Report: Decentralized Application for Joint Accounts and Transactions

B21CS050 and B21CS020

Abstract

This report describes the development of a decentralized application (DApp) that enables users to create joint accounts and perform transactions over a connected user network. The DApp simulates transactions between users using a network topology and evaluates the transaction success ratio over time. The project demonstrates the capabilities of Solidity-based smart contracts and Python scripting for off-chain computation.

Introduction

Decentralized applications (DApps) operate on blockchain networks, eliminating the need for centralized servers. This DApp enables users to create joint accounts and transact over a user network, leveraging the Ethereum blockchain. The application facilitates transactions along the shortest path in a user network and maintains user balances throughout.

Objectives

- Develop a smart contract to manage joint accounts and transactions.
- Simulate a network of users and perform transactions based on connectivity.
- Evaluate the transaction success ratio over 100 transactions.

Implementation Details

Installation Instructions

1. **Install Node.js and npm**

   Download and install from the official website.

2. **Install Ganache CLI**

   ```
   npm install -g ganache-cli
   ```

Start Ganache CLI:

1. **Open a terminal and run:**

```
ganache-cli -d
```

```
=================
20000000000

Gas Limit
=================
6721975

Call Gas Limit
=================
9007199254740991

Listening on 127.0.0.1:8545
eth_accounts
eth_getBlockByNumber
eth_chainId
eth_chainId
eth_estimateGas
```

on running deployment script

```
KeyboardInterrupt                                   python deploy_contract.py
>> C:\Users\navne\OneDrive\Desktop\sem7\blockchain>
Contract deployed at address: 0xe78A0F7E598Cc8b0Bb87894B0F60dD2a88d6a8Ab
PS C:\Users\navne\OneDrive\Desktop\sem7\blockchain>
```

then running the interact.ipynb file

1. Network Graph

The network is represented as an undirected graph, where:

- **Nodes** represent users.
- **Edges** represent joint accounts with initial balances.

2. Smart Contract

A Solidity smart contract was developed to:

1. **Register users** with unique IDs and usernames.
2. **Create joint accounts** between users, initializing their contributions.
3. **Transfer amounts** between users along the shortest path in the graph.
4. **Update balances** along the path while maintaining balance consistency.

Key Functions

- `registerUser`: Registers a user on the network.
- `createAcc`: Creates a joint account with an initial contribution.
- `sendAmount`: Transfers an amount from one user to another along a specified path.
- `closeAccount`: Closes a joint account between two users.

3. Off-Chain Computation

The shortest path between users was computed off-chain using Python's `networkx` library, and the path was passed to the smart contract for processing. This approach minimizes gas usage and computational overhead on the blockchain.

4. Transaction Simulation

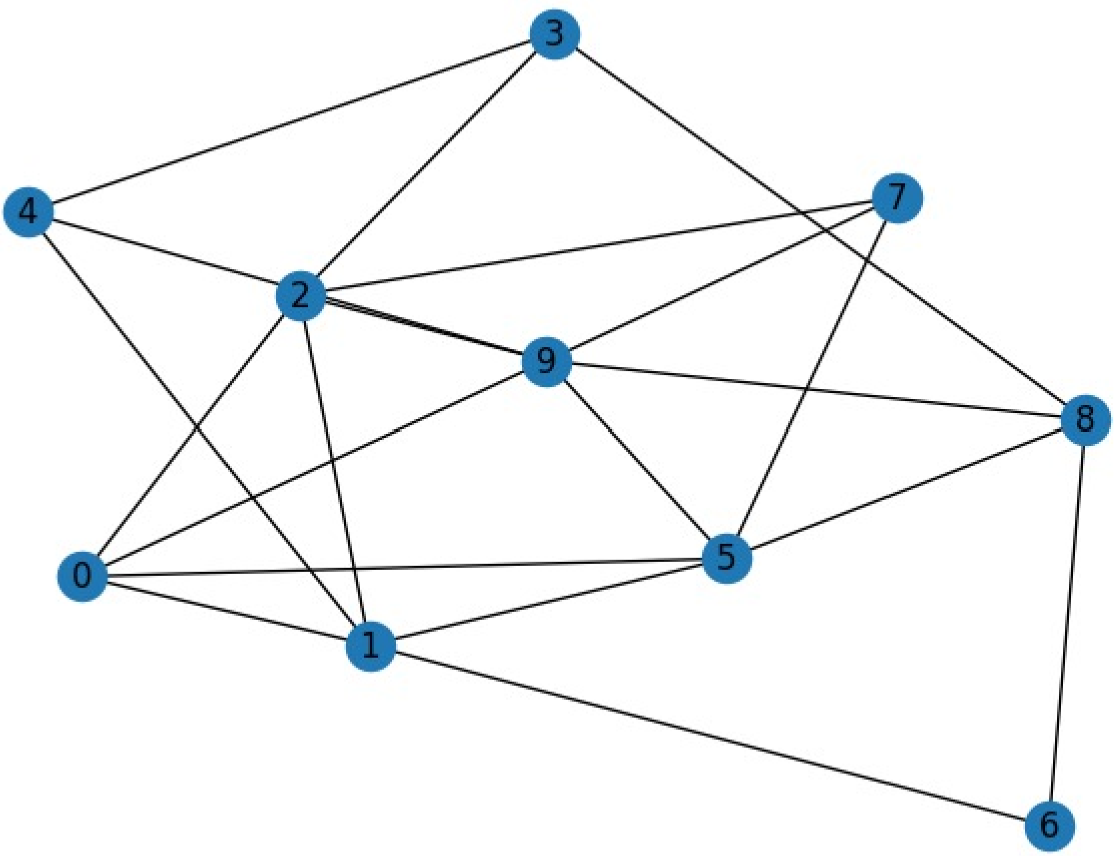
- **Number of Transactions**: 100/1000
- **Amount per Transaction**: 1 unit
- **Logic**: Random sender-receiver pairs were chosen. Transactions were processed only if sufficient balance existed along the path.

Results

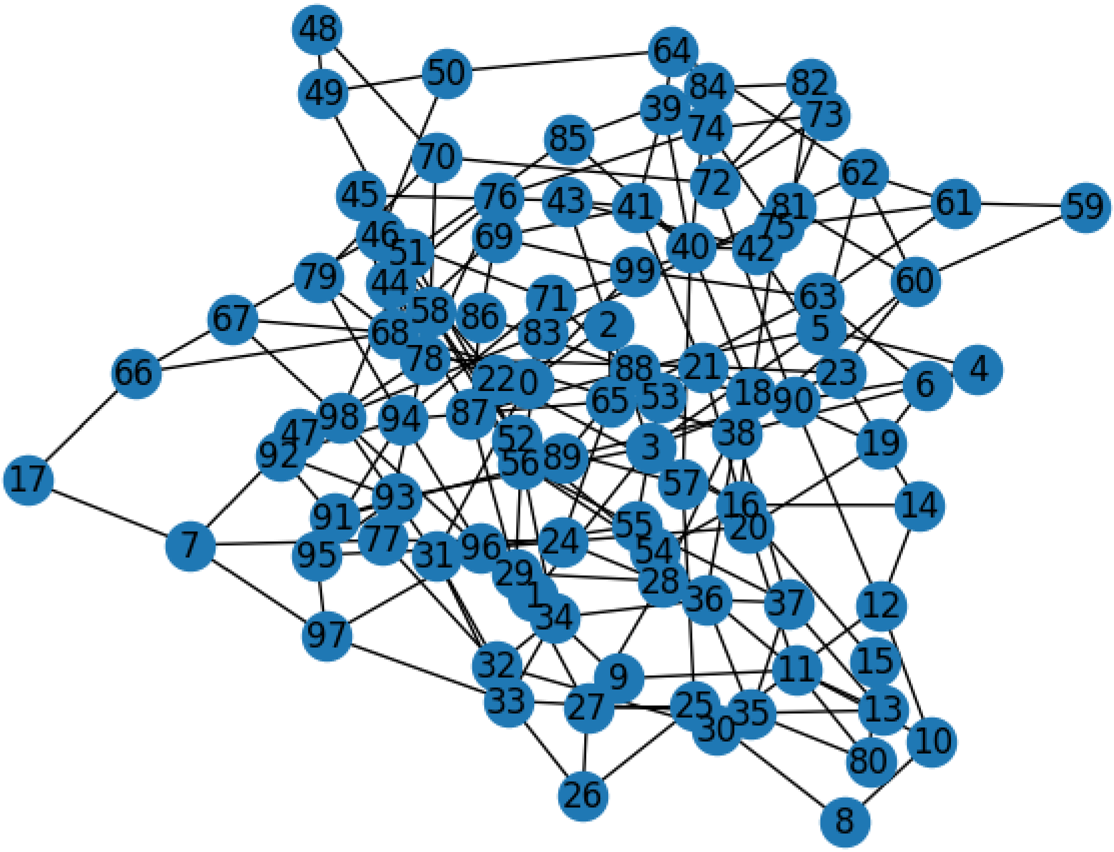
1. Network Graph

The generated network graph for 10 users is displayed below:

graph with 10 users



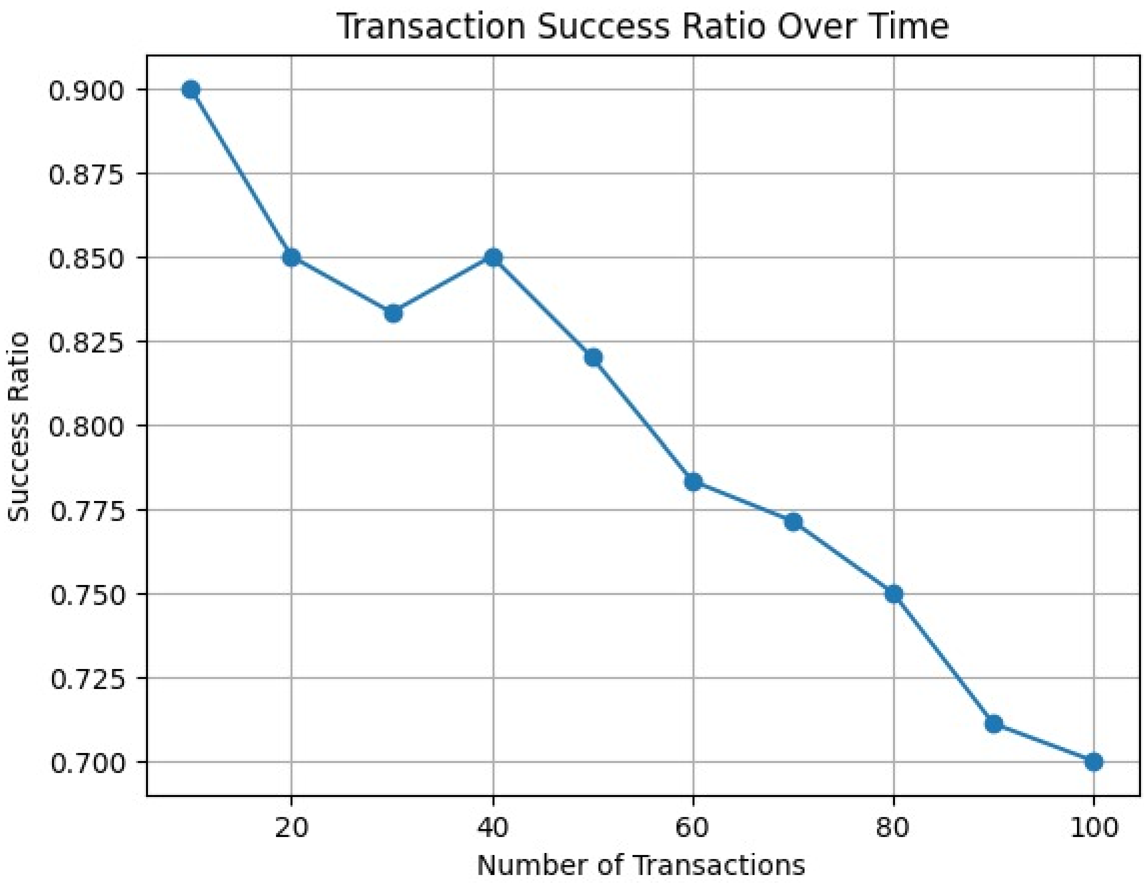
graph with 100 users



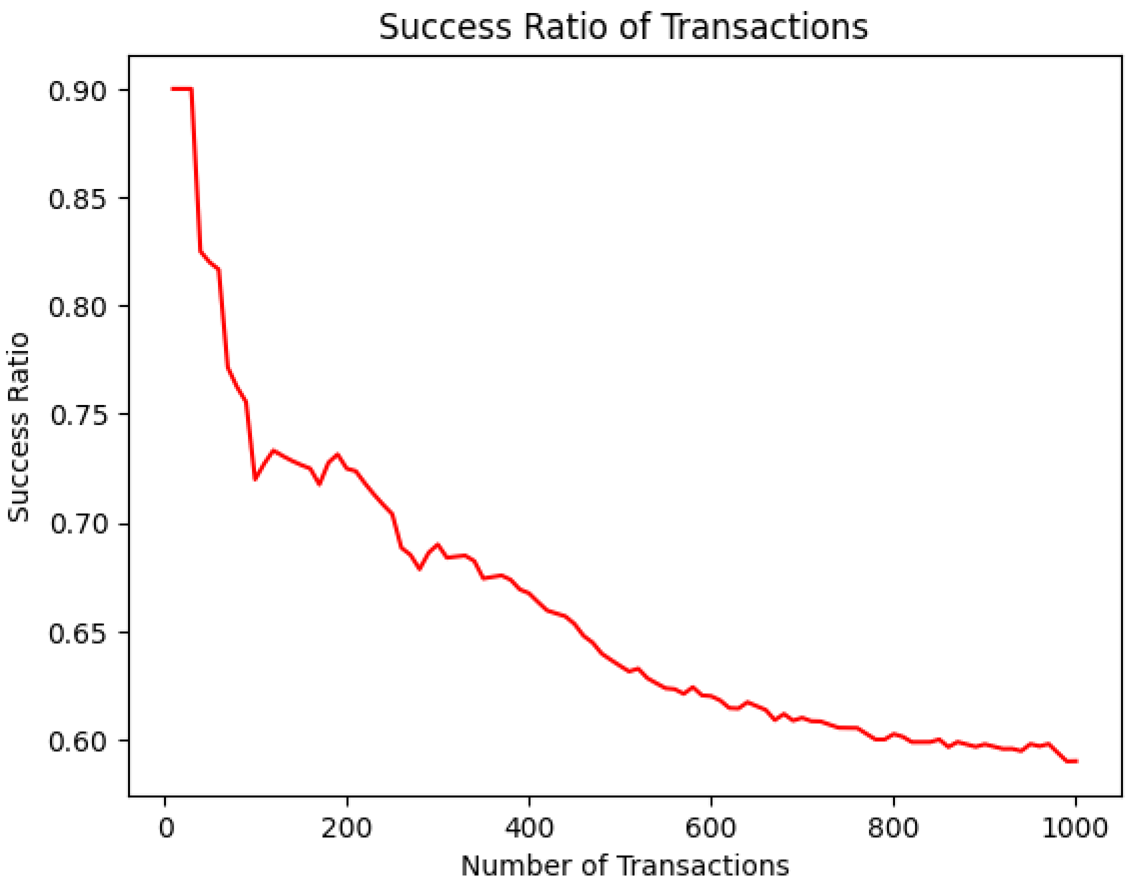
2. Transaction Success Ratio

The success ratio was calculated as the percentage of successful transactions to the total number of attempted transactions. A success is defined as a transaction where sufficient balance exists along the shortest path.

The graph below shows the transaction success ratio over 100 transactions:



The graph below shows the transaction success ratio over 100 transactions:



Discussion

Findings

- The initial success ratio was high (~90%) due to sufficient initial balances and connectivity.
- The success ratio gradually decreased over time as balances along the paths were depleted.
- The drop in success ratio highlights the importance of balance management and network connectivity in sustaining transactions.

Challenges

1. **Gas Costs**: On-chain computation of the shortest path was avoided due to high gas requirements.
2. **Balance Consistency**: Ensuring accurate updates to user contributions along transaction paths was critical.

Optimizations

- **Off-Chain Computation**: Leveraging Python for pathfinding reduced the on-chain computational burden.
- **Balance Initialization**: Ensuring non-zero initial contributions improved the likelihood of successful transactions.

Conclusion

The project successfully demonstrated the functionality of a decentralized joint account system. The implementation highlights the interplay between on-chain and off-chain computations to optimize performance. The results show how network connectivity and balance management impact transaction success.

Future Work

- Scale the network to more users and transactions.
- Implement additional features like dynamic balance adjustments and multi-party transactions.
- Explore alternative pathfinding algorithms to enhance efficiency.

References

1. Ethereum Documentation: ethereum.org
2. NetworkX Library: networkx.org
3. Solidity Documentation: soliditylang.org