

1. What we will do in this lab

Recall from the previous lab (Lab 02), we have created a simple ERC20 token contract with some sell constraints as follows:

- **Tiered Pricing:** First 25% of tokens cost 5 ETH each, remaining tokens cost 10 ETH each
- **Sale Cap:** Maximum 50% of total supply can be sold
- **Duration:** 30-day sale period
- **Automatic Refunds:** Excess ETH is automatically refunded

We have successfully run and tested the contract Remix online IDE (Also tried to deploy against the Sepolia testnet but still facing some issues). In this lab, I will:

- Deploy the ERC20 token contract to a local Hardhat network
- Make the UI web interface to interact with the contract
- Rewrite contracts to align with new [Lab 03 Requirements](#) which:
 - Allow others to buy token from the sale contract
 - Allow the owner to sell tokens back to the sale contract
 - The token price will be calculated as: $\text{price} = \text{basePrice} * (1 + \text{interest rate}) ^ (\text{days since sale started})$

This is same as the formula of compound interest, where:

- `basePrice` is the initial price of the token, the requirement is to set it to 5 ETH
- `interest rate` is the interest rate applied to the token price, equal amount of ETH in the sale contract divided by $2 * 10^9$
- `days since sale started` is the number of days since the sale contract was deployed

2. Deploy ERC20 Contract with Hardhat and Test UI

In the previous lab, I have deploy my contracts in Remix online IDE, but now I will deploy it to a local Hardhat network. The steps are as follows:

Note

Prerequisites to run this lab:

- Node.js (v22 or higher)

- MetaMask browser extension

Step 1: Start Hardhat Local Network

Open a terminal and run:

```
cd /home/chutrunganh/Blockchain-and-Applications-IT4527E/Lab_03 # Run
npm install # Install dependencies
npm run compile # Compile contracts
npm run node # Start Local Hardhat network
```

This will start a local Ethereum blockchain using Hardhat. This simulates a blockchain locally so you can test and deploy contracts quickly and safely. You should see output like:

```
Started HTTP and WebSocket JSON-RPC server at http://127.0.0.1:8545,
```

```
Accounts
=====
```

```
WARNING: These accounts, and their private keys, are publicly known
Any funds sent to them on Mainnet or any other live network WILL BE
```

```
Account #0: 0xf39Fd6e51aad88F6F4ce6aB8827279cFfFb92266 (10000 ETH)
Private Key: 0xac0974bec39a17e36ba4a6b4d238ff944bacb478cbed5efcae784
```

```
Account #1: 0x70997970C51812dc3A010C7d01b50e0d17dc79C8 (10000 ETH)
Private Key: 0x59c6995e998f97a5a0044966f0945389dc9e86dae88c7a8412f46
```

```
Account #2: 0x3C44CdDdB6a900fa2b585dd299e03d12FA4293BC (10000 ETH)
Private Key: 0x5de4111afa1a4b94908f83103eb1f1706367c2e68ca870fc3fb9a
```

```
Account #3: 0x90F79b6f6EB2c4f870365E785982E1f101E93b906 (10000 ETH)
Private Key: 0x7c852118294e51e653712a81e05800f419141751be58f605c3716
```

```
Account #4: 0x15d34AAf54267DB7D7c367839AAf71A00a2C6A65 (10000 ETH)
Private Key: 0x47e179ec197488593b187f80a00eb0da91f1b9d0b13f8733639f8
```

```
WARNING: These accounts, and their private keys, are publicly known
Any funds sent to them on Mainnet or any other live network WILL BE
```

From the output, we clearly see that the network is running on `http://localhost:8545` and we have several test accounts. I have limited to just create 5 test accounts, each is initialized with 10,000 ETH each, for detail, see my [hardhat.config.js](#) file.

Note

Keep this terminal running, don't close it, as it is the local Hardhat network that will be used to deploy and test your contracts. You can open a new terminal for the next steps.

Step 2: Deploy Contracts

Open a new terminal and run:

```
cd /home/chutrunganh/Blockchain-and-Applications-IT4527E/Lab_03
npx hardhat compile # Compile contracts first
npm run deploy:local
```

This will deploy your smart contracts (ERC-20 + Token Sale) to the hardhat local network. The `deploy:local` script runs the `scripts/deploy.js` file as defined in the `package.json` file. To view more about the deployment process, you can check the `deploy.js` file. Anyway, you should see output like this:

chutrunganh@DESKTOP-RUUTEFU:~/Blockchain-and-Applications-IT4527E/L:

```
> deploy:local  
> npx hardhat run scripts/deploy.js --network localhost
```

Deploying contracts with the first account...
Account address: 0xf39Fd6e51aad88F6F4ce6aB8827279cFFb92266
Account balance: 10000.0

Deploying Group13Token...
✅ Group13Token deployed to: 0x5FbDB2315678afecb367f032d93F642f6418

Deploying Group13TokenSale...
✅ Group13TokenSale deployed to: 0xe7f1725E7734CE288F8367e1Bb143E90

Transferring 50000.0 tokens to sale contract...

Adding initial ETH liquidity...
✅ Added 100 ETH initial liquidity

Deployment Summary:
=====

Owner Address:	0xf39Fd6e51aad88F6F4ce6aB8827279cFFb92266
Token Contract:	0x5FbDB2315678afecb367f032d93F642f64180aa3
Sale Contract:	0xe7f1725E7734CE288F8367e1Bb143E90bb3F0512

Initial Setup:

- Total Supply: 100000.0 tokens
- Tokens for Sale: 50000.0
- Initial ETH Liquidity of contract: 100 ETH

✅ Deployment info saved to: /home/chutrunganh/Blockchain-and-Appli

This performs actions as configured inside the [deploy.js](#) script, which deploys two contracts:

- Group13Token: Your custom ERC-20 token contract address.
- Group13TokenSale: Token sale contract that manages pricing and ETH exchanges on the Group13Token.

Then performs some initial setup:

- Takes the first account (the deployer) provided by Hardhat as the owner of the contracts.
- Moves sale-allocated tokens to the sale contract, in this case transfer 500,000 G13 tokens (50% of total supply).
- Adds initial ETH liquidity to the sale contract (100 ETH in this case).

Step 3: Configure MetaMask

1. Add Hardhat Network:

- Open MetaMask browser extension
- Click on the network dropdown (usually shows "Ethereum Mainnet")
- Click "Add a custom network"
- Fill in:
 - Network Name: Hardhat or any name you prefer
 - New RPC URL: `http://127.0.0.1:8545`
 - Chain ID: 1337 (same as the [hardhat.config.js](#) file)
 - Currency Symbol: ETH
- Click "Save"

Select a network



Binance Smart Chain

Add



OP Mainnet

Add



Polygon Mainnet

Add



zkSync Era Mainnet

Add

Show test networks



Sepolia



Linea Sepolia



Mega Testnet



+ Add a custom network

<

Add a custom network

×

Network name

Hardhat

According to our records, the network name may not correctly match this chain ID.

Suggested name: [Localhost 8545](#)

Default RPC URL

127.0.0.1:8545

✓

Chain ID

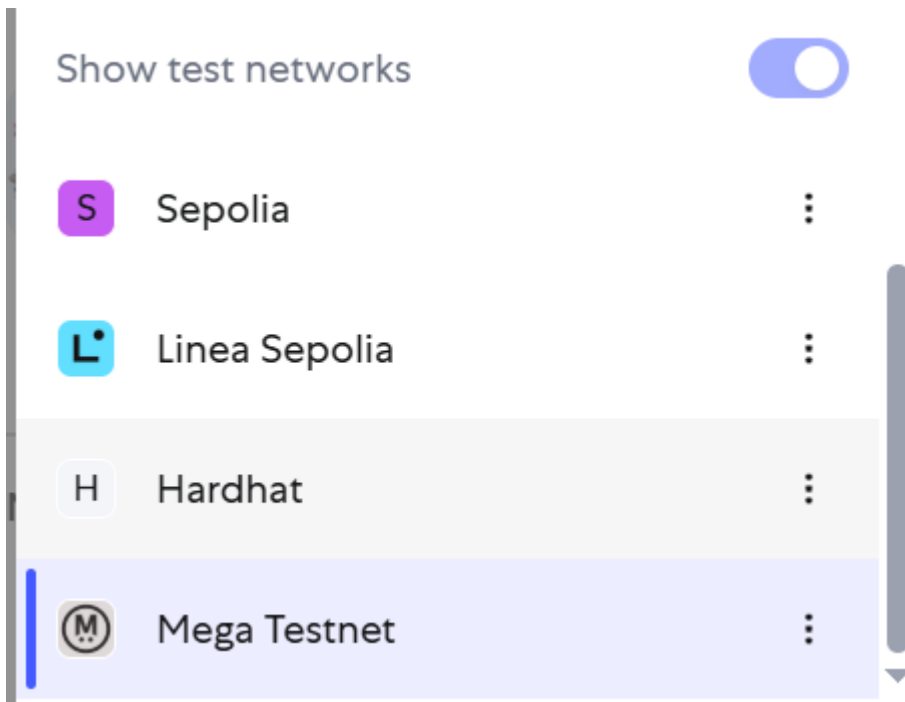
1337

Currency symbol

ETH

Save

Then REMEMBER to choose this network in MetaMask:



2. Import Test Account:

- Click on the account icon in MetaMask
- Select "Import Account"
- Enter one of the private keys from Step 1 when you run the `npm run node` command. For example, in my case I will copy the first private key:

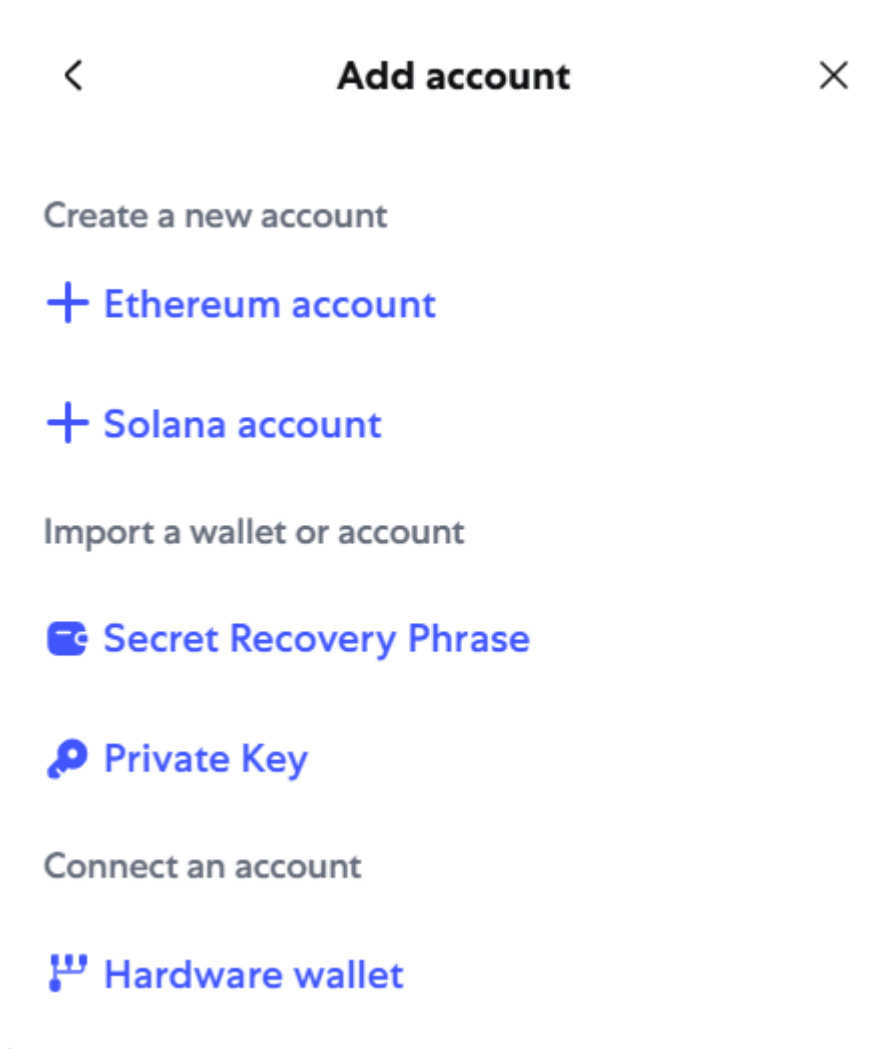
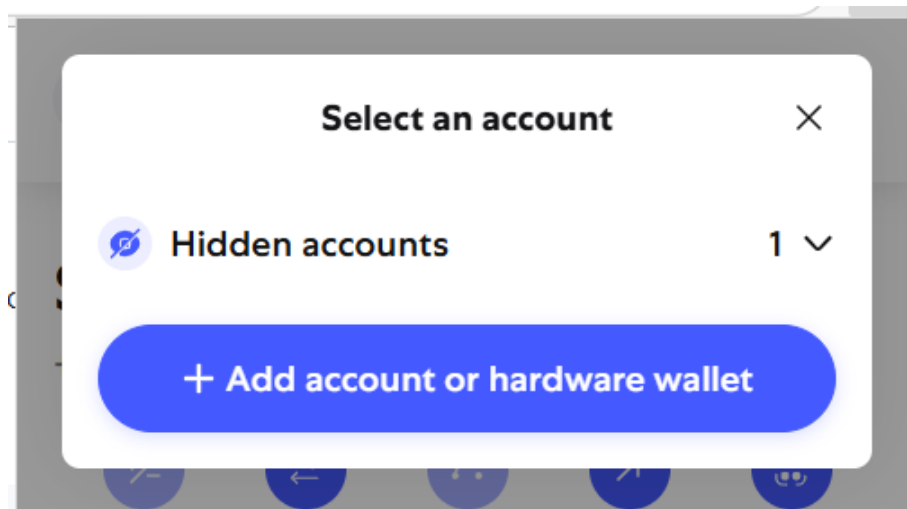
```
0xac0974bec39a17e36ba4a6b4d238ff944bacb478cbed5efcae784d7
```

as the first account (this is the owner of the contracts as we defined in the `deploy.js` script). And the second private key

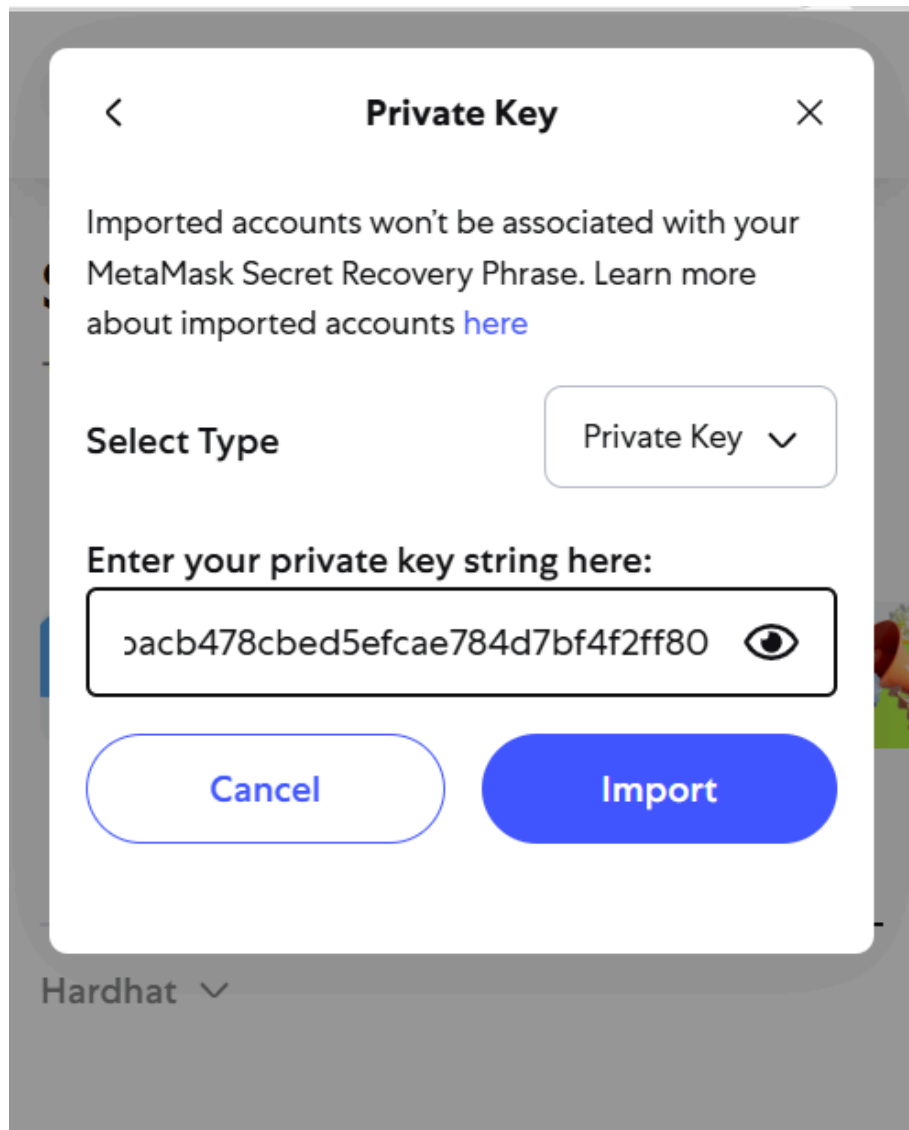
```
0x59c6995e998f97a5a0044966f0945389dc9e86dae88c7a8412f4603
```

as the second account, acts as a normal user who have interest to buy/sell tokens from/to the sale contract.

- Click "Import"



Choose Private Key as the import method, then paste the private key you copied from the terminal in Step 1. You can repeat this step to import more accounts if needed.



Step 4: Start Web Interface

Open a third terminal and run:

```
cd /home/chutrunganh/Blockchain-and-Applications-IT4527E/Lab_03
npm run frontend
```

This will start the NextJS web interface for interacting with your token sale contract. Open your browser and go to: <http://localhost:3000>

Then, it will require you to connect your MetaMask wallet (you should already installed this browser extension). There are some basic instructions on the web interface to guide you through the process as I have mentioned in step 3.

Group13 Token Sale

Buy G13 tokens with our tiered pricing system

Connect Wallet

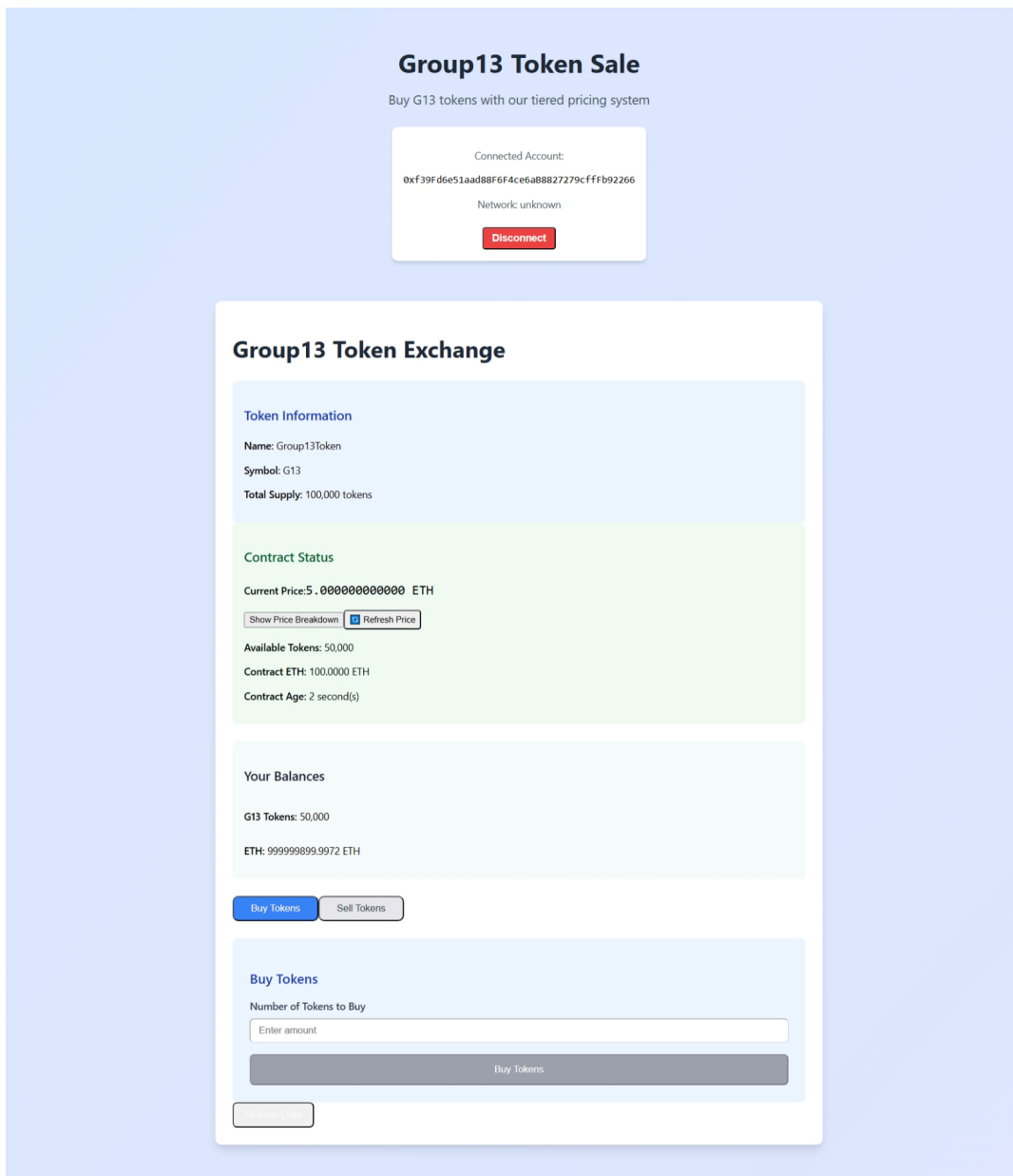
Setup Instructions:

1. Make sure you have MetaMask installed
2. Add Hardhat local network to MetaMask:
 - Network Name: Hardhat
 - RPC URL: `http://127.0.0.1:8545`
 - Chain ID: 1337
 - Currency Symbol: ETH
3. Import a Hardhat account using one of the private keys
4. Start the Hardhat local node: `npx hardhat node`
5. Deploy contracts: `npx hardhat run scripts/deploy.js --network localhost`

Click "Connect Wallet", pay attention the the current chosen Account in MetaMask, the web will connect to the account you have chosen in MetaMask.

3. Interact with the Token Sale

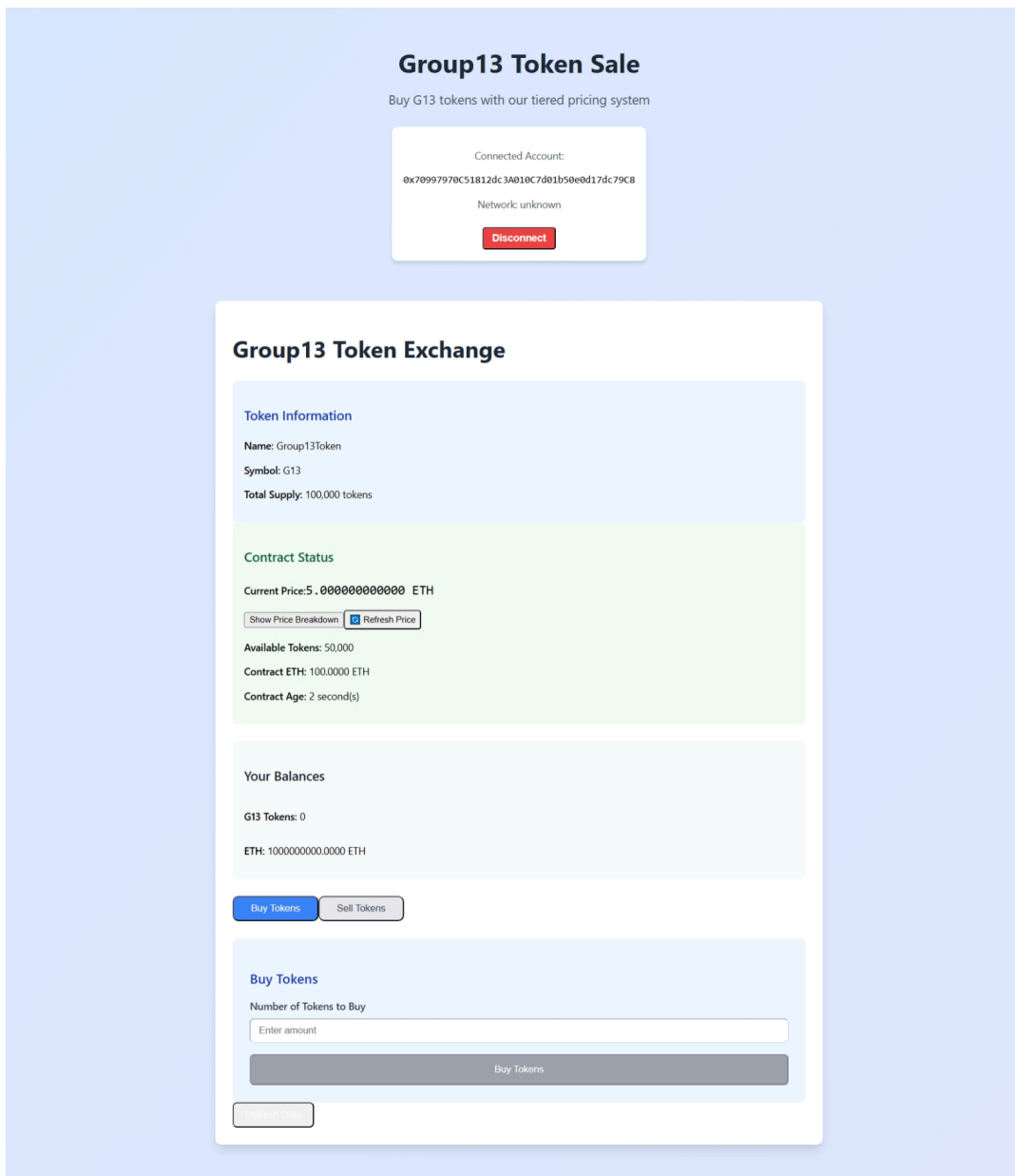
In my case, I am at the first metamask account (the owner of the contracts), I can see the following information:



This is the owner account, so:

- The owner balance with G13 token is 50000 (50% of total supply) as we have transferred this amount to the sale contract in the `deploy.js` script.
- The owner balance with ETH is approximately 1 000 000 000 ETH as we config each created account have 1 million ETH in the `hardhat.config.js` file. (You will see 999 999 999,.. ssince we must spend a little bit ETH when deploying the contracts).
- The sale constract current balance (see in the green box) is 100 ETH, as we have added this amount to the sale contract in the `deploy.js` script.

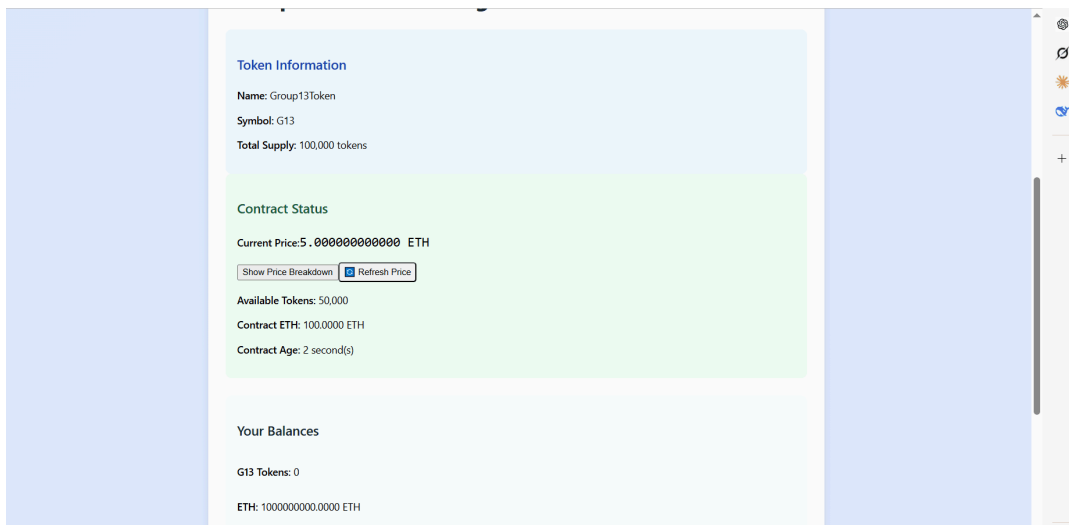
Now switch the account in MetaMask to the second account (the normal user account) and reconnect to the Metamask wallet (open the MetaMask extension, click on the account icon, then click "Connect"). You should see something like this:



The information about the contracts are the same, but the user balance is different:

- The user balance with G13 token is 0 as this account has not bought any tokens yet.
- The user balance with ETH is 1 000 000 000 ETH as we config each created account have 1 million ETH in the `hardhat.config.js` file.

Then try to buy for example 1000 G13 tokens:



This will cost $5 \times 1000 = 5000$ ETH, and the user will pay this amount to the sale contract. The price is calculated as follows:

After buying:

Group13 Token Sale

Buy G13 tokens with our tiered pricing system

Connected Account:

0x70997970c51812dc3A018C7d01b50e0d17dc79C8

Network: unknown

Disconnect

Group13 Token Exchange

Token Information

Name: Group13Token

Symbol: G13

Total Supply: 100,000 tokens

Contract Status

Current Price: 5.000000218845 ETH

[Hide Price Breakdown](#) [Refresh Price](#)

Base Price: 5.0 ETH

ETH Balance: 5100.000219060040505 ETH

Time Elapsed: 0.017164351851851 days

Daily Interest Rate: 0.00025000% per day

Compound Factor: 1.000000043769097222

Formula: $\text{BasePrice} \times (1 + \text{InterestRate})^{\text{Days}}$ (compound interest)

Calculated Price: 5.00000021884548611 ETH

Available Tokens: 49,000

Contract ETH: 5100.0002 ETH

Contract Age: 24 minute(s)

Your Balances

G13 Tokens: 1,000

ETH: 999994999.9997 ETH

Buy Tokens

Sell Tokens

Buy Tokens

Number of Tokens to Buy

Enter amount

Buy Tokens

Transaction Hash:

0xb198844267c2b6c0b99d3b9a7928349c1344356ee88c7c302e7a31bfc605c98

Transaction Hash

Transaction History

1:52:04 PM Purchased
1,000,000,000,000,000,000 G13 Tokens for 21 ETH
[View on Etherscan](#)

1:52:04 PM Sold
1,000 G13 Tokens for 5.0000 ETH
[View on Etherscan](#)

See the new price for each token is now 5.000000218845 ETH (by default it the constract already has 100 ETH) since by the formula:

$$\text{Price} = 5 \times \left(1 + \frac{5100.0002}{2 \times 10^9} \right)^{0.017164} = 5.000000219 \text{ ETH}$$

Where:

- `basePrice` = 5 ETH (as we set in the contract)
- `interest rate` = 5100.0002 ETH / (2 * 10⁹) = 0.00000255 ETH, 5100.002 is the current ETH balance of the sale contract
- `days since sale started` = 0.017164 (approximately 0.017 days since the sale started, which is about 24 hours)

Also notice the change in the sale contract balance, it is now have 5100.0002 ETH, which is the amount of ETH the user has paid to buy the tokens and the token from 50 000 decrease to 49 000 G13 tokens (50 000 - 1000 = 49 000).

Buy one more 1000 G13 tokens, we see that they need to buy with a new price that previous transaction has updated the price, now it is 5.000000218845 ETH:

Buy Tokens

Number of Tokens to Buy

Estimated Cost: 5000.000219 ETH

Buy Tokens

Then after buying this, the price is updated again, it now approximately 5.00000059 ETH:

Contract Status

Current Price: 5.000000592381 ETH

[Hide Price Breakdown](#)

[Refresh Price](#)

Base Price: 5.0 ETH

ETH Balance: 10100.000811734664345 ETH

Time Elapsed: 0.023460648148148148 days

Daily Interest Rate: 0.00050500% per day

Compound Factor: 1.000000118476273148

Formula: $\text{BasePrice} \times (1 + \text{InterestRate})^{\text{Days}}$ (compound interest)

Calculated Price: 5.00000059238136574 ETH

Available Tokens: 48,000

Contract ETH: 10100.0008 ETH

Contract Age: 33 minute(s)

Notice that now the ETH of the sale contract increase to 10100.00081 ETH, and the token balance of the sale contract decrease to 48000 G13 tokens (49 000 - 1000 = 48 000).

See the transaction history:

Transaction History

2:01:08 PMPurchased

1,000,000,000,000,000,000 G13 Tokens 5.000000218845486e+21 ETH

[View on Etherscan](#)

2:01:08 PMSold

1,000 G13 Tokens 5.0000 ETH

[View on Etherscan](#)

1:52:04 PMPurchased

1,000,000,000,000,000,000 G13 Tokens 5e+21 ETH

[View on Etherscan](#)

1:52:04 PMSold

1,000 G13 Tokens 5.0000 ETH

[View on Etherscan](#)

Now I will try to sell back to the contract account 100 G13 tokens, the price is now 5.00000059 ETH from previous transaction:

Sell Tokens

Number of Tokens to Sell

You'll Receive: **500.000059 ETH**

Sell Tokens

After selling, My ETH balance increase and the token decrease (previously after buying 100 tokens two times, I have 200 G13 tokens), selling 100 G13 tokens back to the sale contract, now I only have 1900 G13 tokens left.

Your Balances

G13 Tokens: 1,900

ETH: 999990499.9989 ETH

Buy Tokens

Sell Tokens

See the new updated price is now 5.00000066 ETH:

Contract Status

Current Price: **5.000000660556 ETH**

Hide Price Breakdown

Refresh Price

Base Price: 5.0 ETH

ETH Balance: 9600.000742238715271 ETH

Time Elapsed: 0.027523148148148148 days

Daily Interest Rate: 0.00048000% per day

Compound Factor: 1.000000132111111111

Formula: $\text{BasePrice} \times (1 + \text{InterestRate})^{\text{Days}}$ (compound interest)

Calculated Price: 5.000000660555555555 ETH

Available Tokens: 48,100

Contract ETH: 9600.0007 ETH

Contract Age: 39 minute(s)

The ETH balance in the sale contract is decreased but the time is also increase (more significantly) so by the formula the price is still increased, now it is 5.00000066 ETH.

Let try to make the contract ETH decrease more dramatically by buying more tokens to see if the price is decreased:

Selling 1000 G13 tokens back to the sale contract to make the sale contract ETH balance decrease:

Sell Tokens

Number of Tokens to Sell

You'll Receive: **7500.000991 ETH**

Sell Tokens

Recheck our balance:

Your Balances

G13 Tokens: 400

ETH: 999997999.9998 ETH

Buy Tokens

Sell Tokens

New price is now decreased to 5.00000015 ETH, which is lower than the previous price 5.00000066 ETH:

Contract Status

Current Price:5.000000157972 ETH

Hide Price Breakdown

 Refresh Price

Base Price: 5.0 ETH

ETH Balance: 2099.9996584887152785 ETH

Time Elapsed: 0.030104166666666666 days

Daily Interest Rate: 0.00010495% per day

Compound Factor: 1.000000031594322916

Formula: $\text{BasePrice} \times (1 + \text{InterestRate})^{\text{Days}}$ (compound interest)

Calculated Price: 5.00000015797161458 ETH

Available Tokens: 49,600

Contract ETH: 2099.9997 ETH

Contract Age: 43 minute(s)