Configuration Manual

MSc Research Project
Cybersecurity

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MSc Project Submission Sheet

School of Computing

Student Name:	Mariusz Graczyk
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Programme:	MSCCYBETOP Year: 2024
Module:	Research Project
Supervisor:	Mr. Ross Spelman
Submission Due Date:	12 August 2024
Project Title:	Enhancing SDN Access Control with Private Ethereum Blockchain
Word Count:	510 Page Count 8

I hereby certify that the information contained in this (my submission) is information pertaining to research I conducted for this project. All information other than my own contribution will be fully referenced and listed in the relevant bibliography section at the rear of the project.
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Signature: Mariusz Graczyk

Date: 16 September 2024

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Configuration Manual

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1 Main Dependencies Used

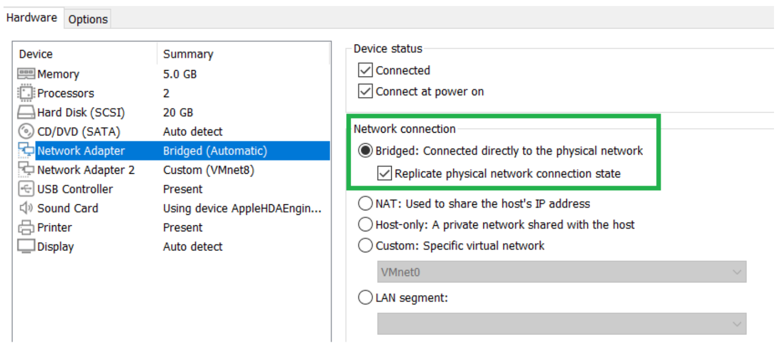
a. VMware Workstation 16 Pro
b. Ryu package version 4.34
c. Ubuntu release 18.04
d. Python3 version 3.7.5
e. Python version 2.7.17 – for deploying Mininet scripts
f. Mininet version 2.2.2
g. Remix IDE v. 0.52.0
h. Geth and Puppeth version: 1.9.24-stable
i. Go Version: 1.15.5
j. Chrome or Firefox with Metamask extension plugin
k. Raspberry Pi 4 with installed Open vSwitch v.2.17.1
l. USB to Ethernet adapter for the Raspberry Pi devices
m. Visual Studio Code 1.92.1

2 Other Dependencies Used

a. VirtualBox v. 6.1
b. Kali Linux release 2024.2
c. Ganache v. 2.7.1
d. Notepad++ v8.4.8 (with Compare plugin)
e. Matplotlib library for Python

3 Deployment of Ubuntu VM

a. Install Ubuntu in VMware. The network adapter should be in bridged mode



Device	Summary
Memory	5.0 GB
Processors	2
Hard Disk (SCSI)	20 GB
CD/DVD (SATA)	Auto detect
Network Adapter	Bridged (Automatic)
Network Adapter 2	Custom (VMnet8)
USB Controller	Present
Sound Card	Using device AppleHDAEngin...
Printer	Present
Display	Auto detect

Device status
✓ Connected
✓ Connect at power on

Network connection
● Bridged: Connected directly to the physical network
✓ Replicate physical network connection state
○ NAT: Used to share the host's IP address
○ Host-only: A private network shared with the host
○ Custom: Specific virtual network
VMnet0
○ LAN segment:

Figure 1: Virtual network adapter in Bridged mode

4 Deployment of Ryu and Mininet

b. Install Ryu package and Mininet emulator in the Ubuntu VM:

```
sudo pip3 install ryu
sudo apt install mininet
```

c. Install Open vSwitch on Raspberry Pi 4[1]

d. Run Ryu Manager with a simple L3 switch [1]:

```
ryu-manager ryu.app.simple_switch_13
```

The script for `simple_switch_13` was borrowed from C²S Consulting[2]

e. Launch Mininet hosts to confirm connectivity to the controller [1]:

```
sudo mn --controller remote,ip=127.0.0.1  --switch
ovsk,protocols=OpenFlow13 --mac --ipbase=10.0.0.0/24 --topo single,4
```

f. Launch the final target Mininet topology from the Python script:

```
sudo python ~/mininet/custom/Nat_Mininet_topology.py
```

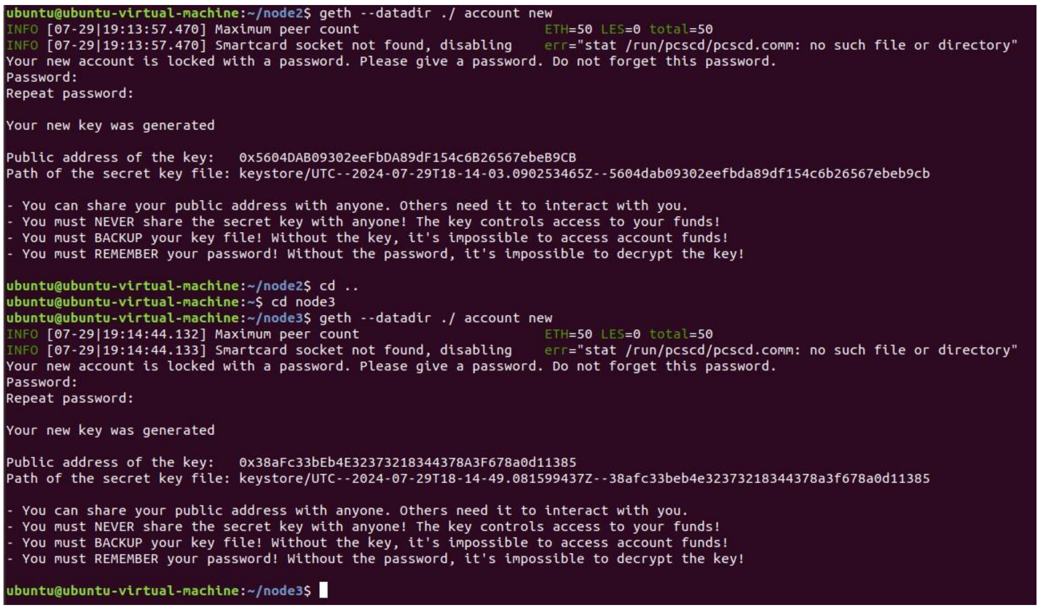
The script `Nat_Mininet_topology.py` was adapted from [3] and [4].

g. Ryu-Manager command that launches the controller alongside the *SDNEther* app, with the required certificates for TLS encryption.

```
ryu-manager --observe-links ~/ryu/flowmanager/flowmanager.py
ryu.app.L3_simple_switch_13 sdnether.py --ctl-privkey
/var/lib/openvswitch/pki/controllerca/ctl-privkey.pem --ctl-cert
/var/lib/openvswitch/pki/controllerca/ctl-cert.pem --ca-certs
/var/lib/openvswitch/pki/switchca/cacert.pem
```

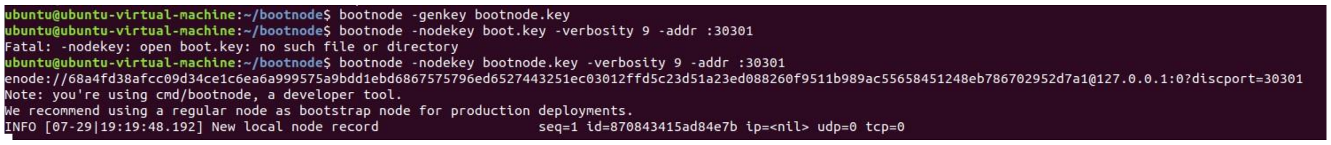
[1] https://shantoroy.com/openflow/how-to-configure-raspberry-pi-as-open-flow-switch/
[2] https://www.obriain.com/training/sdn/RYU_example_scripts_v2.0.1.tgz

5 Deployment of PoA Ethereum Network



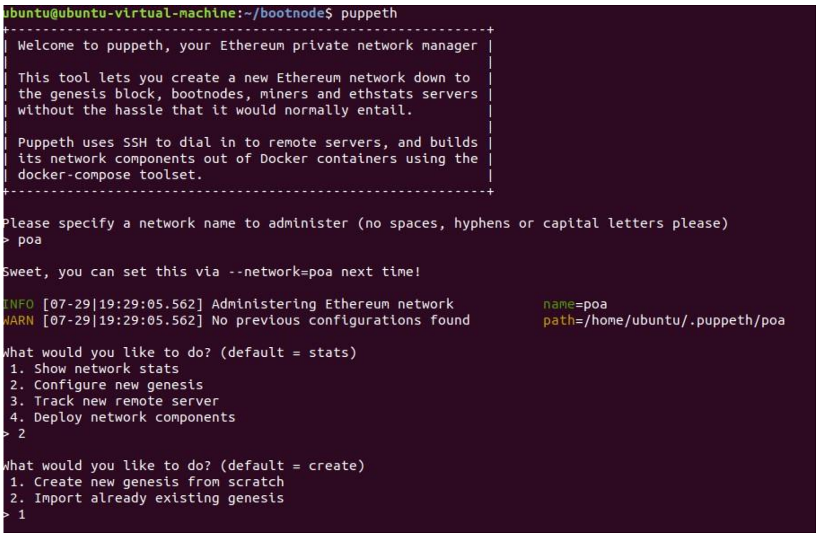
```
ubuntu@ubuntu-virtual-machine:~/node2$ geth --datadir ./ account new
INFO [07-29|19:13:57.470] Maximum peer count                       ETH=50 LES=0 total=50
INFO [07-29|19:13:57.470] Smartcard socket not found, disabling    err="stat /run/pcscd/pcscd.comm: no such file or directory"
Your new account is locked with a password. Please give a password. Do not forget this password.
Password:
Repeat password:

Your new key was generated

Public address of the key:   0x5604DAB09302eeFbDA89dF154c6B26567ebeB9CB
Path of the secret key file: keystore/UTC--2024-07-29T18-14-03.090253465Z--5604dab09302eefbda89df154c6b26567ebeb9cb

- You can share your public address with anyone. Others need it to interact with you.
- You must NEVER share the secret key with anyone! The key controls access to your funds!
- You must BACKUP your key file! Without the key, it's impossible to access account funds!
- You must REMEMBER your password! Without the password, it's impossible to decrypt the key!

ubuntu@ubuntu-virtual-machine:~/node2$ cd ..
ubuntu@ubuntu-virtual-machine:~$ cd node3
ubuntu@ubuntu-virtual-machine:~/node3$ geth --datadir ./ account new
INFO [07-29|19:14:44.132] Maximum peer count                       ETH=50 LES=0 total=50
INFO [07-29|19:14:44.133] Smartcard socket not found, disabling    err="stat /run/pcscd/pcscd.comm: no such file or directory"
Your new account is locked with a password. Please give a password. Do not forget this password.
Password:
Repeat password:

Your new key was generated

Public address of the key:   0x38aFc33bEb4E32373218344378A3F678a0d11385
Path of the secret key file: keystore/UTC--2024-07-29T18-14-49.081599437Z--38afc33beb4e32373218344378a3f678a0d11385

- You can share your public address with anyone. Others need it to interact with you.
- You must NEVER share the secret key with anyone! The key controls access to your funds!
- You must BACKUP your key file! Without the key, it's impossible to access account funds!
- You must REMEMBER your password! Without the password, it's impossible to decrypt the key!

ubuntu@ubuntu-virtual-machine:~/node3$ █
```

Figure 2: Initial activation of a new account for each of the three nodes



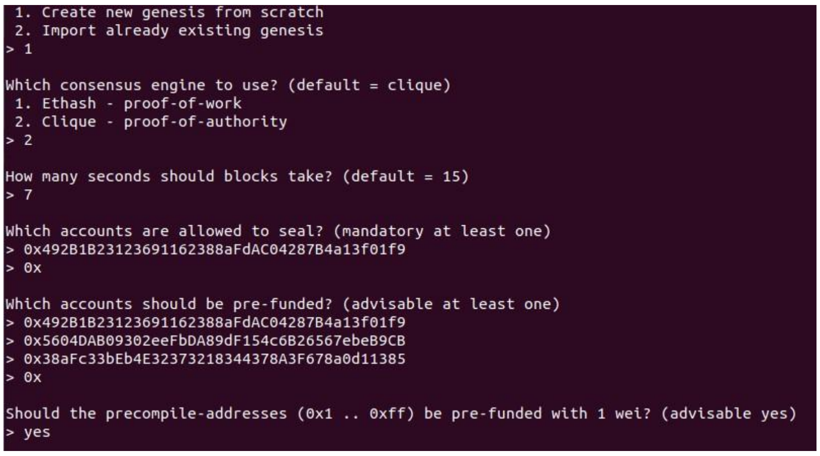
```
ubuntu@ubuntu-virtual-machine:~/bootnode$ bootnode -genkey bootnode.key
ubuntu@ubuntu-virtual-machine:~/bootnode$ bootnode -nodekey boot.key -verbosity 9 -addr :30301
Fatal: -nodekey: open boot.key: no such file or directory
ubuntu@ubuntu-virtual-machine:~/bootnode$ bootnode -nodekey bootnode.key -verbosity 9 -addr :30301
enode://68a4fd38afcc09d34ce1c6ea6a999575a9bdd1ebd6867575796ed6527443251ec03012ffd5c23d51a23ed088260f9511b989ac55658451248eb786702952d7a1@127.0.0.1:0?discport=30301
Note: you're using cmd/bootnode, a developer tool.
We recommend using a regular node as bootstrap node for production deployments.
INFO [07-29|19:19:48.192] New local node record                    seq=1 id=870843415ad84e7b ip=<nil> udp=0 tcp=0
```

Figure 3: New key for the bootnode is generated and the bootnode is launched



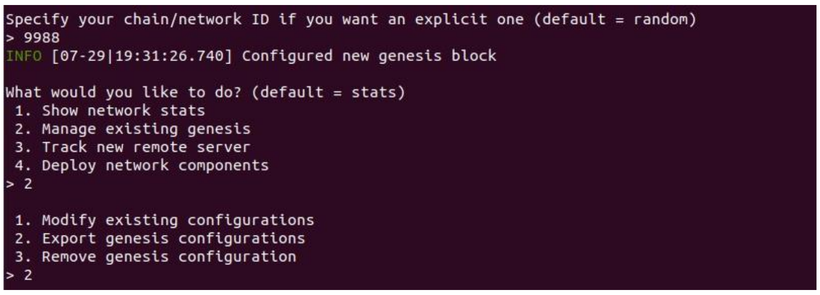
```
buntu@ubuntu-virtual-machine:~/bootnode$ puppeth
+-----------------------------------------------------------+
| Welcome to puppeth, your Ethereum private network manager |
|                                                           |
| This tool lets you create a new Ethereum network down to  |
| the genesis block, bootnodes, miners and ethstats servers |
| without the hassle that it would normally entail.         |
|                                                           |
| Puppeth uses SSH to dial in to remote servers, and builds |
| its network components out of Docker containers using the |
| docker-compose toolset.                                   |
+-----------------------------------------------------------+

lease specify a network name to administer (no spaces, hyphens or capital letters please)
 poa

weet, you can set this via --network=poa next time!

NFO [07-29|19:29:05.562] Administering Ethereum network           name=poa
ARN [07-29|19:29:05.562] No previous configurations found         path=/home/ubuntu/.puppeth/poa

hat would you like to do? (default = stats)
 1. Show network stats
 2. Configure new genesis
 3. Track new remote server
 4. Deploy network components
 2

hat would you like to do? (default = create)
 1. Create new genesis from scratch
 2. Import already existing genesis
 1
```

Figure 4: New Genesis file is created



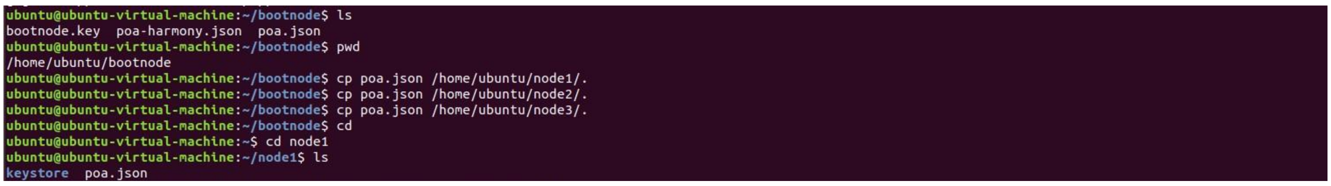
```
 1. Create new genesis from scratch
 2. Import already existing genesis
> 1

Which consensus engine to use? (default = clique)
 1. Ethash - proof-of-work
 2. Clique - proof-of-authority
> 2

How many seconds should blocks take? (default = 15)
> 7

Which accounts are allowed to seal? (mandatory at least one)
> 0x492B1B23123691162388aFdAC04287B4a13f01f9
> 0x

Which accounts should be pre-funded? (advisable at least one)
> 0x492B1B23123691162388aFdAC04287B4a13f01f9
> 0x5604DAB09302eeFbDA89dF154c6B26567ebeB9CB
> 0x38aFc33bEb4E32373218344378A3F678a0d11385
> 0x

Should the precompile-addresses (0x1 .. 0xff) be pre-funded with 1 wei? (advisable yes)
> yes
```

Figure 5: PoA Clique engine is selected and the miner node is designated. All three accounts are pre-funded



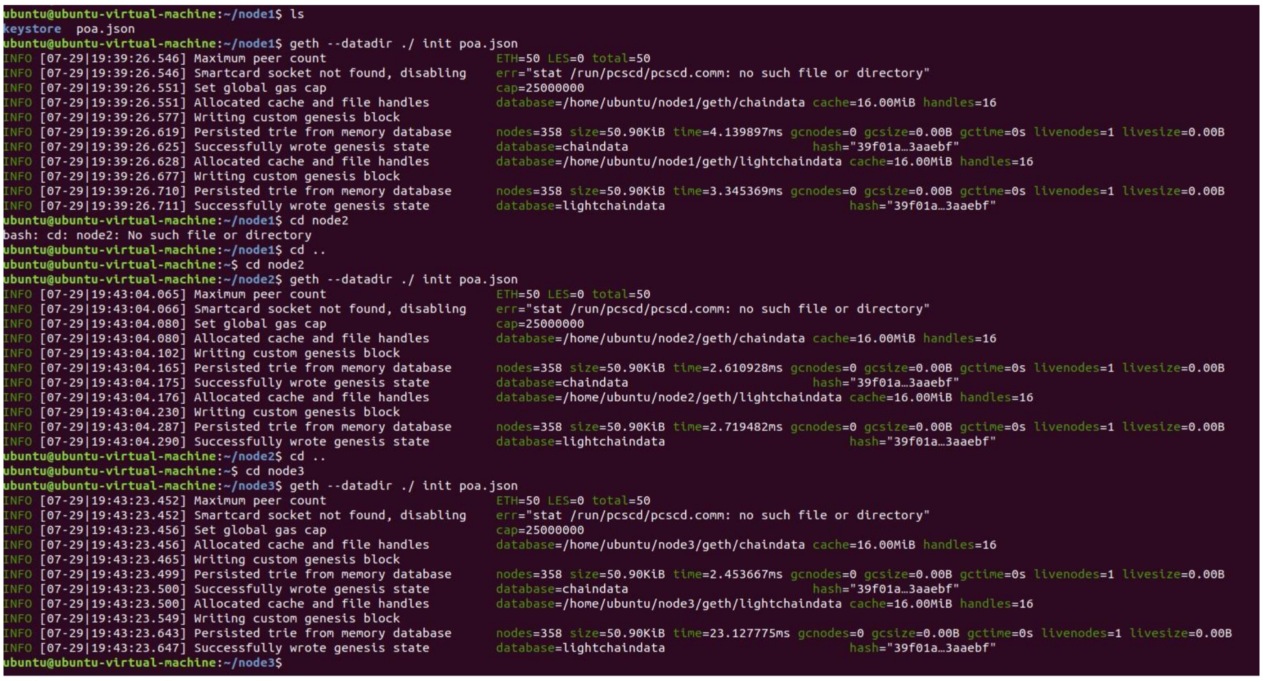
```
Specify your chain/network ID if you want an explicit one (default = random)
> 9988
INFO [07-29|19:31:26.740] Configured new genesis block

What would you like to do? (default = stats)
 1. Show network stats
 2. Manage existing genesis
 3. Track new remote server
 4. Deploy network components
> 2

 1. Modify existing configurations
 2. Export genesis configurations
 3. Remove genesis configuration
> 2
```

Figure 6: The network ID is created and the Genesis configuration is exported



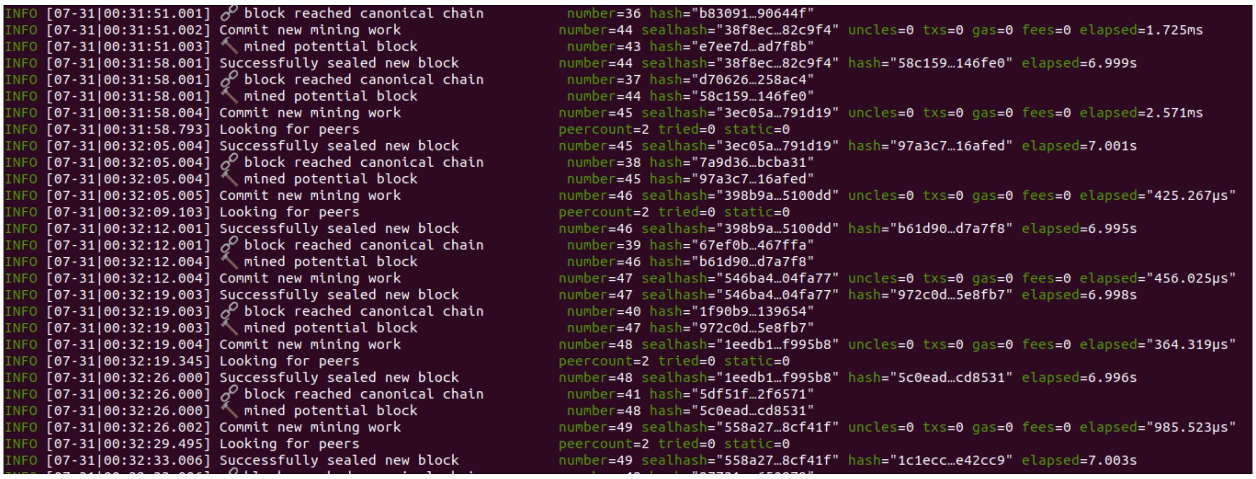
```
ubuntu@ubuntu-virtual-machine:~/bootnode$ ls
bootnode.key  poa-harmony.json  poa.json
ubuntu@ubuntu-virtual-machine:~/bootnode$ pwd
/home/ubuntu/bootnode
ubuntu@ubuntu-virtual-machine:~/bootnode$ cp poa.json /home/ubuntu/node1/.
ubuntu@ubuntu-virtual-machine:~/bootnode$ cp poa.json /home/ubuntu/node2/.
ubuntu@ubuntu-virtual-machine:~/bootnode$ cp poa.json /home/ubuntu/node3/.
ubuntu@ubuntu-virtual-machine:~/bootnode$ cd
ubuntu@ubuntu-virtual-machine:~$ cd node1
ubuntu@ubuntu-virtual-machine:~/node1$ ls
keystore  poa.json
```

Figure 7: The Genesis file is copied to each node's folder and the Genesis is initialised for each node.



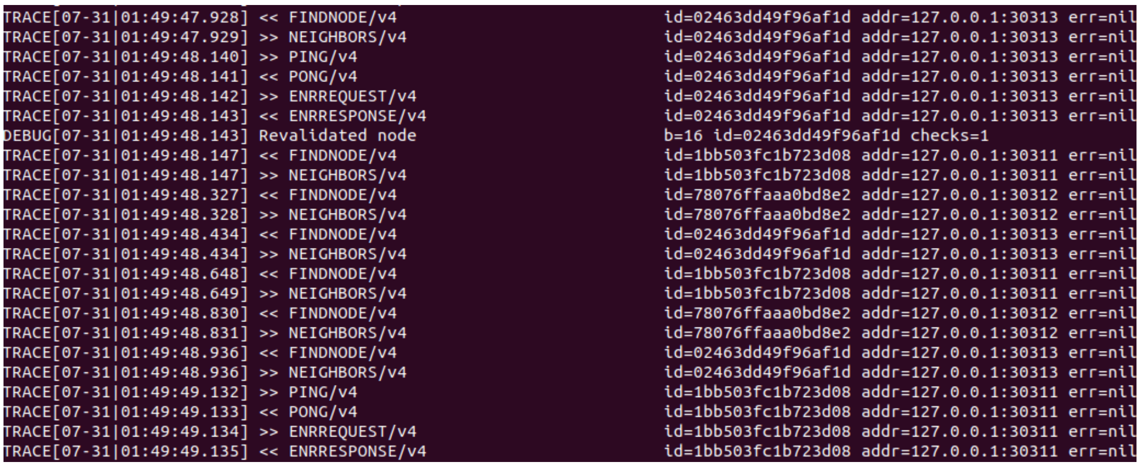
```
ubuntu@ubuntu-virtual-machine:~/node1$ ls
keystore  poa.json
ubuntu@ubuntu-virtual-machine:~/node1$ geth --datadir ./ init poa.json
INFO [07-29|19:39:26.546] Maximum peer count                       ETH=50 LES=0 total=50
INFO [07-29|19:39:26.546] Smartcard socket not found, disabling    err="stat /run/pcscd/pcscd.comm: no such file or directory"
INFO [07-29|19:39:26.551] Set global gas cap                       cap=25000000
INFO [07-29|19:39:26.551] Allocated cache and file handles         database=/home/ubuntu/node1/geth/chaindata cache=16.00MiB handles=16
INFO [07-29|19:39:26.577] Writing custom genesis block
INFO [07-29|19:39:26.619] Persisted trie from memory database      nodes=358 size=50.90KiB time=4.139897ms gcnodes=0 gcsize=0.00B gctime=0s livenodes=1 livesize=0.00B
INFO [07-29|19:39:26.625] Successfully wrote genesis state         database=chaindata                         hash="39f01a…3aaebf"
INFO [07-29|19:39:26.628] Allocated cache and file handles         database=/home/ubuntu/node1/geth/lightchaindata cache=16.00MiB handles=16
INFO [07-29|19:39:26.677] Writing custom genesis block
INFO [07-29|19:39:26.710] Persisted trie from memory database      nodes=358 size=50.90KiB time=3.345369ms gcnodes=0 gcsize=0.00B gctime=0s livenodes=1 livesize=0.00B
INFO [07-29|19:39:26.711] Successfully wrote genesis state         database=lightchaindata                         hash="39f01a…3aaebf"
ubuntu@ubuntu-virtual-machine:~/node1$ cd node2
bash: cd: node2: No such file or directory
ubuntu@ubuntu-virtual-machine:~/node1$ cd ..
ubuntu@ubuntu-virtual-machine:~$ cd node2
ubuntu@ubuntu-virtual-machine:~/node2$ geth --datadir ./ init poa.json
INFO [07-29|19:43:04.065] Maximum peer count                       ETH=50 LES=0 total=50
INFO [07-29|19:43:04.066] Smartcard socket not found, disabling    err="stat /run/pcscd/pcscd.comm: no such file or directory"
INFO [07-29|19:43:04.080] Set global gas cap                       cap=25000000
INFO [07-29|19:43:04.080] Allocated cache and file handles         database=/home/ubuntu/node2/geth/chaindata cache=16.00MiB handles=16
INFO [07-29|19:43:04.102] Writing custom genesis block
INFO [07-29|19:43:04.165] Persisted trie from memory database      nodes=358 size=50.90KiB time=2.610928ms gcnodes=0 gcsize=0.00B gctime=0s livenodes=1 livesize=0.00B
INFO [07-29|19:43:04.175] Successfully wrote genesis state         database=chaindata                         hash="39f01a…3aaebf"
INFO [07-29|19:43:04.176] Allocated cache and file handles         database=/home/ubuntu/node2/geth/lightchaindata cache=16.00MiB handles=16
INFO [07-29|19:43:04.230] Writing custom genesis block
INFO [07-29|19:43:04.287] Persisted trie from memory database      nodes=358 size=50.90KiB time=2.719482ms gcnodes=0 gcsize=0.00B gctime=0s livenodes=1 livesize=0.00B
INFO [07-29|19:43:04.290] Successfully wrote genesis state         database=lightchaindata                         hash="39f01a…3aaebf"
ubuntu@ubuntu-virtual-machine:~/node2$ cd ..
ubuntu@ubuntu-virtual-machine:~$ cd node3
ubuntu@ubuntu-virtual-machine:~/node3$ geth --datadir ./ init poa.json
INFO [07-29|19:43:23.452] Maximum peer count                       ETH=50 LES=0 total=50
INFO [07-29|19:43:23.452] Smartcard socket not found, disabling    err="stat /run/pcscd/pcscd.comm: no such file or directory"
INFO [07-29|19:43:23.456] Set global gas cap                       cap=25000000
INFO [07-29|19:43:23.456] Allocated cache and file handles         database=/home/ubuntu/node3/geth/chaindata cache=16.00MiB handles=16
INFO [07-29|19:43:23.465] Writing custom genesis block
INFO [07-29|19:43:23.499] Persisted trie from memory database      nodes=358 size=50.90KiB time=2.453667ms gcnodes=0 gcsize=0.00B gctime=0s livenodes=1 livesize=0.00B
INFO [07-29|19:43:23.500] Successfully wrote genesis state         database=chaindata                         hash="39f01a…3aaebf"
INFO [07-29|19:43:23.500] Allocated cache and file handles         database=/home/ubuntu/node3/geth/lightchaindata cache=16.00MiB handles=16
INFO [07-29|19:43:23.549] Writing custom genesis block
INFO [07-29|19:43:23.643] Persisted trie from memory database      nodes=358 size=50.90KiB time=23.127775ms gcnodes=0 gcsize=0.00B gctime=0s livenodes=1 livesize=0.00B
INFO [07-29|19:43:23.647] Successfully wrote genesis state         database=lightchaindata                         hash="39f01a…3aaebf"
ubuntu@ubuntu-virtual-machine:~/node3$
```

Figure 8: Each node is initialised with the Genesis file



```
INFO [07-31|00:31:51.001] 🔗 block reached canonical chain          number=36 hash="b83091…90644f"
INFO [07-31|00:31:51.002] Commit new mining work                   number=44 sealhash="38f8ec…82c9f4" uncles=0 txs=0 gas=0 fees=0 elapsed=1.725ms
INFO [07-31|00:31:51.003] 🔨 mined potential block                  number=43 hash="e7ee7d…ad7f8b"
INFO [07-31|00:31:58.001] Successfully sealed new block            number=44 sealhash="38f8ec…82c9f4" hash="58c159…146fe0" elapsed=6.999s
INFO [07-31|00:31:58.001] 🔗 block reached canonical chain          number=37 hash="d70626…258ac4"
INFO [07-31|00:31:58.001] 🔨 mined potential block                  number=44 hash="58c159…146fe0"
INFO [07-31|00:31:58.004] Commit new mining work                   number=45 sealhash="3ec05a…791d19" uncles=0 txs=0 gas=0 fees=0 elapsed=2.571ms
INFO [07-31|00:31:58.793] Looking for peers                        peercount=2 tried=0 static=0
INFO [07-31|00:32:05.004] Successfully sealed new block            number=45 sealhash="3ec05a…791d19" hash="97a3c7…16afed" elapsed=7.001s
INFO [07-31|00:32:05.004] 🔗 block reached canonical chain          number=38 hash="7a9d36…bcba31"
INFO [07-31|00:32:05.004] 🔨 mined potential block                  number=45 hash="97a3c7…16afed"
INFO [07-31|00:32:05.005] Commit new mining work                   number=46 sealhash="398b9a…5100dd" uncles=0 txs=0 gas=0 fees=0 elapsed="425.267µs"
INFO [07-31|00:32:09.103] Looking for peers                        peercount=2 tried=0 static=0
INFO [07-31|00:32:12.001] Successfully sealed new block            number=46 sealhash="398b9a…5100dd" hash="b61d90…d7a7f8" elapsed=6.995s
INFO [07-31|00:32:12.001] 🔗 block reached canonical chain          number=39 hash="67ef0b…467ffa"
INFO [07-31|00:32:12.004] 🔨 mined potential block                  number=46 hash="b61d90…d7a7f8"
INFO [07-31|00:32:12.004] Commit new mining work                   number=47 sealhash="546ba4…04fa77" uncles=0 txs=0 gas=0 fees=0 elapsed="456.025µs"
INFO [07-31|00:32:19.003] Successfully sealed new block            number=47 sealhash="546ba4…04fa77" hash="972c0d…5e8fb7" elapsed=6.998s
INFO [07-31|00:32:19.003] 🔗 block reached canonical chain          number=40 hash="1f90b9…139654"
INFO [07-31|00:32:19.003] 🔨 mined potential block                  number=47 hash="972c0d…5e8fb7"
INFO [07-31|00:32:19.004] Commit new mining work                   number=48 sealhash="1eedb1…f995b8" uncles=0 txs=0 gas=0 fees=0 elapsed="364.319µs"
INFO [07-31|00:32:19.345] Looking for peers                        peercount=2 tried=0 static=0
INFO [07-31|00:32:26.000] Successfully sealed new block            number=48 sealhash="1eedb1…f995b8" hash="5c0ead…cd8531" elapsed=6.996s
INFO [07-31|00:32:26.000] 🔗 block reached canonical chain          number=41 hash="5df51f…2f6571"
INFO [07-31|00:32:26.000] 🔨 mined potential block                  number=48 hash="5c0ead…cd8531"
INFO [07-31|00:32:26.002] Commit new mining work                   number=49 sealhash="558a27…8cf41f" uncles=0 txs=0 gas=0 fees=0 elapsed="985.523µs"
INFO [07-31|00:32:29.495] Looking for peers                        peercount=2 tried=0 static=0
INFO [07-31|00:32:33.006] Successfully sealed new block            number=49 sealhash="558a27…8cf41f" hash="1c1ecc…e42cc9" elapsed=7.003s
```

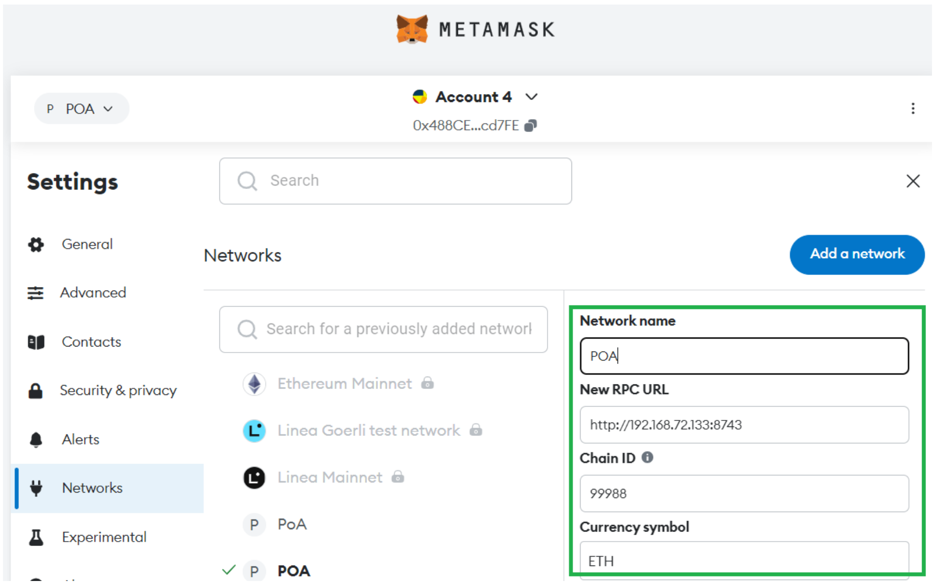
Figure 9: Miner (sealer) node is launched



```
TRACE[07-31|01:49:47.928] << FINDNODE/v4                            id=02463dd49f96af1d addr=127.0.0.1:30313 err=nil
TRACE[07-31|01:49:47.929] >> NEIGHBORS/v4                           id=02463dd49f96af1d addr=127.0.0.1:30313 err=nil
TRACE[07-31|01:49:48.140] >> PING/v4                                id=02463dd49f96af1d addr=127.0.0.1:30313 err=nil
TRACE[07-31|01:49:48.141] << PONG/v4                                id=02463dd49f96af1d addr=127.0.0.1:30313 err=nil
TRACE[07-31|01:49:48.142] >> ENRREQUEST/v4                          id=02463dd49f96af1d addr=127.0.0.1:30313 err=nil
TRACE[07-31|01:49:48.143] << ENRRESPONSE/v4                         id=02463dd49f96af1d addr=127.0.0.1:30313 err=nil
DEBUG[07-31|01:49:48.143] Revalidated node                          b=16 id=02463dd49f96af1d checks=1
TRACE[07-31|01:49:48.147] << FINDNODE/v4                            id=1bb503fc1b723d08 addr=127.0.0.1:30311 err=nil
TRACE[07-31|01:49:48.147] >> NEIGHBORS/v4                           id=1bb503fc1b723d08 addr=127.0.0.1:30311 err=nil
TRACE[07-31|01:49:48.327] << FINDNODE/v4                            id=78076ffaaa0bd8e2 addr=127.0.0.1:30312 err=nil
TRACE[07-31|01:49:48.328] >> NEIGHBORS/v4                           id=78076ffaaa0bd8e2 addr=127.0.0.1:30312 err=nil
TRACE[07-31|01:49:48.434] << FINDNODE/v4                            id=02463dd49f96af1d addr=127.0.0.1:30313 err=nil
TRACE[07-31|01:49:48.434] >> NEIGHBORS/v4                           id=02463dd49f96af1d addr=127.0.0.1:30313 err=nil
TRACE[07-31|01:49:48.648] << FINDNODE/v4                            id=1bb503fc1b723d08 addr=127.0.0.1:30311 err=nil
TRACE[07-31|01:49:48.649] >> NEIGHBORS/v4                           id=1bb503fc1b723d08 addr=127.0.0.1:30311 err=nil
TRACE[07-31|01:49:48.830] << FINDNODE/v4                            id=78076ffaaa0bd8e2 addr=127.0.0.1:30312 err=nil
TRACE[07-31|01:49:48.831] >> NEIGHBORS/v4                           id=78076ffaaa0bd8e2 addr=127.0.0.1:30312 err=nil
TRACE[07-31|01:49:48.936] << FINDNODE/v4                            id=02463dd49f96af1d addr=127.0.0.1:30313 err=nil
TRACE[07-31|01:49:48.936] >> NEIGHBORS/v4                           id=02463dd49f96af1d addr=127.0.0.1:30313 err=nil
TRACE[07-31|01:49:49.132] >> PING/v4                                id=1bb503fc1b723d08 addr=127.0.0.1:30311 err=nil
TRACE[07-31|01:49:49.133] << PONG/v4                                id=1bb503fc1b723d08 addr=127.0.0.1:30311 err=nil
TRACE[07-31|01:49:49.134] >> ENRREQUEST/v4                          id=1bb503fc1b723d08 addr=127.0.0.1:30311 err=nil
TRACE[07-31|01:49:49.135] << ENRRESPONSE/v4                         id=1bb503fc1b723d08 addr=127.0.0.1:30311 err=nil
```

Figure 10: Bootnode is launched and it facilitates communication among all the nodes

6 Deploying the Smart Contract with Remix and Metamask



Network name

POA

New RPC URL

http://192.168.72.133:8743

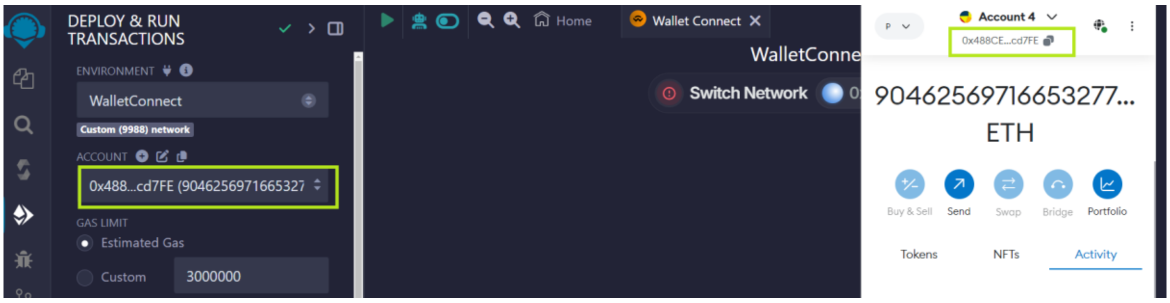
Chain ID

99988

Currency symbol

ETH

Figure 11: PoA network needs to be set up with URL, network ID and currency


DEPLOY & RUN TRANSACTIONS

ENVIRONMENT: WalletConnect

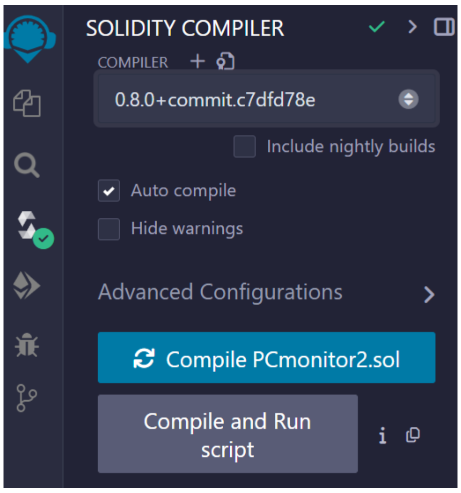
Custom (9988) network

ACCOUNT: 0x488...cd7FE (9046256971665327

GAS LIMIT: Estimated Gas

Custom 3000000

Figure 12: Metamask account needs to be connected with Remix via WalletConnect


SOLIDITY COMPILER

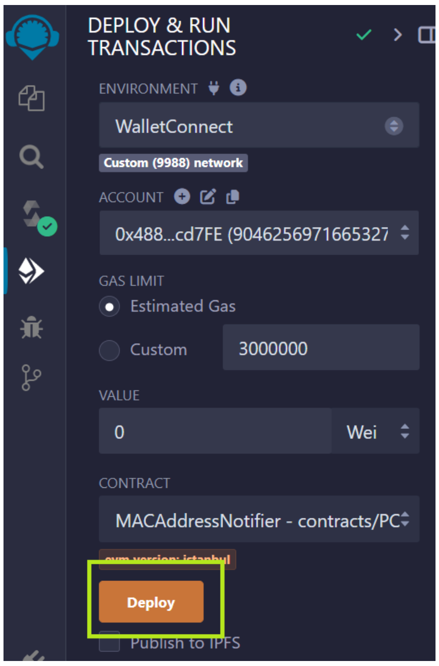
COMPILER: 0.8.0+commit.c7dfd78e

☐ Include nightly builds

☑ Auto compile

☐ Hide warnings

Figure 13: Smart Contract code needs to be compiled with the correct version of compiler corresponding to the correct pragma solidity ^0.8.0;


DEPLOY & RUN TRANSACTIONS

ENVIRONMENT: WalletConnect

Custom (9988) network

ACCOUNT: 0x488...cd7FE (9046256971665327

GAS LIMIT: Estimated Gas

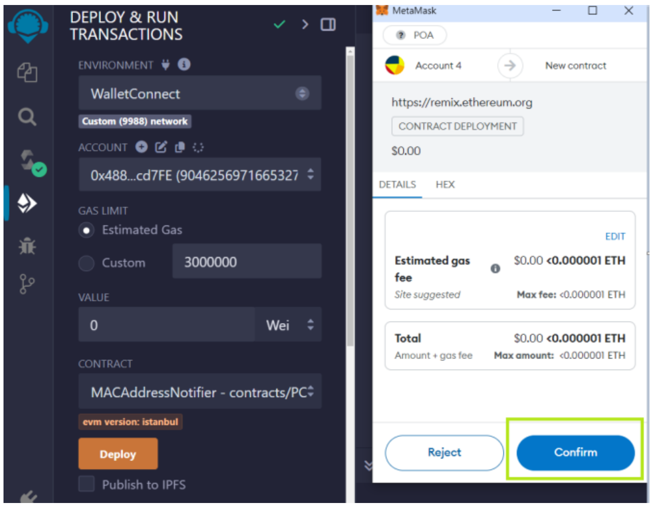
Custom 3000000

VALUE: 0 Wei

CONTRACT: MACAddressNotifier - contracts/PC

evm version: istanbul

Figure 14: Smart Contract is deployed to the BC


DEPLOY & RUN TRANSACTIONS

ENVIRONMENT: WalletConnect

Custom (9988) network

ACCOUNT: 0x488...cd7FE (9046256971665327

GAS LIMIT: Estimated Gas

Custom: 3000000

VALUE: 0 Wei

CONTRACT: MACAddressNotifier - contracts/PC

evm version: istanbul

Deploy

Publish to IPFS

MetaMask

POA

Account 4 → New contract

https://remix.ethereum.org

CONTRACT DEPLOYMENT

$0.00

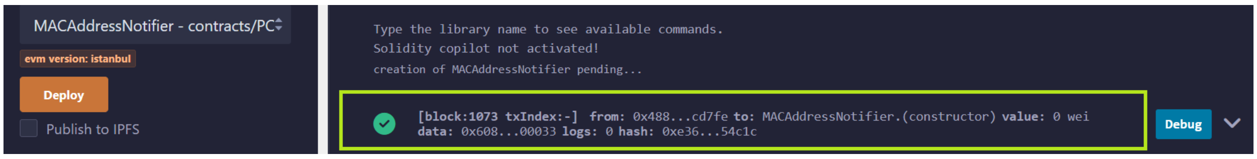
DETAILS HEX

EDIT

Estimated gas fee	$0.00 <0.000001 ETH
Site suggested	Max fee: <0.000001 ETH
Total	$0.00 <0.000001 ETH
Amount + gas fee	Max amount: <0.000001 ETH

Reject Confirm

Figure 15: Final stage: contract deployment confirmation in Metamask


MACAddressNotifier - contracts/PC

evm version: istanbul

Deploy

Publish to IPFS

```
Type the library name to see available commands.
Solidity copilot not activated!
creation of MACAddressNotifier pending...

[block:1073 txIndex:-] from: 0x488...cd7fe to: MACAddressNotifier.(constructor) value: 0 wei
data: 0x608...00033 logs: 0 hash: 0xe36...54c1c
```

Debug

Figure 16: Successful transaction has been confirmed

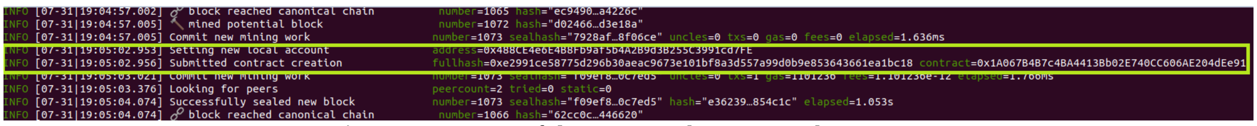
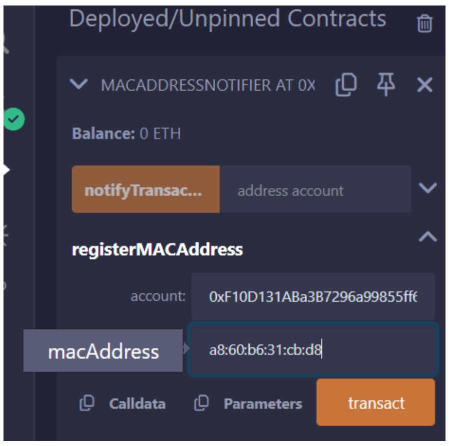

```
INFO [07-31|19:04:57.002] 🔗 block reached canonical chain         number=1065 hash="ec9490…a4226c"
INFO [07-31|19:04:57.005] 🔨 mined potential block                 number=1072 hash="d02466…d3e18a"
INFO [07-31|19:04:57.005] Commit new mining work                  number=1073 sealhash="7928af…8f06ce" uncles=0 txs=0 gas=0 fees=0 elapsed=1.636ms
INFO [07-31|19:05:02.953] Setting new local account               address=0x488CE4e6E4B8Fb9af5b4A2B9d3B255C3991cd7FE
INFO [07-31|19:05:02.956] Submitted contract creation             fullhash=0xe2991ce58775d296b30aeac9673e101bf8a3d557a99d0b9e853643661ea1bc18 contract=0x1A067B4B7c4BA4413Bb02E740CC606AE204dEe91
INFO [07-31|19:05:03.021] Commit new mining work                  number=1073 sealhash="f09ef8…0c7ed5" uncles=0 txs=1 gas=1101236 fees=1.101236e-12 elapsed=1.766ms
INFO [07-31|19:05:03.376] Looking for peers                       peercount=2 tried=0 static=0
INFO [07-31|19:05:04.074] Successfully sealed new block           number=1073 sealhash="f09ef8…0c7ed5" hash="e36239…854c1c" elapsed=1.053s
INFO [07-31|19:05:04.074] 🔗 block reached canonical chain         number=1066 hash="62cc0c…446620"
```

Figure 17: Successful contract submision in the BC


Deployed/Unpinned Contracts

MACADDRESSNOTIFIER AT 0X

Balance: 0 ETH

notifyTransac... address account

registerMACAddress

account: 0xF10D131ABa3B7296a99855ff€

macAddress a8:60:b6:31:cb:d8

Calldata Parameters transact

Figure 18: End-user MAC address and its correspoding BC account address can be registered in the SC from Remix IDE

References

[1] “RYU SDN Testbed Manual Diarmuid Ó Briain engcore advancing technology.” Available: https://www.obriain.com/training/sdn/RYU_Soft_Testbed_v2.0.pdf. (Accessed 12 Jun., 2024).

[2] “Setup TLS Connection — Ryu 4.34 documentation,” Readthedocs.io, 2022. https://ryu.readthedocs.io/en/latest/tls.html (Accessed 30 Jun., 2024).

[3] “Open vSwitch with SSL and Mininet,” Tech and Trains, Apr. 27, 2014. https://techandtrains.com/2014/04/27/open-vswitch-with-ssl-and-mininet/ (accessed Aug. 9, 2024).

[4] Mininet, “mininet/examples/natnet.py at master mininet/mininet,” GitHub, 2024. https://github.com/mininet/mininet/blob/master/examples/natnet.py (accessed Jun. 2, 2024).