Experiment No. 5

Aim: Deploying a Voting/Ballot Smart Contract

Theory:

1. Relevance of require Statements in Solidity Programs

In Solidity, the require statement acts as a **guard condition** within functions. It ensures that only valid inputs or authorized users can execute certain parts of the code. If the condition inside require is not satisfied, the function execution stops immediately, and all state changes made during that transaction are reverted to their original state. This rollback mechanism ensures that invalid transactions do not corrupt the blockchain data.

For example, in a **Voting Smart Contract**, require can be used to check:

- Whether the person calling the function has the right to vote (require(voters[msg.sender].weight > 0, "Has no right to vote");).
- Whether a voter has already voted before allowing them to vote again.
- Whether the function caller is the **chairperson** before granting voting rights.

Thus, require statements enforce **security, correctness, and reliability** in smart contracts. They also allow developers to attach error messages, making debugging and contract interaction easier for users.

2. Keywords: mapping, storage, and memory

- **mapping**:
  A mapping is a special data structure in Solidity that links keys to values, similar to a hash table. Its syntax is mapping(keyType => valueType). For example:

  mapping(address => Voter) public voters;

  Here, each address (Ethereum account) is mapped to a Voter structure. Mappings are very useful for contracts like **Ballot**, where you need to associate voters with their data (whether they voted, which proposal they chose, etc.). Unlike arrays, mappings do not have a length property and cannot be iterated over directly, making them **gas efficient** for lookups but limited for enumeration.

- **storage**:
  In Solidity, storage refers to the **permanent memory** of the contract, stored on the Ethereum blockchain. Variables declared at the contract

level are stored in storage by default. Data stored in storage is persistent across transactions, which means once written, it remains available unless explicitly modified. However, because writing to blockchain storage consumes gas, it is more expensive. For example, a voter's information saved in the voters mapping remains available throughout the contract's lifecycle.

- **memory**:
  In contrast, memory is **temporary storage**, used only for the lifetime of a function call. When the function execution ends, the data stored in memory is discarded. Memory is mainly used for temporary variables, function arguments, or computations that don't need to be permanently stored on the blockchain. It is cheaper than storage in terms of gas cost. For instance, when handling proposal names or temporary string manipulations, memory is often used.

Thus, a smart contract developer must **balance between storage and memory** to ensure efficiency and cost-effectiveness.

3. Why bytes32 Instead of string?

In earlier implementations of the Ballot contract, bytes32 was used for proposal names instead of string. The reason lies in **efficiency and gas optimization**.

- **bytes32** is a **fixed-size type**, meaning it always stores exactly 32 bytes of data. This makes storage simple, comparison operations faster, and gas costs lower. However, it limits proposal names to 32 characters, which is not very flexible for user-friendly names.
- **string** is a **dynamically sized type**, meaning it can store text of variable length. While it is easier for developers and users (since names can be written normally), it requires more complex handling inside the Ethereum Virtual Machine (EVM). This increases gas usage and may slow down comparisons or manipulations.

To make the system more user-friendly, modern implementations of the Ballot contract often convert from bytes32 to string. Tools like the **Web3 Type Converter** help developers easily switch between these two types for deployment and testing.

In summary, bytes32 is used when performance and gas efficiency are priorities, while string is preferred for readability and ease of use.

Code:

```
// SPDX-License-Identifier: GPL-3.0
pragma solidity ^0.8.20;
```

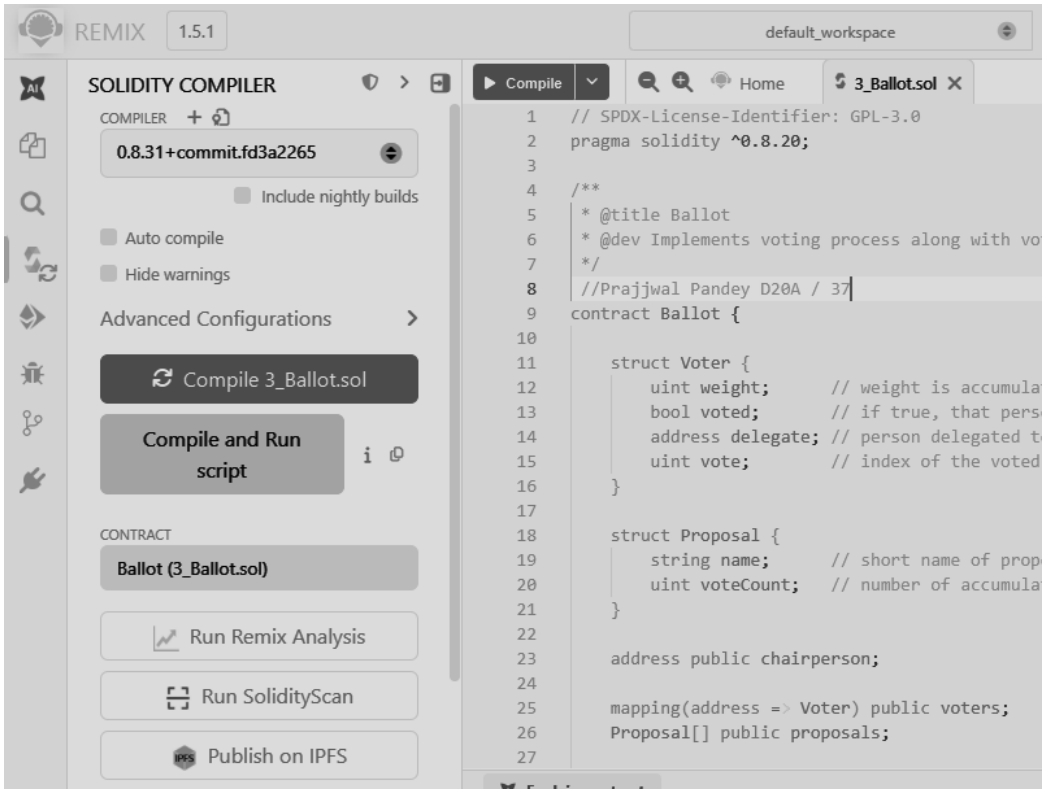
```
/**
 * @title Ballot
 * @dev Implements voting process along with vote delegation
 */
 //Prajjwal Pandey D20A / 37
contract Ballot {

   struct Voter {
      uint weight;      // weight is accumulated by delegation
      bool voted;       // if true, that person already voted
      address delegate; // person delegated to
      uint vote;        // index of the voted proposal
   }

   struct Proposal {
      string name;      // short name of proposal
      uint voteCount;   // number of accumulated votes
   }

   address public chairperson;

   mapping(address => Voter) public voters;
   Proposal[] public proposals;

   /**
    * @dev Create a new ballot to choose one of `proposalNames`.
    */
   constructor(string[] memory proposalNames) {
      require(proposalNames.length > 0, "Must provide proposals");

      chairperson = msg.sender;
      voters[chairperson].weight = 1;

      for (uint i = 0; i < proposalNames.length; i++) {
         proposals.push(Proposal({
            name: proposalNames[i],
            voteCount: 0
         }));
      }
   }

   /**
    * @dev Give `voter` the right to vote on this ballot.
    * Can only be called by chairperson.
    */
```

```
function giveRightToVote(address voter) external {
    require(msg.sender == chairperson, "Only chairperson can give right to vote");
    require(!voters[voter].voted, "The voter already voted");
    require(voters[voter].weight == 0, "Voter already has right to vote");

    voters[voter].weight = 1;
}

/**
 * @dev Delegate your vote to the voter `to`.
 */
function delegate(address to) external {
    Voter storage sender = voters[msg.sender];

    require(sender.weight != 0, "You have no right to vote");
    require(!sender.voted, "You already voted");
    require(to != msg.sender, "Self-delegation is disallowed");

    // Follow delegation chain
    while (voters[to].delegate != address(0)) {
        to = voters[to].delegate;
        require(to != msg.sender, "Found loop in delegation");
    }

    Voter storage delegate_ = voters[to];

    require(delegate_.weight >= 1, "Delegate has no right to vote");

    sender.voted = true;
    sender.delegate = to;

    if (delegate_.voted) {
        proposals[delegate_.vote].voteCount += sender.weight;
    } else {
        delegate_.weight += sender.weight;
    }
}

/**
 * @dev Give your vote (including delegated votes) to proposal `proposal`.
 */
function vote(uint proposal) external {
    require(proposal < proposals.length, "Invalid proposal");

    Voter storage sender = voters[msg.sender];
```

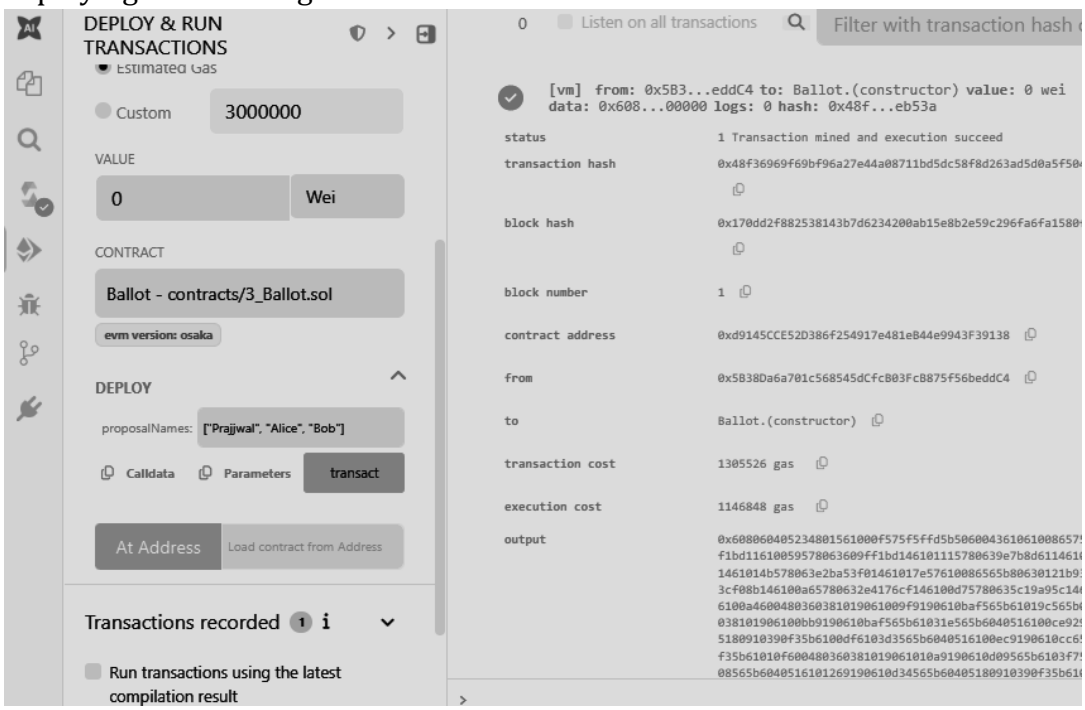
```
        require(sender.weight != 0, "Has no right to vote");
        require(!sender.voted, "Already voted");

        sender.voted = true;
        sender.vote = proposal;

        proposals[proposal].voteCount += sender.weight;
    }

    /**
     * @dev Computes the winning proposal.
     */
    function winningProposal() public view returns (uint winningProposal_) {
        uint winningVoteCount = 0;

        for (uint p = 0; p < proposals.length; p++) {
            if (proposals[p].voteCount > winningVoteCount) {
                winningVoteCount = proposals[p].voteCount;
                winningProposal_ = p;
            }
        }
    }

    /**
     * @dev Returns the name of the winning proposal.
     */
    function winnerName() external view returns (string memory winnerName_) {
        winnerName_ = proposals[winningProposal()].name;
    }
}
```

Output Screenshot:

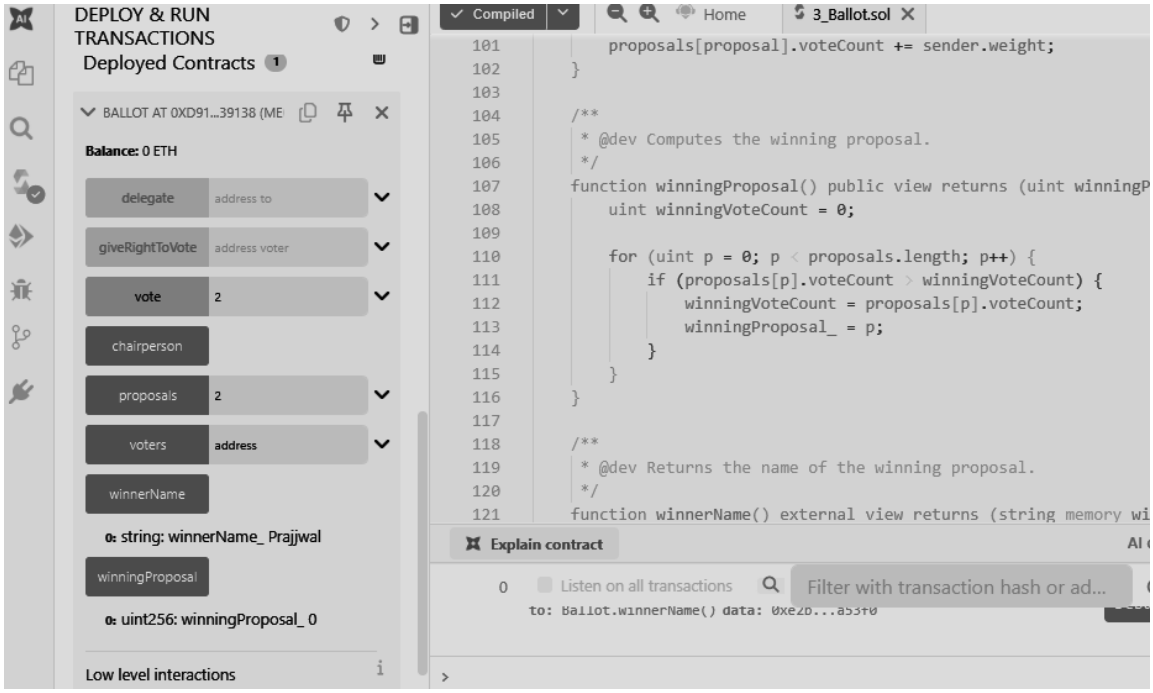
1. Compiled Ballot.sol contract



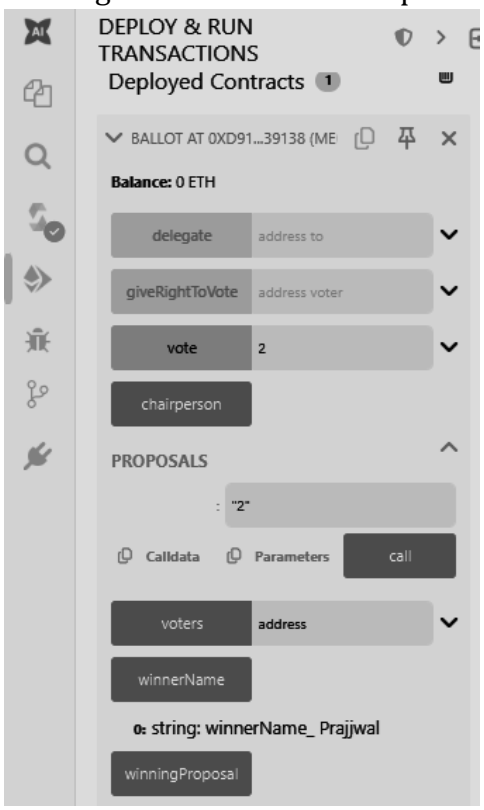
2. Deploying and running of the contract



3. Loading the Proposal Candidate's Names (string)

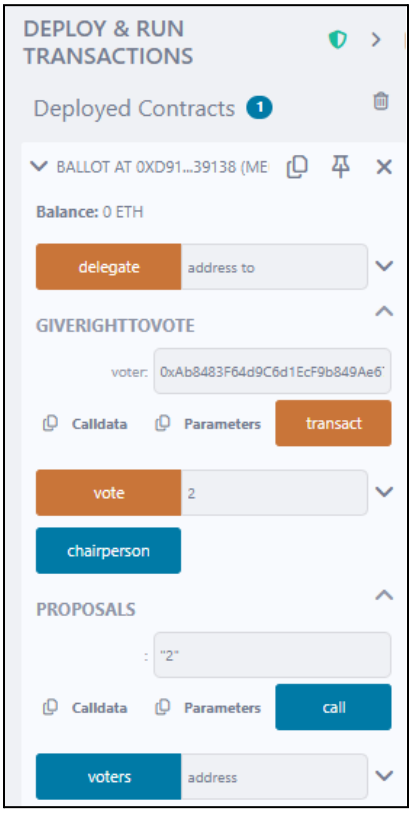


4. Viewing the details of the Proposal Candidate

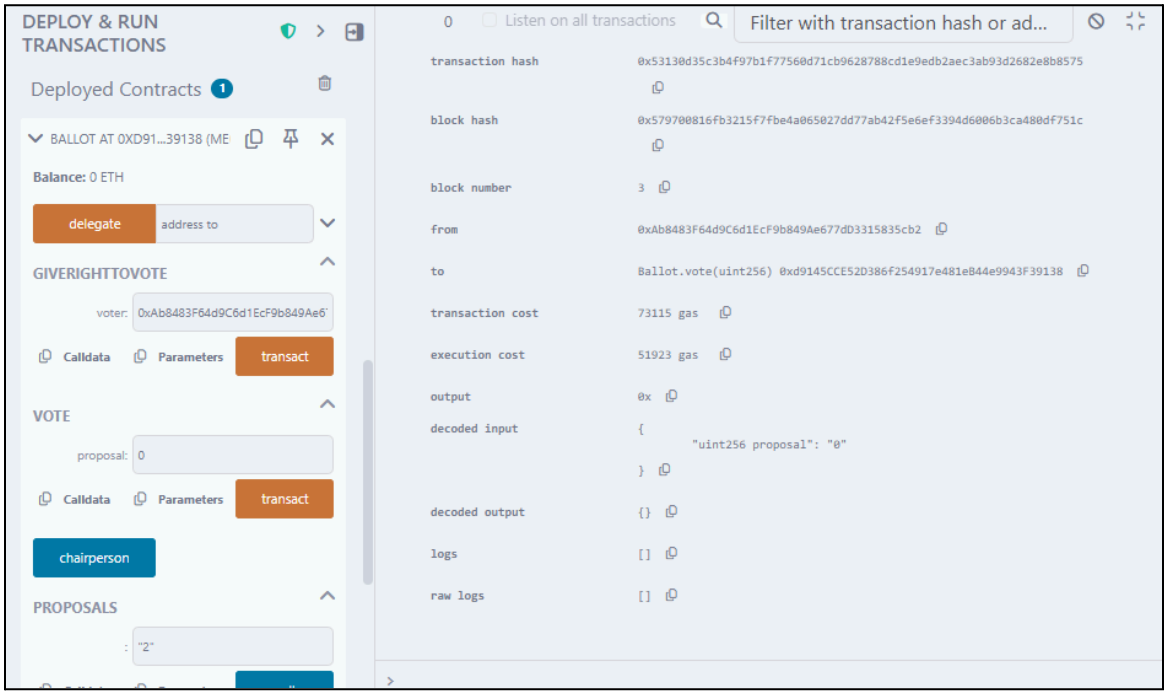


5. Giving the right to an account other than and by the chairman

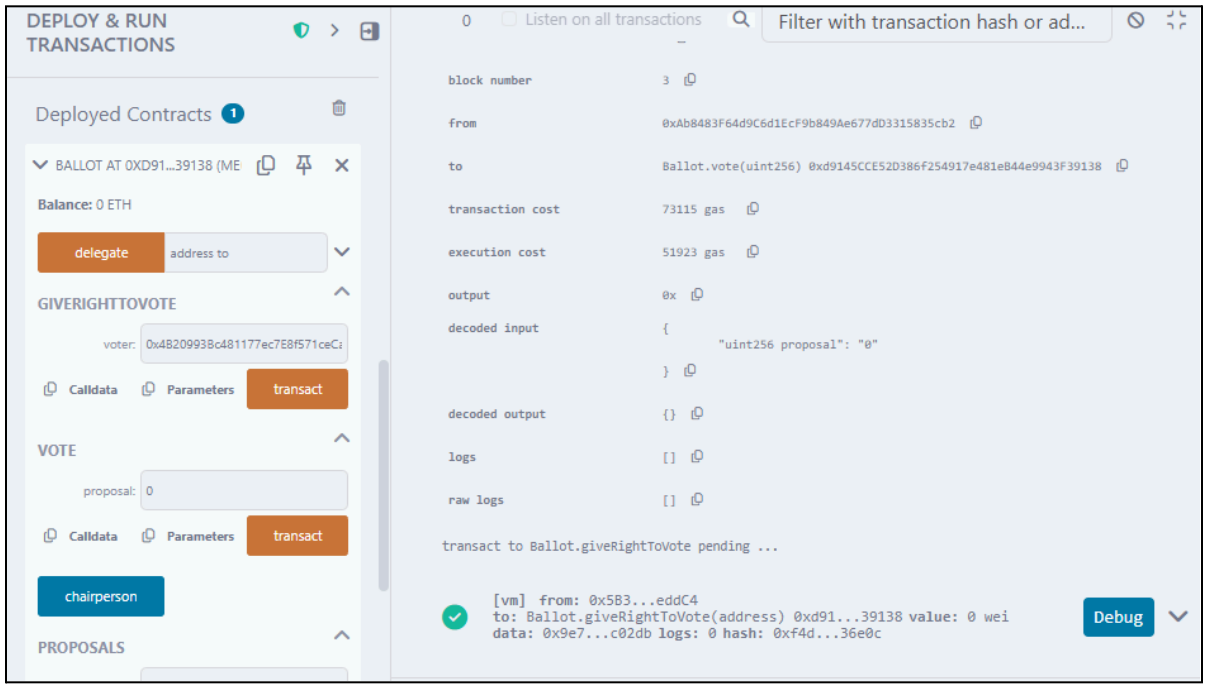
6. Selecting the account which was given the right to vote and then writing the proposal candidate's index to vote.



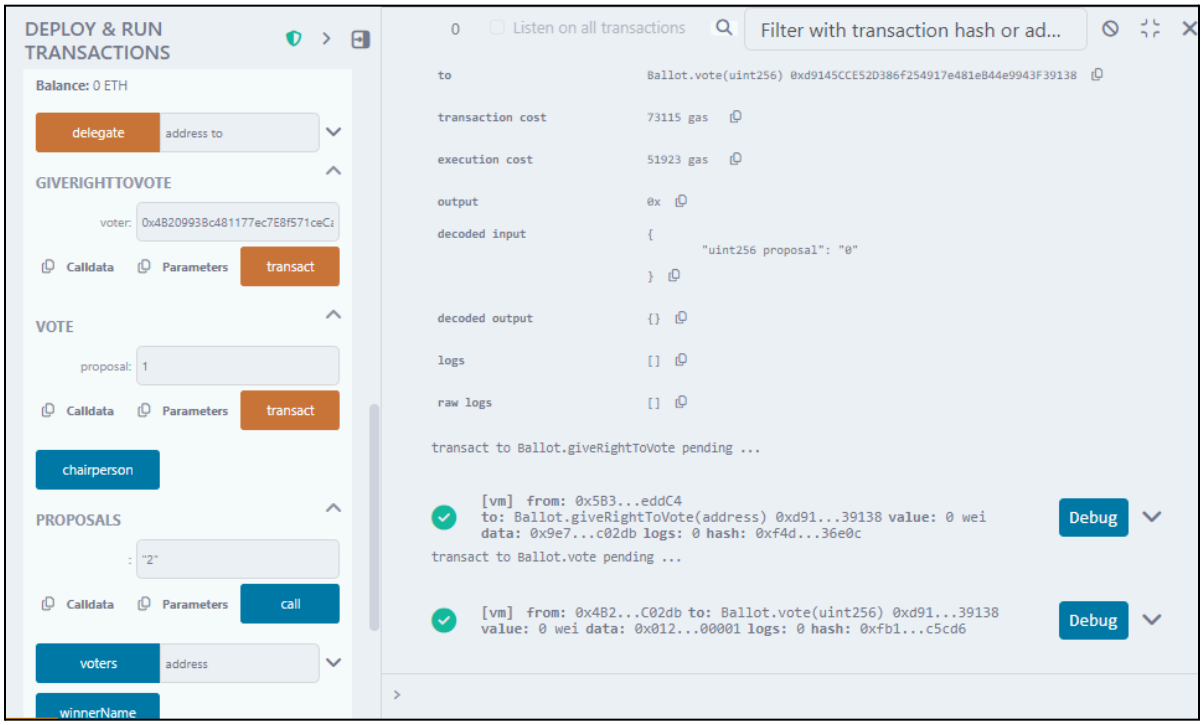
7. We can view the Voter's Information

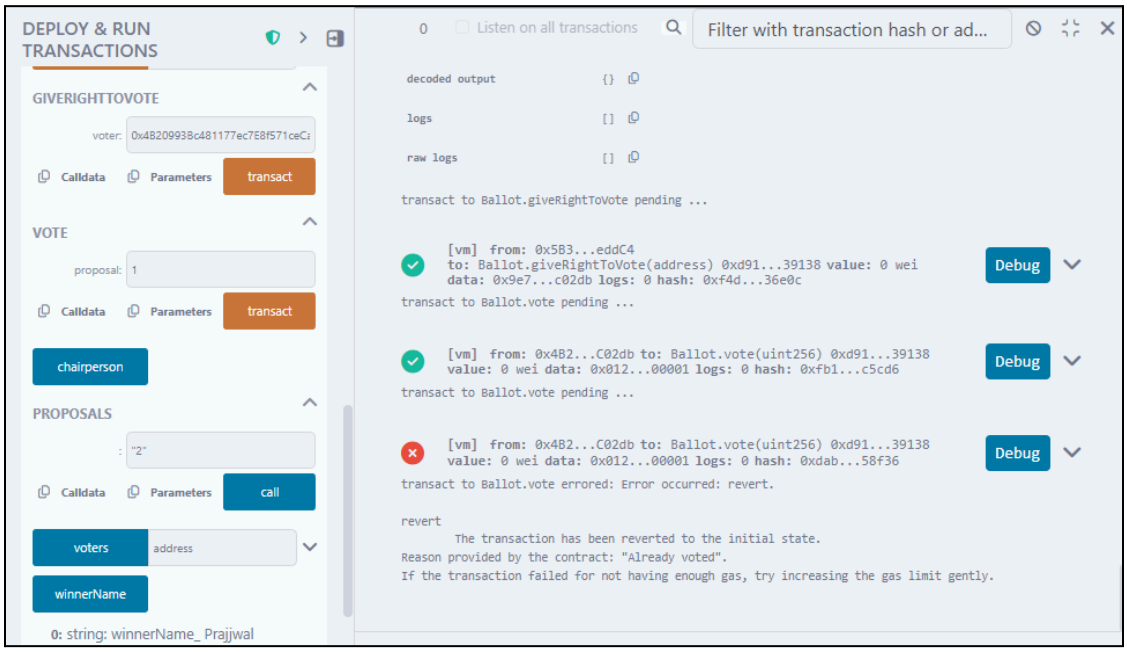


8. Selecting the account of the delegator and then writing the address of the voter to be delegated to.

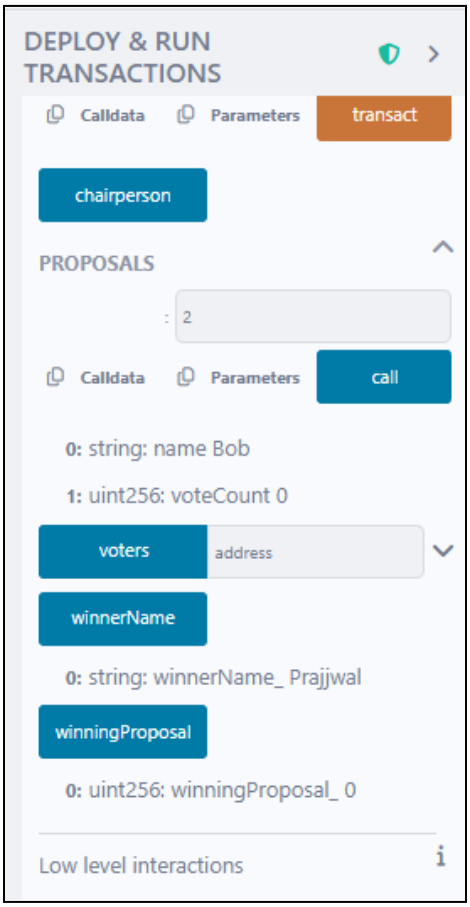


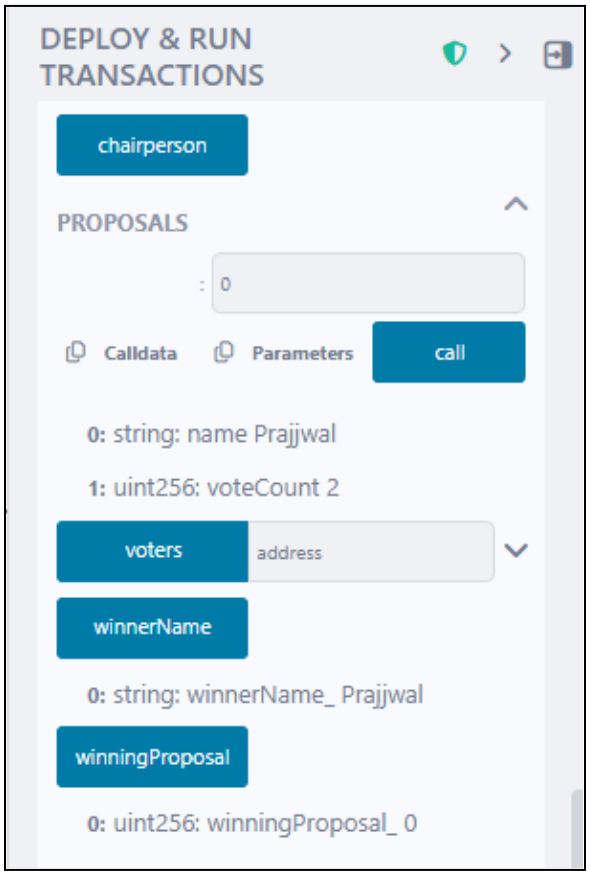
9. Proposal Candidate's Information before giving the Delegate's vote.





10. In this final screenshot we can see that after the delegation's vote the weight of one vote of the one voter who was delegated is the number of people who delegated the voter as their voter (Default weight of any voter is 1).





Conclusion: In this experiment, a Voting/Ballot smart contract was deployed using Solidity on the Remix IDE. The concepts of require statements, mapping, and data location specifiers like storage and memory were explored to understand their role in ensuring security, efficiency, and correctness in smart contracts. The difference between using bytes32 and string for proposal names was also studied, highlighting the trade-off between gas efficiency and readability. Overall, the experiment provided practical insights into the design and deployment of voting contracts on the blockchain.