AKIRA TECH

PROJECT

Roe

REVIEWERS

Andrei Simion

@andreiashu

DATE

April 2022

Table of Contents

Details

- **Date** April 2022
- **Reviewers** Andrei Simion (@andreiashu)
- **Repository**: Roe
- **Commit hash** `2d2018cd30831ceaa3a1f8153714ca525e89f4c9`
- **Technologies**
  - Solidity

Issues Summary

SEVERITY	OPEN	CLOSED
Informational	0	0
Minor	2	0
Medium	2	0
Major	2	0

Executive summary

This report represents the results of the engagement with **Jun Yi Zheng** to review **Roe**.

The review was conducted over the course of **2 weeks** from **April 18th to April 29th, 2022**. A total of **10 person-days** were spent reviewing the code.

Scope

The initial review focused on the Roe repository, identified by the commit hash `2d2018cd30831ceaa3a1f8153714ca525e89f4c9`.

I focused on manually reviewing the codebase, searching for security issues such as, but not limited to, re-entrancy problems, transaction ordering, block timestamp dependency, exception handling, call stack depth limitation, integer overflow/underflow, self-destructible contracts, unsecured balance, use of origin, costly gas patterns, architectural problems, code readability.

Includes:

- code/contracts/aux/FlashLoan_Uniswap.sol
- code/contracts/aux/ETHUSDCLP_Oracle.sol
- code/contracts/aux/HistoricPriceConsumerV3.sol
- code/contracts/aux/FlashLoan_Unwind.sol
- code/contracts/aux/WindUniswap.sol
- code/contracts/LPVault.sol

Excludes:

- code/contracts/openzeppelin-solidity/*

Recommendations

I identified a few possible general improvements that are not security issues during the review, which will bring value to the developers and the community reviewing and using

the product.

Increase the number of tests

A good rule of thumb is to have 100% test coverage. This does not guarantee the lack of security problems, but it means that the desired functionality behaves as intended. The negative tests also bring a lot of value because not allowing some actions to happen is also part of the desired behavior.

Issues

`FlashLoanReceiverBase_Unwind.clearSingleSidedDebt` is vulnerable to price manipulation attacks

Status Open Severity Major

Description

`clearSingleSidedDebt` function calls Uniswap V2's `getReserves`:

code/contracts/aux/FlashLoan_Unwind.sol#L123-L129

```
function clearSingleSidedDebt(address borrowedAsset) external {
  //IERC20 varDebt = IERC20( LENDING_POOL.getReserveData(borrowedAsset).variableDebtTokenAddress );

  uint needA;
  uint needB;
  {
    (uint resA, uint resB, ) = IUniswapV2Pair(borrowedAsset).getReserves();
```

The issue with relying on the `getReserves` function to calculate pricing data is that it's easy to manipulate its output for profits:

> consider a malicious actor who sees this transaction before it is confirmed. They could execute a swap which dramatically changes the DAI/WETH price immediately before the naive swap goes through, wait for the naive swap to execute at a bad rate, and then swap to change the price back to what it was before the naive swap. This attack is fairly cheap and low-risk, and can typically be performed for a profit.

source: Uniswap V2 Documentation on Pricing

Recommendation

`clearSingleSidedDebt` function show either allow the caller to specify the real price of the tokens involved, or should make use of an external, reliable, oracle to fetch the latest

price for a given pair of tokens:

> To prevent these types of attacks, it's vital to submit swaps that have access to knowledge about the "fair" price their swap should execute at. In other words, swaps need access to an oracle, to be sure that the best execution they can get from Uniswap is close enough to what the oracle considers the "true" price. While this may sound complicated, the oracle can be as simple as an off-chain observation of the current market price of a pair. Because of arbitrage, it's typically the case that the ratio of the intra-block reserves of a pair is close to the "true" market price. So, if a user submits a trade with this knowledge in mind, they can ensure that the losses due to front-running are tightly bounded.

source: Uniswap V2 Documentation on Pricing

`premium` is sent to the wrong address

Description

During a flash loan operation to the Aave Lending Pool, the execution control is passed to the `executeOperation` function:

code/contracts/aux/FlashLoan_Uniswap.sol#L32-L38

```
function executeOperation(
  address[] calldata assets,
  uint256[] calldata amounts,
  uint256[] calldata premiums,
  address initiator,
  bytes calldata params
) override external returns (bool) {
```

In this call the premium is transferred to the `initiator` of the flash loan:

code/contracts/aux/FlashLoan_Uniswap.sol#L59

```
    IERC20(assets[0]).safeTransfer(initiator, premiums[0]);
```

The issue here is that the initiator is the `msg.sender` (caller) of the `flashLoan` function against the `LendingPool` contract. The call from AAve's `flashLoan` looks like this:

```
require(
  vars.receiver.executeOperation(assets, amounts, premiums, msg.sender, params),
  Errors.LP_INVALID_FLASH_LOAN_EXECUTOR_RETURN
);
```

The 4th argument to `executeOperation` callback is the `initiator` in our case:

code/contracts/aux/FlashLoan_Uniswap.sol#L32-L36

```
function executeOperation(
  address[] calldata assets,
  uint256[] calldata amounts,
  uint256[] calldata premiums,
  address initiator,
```

The amount flash loaded and the premium will be taken back from the contract via `transferFrom` by the LendingPool in case of a mode-0 flash loan, or in the current case, it will count towards the debt amount for a mode-2 flash loan.

Recommendation

Remove the transfer of premium from line 59:

code/contracts/aux/FlashLoan_Uniswap.sol#L59

```
    IERC20(assets[0]).safeTransfer(initiator, premiums[0]);
```

`LPVault.withdrawOnBehalf` might revert in some cases

Status Open Severity Medium

Description

The `LPVault.withdrawOnBehalf` function enables an address to withdraw their `COLLAT_LP` tokens from the Vault:

code/contracts/LPVault.sol#L278

```
    function withdrawOnBehalf(address onBehalfOf) checkInvariant public returns (uint256) {
```

Since the same `COLLAT_LP` tokens are deposited into Aave Lending Pool as a way to facilitate lending them, there is a possibility that the `LPVault` does not have enough funds to cover the withdrawal amount. In this case, the difference in funds is extracted from the Lending Pool:

code/contracts/LPVault.sol#L293-L298

```
            uint vaultBalance = COLLAT_LP.balanceOf( address(this) );
            if (exitAmt > vaultBalance ) {                                          // If insufficient amou
                aaveV2LendingPool.withdraw( address(COLLAT_LP), exitAmt - vaultBalance, address(this) );
                collatLentOut -= exitAmt - vaultBalance;
```

```
        }
        ERC20(address(COLLAT_LP)).safeTransfer(onBehalfOf, exitAmt);
```

The issue, however, is that since lending will be enabled in the Lending Pool against the LP_COLLAT tokens, there might not be `exitAmt - vaultBalance` amount of tokens in the pool. In that case the `withdraw` function will revert:

code/contracts/LPVault.sol#L295

```
            aaveV2LendingPool.withdraw( address(COLLAT_LP), exitAmt - vaultBalance, address(this) );
```

Recommendation

Ensure that the request for the number of tokens withdrawn from Aave's Lending Pool is at most the funds that the `LPVault` contract has in the Lending Pool.

`executeOperation` should only permit the LendingPool to call it

Status Open Severity Medium

Description

`FlashLoanReceiverBase.executeOperation` is the callback function called by Aave's LendingPool during a `flashLoan` operation:

code/contracts/aux/FlashLoan_Uniswap.sol#L32-L38

```
function executeOperation(
  address[] calldata assets,
  uint256[] calldata amounts,
  uint256[] calldata premiums,
  address initiator,
  bytes calldata params
) override external returns (bool) {
```

The `executeOperation` function should whitelist the caller to only allow the Lending Pool to call into it. There are some examples of this in Aave's repository - `UniswapLiquiditySwapAdapter` contains code to restrict `msg.sender` only to the Lending Pool:

```
require(msg.sender == address(LENDING_POOL), 'CALLER_MUST_BE_LENDING_POOL');
```

Recommendation

Only allow the Lending Pool to call `executeOperation`. This applies to both `FlashLoanReceiverBase` and `FlashLoanReceiverBase_Unwind` contracts.

References

UniswapLiquiditySwapAdapter.sol

`FlashLoan_Uniswap` should not approve for maximum value

Status Open Severity Minor

Description

The `flashLeverage` function issues an approval call for the Aave Lending Pool contract and the Lending Pool's AToken:

code/contracts/aux/FlashLoan_Uniswap.sol#L64-L74

```
function flashLeverage(address asset, uint amount) external {
  address[] memory assets = new address[](1);
  uint[] memory amounts = new uint[](1);
  uint[] memory flashtype = new uint[](1);
  assets[0] = asset;
  amounts[0] = amount;
  flashtype[0] = 2;
  IERC20(asset).approve( address(LENDING_POOL), 2**256-1);
  IERC20(asset).approve( LENDING_POOL.getReserveData(asset).aTokenAddress, 2**256-1);
  LENDING_POOL.flashLoan( address(this), assets, amounts, flashtype, msg.sender, abi.encode(msg.sender),
}
```

Since the approval is the maximum value, I initially thought it would be best to just move these calls to the `constructor` of the contract since that would save gas. But the issue with this approach is that `ERC20.transferFrom` decreases the allowance on every call (`_approve(sender, _msgSender(), currentAllowance - amount);`), so it's not a reliable solution.

Recommendation

Only issue an `approve` for the exact amount of tokens involved in the flash loan. This approach would also surface any bugs present in the flash loan process, like #4.

Uniswap V2 `deadline` argument can be passed as `block.timestamp` only

Status Open Severity Minor

Description

Calls to Uniswap's V2 Router require passing a `deadline` argument that expresses the last timestamp when the call to the respective function should be considered valid:

code/contracts/LPVault.sol#L345

```
            (uint collat0_amt, uint collat1_amt) = ROUTER.removeLiquidity(address(COLLAT_0), address(COLLA
```

code/contracts/LPVault.sol#L433-L444

```
                    swapped = ROUTER.swapExactTokensForTokens(getSwapAmt(asset0_balance - added0, r0 +
                    (uint256 added0_2, uint256 added1_2, uint256 liquidity) = ROUTER.addLiquidity(addr
                    added0 += added0_2;
                    added1 += added1_2;
                    collatReturned += liquidity;
                } else if (asset1_balance >= asset1_needed) {
                    (added0, added1, collatReturned) = ROUTER.addLiquidity(address(COLLAT_0), address(
                    address[] memory path = new address[](2);
                    path[0] = address(COLLAT_1);
                    path[1] = address(COLLAT_0);
                    swapped = ROUTER.swapExactTokensForTokens(getSwapAmt(asset1_balance - added1, r1 +
                    (uint256 added0_2, uint256 added1_2, uint256 liquidity) = ROUTER.addLiquidity(addr
```

In `UniswapV2Router02.sol`, the `deadline` value is passed to the `ensure` modifier:

```
    modifier ensure(uint deadline) {
        require(deadline >= block.timestamp, 'UniswapV2Router: EXPIRED');
        _;
    }
```

Since the deadline value is checked against the current block's timestamp with a `>=` sign, it's safe for an external contract to only pass the `block.timestamp` value when calling such functions.

Passing a deadline as a future timestamp is helpful for front ends that cannot guarantee that the transaction will be mined in the immediate next block.

Recommendation

Replace all `deadline` values that specify a value in the future (`block.timestamp + 3600`) with `block.timestamp` .

Artifacts

Surya

Sūrya is a utility tool for smart contract systems. It provides a number of visual outputs and information about the structure of smart contracts. It also supports querying the function call graph in multiple ways to aid in the manual inspection and control flow analysis of contracts.

Sūrya's Description Report

Files Description Table

File Name	SHA-1 Hash
code/contracts/aux/FlashLoan_Uniswap.sol	98736cb682e16a1900b8902bc7ee
code/contracts/aux/ETHUSDCLP_Oracle.sol	d3a54249a5adb857033941520dbc
code/contracts/aux/HistoricPriceConsumerV3.sol	14fab40089d63046bf2701ce629af
code/contracts/aux/FlashLoan_Unwind.sol	33f30310d8b3241c462c3824617a
code/contracts/aux/WindUniswap.sol	770cde1e73eefdf1701718c7d4e5d
code/contracts/LPVault.sol	23cb7ccd0af9d23a01f0e14a7a3aa

Contracts Description Table

Contract	Type	Ba
└	**Function Name**	**Vis**
FlashLoanReceiverBase	Implementation	IFlashLo
└		Pub
└	executeOperation	Exte
└	flashLeverage	Exte
UniswapV2Pair	Interface	
└	totalSupply	Exte
└	getReserves	Exte
LPOracle	Implementation	
└	decimals	Exte
└	sqrt	Inte
└	getAnswer	Pub
└	latestAnswer	Exte
AggregatorInterface	Interface	
└	latestAnswer	Exte
└	latestTimestamp	Exte
└	latestRound	Exte
└	getAnswer	Exte
└	getTimestamp	Exte
AggregatorV3Interface	Interface	
└	decimals	Exte
└	description	Exte
└	version	Exte
└	getRoundData	Exte
└	latestRoundData	Exte
AggregatorV2V3Interface	Interface	Aggregat Aggregato

Contract	Type	Ba
AggregatorProxy	Interface	Aggregator'
└	phaseId	Exte
HistoricalPriceConsumerV3	Interface	
└	getPriceAfterTimestamp	Exte
└	getLatestPriceX1e6	Exte
HistoricalPriceConsumerV3_1	Implementation	
└	getHistoricalPrice	Inte
└	getLatestPrice	Inte
└	getPriceAfterTimestamp	Exte
└	findBlockSamePhase	Inte
└	checkAggregatorDecimals	Exte
└	getLatestPriceX1e6	Pub
HistoricalPriceConsumerV3_RATIO	Implementation	
└		Pub
└	getQuotePrice	Pub
└	getQuoteMantissa	Inte
└	getHistoricalPrice	Pub
└	getLatestPrice	Pub
└	findPriceAfterTimestamp	Pub
└	getPriceAfterTimestamp	Pub
└	findBlockSamePhase	Pub
└	checkAggregatorDecimals	Exte
└	getLatestPriceX1e6	Pub
HistoricalPriceConsumerV3_FIXEDPRICE	Implementation	
└		Pub
└	setPrice	Exte
└	setOracle	Exte
└	getLatestPrice	Pub

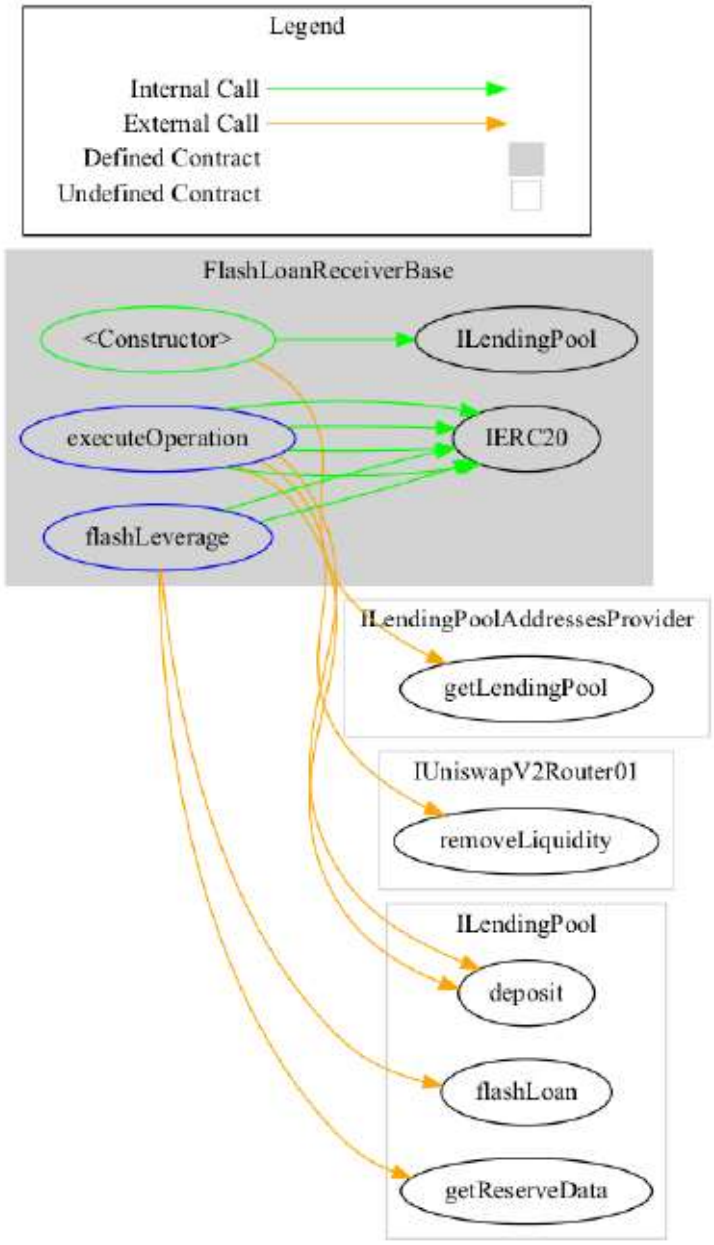
Contract	Type	Ba
└	getPriceAfterTimestamp	Pub
└	getLatestPriceX1e6	Pub
└	checkAggregatorDecimals	Exte
FlashLoanReceiverBase_Unwind	Implementation	IFlashLo
└		Pub
└	executeOperation	Exte
└	flashDeleverage	Exte
└	clearSingleSidedDebt	Exte
WindUniV2LP	Implementation	Ow
└		Pub
└	levUp	Exte
└	levDown	Exte
└	withdraw	Exte
VaultHook	Interface	
└	onInit	Exte
└	onSettle	Exte
LPVault	Implementation	Reentra EF
└		Pub
└	priceWithinRangeX1e6	Inte
└	name	Pub
└	symbol	Pub
└	sqrt	Inte
└	epochExpiry	Pub
└	deposit	Exte
└	depositOnBehalf	Pub

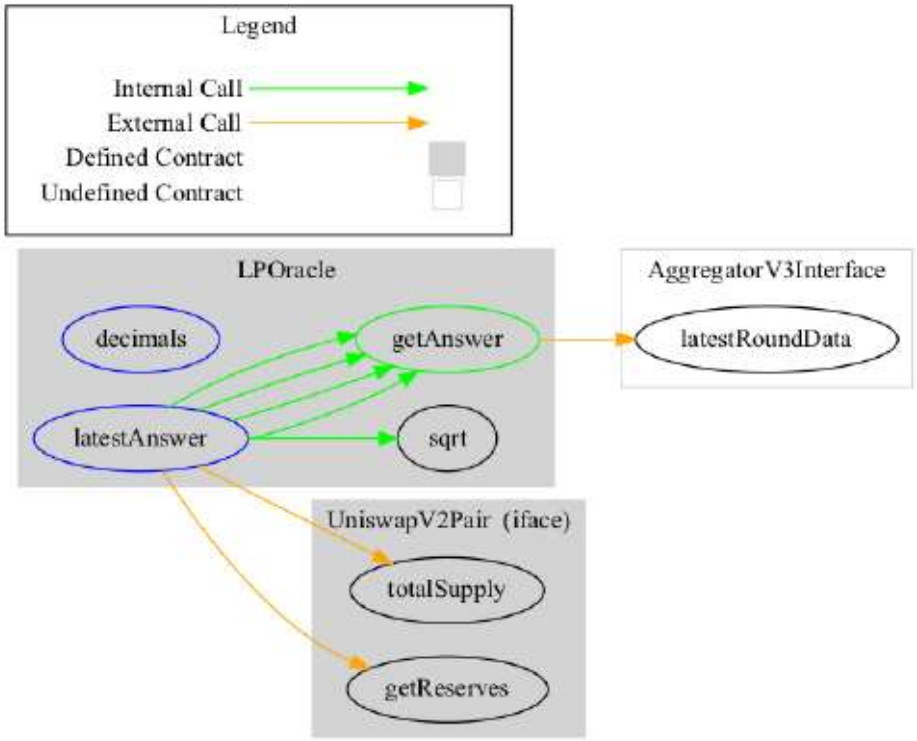
Contract	Type	Ba
└	initWithdraw	Exte
└	initWithdrawOnBehalf	Pub
└	directWithdraw	Inte
└	withdraw	Exte
└	withdrawOnBehalf	Pub
└	initNewRound	Exte
└	getSwapAmt	Inte
└	settle	Pub
└	setOwner	Exte
└	setExpiry	Exte
└	setMaxCap	Exte
└	setMaker	Exte
└	setPriceReader	Exte
└	emergencyWithdraw	Exte
└	setAllowInteraction	Exte
└	setValidator	Exte
└	setVaultHook	Exte
└	syncBalance	Exte
└	setAaveAddressProvider	Exte
└	depositIntoLendingPool	Exte
└	withdrawFromLendingPool	Exte
└	setFeeCollector	Exte
└	setFeePerYearX1e6	Exte

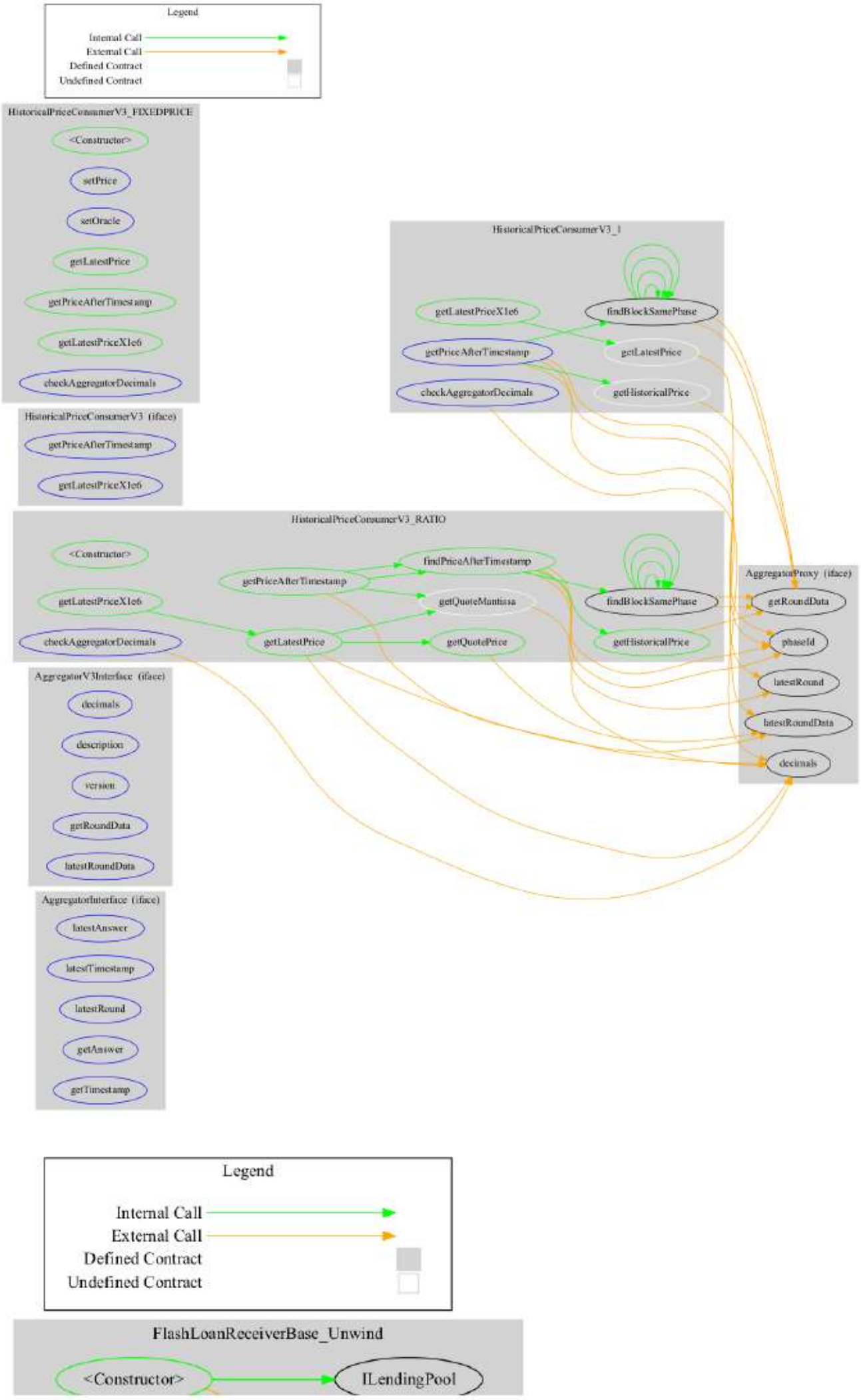
Legend

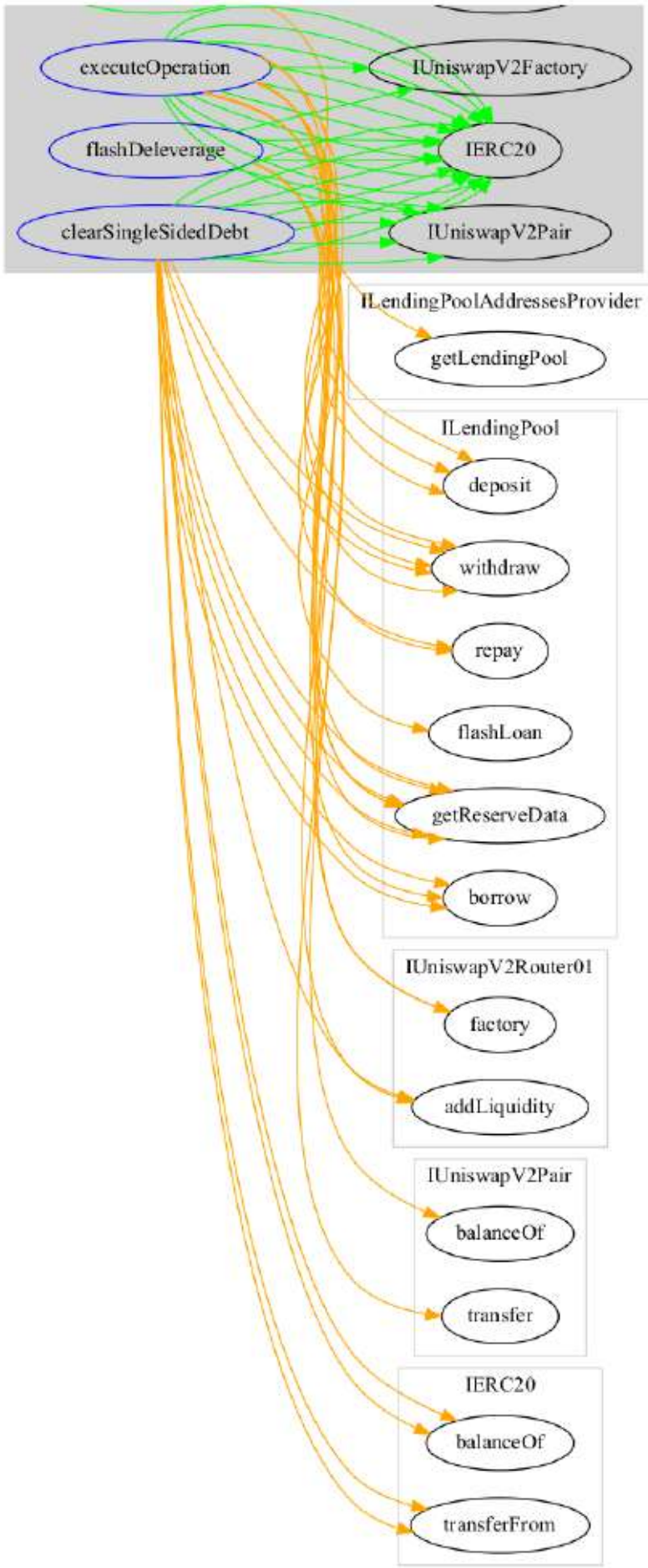
Symbol	Meaning
	Function can modify state
	Function is payable

Graphs

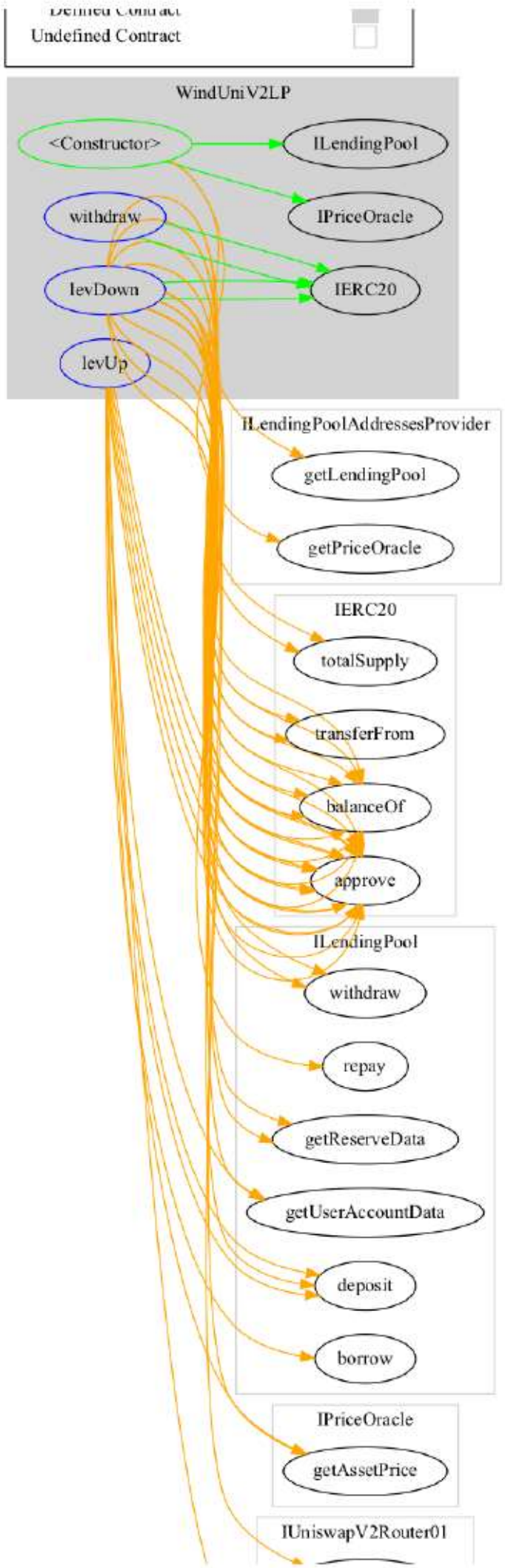



Legend
Internal Call
External Call
Defined Contract
Undefined Contract
LPOracle
decimals
getAnswer
latestAnswer
sqrt
AggregatorV3Interface
latestRoundData
UniswapV2Pair (iface)
totalSupply
getReserves


Legend
Internal Call
External Call
Defined Contract
Undefined Contract
HistoricalPriceConsumerV3_FIXEDPRICE
<Constructor>
setPrice
setOracle
getLatestPrice
getPriceAfterTimestamp
getLatestPriceX1e6
checkAggregatorDecimals
HistoricalPriceConsumerV3_1
getLatestPriceX1e6
findBlockSamePhase
getPriceAfterTimestamp
getLatestPrice
checkAggregatorDecimals
getHistoricalPrice
HistoricalPriceConsumerV3 (iface)
getPriceAfterTimestamp
getLatestPriceX1e6
HistoricalPriceConsumerV3_RATIO
<Constructor>
findPriceAfterTimestamp
getPriceAfterTimestamp
getLatestPriceX1e6
getQuoteMantissa
findBlockSamePhase
checkAggregatorDecimals
getLatestPrice
getQuotePrice
getHistoricalPrice
AggregatorProxy (iface)
getRoundData
phaseId
latestRound
latestRoundData
decimals
AggregatorV3Interface (iface)
decimals
description
version
getRoundData
latestRoundData
AggregatorInterface (iface)
latestAnswer
latestTimestamp
latestRound
getAnswer
getTimestamp
Legend
Internal Call
External Call
Defined Contract
Undefined Contract
FlashLoanReceiverBase_Unwind
<Constructor>
ILendingPool


executeOperation
flashDeleverage
clearSingleSidedDebt
IUniswapV2Factory
IERC20
IUniswapV2Pair
ILendingPoolAddressesProvider
getLendingPool
ILendingPool
deposit
withdraw
repay
flashLoan
getReserveData
borrow
IUniswapV2Router01
factory
addLiquidity
IUniswapV2Pair
balanceOf
transfer
IERC20
balanceOf
transferFrom


Legend
Internal Call
External Call


Undefined Contract
WindUniV2LP
<Constructor>
ILendingPool
IPriceOracle
withdraw
levDown
IERC20
levUp
ILendingPoolAddressesProvider
getLendingPool
getPriceOracle
IERC20
totalSupply
transferFrom
balanceOf
approve
ILendingPool
withdraw
repay
getReserveData
getUserAccountData
deposit
borrow
IPriceOracle
getAssetPrice
IUniswapV2Router01


addLiquidity
removeLiquidity
Legend
Internal Call
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VaultHook (iface)
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setExpiry
setMaxCap
setMaker
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setAllowInteraction
setValidator
setVaultHook
setPriceReader
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setFeeCollector
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checkInvariant
notDuringAuction
initNewRound
deposit
initWithdrawOnBehalf
directWithdraw
type
ILendingPool
balanceOf
withdraw
_burn
epochExpiry
depositOnBehalf
withdrawOnBehalf
settle
<Constructor>
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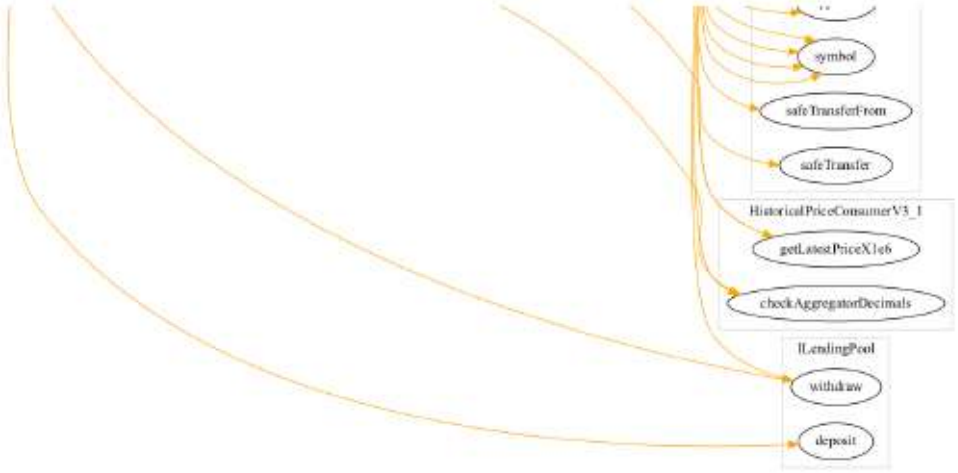
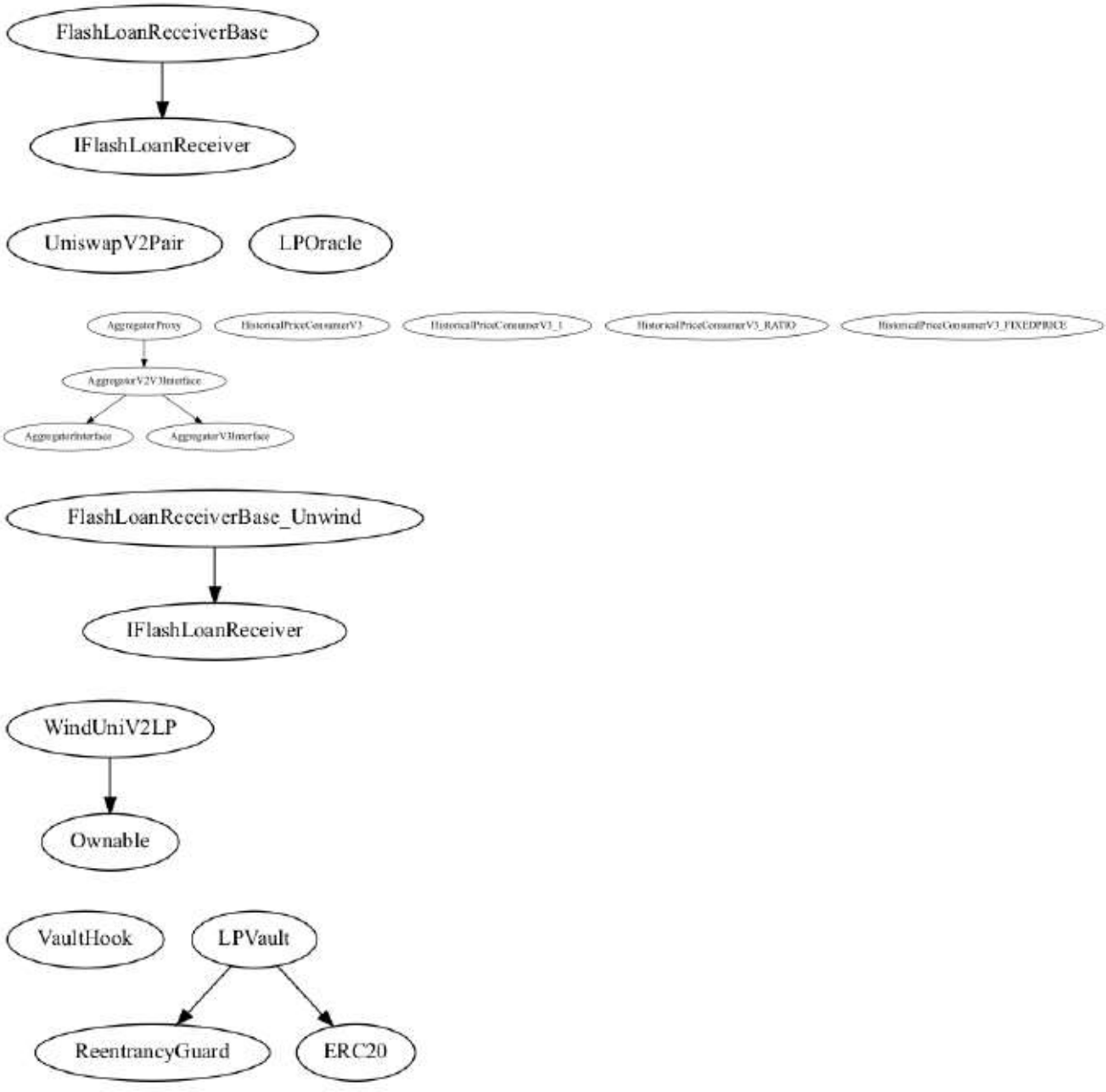
mint
sqrt
getSwapAmt
ERC20
priceWithinRangeX1e6
IUniswapV2Router01
IUniswapV2Pair
ECDSA
recover
toEthSignedMessageHash
IUniswapV2Router01
swapExactTokensForTokens
addLiquidity
removeLiquidity
ERC20
transfer
balanceOf
decimals
approve
ILendingPoolAddressesProvider
getLendingPool



Inheritance



Describe

```
$ npx surya describe code/contracts/aux/FlashLoan_Uniswap.sol code/contracts/aux/ETHUSDCLP_Oracle.sol code
+  FlashLoanReceiverBase (IFlashLoanReceiver)
   - [Pub] <Constructor> #
   - [Ext] executeOperation #
   - [Ext] flashLeverage #

+ [Int] UniswapV2Pair
   - [Ext] totalSupply
   - [Ext] getReserves

+  LPOracle
   - [Ext] decimals
   - [Int] sqrt
   - [Pub] getAnswer
   - [Ext] latestAnswer

+ [Int] AggregatorInterface
   - [Ext] latestAnswer
   - [Ext] latestTimestamp
   - [Ext] latestRound
   - [Ext] getAnswer
   - [Ext] getTimestamp

+ [Int] AggregatorV3Interface
   - [Ext] decimals
   - [Ext] description
   - [Ext] version
   - [Ext] getRoundData
   - [Ext] latestRoundData

+ [Int] AggregatorV2V3Interface (AggregatorInterface, AggregatorV3Interface)

+ [Int] AggregatorProxy (AggregatorV2V3Interface)
   - [Ext] phaseId

+ [Int] HistoricalPriceConsumerV3
   - [Ext] getPriceAfterTimestamp
   - [Ext] getLatestPriceX1e6

+  HistoricalPriceConsumerV3_1
   - [Int] getHistoricalPrice
   - [Int] getLatestPrice
   - [Ext] getPriceAfterTimestamp
   - [Int] findBlockSamePhase
   - [Ext] checkAggregatorDecimals
   - [Pub] getLatestPriceX1e6

+  HistoricalPriceConsumerV3_RATIO
   - [Pub] <Constructor> #
   - [Pub] getQuotePrice
   - [Int] getQuoteMantissa
```

```
    - [Pub] getHistoricalPrice
    - [Pub] getLatestPrice
    - [Pub] findPriceAfterTimestamp
    - [Pub] getPriceAfterTimestamp
    - [Pub] findBlockSamePhase
    - [Ext] checkAggregatorDecimals
    - [Pub] getLatestPriceX1e6

+   HistoricalPriceConsumerV3_FIXEDPRICE
    - [Pub] <Constructor> #
    - [Ext] setPrice #
    - [Ext] setOracle #
    - [Pub] getLatestPrice
    - [Pub] getPriceAfterTimestamp
    - [Pub] getLatestPriceX1e6
    - [Ext] checkAggregatorDecimals

+   FlashLoanReceiverBase_Unwind (IFlashLoanReceiver)
    - [Pub] <Constructor> #
    - [Ext] executeOperation #
    - [Ext] flashDeleverage #
    - [Ext] clearSingleSidedDebt #

+   WindUniV2LP (Ownable)
    - [Pub] <Constructor> #
    - [Ext] levUp #
    - [Ext] levDown #
    - [Ext] withdraw #
       - modifiers: onlyOwner

+ [Int] VaultHook
    - [Ext] onInit #
    - [Ext] onSettle #

+   LPVault (ReentrancyGuard, ERC20)
    - [Pub] <Constructor> #
    - [Int] priceWithinRangeX1e6
    - [Pub] name
    - [Pub] symbol
    - [Int] sqrt
    - [Pub] epochExpiry
    - [Ext] deposit #
    - [Pub] depositOnBehalf #
       - modifiers: nonReentrant,notDuringAuction,checkInvariant
    - [Ext] initWithdraw #
    - [Pub] initWithdrawOnBehalf #
       - modifiers: nonReentrant,notDuringAuction,checkInvariant
    - [Int] directWithdraw #
    - [Ext] withdraw #
    - [Pub] withdrawOnBehalf #
       - modifiers: checkInvariant
```

```
    - [Ext] initNewRound #
    - [Int] getSwapAmt
    - [Pub] settle #
       - modifiers: nonReentrant
    - [Ext] setOwner #
    - [Ext] setExpiry #
    - [Ext] setMaxCap #
    - [Ext] setMaker #
    - [Ext] setPriceReader #
    - [Ext] emergencyWithdraw #
    - [Ext] setAllowInteraction #
    - [Ext] setValidator #
    - [Ext] setVaultHook #
    - [Ext] syncBalance #
    - [Ext] setAaveAddressProvider #
    - [Ext] depositIntoLendingPool #
    - [Ext] withdrawFromLendingPool #
    - [Ext] setFeeCollector #
    - [Ext] setFeePerYearX1e6 #


($) = payable function
# = non-constant function
```

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