Insufficiently Random Values	✅
SWC-119	Shadowing State Variables	CWE-710: Improper Adherence to Coding Standards	✅
SWC-118	Incorrect Constructor Name	CWE-665: Improper Initialization	✅
SWC-117	Signature Malleability	CWE-347: Improper Verification of Cryptographic Signature	✅
SWC-116	Timestamp Dependence	CWE-829: Inclusion of Functionality from Untrusted Control Sphere	✅
SWC-115	Authorization through tx.origin	CWE-477: Use of Obsolete Function	✅
SWC-114	Transaction Order Dependence	CWE-362: Concurrent Execution using Shared Resource with Improper Synchronization ('Race Condition')	✅

ID	Title	Relationships	Test Result
SWC-113	DoS with Failed Call	CWE-703: Improper Check or Handling of Exceptional Conditions	✅
SWC-112	Delegatecall to Untrusted Callee	CWE-829: Inclusion of Functionality from Untrusted Control Sphere	✅
SWC-111	Use of Deprecated Solidity Functions	CWE-477: Use of Obsolete Function	✅
SWC-110	Assert Violation	CWE-670: Always-Incorrect Control Flow Implementation	✅
SWC-109	Uninitialized Storage Pointer	CWE-824: Access of Uninitialized Pointer	✅
SWC-108	State Variable Default Visibility	CWE-710: Improper Adherence to Coding Standards	✅
SWC-107	Reentrancy	CWE-841: Improper Enforcement of Behavioral Workflow	✅
SWC-106	Unprotected SELFDESTRUCT Instruction	CWE-284: Improper Access Control	✅
SWC-105	Unprotected Ether Withdrawal	CWE-284: Improper Access Control	✅
SWC-104	Unchecked Call Return Value	CWE-252: Unchecked Return Value	✅

ID	Title	Relationships	Test Result
SWC-103	Floating Pragma	CWE-664: Improper Control of a Resource Through its Lifetime	X
SWC-102	Outdated Compiler Version	CWE-937: Using Components with Known Vulnerabilities	✅
SWC-101	Integer Overflow and Underflow	CWE-682: Incorrect Calculation	✅
SWC-100	Function Default Visibility	CWE-710: Improper Adherence to Coding Standards	✅

5.3. Verify Claims

5.3.1 The smart contract is coded according to the newest standards and in a secure way
Status: tested and verified ✅

5.3.2 The smart contract is coded gas efficient
Status: tested and verified ✅

5.3.3 Each next Merkle Tree root replaces previous one and should contain cumulative balances of all the participants
Status: tested and verified ✅

5.3.4 Cumulative claimed amount is used as invalidation for every participant
Status: tested and verified ✅

5.4. Unit test

```
$ hardhat test
Downloading compiler 0.8.6
Compiling 15 files with 0.8.6
Compilation finished successfully
(node:2538) [DEP0128] DeprecationWarning: Invalid 'main' field in '/Users/privat/Desktop/1inch/cumulative-
merkle-drop-master/node_modules/ansi-mark/package.json' of 'ansi-mark'. Please either fix that or report it
to the module author
(Use `node --trace-deprecation ...` to show where the warning was created)
(node:2538) [DEP0128] DeprecationWarning: Invalid 'main' field in '/Users/privat/Desktop/1inch/cumulative-
merkle-drop-master/node_modules/super-split/package.json' of 'super-split'. Please either fix that or
report it to the module author

  Contract: CumulativeMerkleDrop
    ✓ Benchmark 30000 wallets (merkle tree height 15)
```

```
  Single drop for 4 wallets: [1, 2, 3, 4]
    Single drop for 4 wallets: [1, 2, 3, 4]
      First wallet
        ✓ should succeed to claim 1 token
        ✓ should fail to claim second time
      Second wallet
        ✓ should succeed to claim
        ✓ should fail to claim second time
      Third wallet
        ✓ should succeed to claim
        ✓ should fail to claim second time
      Forth wallet
        ✓ should succeed to claim
        ✓ should fail to claim 1 tokens after 4 tokens
  Double drop for 4 wallets: [1, 2, 3, 4] + [2, 3, 4, 5] = [3, 5, 7, 9]
    First wallet checks
      ✓ should success to claim 1 token, second drop and claim 2 tokens
      ✓ should success to claim 1 token, second drop and claim 2 tokens twice
      ✓ should success to claim all 3 tokens after second drop
      ✓ should fail to claim after succelfful claim of all 3 tokens after second drop

Contract: CumulativeMerkleDrop128
  ✓ Benchmark 30000 wallets (merkle tree height 15)
  Single drop for 4 wallets: [1, 2, 3, 4]
    Single drop for 4 wallets: [1, 2, 3, 4]
      First wallet
        ✓ should succeed to claim 1 token
        ✓ should fail to claim second time
      Second wallet
        ✓ should succeed to claim
        ✓ should fail to claim second time
      Third wallet
        ✓ should succeed to claim
        ✓ should fail to claim second time
      Forth wallet
```

```
        ✓ should succeed to claim
        ✓ should fail to claim 1 tokens after 4 tokens
  Double drop for 4 wallets: [1, 2, 3, 4] + [2, 3, 4, 5] = [3, 5, 7, 9]
    First wallet checks
      ✓ should success to claim 1 token, second drop and claim 2 tokens
      ✓ should success to claim 1 token, second drop and claim 2 tokens twice
      ✓ should success to claim all 3 tokens after second drop
      ✓ should fail to claim after succelfful claim of all 3 tokens after second drop

Contract: CumulativeMerkleDrop160
  ✓ Benchmark 30000 wallets (merkle tree height 15)
  Single drop for 4 wallets: [1, 2, 3, 4]
    Single drop for 4 wallets: [1, 2, 3, 4]
      First wallet
        ✓ should succeed to claim 1 token
        ✓ should fail to claim second time
      Second wallet
        ✓ should succeed to claim
        ✓ should fail to claim second time
      Third wallet
        ✓ should succeed to claim
        ✓ should fail to claim second time
      Forth wallet
        ✓ should succeed to claim
        ✓ should fail to claim 1 tokens after 4 tokens
  Double drop for 4 wallets: [1, 2, 3, 4] + [2, 3, 4, 5] = [3, 5, 7, 9]
    First wallet checks
      ✓ should success to claim 1 token, second drop and claim 2 tokens
      ✓ should success to claim 1 token, second drop and claim 2 tokens twice
      ✓ should success to claim all 3 tokens after second drop
      ✓ should fail to claim after succelfful claim of all 3 tokens after second drop
```

Solc version: 0.8.6	Optimizer enabled: true	Runs: 1000000	Block limit: 30000000 gas

Methods						
		Min	Max	Avg		
CumulativeMerkleDrop	claim	50082	76021	65506	15	–
CumulativeMerkleDrop	setMerkleRoot	30332	47432	43408	17	–
CumulativeMerkleDrop128	claim	49473	72090	64658	15	–
CumulativeMerkleDrop128	setMerkleRoot	30350	47450	43418	17	–
CumulativeMerkleDrop160	claim	49777	73218	65026	15	–
CumulativeMerkleDrop160	setMerkleRoot	30375	47475	43451	17	–
TokenMock	mint	36223	70435	55563	207	–
Deployments						
CumulativeMerkleDrop		–	–	775204	2.6 %	–
CumulativeMerkleDrop128		826537	826549	826546	2.8 %	–
CumulativeMerkleDrop160		–	–	826729	2.8 %	–
TokenMock		–	–	1145100	3.8 %	–

39 passing (11s)

✨ Done in 18.23s.

6. Executive Summary

Two (2) independent Chainsulting experts performed an unbiased and isolated audit of the smart contract codebase. The final debrief took place on the September 06, 2021. The main goal of the audit was to verify the claims regarding the security of the smart contract.

During the audit, no critical issues were found after the manual and automated security testing and the claims been successfully verified.

7. Deployed Smart Contract

PENDING