ZKU Assignment 1

Name: Shyam Patel
Discord: L_guy#4297
Email: shyampkira@gmail.com
GitHub Repo: [Link]

Question:1 Intro to circom

1. Construct circuit for merkleTree

merkleProof.circom: Link to GitHub [merkleProof.circom]

```
pragma circom 2.0.0;
include "node_modules/circomlib/circuits/mimc.circom";
// Helper template that computes hashes of the next tree layer
template branch(height) {
 var items = 1 << height;
 // input array
 signal input ins[items * 2];
 // output array
 signal output outs[items];
 component hash[items];
 for(var i = 0; i < items; i++) {
   hash[i] = MultiMiMC7(2,91);
   hash[i].in[0] <== ins[i * 2];
   hash[i].in[1] <== ins[i * 2 + 1];
   hash[i].k <== 0;
   hash[i].out ==> outs[i];
 }
}
// Builds a merkle tree from leaf array
template merkleProof(levels) {
 signal input leaves[1 << levels];
 signal output root;
 component layers[levels];
 for(var level = levels - 1; level >= 0; level--) {
   layers[level] = branch(level);
   for(var i = 0; i < (1 << (level + 1)); i++) {
     layers[level].ins[i] <== level == levels - 1 ? leaves[i] : layers[level +
1].outs[i];
   }
 }
 root <== levels > 0 ? layers[0].outs[0] : leaves[0];
}
component main{public [leaves]} = merkleProof(3);
```

2. Errors encountered and solution:

This was the first error I encountered with the input array of bigger size(8):

```
[ERROR] snarkJS: circuit too big for this power of tau ceremony.
5096*2 > 2**12
```

I encountered this while starting a new “power of tau” ceremony :

```
snarkjs powersoftau new bn128 12 pot12_0000.ptau -v
```

I resolved it by increasing the “power of tau” such that it is greater than the required number. So increasing the power to 14 resolved this since 2**14 > 5096*2.

3. Theory Question:

We do not need zero-knowledge proof for this same functionality. A publicly verifiable smart contract that computes Merkle root will achieve the same. We are still able to construct a Merkle Tree without zero knowledge proofs. Zero-knowledge proofs allow us to improve the security nature if heightened security is needed. It also allows transactions and interactions to be noninteractive, as well as making transactions cheaper and resource efficient. A scenario where this ZKP can be useful is if we want to achieve the same merkleTree functionality without revealing other unnecessary data like inputs and such. One such application: ZKRollup that uses ZKPs where many transactions (leaves) are bundled up together and submitted on an L1 for a verifier contract to verify that they are valid.

=> ScreenShots and public.json

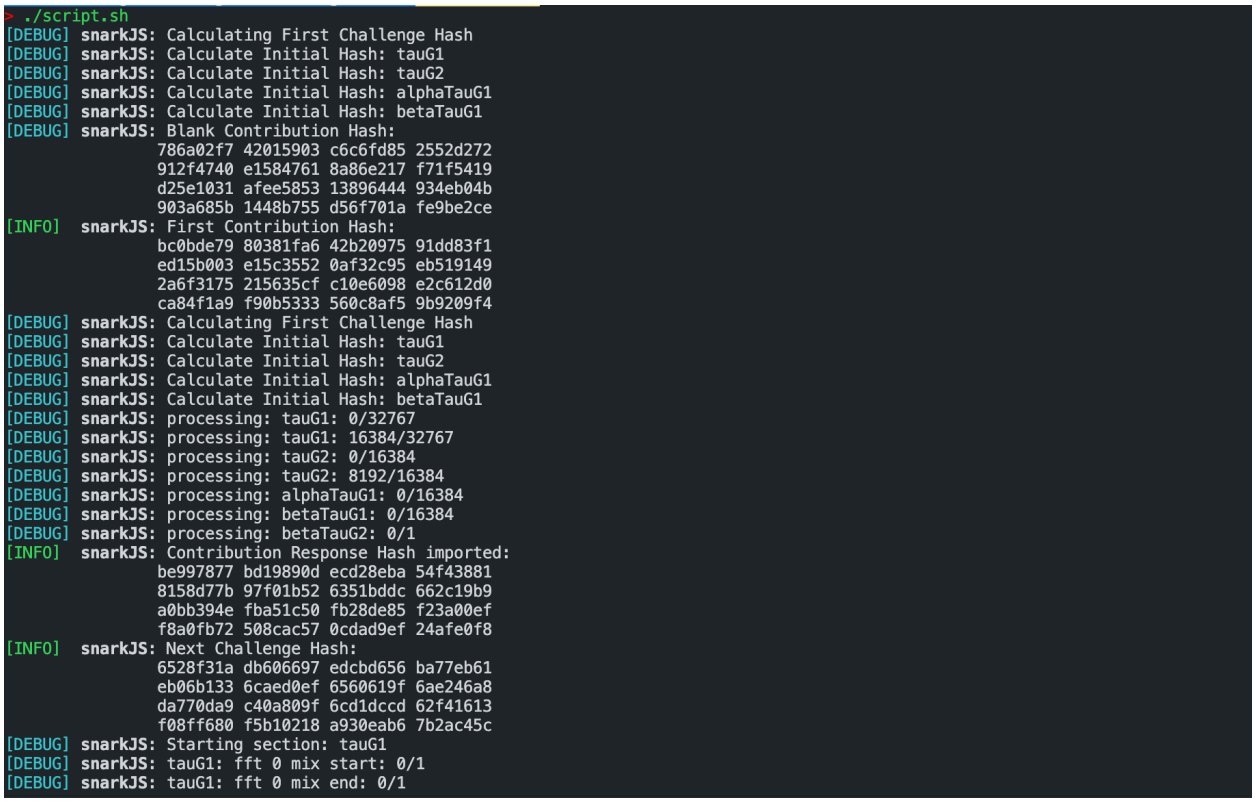
I used a shell script to run the commands simultaneously: Updated Github Link for script.sh

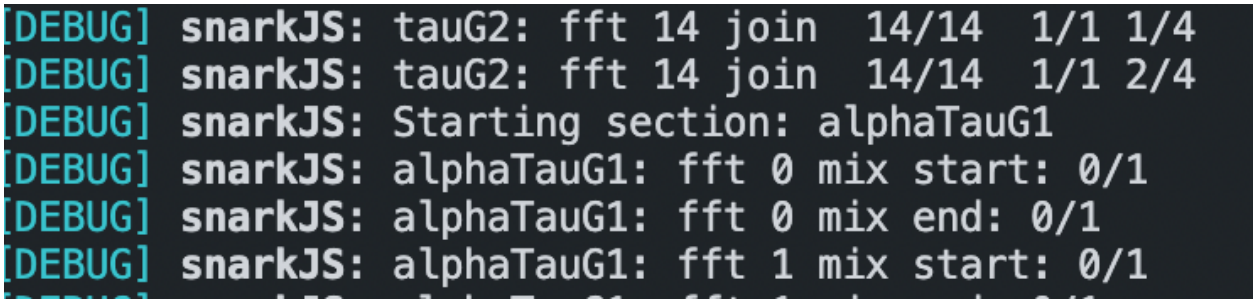
[Link]

```
snarkjs powersoftau new bn128 14 pot12_0000.ptau -v
snarkjs powersoftau contribute pot12_0000.ptau pot12_0001.ptau --name="First contribution"
-v -e="kira"


snarkjs powersoftau prepare phase2 pot12_0001.ptau pot12_final.ptau -v
snarkjs groth16 setup merkleProof.r1cs pot12_final.ptau merkleProof_0000.zkey

snarkjs zkey contribute merkleProof_0000.zkey merkleProof_0001.zkey --name="1st Contributor
Name" -v -e="kira"
snarkjs zkey export verificationkey merkleProof_0001.zkey verification_key.json

cp merkleProof_js/witness.wtns .

snarkjs groth16 prove merkleProof_0001.zkey witness.wtns proof.json public.json
```

```
snarkjs groth16 verify verification_key.json public.json proof.json

#snarkjs zkey export solidityverifier merkleProof_0001.zkey verifier.sol
#snarkjs generatecall
```

Screenshots for running the script.sh





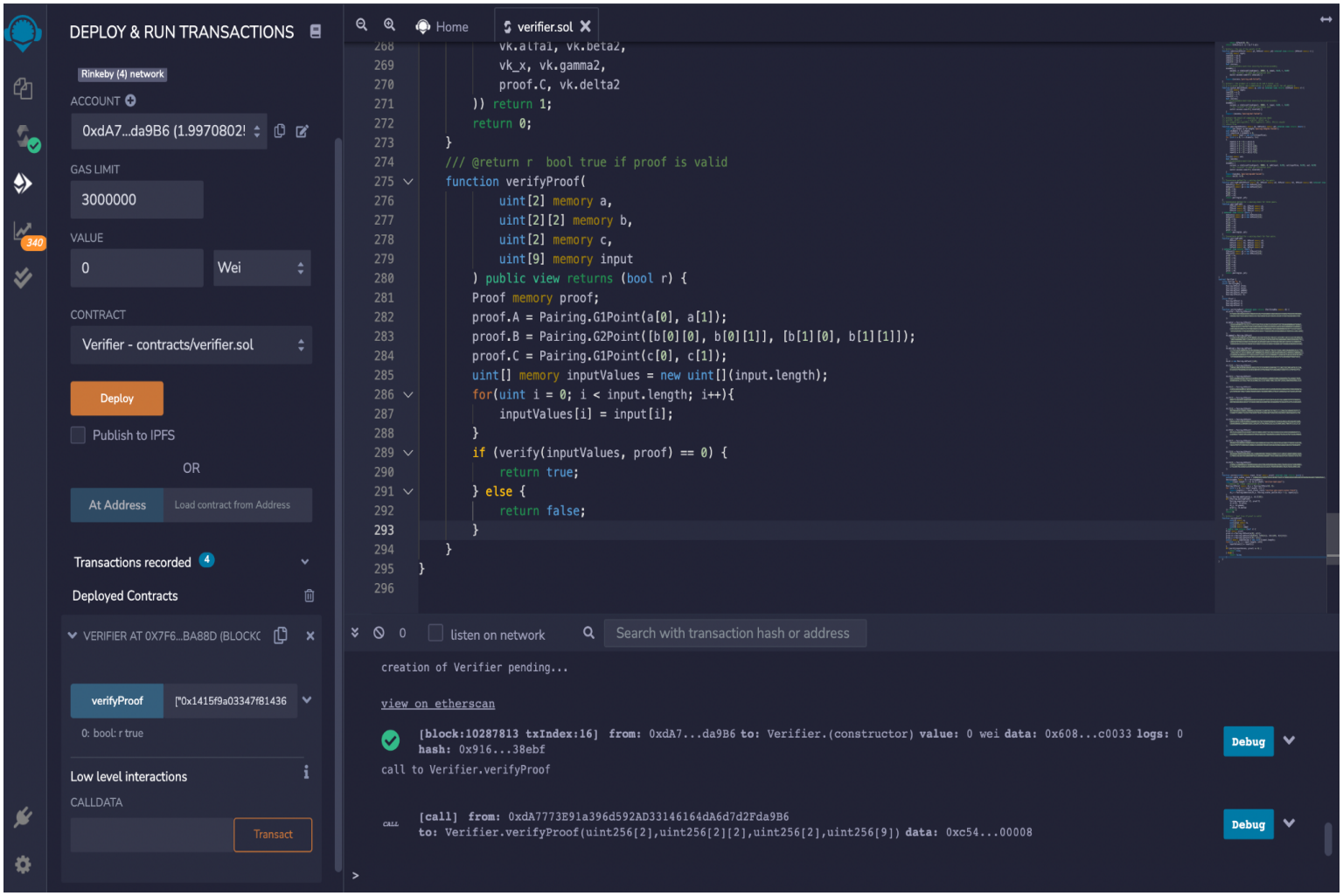
```
[DEBUG] snarkJS: alphaTauG1: fft 14 join  14/14  1/1 0/4
[DEBUG] snarkJS: alphaTauG1: fft 14 join  14/14  1/1 2/4
[DEBUG] snarkJS: alphaTauG1: fft 14 join  14/14  1/1 1/4
[DEBUG] snarkJS: Starting section: betaTauG1
[DEBUG] snarkJS: betaTauG1: fft 0 mix start: 0/1
[DEBUG] snarkJS: betaTauG1: fft 0 mix end: 0/1
[DEBUG] snarkJS: betaTauG1: fft 1 mix start: 0/1
```

```
[DEBUG] snarkJS: betaTauG1: fft 14 join  14/14  1/1 3/4
[DEBUG] snarkJS: betaTauG1: fft 14 join  14/14  1/1 1/4
[DEBUG] snarkJS: betaTauG1: fft 14 join  14/14  1/1 0/4
[DEBUG] snarkJS: betaTauG1: fft 14 join  14/14  1/1 2/4
[INFO]  snarkJS: Reading r1cs
[INFO]  snarkJS: Reading tauG1
[INFO]  snarkJS: Reading tauG2
[INFO]  snarkJS: Reading alphatauG1
[INFO]  snarkJS: Reading betatauG1
[INFO]  snarkJS: Circuit hash:
                0dfa5c33 c3c38e1e ab636b2a fa7db1a8
                650a5d9c 57826d28 fe777603 b63f1bad
                fbe45f72 7ff71140 b5a94ddd 5639e2cb
                73870f26 3247e087 1fcdccb8 85c3a298
[DEBUG] snarkJS: Applying key: L Section: 0/5103
[DEBUG] snarkJS: Applying key: H Section: 0/8192
[INFO]  snarkJS: Circuit Hash:
                0dfa5c33 c3c38e1e ab636b2a fa7db1a8
                650a5d9c 57826d28 fe777603 b63f1bad
                fbe45f72 7ff71140 b5a94ddd 5639e2cb
                73870f26 3247e087 1fcdccb8 85c3a298
[INFO]  snarkJS: Contribution Hash:
                e73e3316 9b410f39 e8c80321 a4daebfa
                ac12a754 e0417571 1346a257 e2580a99
                791538c0 84494dc5 101718a7 f12473fa
                705fe4f3 c1c0d854 147c51d8 277e1098
[INFO]  snarkJS: OK!
```

public.json: GitHub Link to public.json: [Link]


```
[
"14075477420338855047846876569733296091014866770910171554054559505431936618782",
"1",
"2",
"3",
"4",
"5",
"6",
"7",
"8"
]
```

=> SmartContract Deployment and verification on remix: Link to Verifier.sol

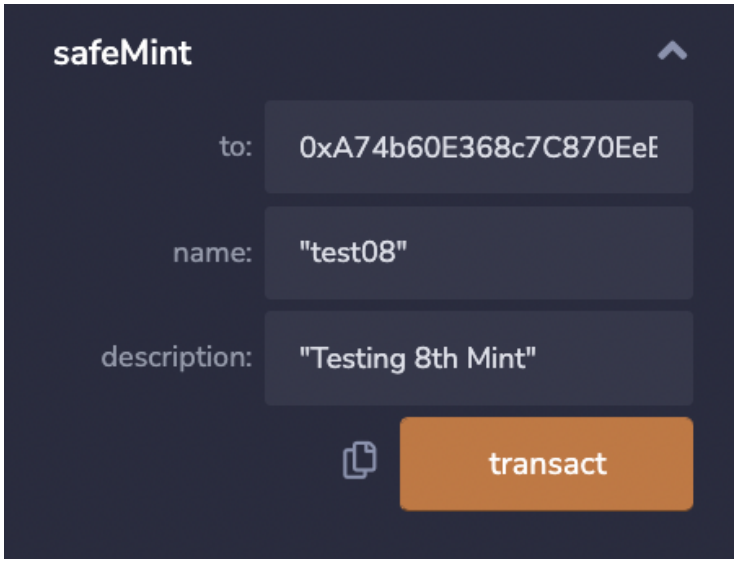


Question:2

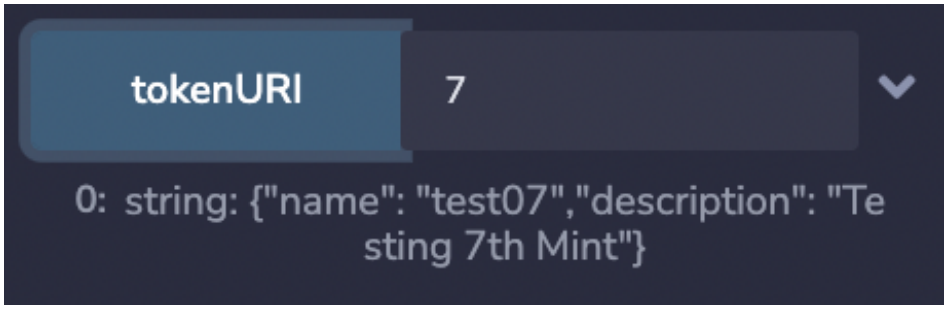
1. NFT Contract and merkle Tree:

- Link to code for ERC721 contract that can mint NFTs: [NFT.sol].
- Link to code for merkle tree used within NFT.sol : [merkleTree.sol].
- The token URI is stored on-chain and also includes name and description field
- Screenshots for methods of deployed Contracts are attached below and mintDetails screenshots are also included below them.

- SafeMint() Method used for minting the NFT to specific address:



- Retrieval of metaData from the token URI:



2 & 3. Screenshots and Gas Used:

can be Verified in screenshots below and on this [link]

No.	tokenURI	gasUsed
1	0	296789
2	1	194129
3	2	211313
4	3	194165
5	4	226313
6	5	213765
7	6	211713
8	7	196665

Minting screenShots for 1st and 2nd NFTs

ScreenShot 3rd and 7th NFT Mint:

view on etherscan

[block:10288694 txIndex:9] from: 0xdA7...da9B6 to: ZKMint.safeMint(address,string,string) 0x416...F4C39 value: 0 wei data: 0xeca...00000 logs: 1 hash: 0x4ed...6eccb

Debug

status: true Transaction mined and execution succeed

transaction hash: 0x237b32f92767137042c3353f40787cfb01a4e899be9878bf585241a998420218

from: 0xdA7773E91a396d592AD33146164dA6d7d2Fda9B6

to: ZKMint.safeMint(address,string,string) 0x416b214868417EF9C08624b430d6024f7F6F4C39

gas: 211713 gas

transaction cost: 211713 gas

hash: 0x237b32f92767137042c3353f40787cfb01a4e899be9878bf585241a998420218

input: 0xeca...00000

decoded input:

```
{
        "address to": "0xA74b60E368c7C870EeB581dc899cFA8158058bb8",
        "string name": "test07",
        "string description": "Testing 7th Mint"
}
```

decoded output: -

logs:

```
[
        {
                "from": "0x416b214868417EF9C08624b430d6024f7F6F4C39",
                "topic": "0xddf252ad1be2c89b69c2b068fc378daa952ba7f163c4a11628f55a4df523b3ef",
                "event": "Transfer",
                "args": {
                        "0": "0x0000000000000000000000000000000000000000",
                        "1": "0xA74b60E368c7C870EeB581dc899cFA8158058bb8",
                        "2": "6",
                        "from": "0x0000000000000000000000000000000000000000",
                        "to": "0xA74b60E368c7C870EeB581dc899cFA8158058bb8",
                        "tokenId": "6"
                }
        }
]
```

val: 0 wei

transact to ZKMint.safeMint pending ...

view on etherscan

[block:10288492 txIndex:10] from: 0xdA7...da9B6 to: ZKMint.safeMint(address,string,string) 0x416...F4C39 value: 0 wei data: 0xeca...00000 logs: 1 hash: 0xbb8...a3b26

Debug

status: true Transaction mined and execution succeed

transaction hash: 0xc8f5075cbdb89014ce7101913256544fa689b41c8cad478b438685f29753eab7

from: 0xdA7773E91a396d592AD33146164dA6d7d2Fda9B6

to: ZKMint.safeMint(address,string,string) 0x416b214868417EF9C08624b430d6024f7F6F4C39

gas: 211313 gas

transaction cost: 211313 gas

hash: 0xc8f5075cbdb89014ce7101913256544fa689b41c8cad478b438685f29753eab7

input: 0xeca...00000

decoded input:

```
{
        "address to": "0xdA7773E91a396d592AD33146164dA6d7d2Fda9B6",
        "string name": "test03",
        "string description": "Testing 3rd Mint"
}
```

decoded output: -

logs:

```
[
        {
                "from": "0x416b214868417EF9C08624b430d6024f7F6F4C39",
                "topic": "0xddf252ad1be2c89b69c2b068fc378daa952ba7f163c4a11628f55a4df523b3ef",
                "event": "Transfer",
                "args": {
                        "0": "0x0000000000000000000000000000000000000000",
                        "1": "0xdA7773E91a396d592AD33146164dA6d7d2Fda9B6",
                        "2": "2",
                        "from": "0x0000000000000000000000000000000000000000",
                        "to": "0xdA7773E91a396d592AD33146164dA6d7d2Fda9B6",
                        "tokenId": "2"
                }
        }
]
```

>

Last minted NFT:

Transactions for all Minted NFT can found in this [Link] with SafeMint Method:

Question 3: Understanding and generating ideas about ZK technologies

1. Differences between SNARKs and STARKs

The proof size of SNARKs are much smaller than STARKs meaning it would take less storage on-chain. Therefore SNARKs are estimated to require much more gas than SNARKs and that makes STARKs economically expensive for end users compared to SNARKs.

Zk-SNARK proofs are dependent on an initial trusted setup between a prover and verifier and this could create a potential centralization issue. They can be used in blockchain based applications much easily as they are smaller in size and can be verified on-chain.
Zk-STARKs don't require a trusted setup but disadvantage is that a prover with enough computational power could create fake proofs. They can be used in advanced p2p systems where there is no trusted setup (Binance p2p).

2. Differences between the trusted setup process between groth16 and PLONK.

The setup process in groth16 has to be repeated for each circuit. For example, we need to create a unique setup for every different circuit. Whereas in PLONK, one trusted setup can be used to validate all the circuits.

3. Give an idea of how we can apply ZK to create unique usage for NFTs.

ZK can be used to check if you have any NFT of a particular collection without revealing the tokenID. It can also be used to hide certain attributes/metadata of an NFT.

4. Give a novel idea on how we can apply ZK for Dao Tooling.

We know voting is a very popular idea but we can take one step further by making the voter identity secret. ZK can be used in hiding the identity of a proposer and voter.
ZK can help a Grants DAO to hide its abstract details. It can also be used for running a freelancers' network. One futuristic idea can be verifying the integrity of pharmaceutical products like medicines, vaccines, even vaccine certificates.