



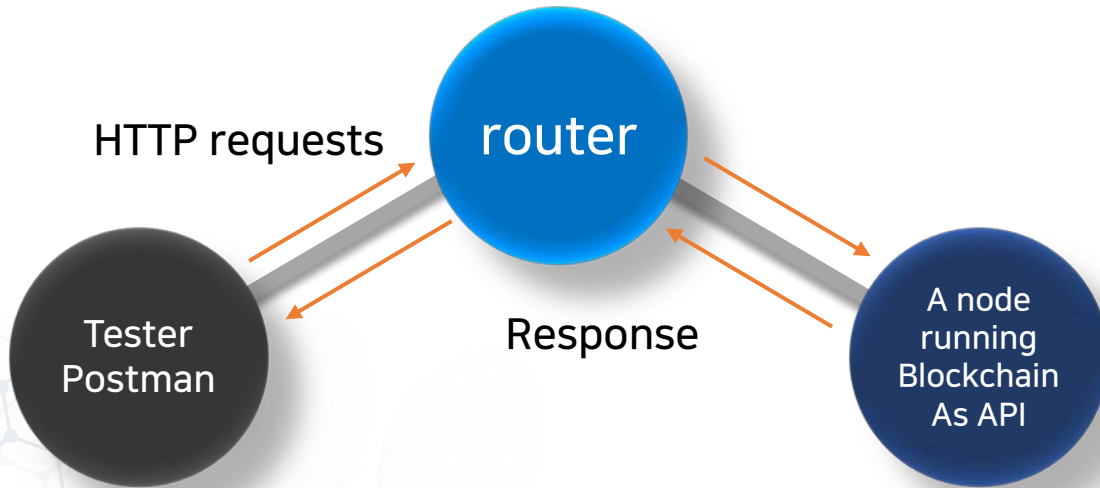
Goal of this lecture note

- Running and Testing Blockchain API
- Blockchain Internet
- Six Node Blockchain Network

1 Running and Testing Blockchain API

- Aim to test the core.
- Run the core at a single node.
- Step-by-step testing each routine
 - Register its neighbors.
 - Generate new transactions
 - Mine new blocks (mint coins)
 - Blocks are chained using PoWs.
 - Difficulty level of PoW is changed with leading number zeros.

1 Running and Testing Blockchain API



1 Running and Testing Blockchain API

- Have API running core at 127.0.0.21:2000

Append this code inside blockchain.py

```
if __name__ == '__main__':  
    from argparse import ArgumentParser  
  
    parser = ArgumentParser()  
    parser.add_argument('-p', '--port', default=5000, type=int, help='port to listen on')  
    args = parser.parse_args()  
    port = args.port  
  
    app.run(host='127.0.0.1', port=2000)
```

At the console

```
In [3]: runfile('C:/Users/Heung-No Lee/  
Desktop/Bitcoin/MooC 강의/블록체인 Python/  
blockchain_homework_python/  
blockchain_core.py', wdir='C:/Users/Heung-No  
Lee/Desktop/Bitcoin/MooC 강의/블록체인 Python/  
blockchain_homework_python')  
* Serving Flask app "blockchain_core" (lazy  
loading)  
* Environment: production  
  WARNING: Do not use the development server  
in a production environment.  
  Use a production WSGI server instead.  
* Debug mode: off  
* Running on http://127.0.0.1:2000/ (Press  
CTRL+C to quit)
```

Now, we can use Postman to interact with this API!

1 Running and Testing Blockchain API

- Post a transaction

```
@app.route('/transactions/new', methods=['POST'])
def new_transaction():
    values = request.get_json()

    # Check that the required fields are in the POST'ed data
    required = ['sender', 'recipient', 'amount']
    if not all(k in values for k in required):
        return 'Missing values', 400

    # Create a new Transaction
    index = blockchain.new_transaction(values['sender'], values['recipient'], values['amount'])

    response = {'message': f'Transaction will be added to Block {index}'}
    return jsonify(response), 201
```

1 Running and Testing Blockchain API

- Post a transaction
 - Use Postman
 - Put the following JSON script into the Body
 - Select "raw" in the window
 - Select JSON(application/json) from the pull down menu

1 Running and Testing Blockchain API

- Post a transaction

```
{  
  "sender": "d4ee26eee15148ee92c6cd394edd974e",  
  "recipient": "HNLee",  
  "amount": 5  
}
```

- If successful, you will see this message:

```
{  
  "message": "Transaction will be added to Block 2"  
}
```

1 Running and Testing Blockchain API

The screenshot shows the Postman interface with a workspace named "My Workspace". A POST request is configured to the endpoint `127.0.0.1:2000/transactions/new`. The request body is a JSON object:

```
1 {
2   "sender": "d4ee26eee15148ee92c6cd394edd974e",
3   "recipient": "HWLew",
4   "amount": 5
5 }
```

The response status is `201 CREATED` with a time of `19 ms` and a size of `202 B`. The response body is:

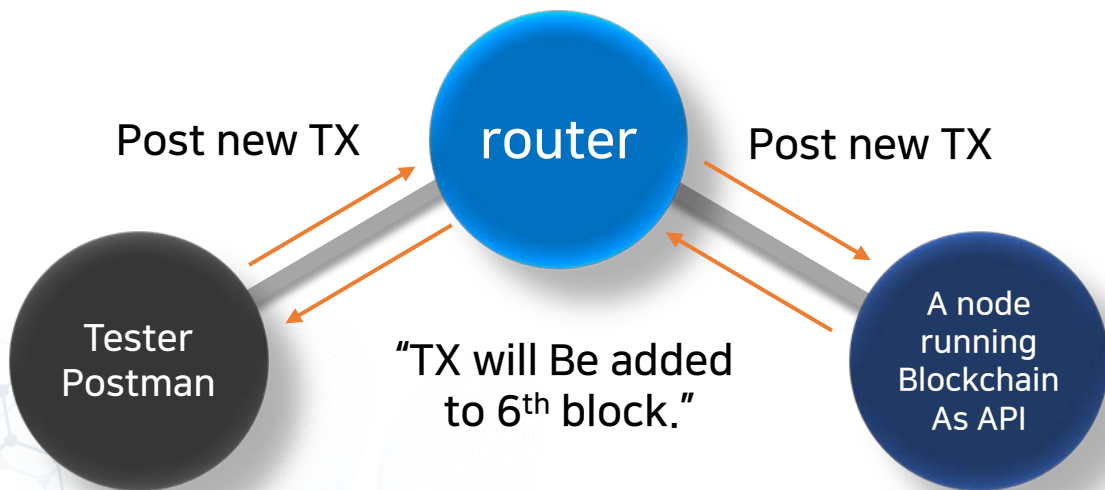
```
1 {
2   "message": "Transaction will be added to Block 6"
3 }
```

The interface also shows a history of previous requests, including several GET requests to `127.0.0.1:2000/mine`.

1 Running and Testing Blockchain API

```
In [3]: runfile('C:/Users/Heung-No Lee/
Desktop/Bitcoin/MooC 강의/블록체인 Python/
blockchain_homework_python/
blockchain_core.py', wdir='C:/Users/Heung-No
Lee/Desktop/Bitcoin/MooC 강의/블록체인 Python/
blockchain_homework_python')
* Serving Flask app "blockchain_core" (lazy
loading)
* Environment: production
  WARNING: Do not use the development server
in a production environment.
  Use a production WSGI server instead.
* Debug mode: off
* Running on http://127.0.0.1:2000/ (Press
CTRL+C to quit)
127.0.0.1 - - [17/Oct/2019 22:10:50] "POST /
transactions/new HTTP/1.1" 201 -
```

1 Running and Testing Blockchain API



1 Running and Testing Blockchain API

- Mine a block

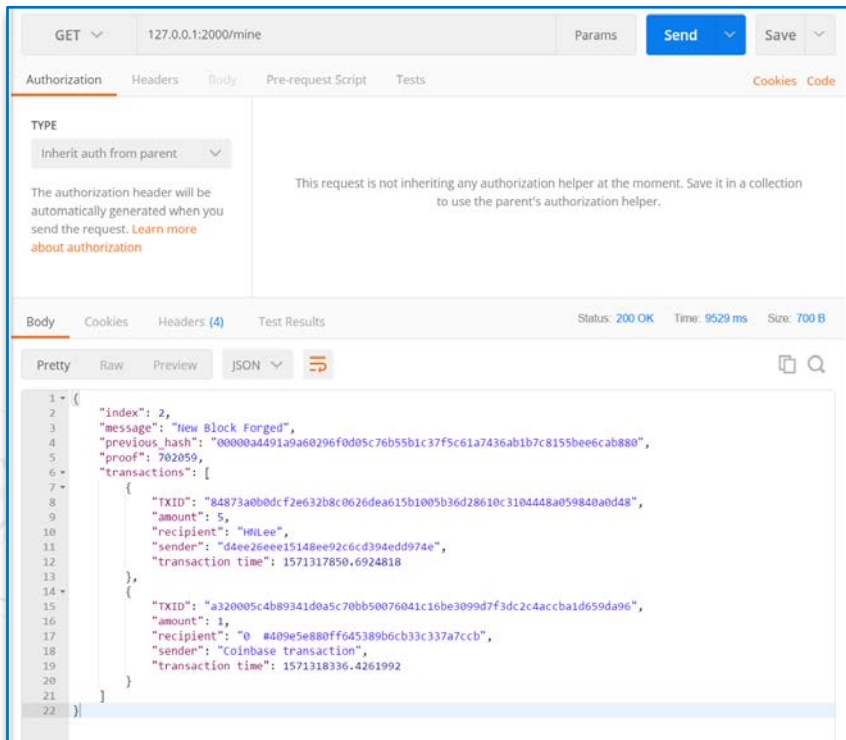
```
@app.route('/mine', methods=['GET'])
def mine():
    # We run the proof of work algorithm to get the next proof...
    last_block = blockchain.last_block
    proof = blockchain.proof_of_work(last_block)

    # We must receive a reward for finding the proof.
    # The sender is "0" to signify that this node has mined a new coin.
    blockchain.new_transaction(
        sender="0",
        recipient=node_id_identifier,
        amount=1,
    )

    # Forge the new Block by adding it to the chain
    previous_hash = blockchain.hash(last_block)
    block = blockchain.new_block(proof, previous_hash)

    response = {
        'message': "New Block Forged",
        'index': block['index'],
        'transactions': block['transactions'],
        'proof': block['proof'],
        'previous_hash': block['previous_hash'],
    }
    return jsonify(response), 200
```

1 Running and Testing Blockchain API



GET 127.0.0.1:2000/mine Params Send Save

Authorization Headers Body Pre-request Script Tests Cookies Code

TYPE

Inherit auth from parent

This request is not inheriting any authorization helper at the moment. Save it in a collection to use the parent's authorization helper.

The authorization header will be automatically generated when you send the request. [Learn more about authorization](#)

Body Cookies Headers (4) Test Results Status: 200 OK Time: 9529 ms Size: 700 B

Pretty Raw Preview JSON

```
1 - {
2
3   "index": 2,
4   "message": "New Block Forged",
5   "previous_hash": "00000a4491a9a0296f0d05c76b55b1c37f5c61a7436ab1b7c8155bee6cab880",
6   "proof": 702059,
7   "transactions": [
8     {
9       "TXID": "84873a0bd8cf2e632b8c0626dea615b1005b36d28610c3104448a059840a0d48",
10      "amount": 5,
11      "recipient": "HWLee",
12      "sender": "d4ee26eee15148ee92c6cd394edd974e",
13      "transaction time": 1571317850.6924818
14    },
15    {
16      "TXID": "a320005c4b89341d0a5c70bb50076041c16be3099d7f3dc2c4accba1d659da9e",
17      "amount": 1,
18      "recipient": "0 #409e5e880ff645389b6cb33c337a7ccb",
19      "sender": "coinbase transaction",
20      "transaction time": 1571318336.4261992
21    }
22  ]
}
```

1 Running and Testing Blockchain API

- Chain the blocks

```
@app.route('/chain', methods=['GET'])
def full_chain():
    response = {
        'chain': blockchain.chain,
        'length': len(blockchain.chain),
    }
    return jsonify(response), 200
```


1 Running and Testing Blockchain API

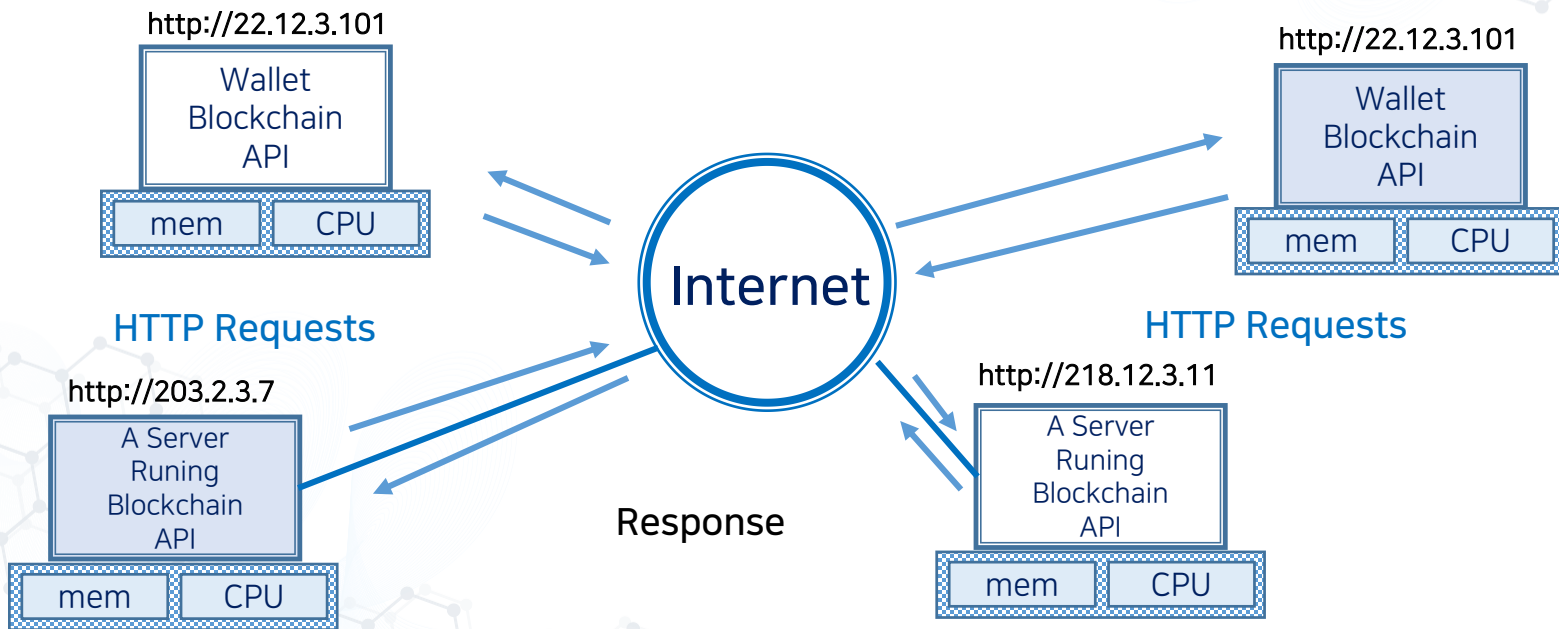
- We can test out others as well
 - Get transactions
 - Get chain updates
 - Register a node
 - Make consensus
 - Shut down
- Step-by-step guidance at <https://infonet.gist.ac.kr/>

2 Blockchain Internet

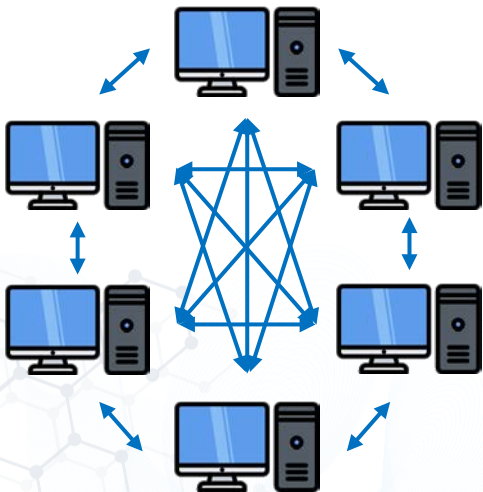
- Any node which downloads the core can serve as a P2P node.
- Collection of these nodes form a blockchain internet.
 - Wallet holders
 - Miners
 - Full nodes

2 Blockchain Internet

- Blockchain Internet



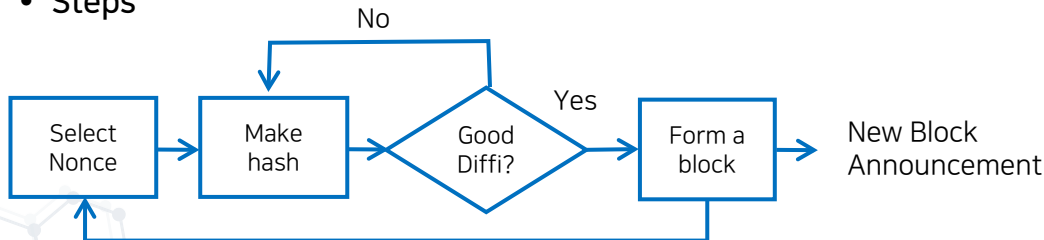
3 Six Node Blockchain Network



• Simple Chain Structure

Index	8	Index	9	Index	10
Nonce	66808	Nonce	254479	Nonce	157752
Body	Transactions : {'Sender' : '0', 'Recipient' : '8911...', 'Amount' : 50} Num_zeros : 5	Transactions : {'Sender' : '0', 'Recipient' : '6a06...', 'Amount' : 50, 'Sender' : '89a4...', 'Recipient' : '27b6...', 'Amount' : 50, 'Sender' : '...'} Num_zeros : 5	Transactions : {'Sender' : '0', 'Recipient' : '6e30...', 'Amount' : 50} Num_zeros : 5		
Previous hash	0000c567d49cfd12272e...	0000f562087e3a5c75776...	0000dabc94224d86c5076...		
Current hash	0000f562087e3a5c75776...	0000dabc94224d86c5076...	0000g922087e3a5c24376...		

• Steps



3 Six Node Blockchain Network

- Aim is to show how blockchain works.
- Simplicity is the key
 - BH: index (block height), nonce, prev_hash, num_zeros
 - BB: TXs
- Change difficulty by leading number of zeros.
- Networking and longest chain consensus
 - Each node asks for the longest chain upon starting.
 - Listens TXs and get them to its new block.
 - Listens new chain announcements.
 - Compares and adopts the longest valid chain.

3 Six Node Blockchain Network

- The **five miner nodes** running `miner.py` are
 - Node 1 (IP: 172.26.16.41) is a mining node.
 - Node 2 (IP: 172.26.16.66) is a mining node.
 - Node 3 (IP: 172.26.16.43) is a mining node.
 - Node 4 (IP: 172.26.16.42) is a mining node.
 - Node 5 (IP: 172.26.16.32) is a mining node.
- The **trader node** running `trader.py` is
 - Node 6 (IP: 203.237.54.101) which is the transaction generating node
- The port number is 5000 for all nodes.

3 Six Node Blockchain Network

- We ran the experimental set up and captured it into a video file.
- The captured video is the feed ran at the console of Node 1.
 - Open up an Anaconda console at Node 1
 - Move to the directory in which the blockchain core file is located.
 - Run blockchain with the command:

```
>python blockchain.py
```
- Make sure the core is running at the console.
- Node 1 is now a blockchain server in this small network.
- Other nodes shall be started off as well with the same procedure.
- This is not shown in this console since this console is at Node 1.

3 Six Node Blockchain Network

```
(E:\Anaconda3) C:\Users\양기원>cd C:\Users\양기원\Desktop\Bitcoin\Building Blockchain by Python\blockchain-master\blockchain-master
```

```
(E:\Anaconda3) C:\Users\양기원\Desktop\Bitcoin\Building Blockchain by Python\blockchain-master\blockchain-master>python info_blockchain1.py
```

```
* Running on http://172.26.16.41:5000/ (Press CTRL+C to quit)  
172.26.16.41 - - [13/Sep/2018 19:47:20] "POST /nodes/register HTTP/1.1" 201 -  
172.26.16.41 - - [13/Sep/2018 19:48:30] "GET /mine HTTP/1.1" 200 -
```

Infonet blockchain
Num_zeros : 5

3 Six Node Blockchain Network

- First, other nodes get registered as neighbors of Node 1.
- Node 1 (IP: 172.26.16.41) starts mining!
 - As soon as it has started mining, it first aims to gather all the chains from its neighbors.

3 Six Node Blockchain Network

```
(E:\Anaconda3) C:\Users\양기원>cd C:\Users\양기원\Desktop\Bitcoin\Building Blockchain by Python\blockchain-master\blockchain-master
```

```
(E:\Anaconda3) C:\Users\양기원\Desktop\Bitcoin\Building Blockchain by Python\blockchain-master\blockchain-master>python info_blockchain1.py
```

```
* Running on http://172.26.16.41:5000/ (Press CTRL+C to quit)  
172.26.16.41 - - [13/Sep/2018 19:47:20] "POST /nodes/register HTTP/1.1" 201 -  
172.26.16.41 - - [13/Sep/2018 19:48:30] "GET /mine HTTP/1.1" 200 -
```

Infonet blockchain

Num_zeros : 5

Mining is begun.

3 Six Node Blockchain Network

- Node 1 requests to get chains from its neighbors,
 - that of Node 4 (IP: 172.26.16.42),
 - that of Node 3 (IP: 172.26.16.43), and
 - that of Node 5 (IP: 172.26.16.32).

3 Six Node Blockchain Network

```
(E:\Anaconda3) C:\Users\양기원>cd C:\Users\양기원\Desktop\Bitcoin\Building Blockchain by Python\blockchain-master\blockchain-master
```

```
(E:\Anaconda3) C:\Users\양기원\Desktop\Bitcoin\Building Blockchain by Python\blockchain-master\blockchain-master>python info_blockchain1.py
```

```
* Running on http://172.26.16.41:5000/ (Press CTRL+C to quit)
172.26.16.41 -- [13/Sep/2018 19:47:20] "POST /nodes/register HTTP/1.1" 201 -
172.26.16.41 -- [13/Sep/2018 19:48:30] "GET /mine HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:48:43] "GET /chain HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:48:43] "GET /chain HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:48:46] "GET /chain HTTP/1.1" 200 -
.
```

Infonet blockchain
Num_zeros : 5

3 Six Node Blockchain Network

- Node 1 announces its mining success to neighbors.
 - Other nodes stop mining their current block, accept this chain and start mining again aiming to grow this adopted chain.

3 Six Node Blockchain Network

```
(E:\Anaconda3) C:\Users\양기원>cd C:\Users\양기원\Desktop\Bitcoin\Building Blockchain by Python\blockchain-master\blockchain-master
(E:\Anaconda3) C:\Users\양기원\Desktop\Bitcoin\Building Blockchain by Python\blockchain-master>python info_blockchain.py
* Running on http://172.26.16.41:5000/ (Press CTRL+C to quit)
172.26.16.41 -- [13/Sep/2018 19:47:20] "POST /nodes/register HTTP/1.1" 201 -
172.26.16.41 -- [13/Sep/2018 19:48:30] "GET /mine HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:48:43] "GET /chain HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:48:43] "GET /chain HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:48:46] "GET /chain HTTP/1.1" 200 -

MINING SUCCESS !

-----
Index      : 2
Transactions : ('Sender': '0', 'Recipient': '6e306fa658234aeab126212a0234b9bd', 'Amount': 50)
Proof      : 2240456
Num_zeros  : 5
Previous_hash : e42316439fff27b47ba5bb91683abfc02ba8397a8a5e4fb286f03df3e4b339b7
Present_hash : 0000037f941469b69cfeb62fa67a1d3f8523af671784c2641c458f20aa511a08
-----

Message is transferred

172.26.16.43 -- [13/Sep/2018 19:48:54] "GET /chain HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:48:54] "GET /chain HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:48:54] "GET /chain HTTP/1.1" 200 -
```

InfoNet blockchain
Num_zeros : 5

3 Six Node Blockchain Network

- Node 4 announces the third block mining success.
 - Adopting it by other nodes follows.
- Again, Node 4 mines the 4th block.
- The 5th block is mined by Node 3.
- Node 6 generates a transaction.
- It is included in the 6th block which is mined by Node 2.

3 Six Node Blockchain Network

```
172.26.16.43 -- [13/Sep/2018 19:48:54] "GET /chain HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:48:54] "GET /chain HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:48:54] "GET /chain HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:48:57] "GET /chain HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:48:58] "GET /chain HTTP/1.1" 200 -
```

Node4 has mined!

```
172.26.16.42 -- [13/Sep/2018 19:48:58] "GET /message HTTP/1.1" 200 -
```

```
-----
Index      : 3
Transactions : ('Sender': '0', 'Recipient': '8911a636c7904d92abcb87ef428743bc', 'Amount': 50)
Proof      : 317538
Num_zeros  : 5
Previous_hash : 00000d7f941469b93cfeb62fa67a1d3f6523af671784c2641c458f20aa511a08
Present_hash : 000002acb0e8b935849cc8ae7844e65e2f0119f2f350c5aff5287f6efc2ef7dc
-----
```

```
172.26.16.42 -- [13/Sep/2018 19:48:58] "GET /get_block HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:48:58] "GET /chain HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:48:58] "GET /chain HTTP/1.1" 200 -
```

Node4 has mined!

```
172.26.16.42 -- [13/Sep/2018 19:48:58] "GET /message HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:48:59] "GET /chain HTTP/1.1" 200 -
```

```
-----
Index      : 4
Transactions : ('Sender': '0', 'Recipient': '8911a636c7904d92abcb87ef428743bc', 'Amount': 50)
Proof      : 39250
Num_zeros  : 5
Previous_hash : 000002acb0e8b935849cc8ae7844e65e2f0119f2f350c5aff5287f6efc2ef7dc
Present_hash : 000004dfeb5dc6c60ade4aa947abeb9a8fac899ce1b8f7837b1f0e9062244488
-----
```

```
172.26.16.42 -- [13/Sep/2018 19:48:59] "GET /get_block HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:49:00] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:49:01] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:49:01] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:49:01] "GET /chain HTTP/1.1" 200 -
```

Node3 has mined!

```
172.26.16.43 -- [13/Sep/2018 19:49:01] "GET /message HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:49:01] "GET /chain HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:49:02] "GET /chain HTTP/1.1" 200 -
```

Infonet blockchain
Num_zeros : 5

3 Six Node Blockchain Network

- Node 6 generates a transaction.
 - It is included in the 6th block which is mined by Node 2.
- In each block, the first TX is the coinbase TX, and mining reward of 50 coins is paid to miner's address.

3 Six Node Blockchain Network

```
Previous_hash : 000002acb0e8935849cc8ae7844e65e2f0119f2f350c5aff5287f6efc2ef7dc
Present_hash  : 000004dfeb5dc6c80ade4aa947abeb9a8fac899ce1b8f7837b1f0e9062244488
```

```
172.26.16.42 -- [13/Sep/2018 19:48:59] "GET /get_block HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:49:00] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:49:01] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:49:01] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:49:01] "GET /chain HTTP/1.1" 200 -
```

Node3 has mined!

```
172.26.16.43 -- [13/Sep/2018 19:49:01] "GET /message HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:49:01] "GET /chain HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:49:02] "GET /chain HTTP/1.1" 200 -
```

```
Index      : 5
Transactions : ('Sender': '0', 'Recipient': '3e4d91d9ca6a43a82b3d846a8caba5bf', 'Amount': 50)
Proof      : 258150
Num_zeros  : 5
Previous_hash : 000004dfeb5dc6c80ade4aa947abeb9a8fac899ce1b8f7837b1f0e9062244488
Present_hash  : 000007f905c10024beea27e804dfb7c96049ca100440c9b73a90c3a2ba7e41b
```

```
172.26.16.43 -- [13/Sep/2018 19:49:02] "GET /get_block HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:49:02] "GET /chain HTTP/1.1" 200 -
209.237.54.101 -- [13/Sep/2018 19:49:02] "POST /transactions/get HTTP/1.1" 201 -
```

Node2 has mined!

```
172.26.16.166 -- [13/Sep/2018 19:49:05] "GET /message HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:49:05] "GET /chain HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:49:06] "GET /chain HTTP/1.1" 200 -
```

```
Index      : 6
Transactions : ('Sender': '0', 'Recipient': '0219783336594a3894a6c0b7d8e54eef', 'Amount': 50)
              ('Sender': '89a4cbb9032a62d93cfc2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d3771e', 'Amount': 10)
Proof      : 306053
Num_zeros  : 5
Previous_hash : 000007f905c10024beea27e804dfb7c96049ca100440c9b73a90c3a2ba7e41b
Present_hash  : 000001d6c556590a4baae37379b4cfa40aa470d9fd18e18b8d372ae4731bd5
```

```
172.26.16.166 -- [13/Sep/2018 19:49:06] "GET /get_block HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:49:06] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:49:06] "GET /chain HTTP/1.1" 200 -
```

Infonet blockchain
Num_zeros : 5

A new transaction is created and sent to miners.

The created transaction is saved into the sixth block.

3 Six Node Blockchain Network

- This continues...
- 7th Block mined by Node 4.
- 8th Block mined by Node 4.
- 9th Block mined by Node 5.

- 16th block has two transactions.

3 Six Node Blockchain Network

```
Previous_hash : 00000f8476e73cfbcb090897b142d21574c06ef78c2f02fcedc10e8986310119
Present_hash  : 0000041eb81d5b7b4fa1d115a0ddd9f14081ede36e642081fb25693d6426cd57ee
```

```
172.26.16.43 -- [13/Sep/2018 19:49:39] "GET /get_block HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:49:39] "GET /chain HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:49:39] "GET /chain HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:49:39] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:49:40] "GET /chain HTTP/1.1" 200 -
```

Node4 has mined!

```
172.26.16.42 -- [13/Sep/2018 19:49:40] "GET /message HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:49:40] "GET /chain HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:49:40] "GET /chain HTTP/1.1" 200 -
```

```
Index : 15
Transactions :
  ('Sender': '0', 'Recipient': '8911a596c7904d92abcb87ef428743bc', 'Amount': 50)
Proof : 160906
Num_zeros : 5
Previous_hash : 0000041eb81d5b7b4fa1d115a0ddd9f14081ede36e642091fb25693d6426cd57ee
Present_hash  : 0000059eb6412bb892f92996f6ad9d7a9b455b24a794b0b5a69adca1d9ce0ba2
```

```
172.26.16.42 -- [13/Sep/2018 19:49:41] "GET /get_block HTTP/1.1" 200 -
208.237.54.101 -- [13/Sep/2018 19:49:41] "POST /transactions/get HTTP/1.1" 201 -
172.26.16.42 -- [13/Sep/2018 19:49:41] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:49:43] "GET /chain HTTP/1.1" 200 -
```

Node3 has mined!

```
172.26.16.43 -- [13/Sep/2018 19:49:43] "GET /message HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:49:43] "GET /chain HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:49:43] "GET /chain HTTP/1.1" 200 -
```

```
Index : 16
Transactions :
  ('Sender': '0', 'Recipient': '3e4d91d9caba434a828d9446a8caba5bf', 'Amount': 50)
  ('Sender': '89a4bcb69032a62d93cef2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d3771e', 'Amount': 18)
Proof : 264378
Num_zeros : 5
Previous_hash : 0000059eb6412bb892f92996f6ad9d7a9b455b24a794b0b5a69adca1d9ce0ba2
Present_hash  : 000009c4f609032a75a27b8f4d297449c7a8c10adbc196b277a9d75ade4cc7fa
```

```
172.26.16.43 -- [13/Sep/2018 19:49:44] "GET /get_block HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:49:44] "GET /chain HTTP/1.1" 200 -
```

Infonet blockchain
Num_zeros : 5

3 Six Node Blockchain Network

- This continues...until 30th block.
- From 31st block, difficulty is changed to Num_zeros = 6.

3 Six Node Blockchain Network

- It takes avg. 4.7 sec to mine a block at **5 leading zeros**.
 - This is hexadecimal zeros.
 - Thus, one more zero means 16 x longer.
- The expected time to mine a block is
 - $16 \times 4.7 = 75$ sec per block.
 - It will now take more than a minute.

3 Six Node Blockchain Network

```
Proof : ('Sender': '0', 'Recipient': '3e4d31d9caba434a8c8d046a0caba5bf', 'Amount': 50)
        ('Sender': '89a4cbb9032a62d39cef2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d9771e', 'Amount': 23)
Num_zeros : 153240
Index : 5
Previous_hash : 00000d57a85ae8c3948943d093cca21a8cf0de2966f95c731a8048b504e5e640
Present_hash : 00000ffa2924453f60408a10973baa99670fc77ba738e914e84208ddb44b73b7
```

```
172.26.16.43 -- [13/Sep/2018 19:50:16] "GET /get_block HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:50:16] "GET /chain HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:50:16] "GET /chain HTTP/1.1" 200 -
```

Node5 has mined!

```
172.26.16.32 -- [13/Sep/2018 19:50:16] "GET /message HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:50:16] "GET /chain HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:50:16] "GET /chain HTTP/1.1" 200 -
```

```
Index : 28
Transactions : ('Sender': '0', 'Recipient': '6a06496cd61242ecae8051b649464361', 'Amount': 50)
Proof : 10126
Num_zeros : 5
Previous_hash : 00000ffa2924453f60408a10973baa99670fc77ba738e914e84208ddb44b73b7
Present_hash : 000003fe8af957e9fd0390a5369ee234c0b35ce17a8f895b9a6d9dbd1bc59d0
```

```
172.26.16.32 -- [13/Sep/2018 19:50:16] "GET /get_block HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:50:17] "GET /chain HTTP/1.1" 200 -
```

Node2 has mined!

```
172.26.16.166 -- [13/Sep/2018 19:50:20] "GET /message HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:50:20] "GET /chain HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:50:20] "GET /chain HTTP/1.1" 200 -
```

```
Index : 29
Transactions : ('Sender': '0', 'Recipient': '0219783336594a3894a6c0b7d8e54eef', 'Amount': 50)
Proof : 390320
Num_zeros : 5
Previous_hash : 000003fe8af957e9fd0390a5369ee234c0b35ce17a8f895b9a6d9dbd1bc59d0
Present_hash : 00000f6677b9e118e68e1c1c44790df1a7b0a2935f36df55a8584f31c2f057b1
```

```
172.26.16.166 -- [13/Sep/2018 19:50:21] "GET /get_block HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:50:21] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:50:21] "GET /chain HTTP/1.1" 200 -
```

Infonet blockchain
Num_zeros : 5

3 Six Node Blockchain Network

- The difficulty level was posted by node 101 and changed to 6 leading zeros.
 - Notice this at time 02:13.
 - Note that the 31st block, mined by Node, has 6 leading zeros.

3 Six Node Blockchain Network

```
Proof      : 390320
Num_zeros  : 5
Previous_hash : 000003fe8af957e9fa0390a5369ee234c0b35ce17a8f895b9a5a6dbbd1bd59d0
Present_hash : 00000f6677b9e118e68e1c1c44790df1a7b0a2935f36df55a6584f31c2f057b1
```

```
172.26.16.166 -- [13/Sep/2018 19:50:21] "GET /get_block HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:50:21] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:50:21] "GET /chain HTTP/1.1" 200 -
```

Node2 has mined!

```
172.26.16.166 -- [13/Sep/2018 19:50:23] "GET /message HTTP/1.1" 200 -
203.237.54.101 -- [13/Sep/2018 19:50:23] "POST /difficulty/get HTTP/1.1" 201 -
172.26.16.32 -- [13/Sep/2018 19:50:23] "GET /chain HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:50:23] "GET /chain HTTP/1.1" 200 -
```

```
Index      : 30
Transactions : {'Sender': '0', 'Recipient': '021978336594a3894a6c0b7dbe54eef', 'Amount': 50}
Proof      : 158121
Num_zeros  : 5
Previous_hash : 00000f6677b9e118e68e1c1c44790df1a7b0a2935f36df55a6584f31c2f057b1
Present_hash : 000003df6c17049076a4c2d71e59813a4b24e830105ebacfc794d2c0f89fad2
```

```
172.26.16.166 -- [13/Sep/2018 19:50:23] "GET /get_block HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:50:23] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:50:24] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:50:27] "GET /chain HTTP/1.1" 200 -
```

Node4 has mined!

```
172.26.16.42 -- [13/Sep/2018 19:50:27] "GET /message HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:50:27] "GET /chain HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:50:27] "GET /chain HTTP/1.1" 200 -
```

```
Index      : 31
Transactions : {'Sender': '0', 'Recipient': '8911a636c7904d92abcb87ef428743bc', 'Amount': 50}
Proof      : 347355
Num_zeros  : 6
Previous_hash : 000003df6c17049076a4c2d71e59813a4b24e830105ebacfc794d2c0f89fad2
Present_hash : 00000044b494187aef8aaf6d10650b508fc8f4229881c8a29d434b75d0c77d3
```

```
172.26.16.42 -- [13/Sep/2018 19:50:27] "GET /get_block HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:50:28] "GET /chain HTTP/1.1" 200 -
```

Infonet blockchain

Num_zeros : 6

Num_zeros is changed to 6.

3 Six Node Blockchain Network

- The 31st block was a luck and mined quick.
- But it takes avg. more than a min. now.
 - Since it takes longer to mine a block, many TXs are posted, but not included.

3 Six Node Blockchain Network

```
172.26.16.166 -- [13/Sep/2018 19:50:23] "GET /message HTTP/1.1" 200 -
203.237.54.101 -- [13/Sep/2018 19:50:23] "POST /difficulty/get HTTP/1.1" 201 -
172.26.16.32 -- [13/Sep/2018 19:50:23] "GET /chain HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:50:23] "GET /chain HTTP/1.1" 200 -
```

```
Index      : 30
Transactions : ('Sender': '0', 'Recipient': '0219783336594a3894a6c0b7dbe54eef', 'Amount': 50)
Proof      : 158121
Num_zeros  : 5
Previous_hash : 00000f6677b9e118e68e1c1c4479df1a7b0a2935f36df55a8584f31c2f057b1
Present_hash : 0000033df6c17049076a4c2d71e59813a4b24e630105ebacfc794d2c0f89fad2
```

```
172.26.16.166 -- [13/Sep/2018 19:50:23] "GET /get_block HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:50:23] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:50:24] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:50:27] "GET /chain HTTP/1.1" 200 -
```

Node4 has mined!

```
172.26.16.42 -- [13/Sep/2018 19:50:27] "GET /message HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:50:27] "GET /chain HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:50:27] "GET /chain HTTP/1.1" 200 -
```

```
Index      : 31
Transactions : ('Sender': '0', 'Recipient': '6911a636c7904a92abcb87ef428743bc', 'Amount': 50)
Proof      : 347355
Num_zeros  : 6
Previous_hash : 0000033df6c17049076a4c2d71e59813a4b24e630105ebacfc794d2c0f89fad2
Present_hash : 000000446494187aaaf6d106506508fcbf4229681cbad9d434b75dcd77d9
```

```
172.26.16.42 -- [13/Sep/2018 19:50:27] "GET /get_block HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:50:28] "GET /chain HTTP/1.1" 200 -
203.237.54.101 -- [13/Sep/2018 19:50:30] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:50:34] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:50:43] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:50:48] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:50:52] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:50:57] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:51:01] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:51:04] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:51:08] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:51:13] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:51:18] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:51:23] "POST /transactions/get HTTP/1.1" 201 -
```

Infonet blockchain

Num_zeros : 6

3 Six Node Blockchain Network

- On 03:28, node101 posts a difficulty change message and changes it to 4 leading zeros.
- The 32nd block contains all the awaiting transactions.

3 Six Node Blockchain Network

```
203.237.54.101 -- [13/Sep/2018 19:50:34] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:50:43] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:50:49] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:50:52] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:50:57] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:51:01] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:51:04] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:51:08] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:51:13] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:51:18] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:51:23] "POST /transactions/get HTTP/1.1" 201 -
203.237.54.101 -- [13/Sep/2018 19:51:40] "POST /difficultys/get HTTP/1.1" 201 -
172.26.16.166 -- [13/Sep/2018 19:51:40] "GET /chain HTTP/1.1" 200 -
```

Node4 has mined!

```
172.26.16.42 -- [13/Sep/2018 19:51:41] "GET /message HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:51:41] "GET /chain HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:51:41] "GET /chain HTTP/1.1" 200 -
```

```
Index      : 32
Transactions:
  { 'Sender': '0', 'Recipient': '8911a6367904d92abcb87ef428743bc', 'Amount': 50 }
  { 'Sender': '89a4cbb9032a62d33cef2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d3771e', 'Amount': 10 }
  { 'Sender': '89a4cbb9032a62d33cef2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d3771e', 'Amount': 7 }
  { 'Sender': '89a4cbb9032a62d33cef2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d3771e', 'Amount': 21 }
  { 'Sender': '89a4cbb9032a62d33cef2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d3771e', 'Amount': 16 }
  { 'Sender': '89a4cbb9032a62d33cef2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d3771e', 'Amount': 8 }
  { 'Sender': '89a4cbb9032a62d33cef2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d3771e', 'Amount': 9 }
  { 'Sender': '89a4cbb9032a62d33cef2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d3771e', 'Amount': 17 }
  { 'Sender': '89a4cbb9032a62d33cef2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d3771e', 'Amount': 1 }
  { 'Sender': '89a4cbb9032a62d33cef2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d3771e', 'Amount': 10 }
  { 'Sender': '89a4cbb9032a62d33cef2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d3771e', 'Amount': 7 }
  { 'Sender': '89a4cbb9032a62d33cef2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d3771e', 'Amount': 6 }
  { 'Sender': '89a4cbb9032a62d33cef2c392ab122', 'Recipient': '27b63aa197bc10efff46871af2d3771e', 'Amount': 21 }
Proof      : 4110924
```

```
Num_zeros : 4
Previous_hash : 00000446494197aeaf8aef6d10650c6508f9cf4229691c8a9d494b753cc77d9
Present_hash  : 00001ed3b4fe2a2374109683e506528c85dfe798b68292a5078f1e271a20f
```

```
172.26.16.42 -- [13/Sep/2018 19:51:42] "GET /get_block HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:51:42] "GET /chain HTTP/1.1" 200 -
```

Node3 has mined!

```
172.26.16.43 -- [13/Sep/2018 19:51:42] "GET /message HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:51:42] "GET /chain HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:51:42] "GET /chain HTTP/1.1" 200 -
```

Infonet blockchain
Num_zeros : 4

Num_zeros is changed to 4.

All of the unsaved transactions are updated in the thirty-second block.

3 Six Node Blockchain Network

- After that, blocks are mined very quick.
 - About 100 blocks mined for 1 minute, we see.

3 Six Node Blockchain Network

```
Proof : 8000
Num_zeros : 4
Previous_hash : 000001f96a941d66255c3677921732aabfd6973005c456a98e0447df9442f7a6
Present_hash : 000009e54cd5c22555e6386d92c6f49bf6e1680dbe505901ba2215c2a86193c
```

```
172.26.16.43 -- [13/Sep/2018 19:52:37] "GET /get_block HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:52:37] "GET /chain HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:52:37] "GET /chain HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:52:37] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:52:37] "GET /chain HTTP/1.1" 200 -
```

Node4 has mined!

```
172.26.16.42 -- [13/Sep/2018 19:52:37] "GET /message HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:52:37] "GET /chain HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:52:37] "GET /chain HTTP/1.1" 200 -
```

Node2 has mined!

```
172.26.16.166 -- [13/Sep/2018 19:52:37] "GET /message HTTP/1.1" 200 -
```

```
-----
Index : 126
Transactions :
  ('Sender': '0', 'Recipient': '8911a636c7904d92abcb87ef428743bc', 'Amount': 50)
Proof : 21352
Num_zeros : 4
Previous_hash : 0000dde39886a94a45265e7b0651b15e879cde004437fc8b61a45df70a57df6f2
Present_hash : 0000634c8e5b7cb9f5ba134b82bd79f5cbc82e8071f6996223592068814edd
```

```
172.26.16.42 -- [13/Sep/2018 19:52:37] "GET /get_block HTTP/1.1" 200 -
172.26.16.32 -- [13/Sep/2018 19:52:38] "GET /chain HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:52:38] "GET /chain HTTP/1.1" 200 -
```

```
-----
Index : 127
Transactions :
  ('Sender': '0', 'Recipient': '0219783336594a3894a5cb7d8e54eef', 'Amount': 50)
Proof : 1465
Num_zeros : 4
Previous_hash : 0000634c8e5b7cb9f5ba134b82bd79f5cbc82e8071f6996223592068814edd
Present_hash : 0000e02bf091cee3251d2b79a40d8ef911e46541dff177e09f4c24901010cb2
```

```
172.26.16.166 -- [13/Sep/2018 19:52:38] "GET /get_block HTTP/1.1" 200 -
172.26.16.43 -- [13/Sep/2018 19:52:38] "GET /chain HTTP/1.1" 200 -
172.26.16.166 -- [13/Sep/2018 19:52:38] "GET /chain HTTP/1.1" 200 -
172.26.16.42 -- [13/Sep/2018 19:52:38] "GET /chain HTTP/1.1" 200 -
```

Infonet blockchain
Num_zeros : 4

3 Six Node Blockchain Network

- On the time of 04:36, right after 130th block was mined, **the difficulty level is changed back to 5 leading hex zeros.**
 - Note the difficulty change Post by Node 101.
- This continues till the end.

3 Six Node Blockchain Network

- Lessons

- Python and Flask can be used to program P2P blockchain suite.
- P2P computers exchange messages, blocks, and commands.
- They grow the blockchain ledger.
- Block generation speed can be set fast or slow by changing difficulty.