# 192.127 Seminar in Software Engineering (Smart Contracts)
## SWC-124: Write to Arbitrary Storage Location

### *** YOUR NAME AND STUDENT ID ***

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## 1 Weakness and consequences

### 1.1 Solidity storage layout

Any contract's storage is a continuous 256-bit address space consisting of 32-bit values. In order to implement dynamically sized data structures like maps and arrays, Solidity distributes their entries in a pseudo-random location. Due to the vast 256-bit range of addresses collisions are statistically extremely improbable and of no practical relevance.

In the case of a dynamic array at variable slot $p$, data is written to continuous locations starting at $keccak(p)$. The array itself contains the length information.

For maps stored in variable slot $p$ the data for index $k$ can be found at $keccak(k.p)$ where . is the concatenation operator.

### 1.2 The Weakness

Any unchecked array write is potentially dangerous, as the storage-location of all variables is publicly known and an unconstrained array index can be reverse engineered to target them.

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**Algorithm 1:** A completely unchecked array write

```
1   pragma solidity 0.4.25;
2
3   contract MyContract {
4     address private owner;
5     uint[] private arr;
6
7     constructor() public {
8       arr = new uint[](0);
9       owner = msg.sender;
10    }
11
12    function write(unit index, uint value) {
13      arr[index] = value;
14    }
15  }
16
```

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In the following example the *pop* function incorrectly checks for an array $length >= 0$, thereby allowing the value to underflow when called with an empty array. Once this weakness is exploited *update* in Algorithm 2 behaves just like *write* did in Algorithm 1.

**Algorithm 2:** An incorrectly managed array length

```
1    pragma solidity 0.4.25;
2
3    contract MyContract {
4      address private owner;
5      uint[] private arr;
6
7      constructor() public {
8        arr = new uint[](0);
9        owner = msg.sender;
10     }
11
12     function push(value) {
13       arr[arr.length] = value;
14       arr.length++;
15     }
16
17     function pop() {
18       require(arr.length >= 0);
19       arr.length--;
20     }
21
22     function update(unit index, uint value) {
23       require(index < arr.length);
24       arr[index] = value;
25     }
26   }
27
```

## 2 Vulnerable contracts in literature

collect vulnerable contracts used by different papers to motivate/illustrate the weakness

## 3 Code properties and automatic detection

summarize the code properties that tools are looking for so that they can detect the weakness

## 4 Exploit sketch

sketch ways to potentially exploit the different variants of the weakness.
[4] [3] [2] [1]

## References

[1] Jaeseung Choi, Doyeon Kim, Soomin Kim, Gustavo Grieco, Alex Groce, and Sang Kil Cha. Smartian: Enhancing smart contract fuzzing with static and dynamic data-flow analyses. In *2021 36th IEEE/ACM International Conference on Automated Software Engineering (ASE)*, pages 227–239, 2021.

[2] Johannes Krupp and Christian Rossow. teEther: Gnawing at ethereum to automatically exploit smart contracts. In *27th USENIX Security Symposium (USENIX Security 18)*, pages 1317–1333, Baltimore, MD, August 2018. USENIX Association.

[3] Siddhasagar Pani, Harshita Vani Nallagonda, Vigneswaran, Raveendra Kumar Medicherla, and Rajan M. Smartfuzzdrivergen: Smart contract fuzzing automation for golang. In *Proceedings of the 16th*

*Innovations in Software Engineering Conference*, ISEC '23, New York, NY, USA, 2023. Association for Computing Machinery.

[4] Petar Tsankov, Andrei Dan, Dana Drachsler-Cohen, Arthur Gervais, Florian Bünzli, and Martin Vechev. Securify: Practical security analysis of smart contracts. In *Proceedings of the 2018 ACM SIGSAC Conference on Computer and Communications Security*, CCS '18, page 67–82, New York, NY, USA, 2018. Association for Computing Machinery.