BlockChain EXPERIMENT 3

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Aim: Create a Cryptocurrency using Python and perform mining in the Blockchain created.

Theory:

1. Blockchain Overview

A blockchain is a distributed, decentralized digital ledger used to record transactions securely across multiple computers (nodes). Instead of relying on a central authority, every node in the network maintains its own copy of the blockchain.

Each block in the blockchain contains:

- A list of transactions
- A timestamp
- The hash of the previous block
- Its own cryptographic hash

The blocks are linked together using hashes, forming a chain. Any attempt to modify data in a block changes its hash, which breaks the chain and makes tampering easily detectable. This property ensures data integrity, transparency, and immutability.

2. Mining

Mining is the process by which new blocks are added to the blockchain. It involves:

- Collecting pending transactions
- Creating a block header
- Solving a computationally difficult problem known as Proof-of-Work (PoW)

In Proof-of-Work, miners repeatedly change a nonce value to generate a hash that satisfies the network's difficulty requirement (such as leading zeroes). Once a valid hash is found, the block is added to the blockchain and shared with other nodes. As an incentive, miners receive a cryptocurrency reward for their computational effort.

3. Multi-Node Blockchain Network

In this experiment, a multi-node blockchain network is simulated using three nodes running on different ports (5001, 5002, and 5003).

Each node:

- Operates independently
- Maintains its own copy of the blockchain
- Communicates with peer nodes to share newly mined blocks

This setup demonstrates how blockchain achieves decentralization and synchronization without a central server.

4. Consensus Mechanism

To ensure consistency across all nodes, the Longest Chain Rule is used as the consensus mechanism.

When different versions of the blockchain exist, the node accepts the longest valid chain as the correct one. This rule ensures that all nodes eventually agree on a single transaction history, even if temporary differences arise.

5. Transactions and Mining Reward

Transactions in the cryptocurrency system include:

- Sender address
- Receiver address
- Transaction amount

When a block is mined, all pending transactions are added to the block. Additionally, a special transaction is created to reward the miner with newly generated cryptocurrency. This reward mechanism motivates miners to maintain and secure the network.

6. Chain Replacement

The chain replacement process ensures network consistency. When the /replace_chain endpoint is triggered:

- A node requests blockchain data from its peers
- Validates the received chains
- Replaces its own chain if a longer and valid chain is found.

This mechanism helps resolve conflicts and keeps all nodes synchronized.

Code:

```
# Module 2 - Create a Cryptocurrency

# ============================ #
HadCoin Blockchain Node
# ============================
import datetime import hashlib import json from flask import Flask, jsonify, request import requests  from uuid import uuid4 from urllib.parse import urlparse

# ============================
```

```
# Blockchain Class
# ============================
class Blockchain:

    def __init__(self):
self.chain = []
self.transactions = []
self.nodes = set()
self.create_block(proof=1,
previous_hash='0')

    # ----------------------
--     # Create Block
    # ------------------------
def create_block(self,
proof, previous_hash):
block = {
            'index': len(self.chain) + 1,
'timestamp':
str(datetime.datetime.now()),
            'proof': proof,
            'previous_hash': previous_hash,
'transactions': self.transactions.copy()
        }

        # 🔥 IMPORTANT FIX: Clear
transactions after adding to block
self.transactions = []

        self.chain.append(block)
return block

    # ------------------------
# Get Previous Block     # --
----------------------     def
get_previous_block(self):
return self.chain[-1]

    # ----------------------
-    # Proof of Work
    # ------------------------     def
proof_of_work(self, previous_proof):
new_proof = 1         check_proof = False

        while check_proof is False:
hash_operation = hashlib.sha256(
str(new_proof**2 -
previous_proof**2).encode()
            ).hexdigest()

            if hash_operation[:4] == '0000':
check_proof = True             else:
new_proof += 1

        return new_proof

    # ----------------------
--     # Hash Block
    # ------------------------     def hash(self,
block):
encoded_block = json.dumps(block,
sort_keys=True).encode()
        return
hashlib.sha256(encoded_block).hexdigest
()

    # ----------------------
--     # Check Chain
Validity
    # ------------------------     def
is_chain_valid(self, chain):
previous_block = chain[0]
block_index = 1

        while block_index < len(chain):

            block = chain[block_index]

if
block['previous_hash'] !=
self.hash(previous_block):
return False
```

```
        previous_proof =        def replace_chain(self):        previous_block['proof']
        network = self.nodes  proof = block['proof']                    longest_chain =
None              max_length = len(self.chain)             hash_operation =
hashlib.sha256(                  str(proof**2 -                 for node in network:
previous_proof**2).encode()                    response =
        ).hexdigest()                                              requests.get(f'http://{node}/get_chain')

        if hash_operation[:4] != '0000':                                  if response.status_code == 200:
            return False            length = response.json()['length']                chain =
response.json()['chain']
        previous_block = block
block_index += 1                    if length > max_length       and self.is_chain_valid(chain):
return True      max_length = length                        longest_chain = chain
    # ------------------------     # Add
Transaction     # ------------------------     def        if longest_chain:            add_transaction(self,
sender, receiver, self.chain = longest_chain
amount):                                                   return True
        self.transactions.append({
'sender': sender,                                                  return False
        'receiver': receiver,
        'amount': amount                                           # ============================
        })          # Flask App     # ============================
        previous_block =
self.get_previous_block()                app = Flask(__name__)  return
previous_block['index'] + 1
                                                           node_address = str(uuid4()).replace('-', '')
    # ----------------------
-     # Add Node          blockchain = Blockchain()
    # ------------------------     def            add_node(self, address):                # ---
----------------------  parsed_url = urlparse(address)             # Mine Block
self.nodes.add(parsed_url.netloc)       # -------------------------
                                                           @app.route('/mine_block',
    # ----------------------                               methods=['GET']) def mine_block():
-     # Replace Chain
    # ------------------------                                 previous_block =
                                                           blockchain.get_previous_block()
                previous_proof =                           blockchain.proof_of_work(previous_pro
        previous_block['proof']    proof =                 o f)     previous_hash =
                                                           blockchain.hash(previous_block)
```

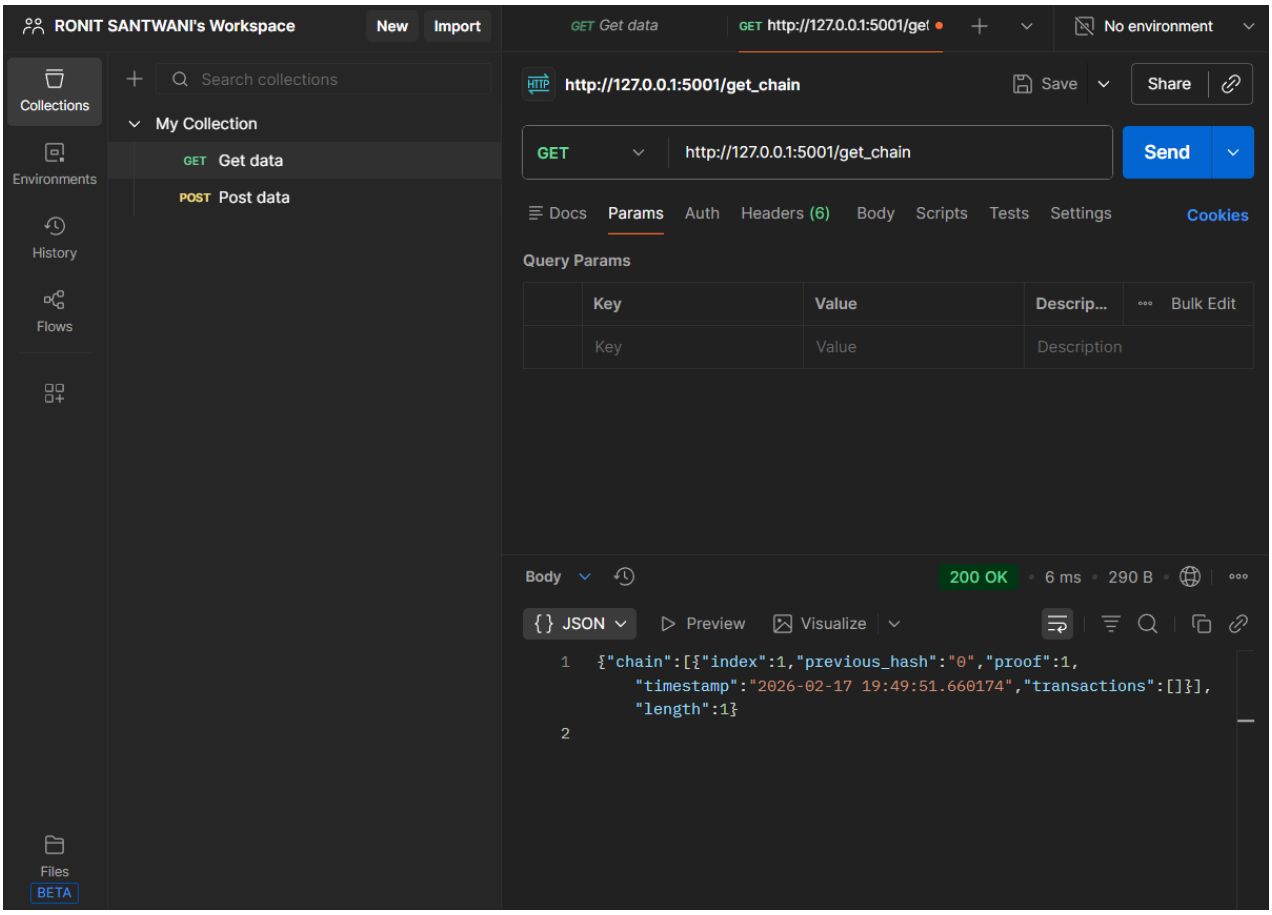
```
    # Reward transaction
blockchain.add_transaction(
sender=node_address,
receiver='Soham',
amount=1
    )

    block =
blockchain.create_block(proof,
previous_hash)

    response = {
'message': 'Block mined
successfully!',
        'block': block
    }

    return jsonify(response), 200

# ------------------------
-- # Get Chain
# --------------------------
@app.route('/get_chain',
methods=['GET']) def get_chain():
response = {         'chain':
blockchain.chain,
        'length': len(blockchain.chain)
    }
    return jsonify(response), 200

# ------------------------
-- # Check Validity
# --------------------------
@app.route('/is_valid', methods=['GET'])
def is_valid():     is_valid =
blockchain.is_chain_valid(blockchain.ch
a
in)

    if is_valid:
        response = {'message': 'Blockchain
                                is
valid.'}     else:
        response = {'message': 'Blockchain
is NOT valid.'}

    return jsonify(response), 200

# ------------------------
-- # Add Transaction
# --------------------------
@app.route('/add_transacti
on', methods=['POST']) def
add_transaction():
    json_data = request.get_json()
required_fields = ['sender', 'receiver',
'amount']

    if not all(field in json_data for field in
required_fields):
        return 'Missing values', 400

    index = blockchain.add_transaction(
json_data['sender'],
json_data['receiver'],
json_data['amount']
    )

    response = {
        'message': f'Transaction will be
added to Block {index}'
    }

    return jsonify(response), 201

# --------------------------
# Connect Nodes
# --------------------------
@app.route('/connect_no de',
methods=['POST']) def connect_node():
    json_data = request.get_json()
    nodes = json_data.get('nodes')
```

```
    if nodes is None:
return "No node", 400

    for node in nodes:
        blockchain.add_node(node)

    response = {
        'message': 'All nodes connected
successfully!',
        'total_nodes': list(blockchain.nodes)
    }

    return jsonify(response), 201

# -------------------------- #
Replace Chain
# --------------------------
@app.route('/replace_chain',
methods=['GET']) def
replace_chain(): is_replaced
= blockchain.replace_chain()

    if is_replaced:
response = {
            'message': 'Chain was replaced.',
            'new_chain': blockchain.chain
        }
else:
        response = {
'message': 'Current chain is
longest.',
            'actual_chain': blockchain.chain
        }

    return jsonify(response), 200

#
============================
# Run App
# ============================
if __name__ == '__main__':
app.run(host='0.0.0.0', port=5001)
```

Output:

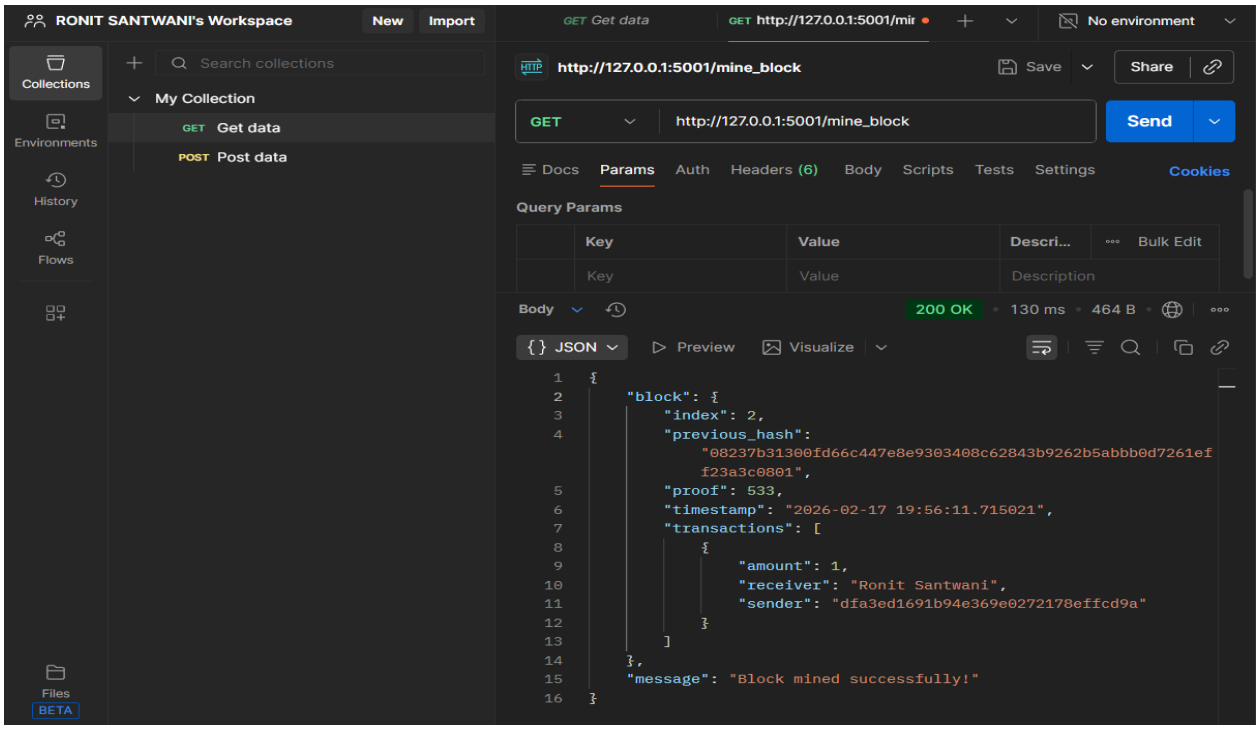
1)/get_chain

This GET request retrieves the complete blockchain from the node, showing all mined blocks and stored transactions.



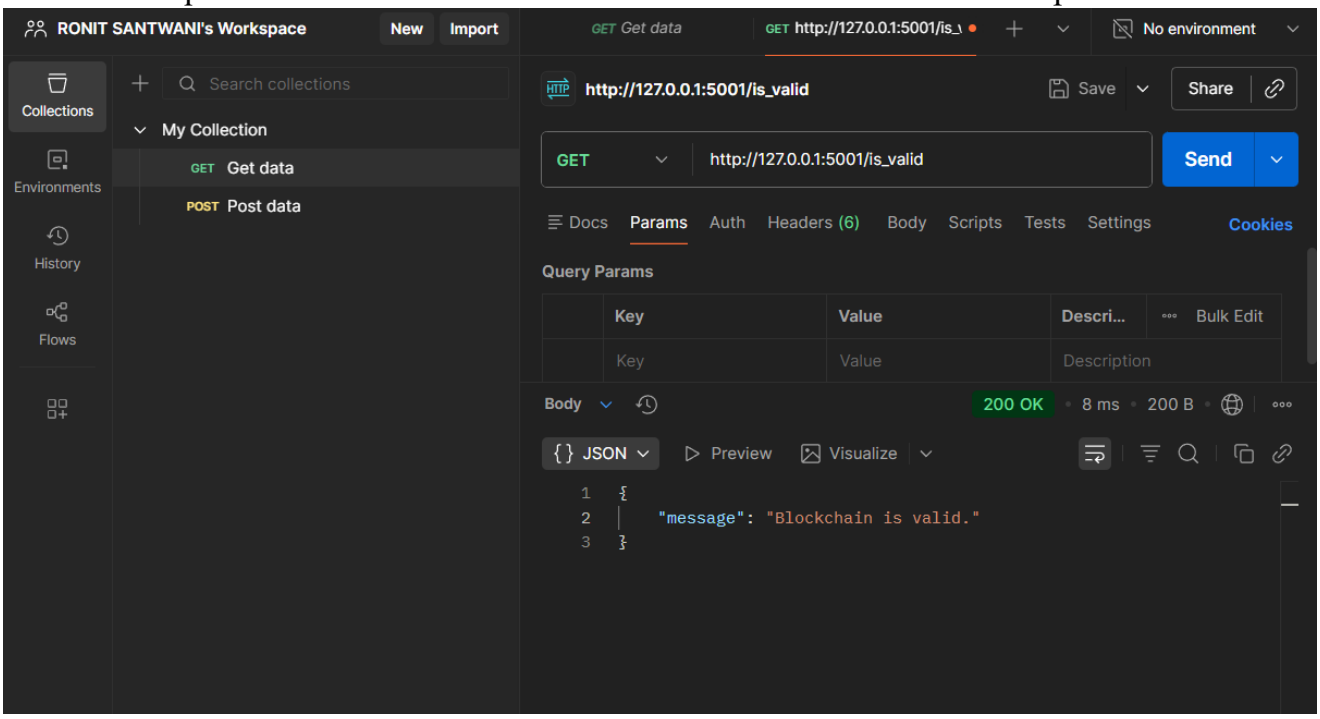
2)/mine_block

This GET request performs the mining process using Proof-of-Work and adds a new block to the blockchain.



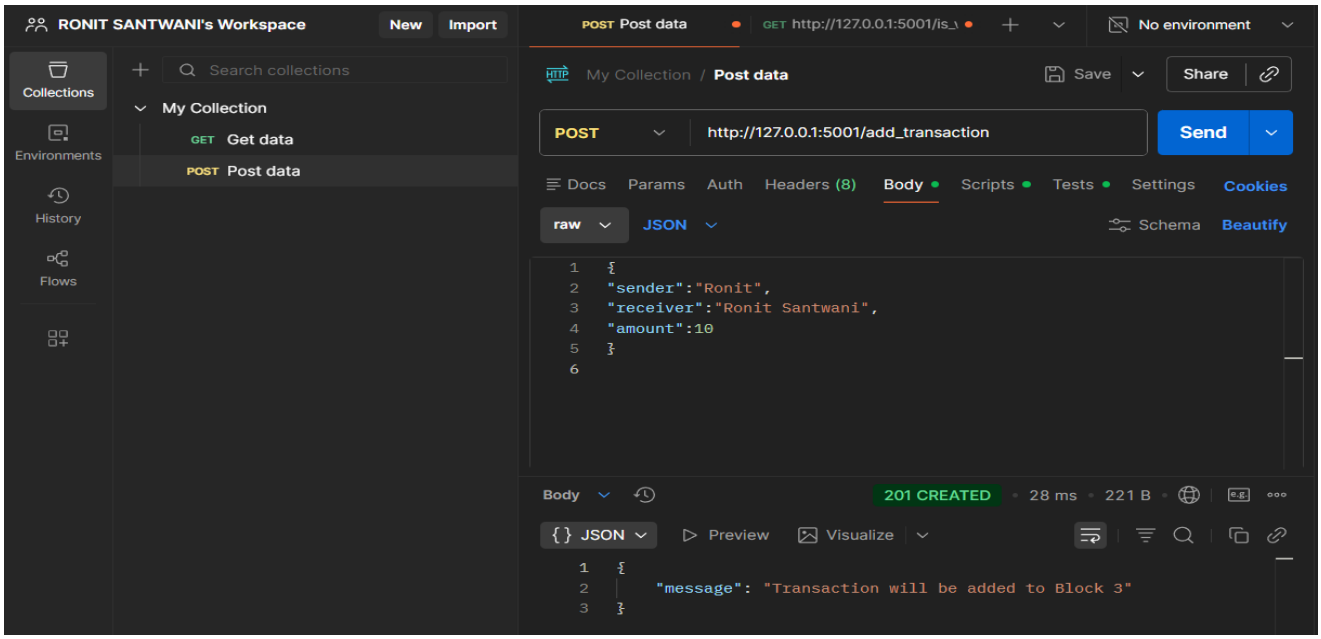
3)/is_valid

This GET request checks whether the current blockchain is valid and untampered.



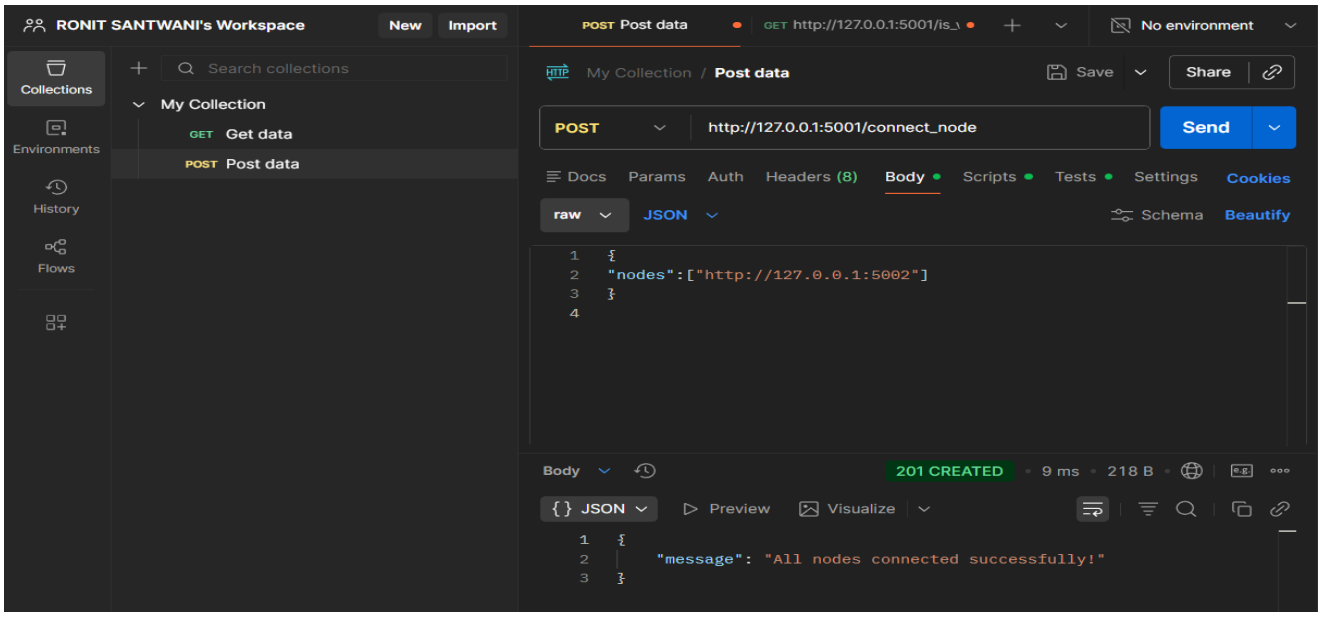
4)/add_transaction

This POST request submits a new transaction (sender, receiver, amount) to be added to the next mined block.



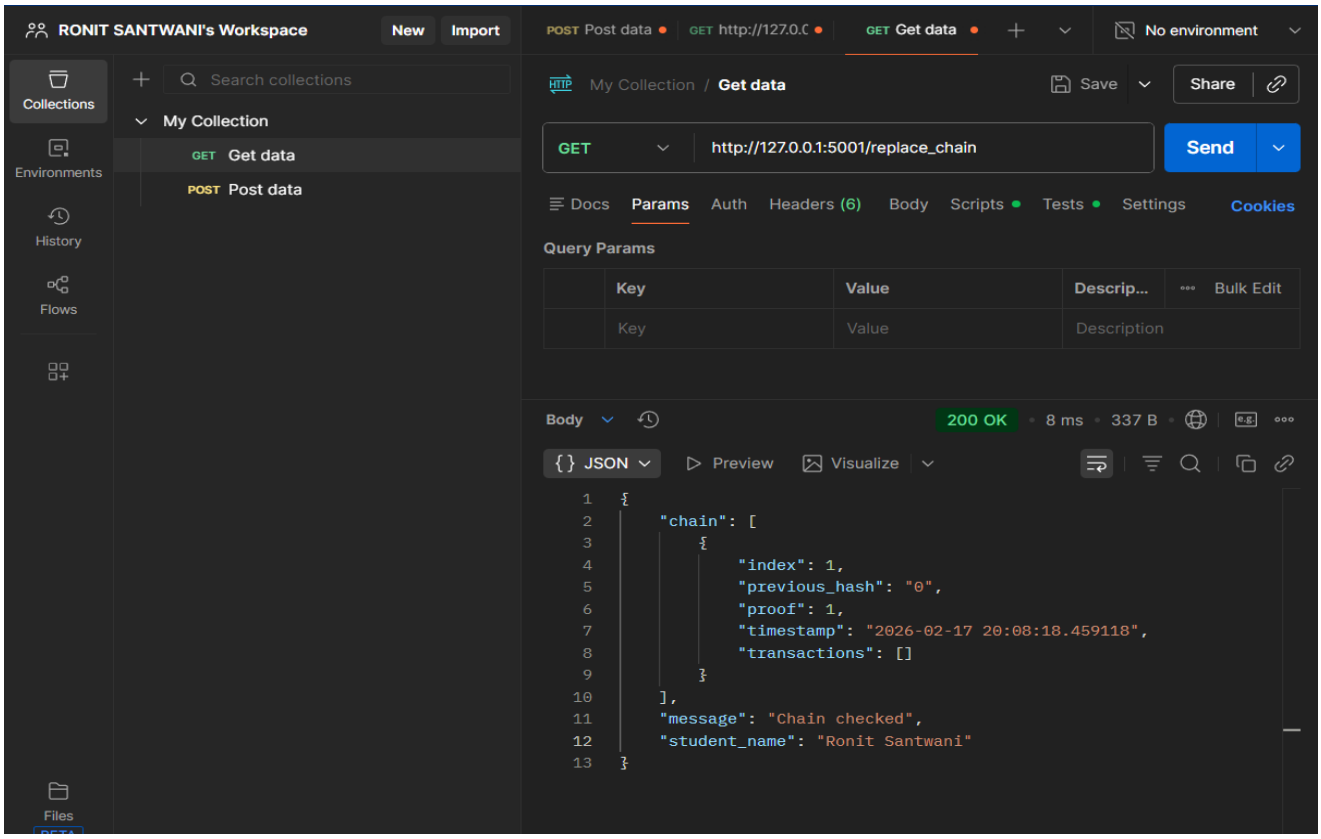
5)/connect_node

This POST request connects the current node with other peer nodes in the blockchain network.



6)/replace_chain

This GET request checks all connected peer nodes and replaces the current blockchain with the longest valid chain, ensuring network-wide consistency.



Conclusion:

In this experiment, a basic cryptocurrency system was designed and implemented using Python by applying fundamental blockchain principles such as block generation, cryptographic hashing, Proof-of-Work mining, transaction processing, and decentralized networking. A Flask-based framework was used to enable communication between multiple nodes, with each node maintaining its own copy of the blockchain ledger.

The mining process required solving the Proof-of-Work challenge, after which new blocks were added to the chain and miners received rewards. The system also supported transaction validation and inclusion of verified transactions into newly mined blocks. Through this implementation, the experiment offered hands-on insight into the functioning of blockchain technology, demonstrating how consensus, decentralization, and mining together enable the secure operation of cryptocurrencies in distributed environments.