BDL Coursework 3 Report

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Part 1 : Smart Contract Programming

High Level Design

The contract implement an Token API, for a user to implement their own Token on the Ethereum blockchain.

Constructor

In this particular contract, the constructor has the following parameters:

- `string memory _name`: The name of the token.
- `string memory _symbol`: The symbol of the token.

The constructor sets the contract owner to the address of the contract deployer, sets the name and symbol of the token to the provided parameters, sets the total supply to 0, and sets the token price to 600 wei.

Internal variables

The following are all the internal variables that are declared in the contract.

- `owner`: The address of the contract owner. This is set in the Constructor. `address` type annotation.
- `total_Supply`: The total token supply. `uint256` is used as type annotation.
- `name`: The name of the token. `string` is used as type.
- `symbol`: The symbol of the token. `string` is used as type.
- `token_price`: The price of the token in wei. This is set to 600 wei during the constructor as specified by the coursework spec. `uint126` is used as type annotation as it is `uint126` in one of the function calls.
- `balances`: A `hashmap` that maps addresses to `uint256`.

Extra things

The only extra thing that was added is the modifier `onlyOwner` to prevent certain users from calling functions in the chain. Everything follow closely to what the coursework spec wants.

Process of buying/selling tokens:

> - Users can buy tokens by requesting the owner to mint a specified amount of tokens for their address, using an out-of-band communication mechanism such as email or messaging. The owner can then call the `mint` function to mint the agreed upon amount of tokens for the user's address.
> - Users can sell tokens by calling the `sell` function and specifying the number of tokens they want to sell. The contract will send the appropriate amount of wei to the user's address.

Gas Evaluation

Everything is in `units` as gas prices change but the computation remain largely the same in solidity.

Contract Deployment

Contract creation
- Transaction hash :
`0xdaf0d7c84b3f0d342b782c88d6a9bea919270d6300e3158b744e8fda96d04b22`
- Deployment address : `0xD260950502A3EfC1f88F06c04C84667dBe8c6D44`
- Gas : `1222807 units`
The heaviest in terms of computation, this makes sense as the it requires setting up all the variables and data structures.

Minting :
- Transaction hash :
`0xf353229b285c38f6e83f6140cb5d1e0adb34b61fc7997e241a07cb0b8a37b3cb`
- Gas : 71688 units
Second heaviest in terms of gas usage, this is most likely due to the additional `require` check with the modifiers.

Fallback :
- Transaction hash :
`0x2526f69223d83b2f5de1a9b48385e96f21b1425864a588240748036569a232f6`
- Gas : 21088 units

transfer :
- Transaction hash :

`0x9956f64534a47d205ff791b83b9b527940791a961d95ec3f170facc092c6e13b`
- Gas : 30580 units

Sell :
- Transaction hash :
`0x9e471945f9724a943a2771595c697e1ccc4b8afd0f8cd6073fec5ac5334ec9a5`
- Gas : 44066 units
Keep this units in mind when comparing with the library version of the code.
Closing :
- Transaction hash :
`0x8c6986674599f7f7643ffbf6ffc43e79c1738b581669eb2ae43e84ebe72ff32d`
- Gas : 28508

other functions

Does not cost any gas as they're just getter functions, they index the contract bytecode in the blockchain.

Improvement techniques

One of the improvements I made was to ensure that all the variables are `internal` instead of `public`. This makes sense because there are getter functions available for viewing these variables if needed, making it redundant and inefficient to have them as public.
Perhaps another step for improvement is using `bytes32` rather than string memory for token name and symbol. I had considered this but it was mentioned in the piazza that this doesn't matter plus it sacrifices some design choices.

Potential Hazards

Here's a list of hazards I shall be talking about, and some other that will be mentioned.

Reintrancy

This should not happen as the token balance is cleared before any sort of transaction happens, but this is dangerous when the custom library is used.

Griefing and Front running

Both of these are avoided as, griefing the `send()` is avoided and in Front running might not happen.

Other hazards

I have made an additional check for overflow for one of the functions, this was unnecessary, but I am leaving it in as looking into if this check was necessary made me see that in solidity 0.8 onwards, you don't these checks or use the library `Safemath` as these checks are now made by the compiler and hence is unnecessary.
Hence, integer overflows and underflows are not possible in this code.
Another scenario is the trust placed on the owner to mint the coins for the user, if the user does not pay and the coin is minted. The user cannot sell their tokens as the contract is devoid of any money (assuming the contract has no money).

Part 2 : Using Libraries

Write a small description of how you linked your contract to the deployed library.

I had to do some googling and found this article that explained how to link a deployed library to a contract. The article :
https://medium.com/remix-ide/deploying-with-libraries-on-remix-ide-24f5f7423b60

Seeing how remix links the library internally, we look at contracts/artifacts/Token.json


```
{
        "deploy": {
                "VM:-": {
                        "linkReferences": {},
                        "autoDeployLib": true
                },
                "main:1": {
                        "linkReferences": {},
                        "autoDeployLib": true
                },
                "ropsten:3": {
                        "linkReferences": {},
                        "autoDeployLib": true
                },
                "rinkeby:4": {
                        "linkReferences": {},
                        "autoDeployLib": true
                },
                "kovan:42": {
                        "linkReferences": {},
                        "autoDeployLib": true
```

```
                },
                "goerli:5": {
                        "linkReferences": {
                                "contracts/customLib.sol": {
                                        "customLib":
"0x9DA4c8B1918BA29eBA145Ee3616BCDFcFAA2FC51"
                                }
                        },
                        "autoDeployLib": false
                }
```

As you can see I've already linked it, but internally this how abi is linked in remix. To mess with this first we need to enable a setting in remix in Settings which generates metadata.

autoDeployLib is set to false as otherwise, remix would deploy our own instance.

Now we can link the library locally and add the relevant lines that will be used. (See code for difference)

Gas difference

During contract creation, an increase in gas units from `1222807` to `1269651` indicates higher computational effort due to more complex logic or more blockchain calls. Similarly, an increase in gas units from `44066` to `57753` for the function `Sell` could be due to a library function call `customSend` in customLib which adds additional computational costs and can increase gas costs of function calls to the contract.

Part 3 : KYC Considerations and Token issuance

Know your customer is basically a way for organisation to prevent fraud like money laundering by verifying certain personal information. This is to ensure that legitimate parties are conducting the transactions.
There needs to be a 3rd party verification that needs to happen in-order to verify that the identity and legitimacy of the user. Once this is done the issuer can then mint the tokens for the user. In order, for the identity of the user to be anonymous we're gonna use a public key encryption.
Assuming, the 3rd party signs the hash of the information of the customer's documents with a private key. The contract issuer has the hash of the information as the id of each customer documents. The customer first does that and then sends the ciphertext to the verifier, which is the contract issuer. The contract issuer has the hash of the documents and uses their

public key to verify the ciphertext and compare it to hash they have.
All this process is done in `Mint` function.
One question is, cant another user just submit real user's ciphertext again. This can be prevented by changing the public key parameters, while this would be slow. This would completely remove the ability to forge a ciphertext or reuse old ones.
Most of these implementation has to be done by a 3rd party as it is not easy to do on-chain.

Appendix

Transaction History

All of this can be viewed in https://goerli.etherscan.io

Without custom library

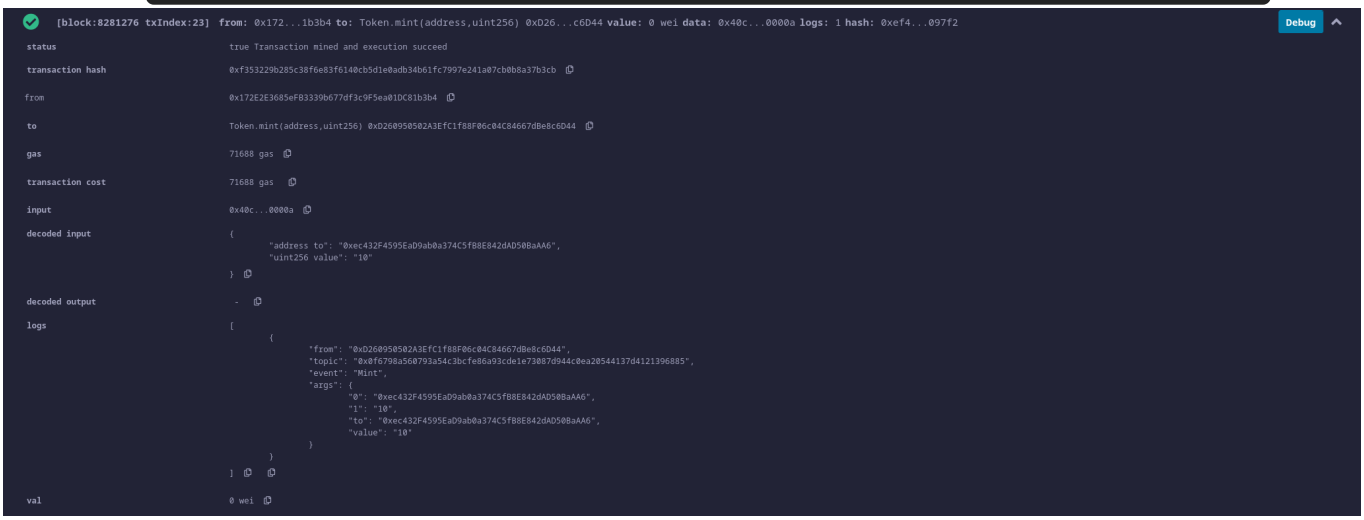
User address : `0xec432F4595EaD9ab0a374C5fB8E842dAD50BaAA6`
Owner address : `0x172E2E3685eFB3339b677df3c9F5ea01DC81b3b4`
Contract address : `0xD260950502A3EfC1f88F06c04C84667dBe8c6D44`

Contract Creation

Tx hash : `0xdaf0d7c84b3f0d342b782c88d6a9bea919270d6300e3158b744e8fda96d04b22`

Owner calls `Mint` function

Tx Hash : `0xf353229b285c38f6e83f6140cb5d1e0adb34b61fc7997e241a07cb0b8a37b3cb`

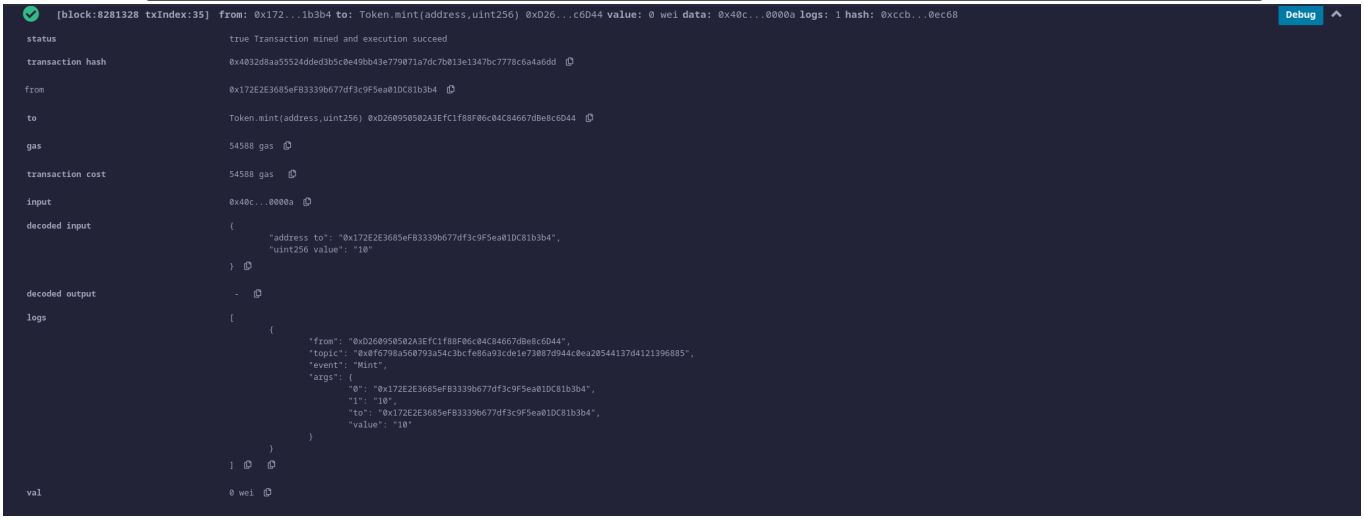


User pays for the tokens by calling fallback functions

Tx hash : `0x2526f69223d83b2f5de1a9b48385e96f21b1425864a588240748036569a232f6`

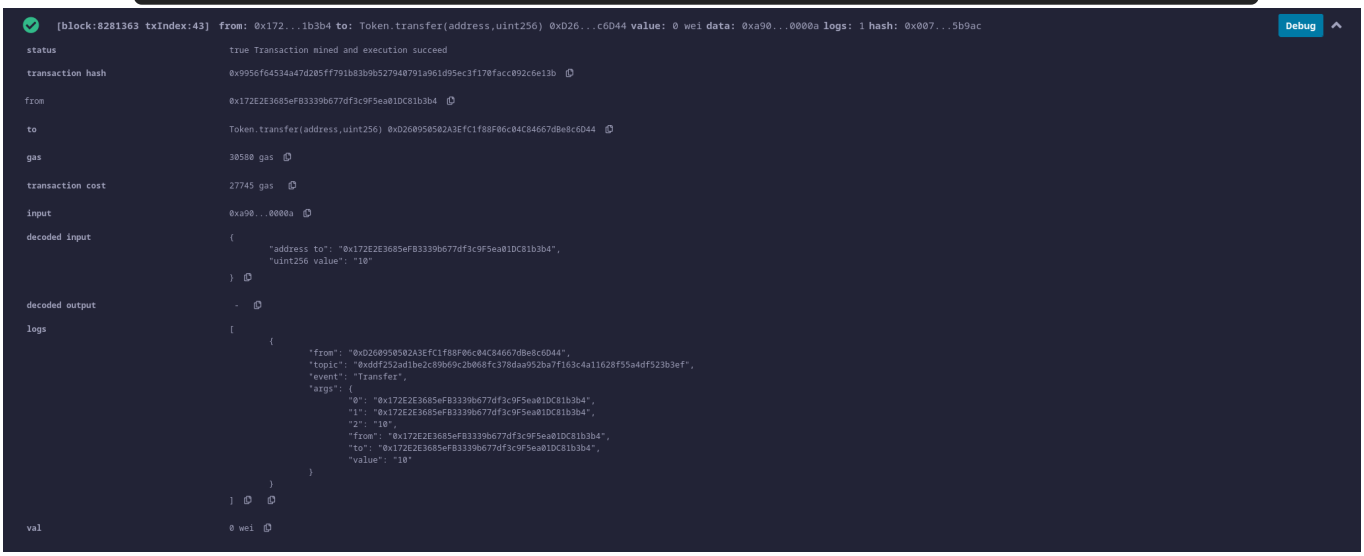
Owner mints coin for themself (to test transfer next step)

Tx hash : `0x4032d8aa55524dded3b5c0e49bb43e779071a7dc7b013e1347bc7778c6a4a6dd`



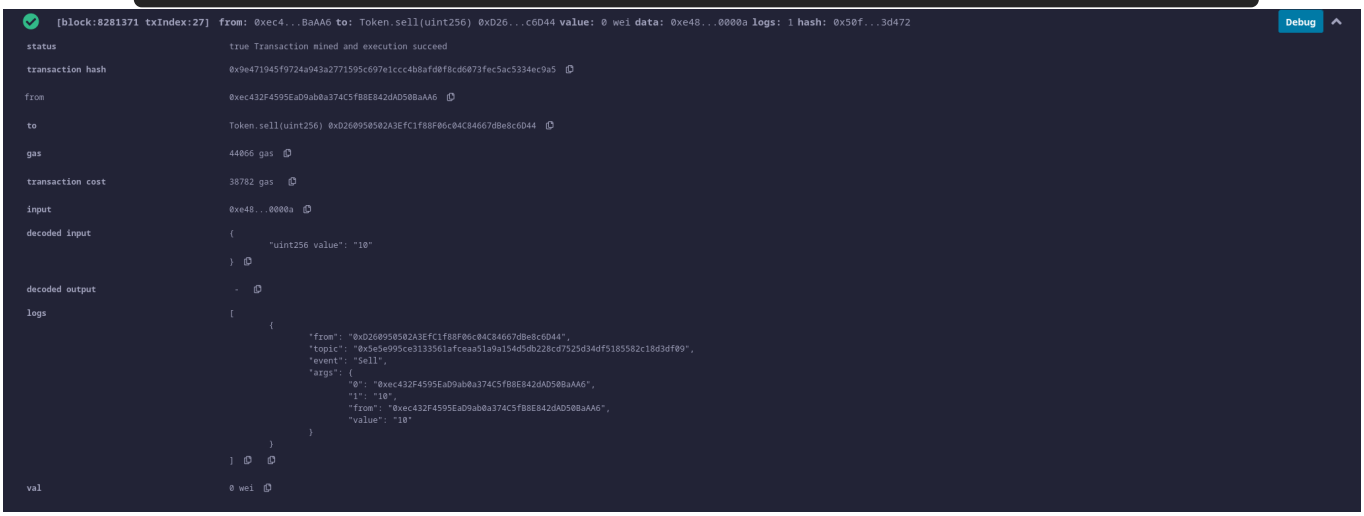
Owner transfers 10 tokens to the User

Tx hash: `0x9956f64534a47d205ff791b83b9b527940791a961d95ec3f170facc092c6e13b`



User sells 10 token

Tx hash: `0x9e471945f9724a943a2771595c697e1ccc4b8afd0f8cd6073fec5ac5334ec9a5`



Owner closes

Tx hash: `0x8c6986674599f7f7643ffbf6ffc43e79c1738b581669eb2ae43e84ebe72ff32d`

With custom library

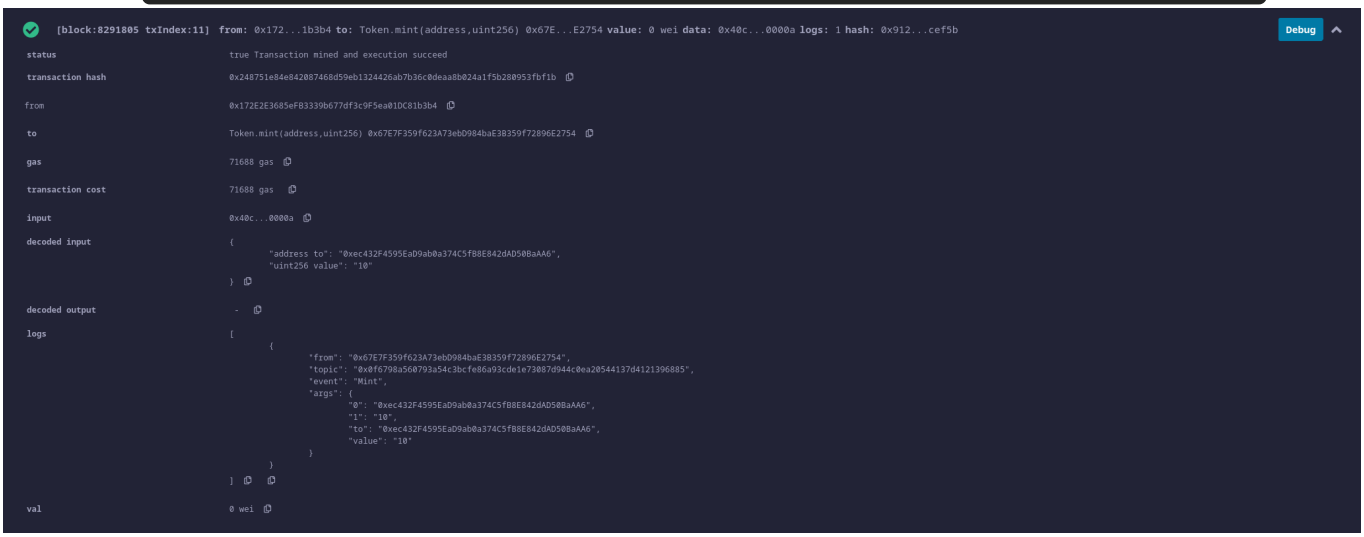
User address : `0xec432F4595EaD9ab0a374C5fB8E842dAD50BaAA6`
Owner address : `0x172E2E3685eFB3339b677df3c9F5ea01DC81b3b4`
Contract address : `0x67E7F359f623A73ebD984baE3B359f72896E2754`

Contract Creation

Tx hash : `0x3b62e4968bbb635bc75f2013eefe22fa95bcde3aaefee27f5d2614afa5c5fc82`

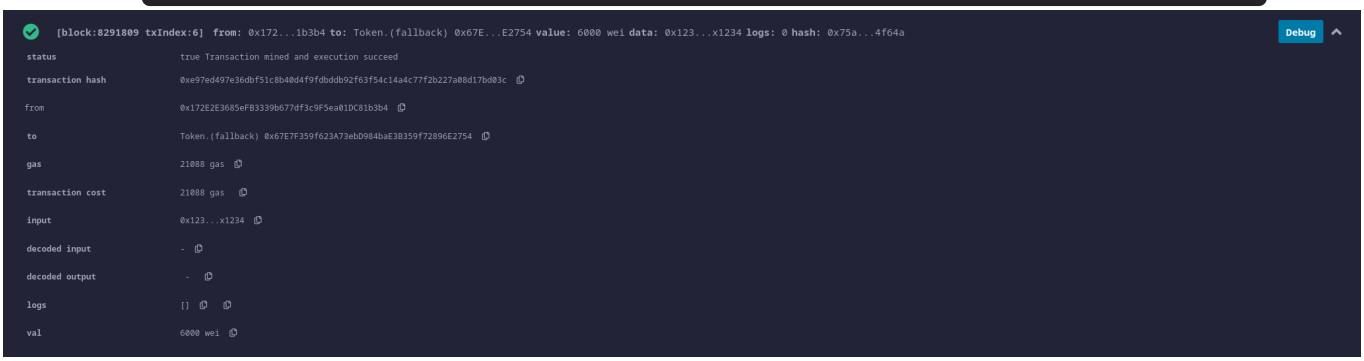
Mint

Tx hash : `0x248751e84e842087468d59eb1324426ab7b36c0deaa8b024a1f5b280953fbf1b`



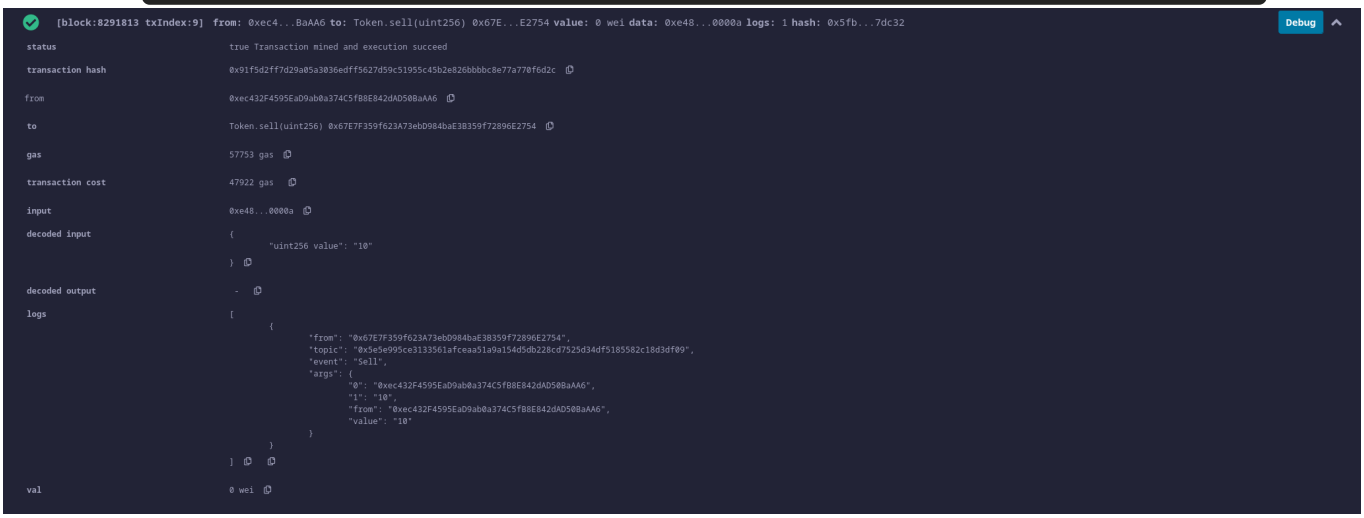
fallback

Tx hash : `0xe97ed497e36dbf51c8b40d4f9fdbddb92f63f54c14a4c77f2b227a08d17bd03c`



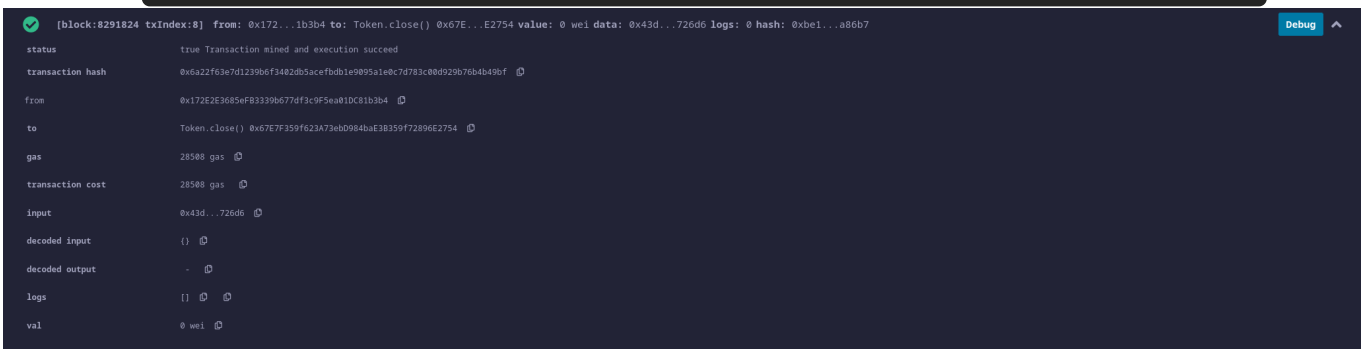
Sell

Tx hash : `0x91f5d2ff7d29a05a3036edff5627d59c51955c45b2e826bbbbc8e77a770f6d2c`



Close

Tx hash : `0x6a22f63e7d1239b6f3402db5acefbdb1e9095a1e0c7d783c00d929b76b4b49bf`



Code

Without library

```
// SPDX-License-Identifier: UNLICENSED
pragma solidity ^0.8.13;



contract Token {
    // The address of the contract owner
    address internal owner;
    // The total token supply
    uint256 internal total_Supply;
    // The token name
    string internal name;
    // The token symbol
```

```
    string internal symbol;
    // The token price in wei
    uint128 internal token_price;

    // Events
    event Transfer(address indexed from, address indexed to, uint256 value);
    event Mint(address indexed to, uint256 value);
    event Sell(address indexed from, uint256 value);


    // mapping that maps addresses to balances
    mapping(address => uint256) public balances;

    // Constructor function that sets the owner, name, symbol, and token
price
    // of the token contract.
    constructor( string memory _name, string memory _symbol) {
        owner = msg.sender;
        name = _name;
        symbol = _symbol;
        total_Supply = 0;
        token_price = 600 wei;
    }

    // return the total supply of the token
    function totalSupply() public view returns (uint256) {
        return total_Supply;
    }

    // function that returns balances of an address
    function balanceOf(address _account) public view returns (uint256) {
        return balances[_account];
    }

    // a view function that returns a string with the token's name
    function getName() public view returns (string memory) {
        return name;
    }
    // a view function that returns a string with the token's symbol
    function getSymbol() public view returns (string memory) {
        return symbol;
    }

    // a view function that returns the token's price in wei
    function getPrice() public view returns (uint128) {
        return token_price;
```

```
    }



    // a function that transfers tokens from the sender to another address
    function transfer(address to, uint256 value) public returns (bool) {
        require(to != address(0), "Invalid address to transfer to");

        // value cannot be zero
        require(value != 0, "Cannot transfer zero tokens");
        // this should prevent underflow
        require(balanceOf(msg.sender) >= value, "Not enough balance to
transfer");
        // make sure balance is not overflowing
        require (balanceOf(to) + value >= balanceOf(to), "Overflow");
        balances[msg.sender] -= value;
        balances[to] += value;
        emit Transfer(msg.sender, to, value);
        return true;
    }



    // a function that enables only the owner to mint tokens to specified
address
    function mint(address to, uint256 value) public onlyOwner returns (bool)
{
        require(to != address(0), "Invalid address to mint to");
        // make sure balance is not overflowing
        require (balanceOf(to) + value >= balanceOf(to), "Overflow");
        // value cannot be zero
        require(value != 0, "Cannot mint zero tokens");
        balances[to] += value;

        total_Supply += value;

        emit Mint(to, value);
        return true;
    }

    // a function that enables the token owners to sell their tokens
    function sell(uint256 value) public payable returns (bool) {
        // value cannot be zero
        require(value != 0, "Cannot sell zero tokens");
        // this should prevent underflow
        require(balanceOf(msg.sender) >= value, "Not enough balance to
sell");
```

```
        // amount = token_price * value
        uint256 amount = token_price * value;

        // make sure the contract has enough balance to pay the seller
        require(address(this).balance >= amount, "Not enough balance to pay
the seller");

        // reduce the balance of the seller
        balances[msg.sender] -= value;

        // reduce the total supply
        total_Supply -= value;
        // transfer from the contract to the sender
        payable(msg.sender).transfer(amount);
        emit Sell(msg.sender, value);
        return true;

    }

    // close() a function that enables only the owner to destroy the
contract; the contract's balance in wei, at the moment of destruction,
should be transferred to the owner address
    function close() public onlyOwner {
        selfdestruct(payable(owner));
    }


    // fallback function to let the contract receive ether
    fallback() external payable {
        //

    }

    // receive function to let the contract receive ether
    receive() external payable {
        //
    }




   // ---------------------- Modifiers ----------------------------

    modifier onlyOwner {
```

```
    require(msg.sender == owner);
    _;
    }



}
```

With library

```
// SPDX-License-Identifier: UNLICENSED
pragma solidity ^0.8.13;

import "./customLib.sol";

contract Token {
    using customLib for uint256;
    using customLib for address;

    // The address of the contract owner
    address internal owner;
    // The total token supply
    uint256 internal total_Supply;
    // The token name
    string internal name;
    // The token symbol
    string internal symbol;
    // The token price in wei
    uint128 internal token_price;

    // Events
    event Transfer(address indexed from, address indexed to, uint256 value);
    event Mint(address indexed to, uint256 value);
    event Sell(address indexed from, uint256 value);


    // mapping that maps addresses to balances
    mapping(address => uint256) public balances;

    // Constructor function that sets the owner, name, symbol, and token
price
    // of the token contract.
    constructor( string memory _name, string memory _symbol) {
        owner = msg.sender;
        name = _name;
        symbol = _symbol;
```

```
        total_Supply = 0;
        token_price = 600;
    }

    // return the total supply of the token
    function totalSupply() public view returns (uint256) {
        return total_Supply;
    }

    // function that returns balances of an address
    function balanceOf(address _account) public view returns (uint256) {
        return balances[_account];
    }

    // a view function that returns a string with the token's name
    function getName() public view returns (string memory) {
        return name;
    }
    // a view function that returns a string with the token's symbol
    function getSymbol() public view returns (string memory) {
        return symbol;
    }

    // a view function that returns the token's price in wei
    function getPrice() public view returns (uint128) {
        return token_price;
    }



    // a function that transfers tokens from the sender to another address
    function transfer(address to, uint256 value) public returns (bool) {
        require(to != address(0), "Invalid address to transfer to");

        // value cannot be zero
        require(value != 0, "Cannot transfer zero tokens");
        require(balanceOf(msg.sender) >= value, "Not enough balance to
transfer");
        balances[msg.sender] -= value;
        balances[to] += value;
        emit Transfer(msg.sender, to, value);
        return true;
    }


    // a function that enables only the owner to mint tokens to specified
```

```
address
    function mint(address to, uint256 value) public onlyOwner returns (bool)
{
        require(to != address(0), "Invalid address to mint to");
        // make sure balance is not overflowing
        require (balanceOf(to) + value >= balanceOf(to), "Overflow");
        // value cannot be zero
        require(value != 0, "Cannot mint zero tokens");
        balances[to] += value;

        total_Supply += value;

        emit Mint(to, value);
        return true;
    }

    // a function that enables the token owners to sell their tokens
    function sell(uint256 value) public payable returns (bool) {
        // value cannot be zero
        require(value != 0, "Cannot sell zero tokens");
        require(balanceOf(msg.sender) >= value, "Not enough balance to
sell");

        // amount = token_price * value
        uint256 amount = token_price * value;

        // make sure the contract has enough balance to pay the seller
        require(address(this).balance >= amount, "Not enough balance to pay
the seller");

        // reduce the balance of the seller
        balances[msg.sender] -= value;

        // reduce the total supply
        total_Supply -= value;
        // transfer from the contract to the sender
        bool success = amount.customSend(msg.sender);
        emit Sell(msg.sender, value);
        return success;

    }

    // close() a function that enables only the owner to destroy the
contract; the contract's balance in wei, at the moment of destruction,
should be transferred to the owner address
    function close() public onlyOwner {
```

```
        selfdestruct(payable(owner));
    }


    // fallback function to let the contract receive ether
    fallback() external payable {
        //

    }

    // receive function to let the contract receive ether
    receive() external payable {
        //
    }




   // ------------------------ Modifiers -----------------------------

    modifier onlyOwner {
    require(msg.sender == owner);
    _;
    }



}
```