Blockchain Smart Contract Lab

Remix Ethereum Platform and UI

2-Hour Hands-On Workshop

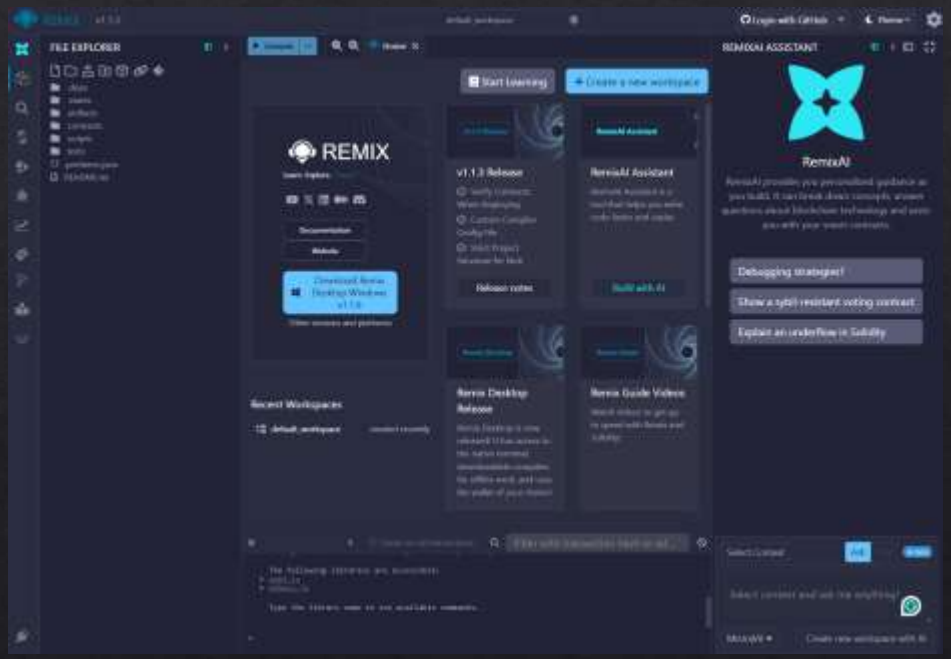
Vangelis Malamas, Dimitris Koutras, Spiros Papagiannopoulos

Quick Overview

- Blockchain is a distributed ledger technology that records transactions across multiple computers securely, immutably, and transparently.
- Ethereum is a blockchain platform that allows developers to create and deploy decentralized applications (dApps) using smart contracts written in Solidity.
- A Smart Contract is a self-executing digital agreement coded in Solidity. It enforces terms automatically without intermediaries.

Remix IDE Introduction

- Remix IDE is a browser-based development environment that supports writing, compiling, deploying, and debugging Solidity smart contracts.



Remix IDE Interface Components

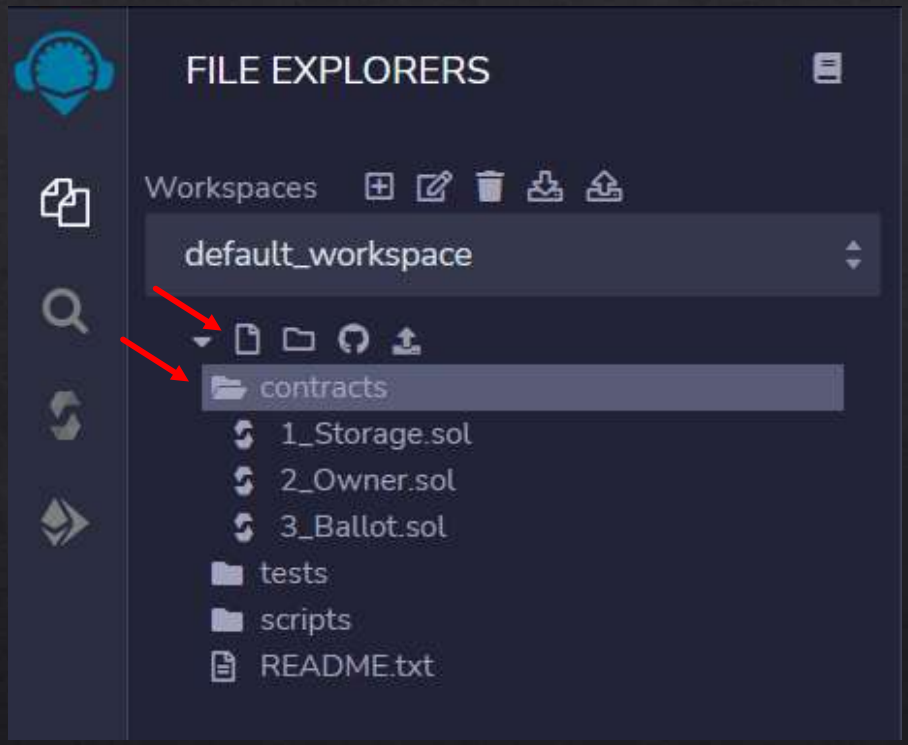
- Begin by opening a browser and navigate to:

https://remix.ethereum.org

File Explorer
Code Editor
Compiler
Deploy & Run panel
Console.

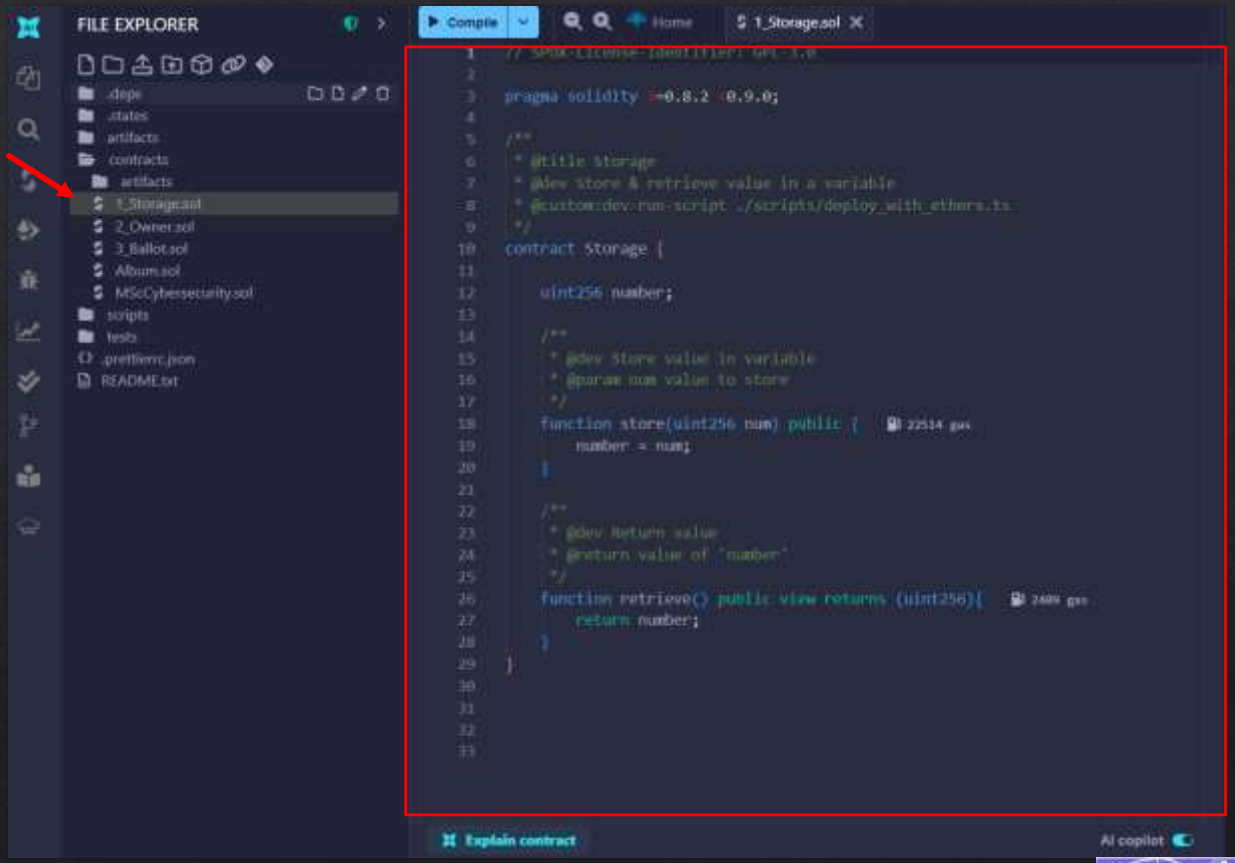
Remix IDE File Explorer

Create a new contract



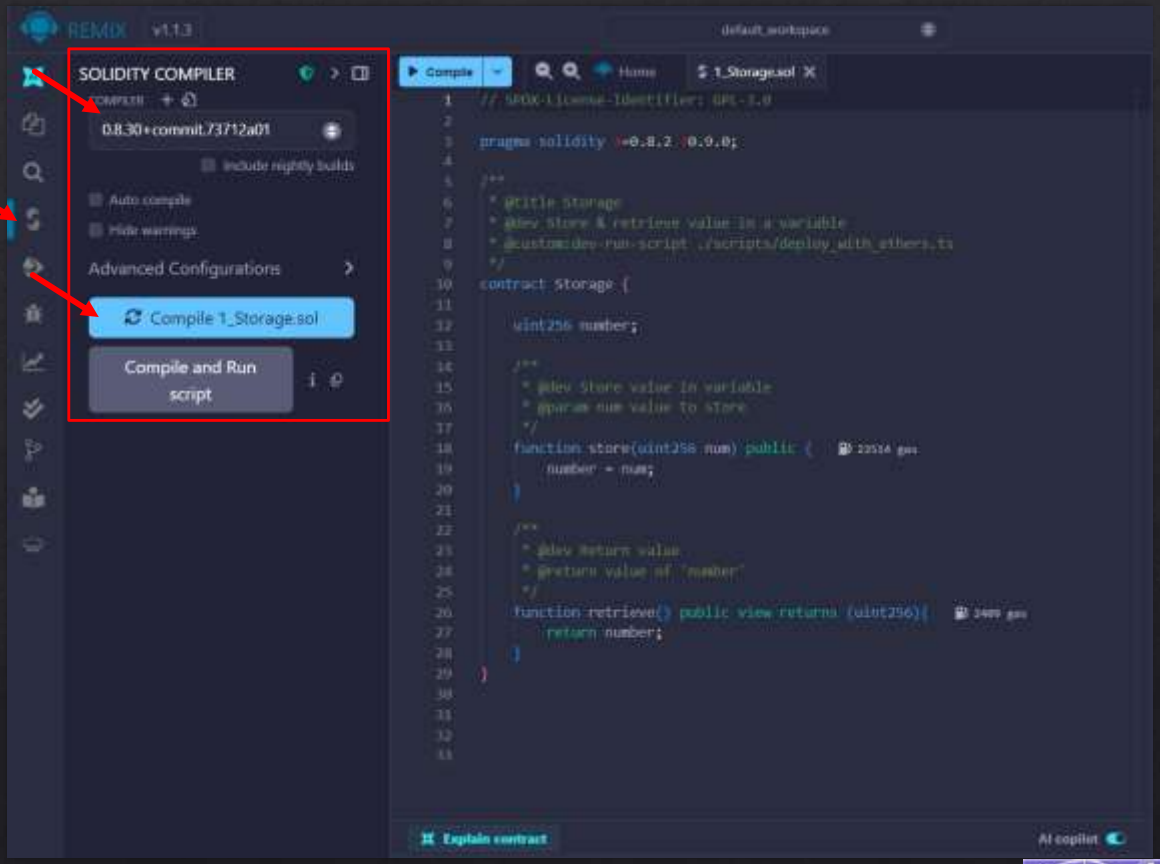
Remix IDE Code Editor

Write the SC



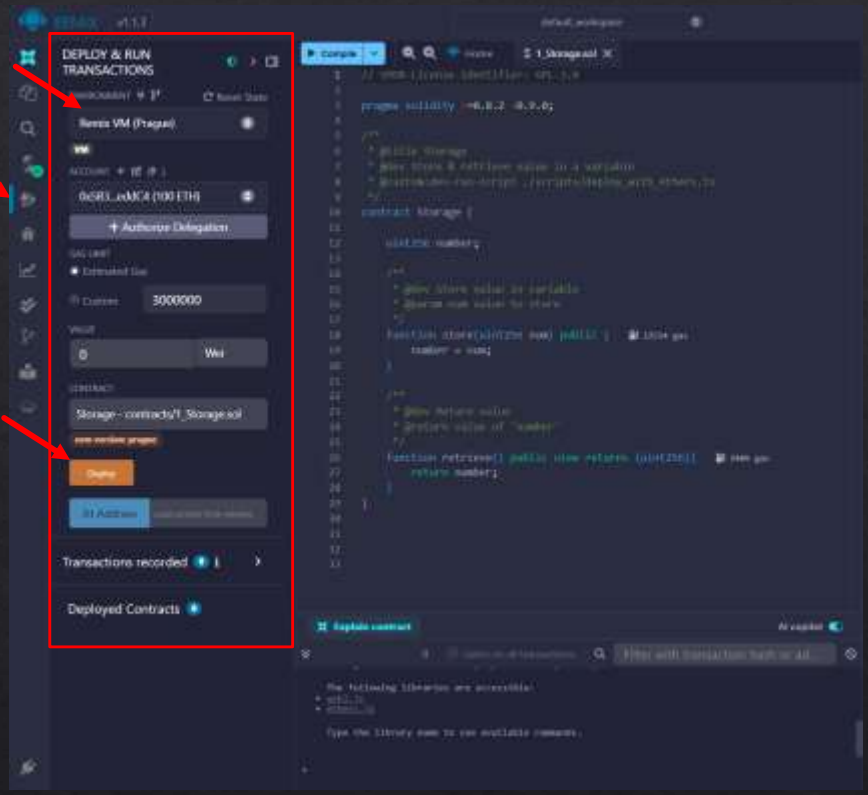
Remix IDE Compiler

Compile the SC

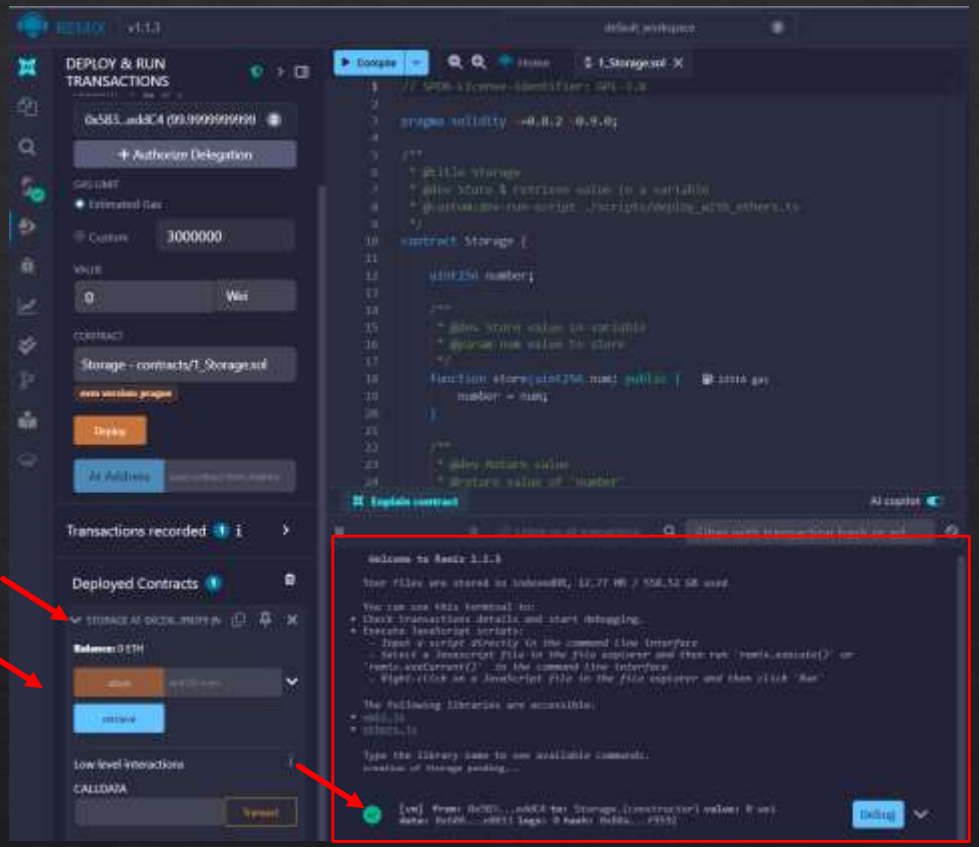


Remix IDE Deploy & Run

Deploy & Run the SC



Remix IDE Console



Developing dApp

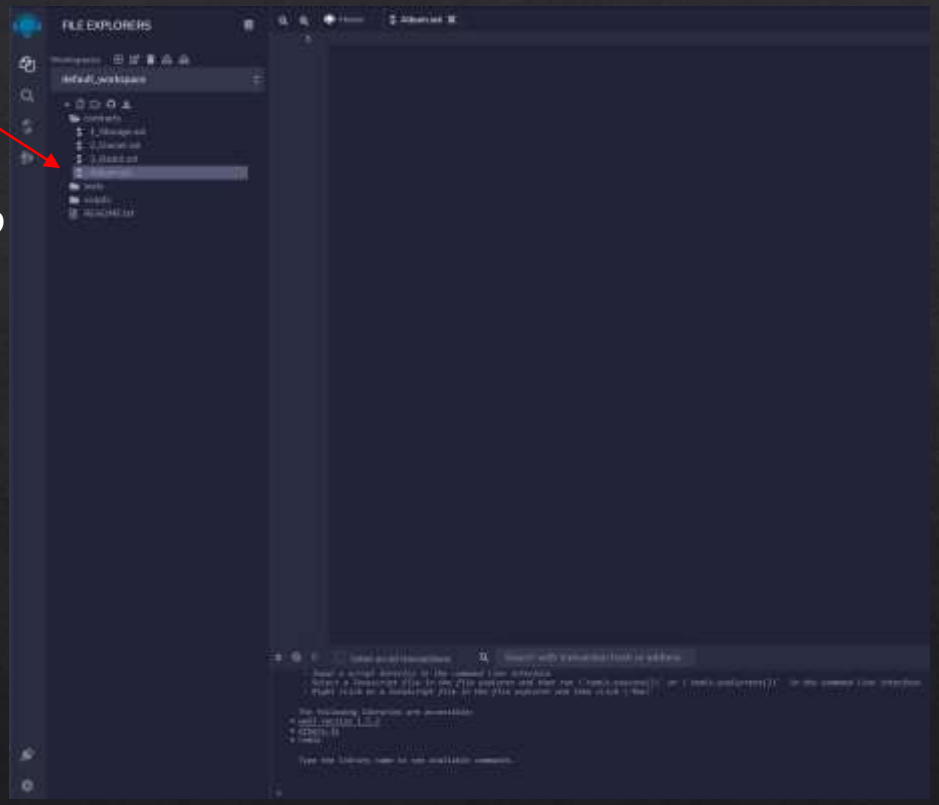
Use Case: Jukebox

- General Description: *Build an app which uses an Ethereum blockchain network to keep track of the albums our Jukebox device is playing. This Jukebox allows users to request not just a song but an entire album.*

  - The decentralized, permanent ledger will serve as the official, trusted source of record for calculating royalty payments to the artists

Writing the First Smart Contract

- First, we create a new SC named "*Album.sol*" from the File Explorer tab




```
// SPDX-License-Identifier: CC-BY-1.0
// Creative Commons Attribution 1.0 Generic

// Contract will be compiled on version 0.7.0 or greater
pragma solidity ^0.7.0;

// A smart contract to model a music album
contract Album {

} // Album
```

Writing the First Smart Contract

- First, we create a new SC named "*Album.sol*" from the File Explorer tab

- Then we add variables. We assume there are three critical properties of an album that should be tracked:
  - *The artist or group*
  - *The title of the album*
  - *The number of tracks on the album*

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.7.0;

contract Album {
    string public artist;
    string public albumTitle;
    uint public tracks;
     }
```

```
7   // A smart contract to model a music album
8   contract Album {
9
10      // Local state variables
11      // The artist/group who recorded the album
12      string artist = 'Nirvana';
13      // The album's title
14      string albumTitle = 'Nevermind';
15      // The number of tracks on the album
16      uint tracks = 13;
17
18  } // Albu
```

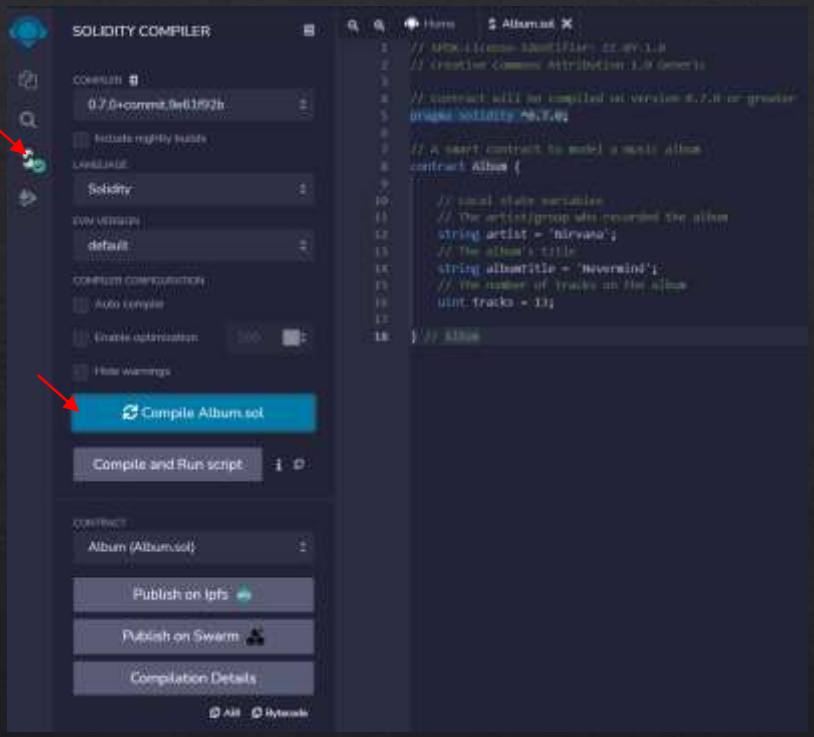
Types of Variables in Solidity

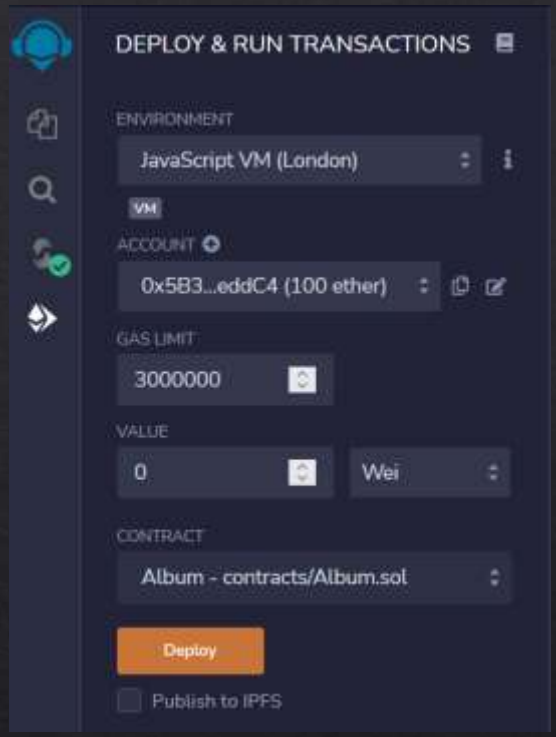
- We need to "characterize" each variable that we use depending on the use purpose:
  - bool: *This is a Boolean type that returns True or False.*
  - int/uint: *Both int and uint represent integers or number values. The main difference is that integer can hold negative numbers as values.*
  - address: *The address type represents a 20byte value, which is meant to store an Ethereum address.*
  - string*: a dynamically signed string (alpha-numeric)*
  - mapping*: Hash tables with key types and values types.*
  - struct*: structs allows us to define new types (objects that contain multiple variables)*
  - bytes*: A dynamically-sized array*

Visibility Specifiers in Solidity

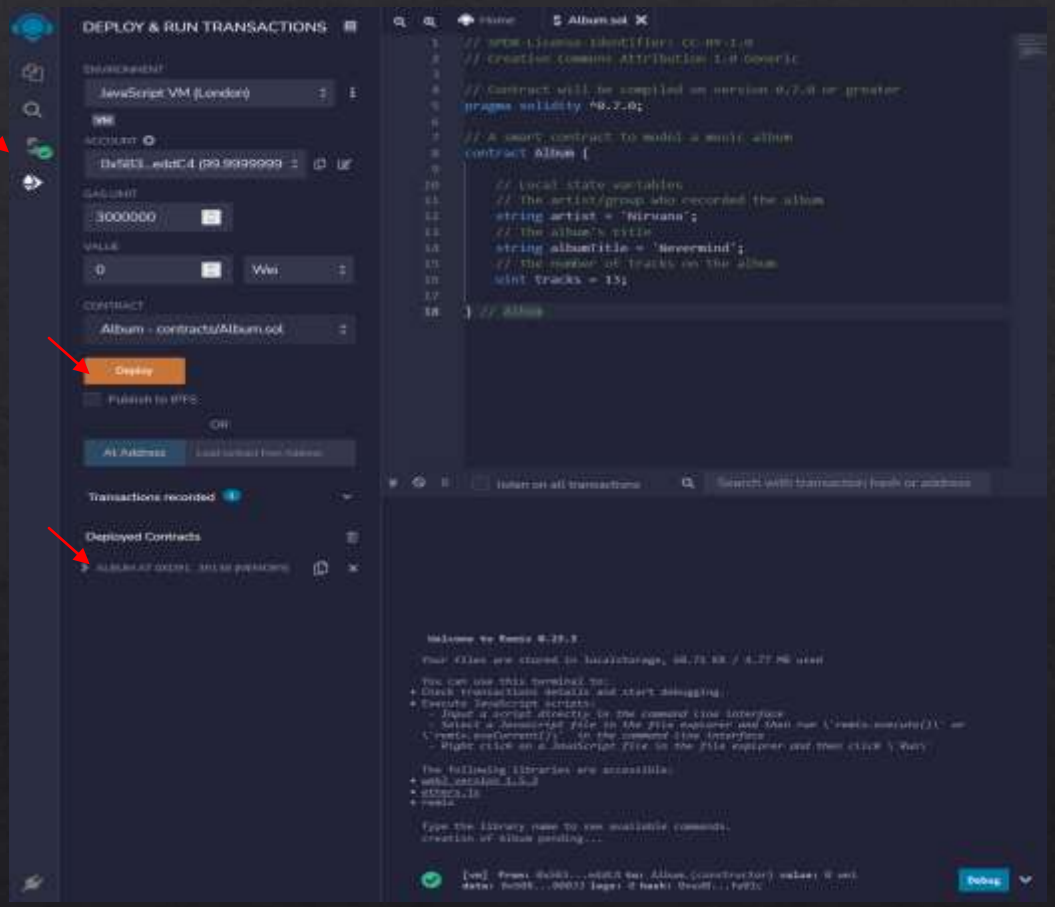
- Solidity has four types of visibilities for both functions and variables:
  - public: *This allows you to define functions or variables that can be called internally or through messages.* [Visible to everyone]
  - private: *private variables and functions are only available to the current contract and not the derived contracts.* [Visible only inside the current contract]
  - internal: *Functions and variables that can only be accessed internally (current contract and derived).* [Visible only inside the current contract and the ones that inherit]
  - external: *functions that can be called from other contracts and transactions. They cannot be called internally, except with "this.functionName()"*

Compile & Deploy "*Album.sol*"





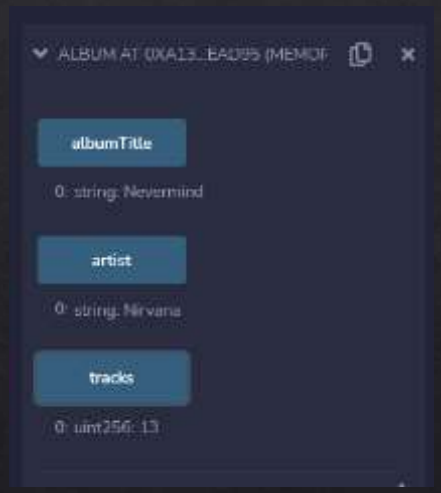
Compile & Deploy "*Album.sol*"



Change variable visibility

- Append the "public" scope modifier to the *artist*, *albumTitle* and *tracks* variables

```
5   pragma solidity ^0.7.0;
6
7   // A smart contract to model a music album
8   contract Album {
9       // Local state variables
10      // The artist/group who recorded the album
11      string public artist = 'Nirvana';
12      // The album's title
13      string public albumTitle = 'Nevermind';
14      // The number of tracks on the album
15      uint public tracks = 13;
16  } // Album
```



Adding a Constructor

- Add a *constructor* to initialize the album data when the contract is deployed:

Constructors are intended to contain any logic that should be performed once initially to ready the application usage

```
// SPDX-License-Identifier: CC-BY-1.0
// Creative Commons Attribution 1.0 Generic

// Contract will be compiled on version 0.7.0 or greater
pragma solidity ^0.7.0;

// A smart contract to model a music album
contract Album {

    // Local state variables
    // The artist/group who recorded the album
    string public artist;
    // The album's title
    string public albumTitle;
    // The number of tracks on the album
    uint public tracks;

    constructor() {
        artist = 'Nirvana';
        albumTitle = 'Nevermind';
        tracks = 13;
    } // constructor

} // Album
```

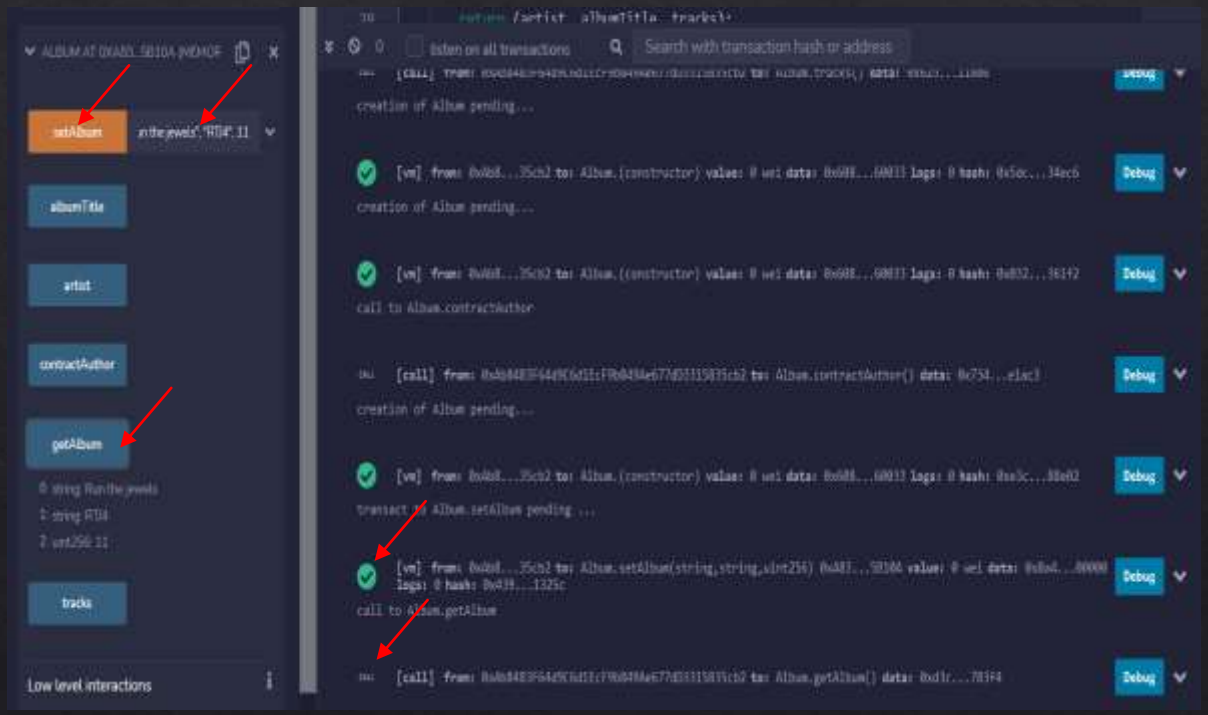
Adding Getter and Setter Functions

- The get function (*getAlbum*) will return the current album information
- The set function (*setAlbum*) will allow the user to change the current album information

```
pragma solidity ^0.7.0;

// A smart contract to model a music album
contract Album {

    // Local state variables
    // The artist/group who recorded the album
    string public artist;
    // The album's title
    string public albumTitle;
    // The number of tracks on the album
    uint public tracks;
        // The author of this smart contract
    string public constant contractAuthor = 'Vangelis Malamas';

    constructor() {
        artist = 'Nirvana';
        albumTitle = 'Nevermind';
        tracks = 13;
    } // constructor

    // Returns the current album information
    function getAlbum() public view returns (string memory, string memory, uint) {
        return (artist, albumTitle, tracks);
    } // getAlbum

    // Set the album information
    function setAlbum(string memory _artist, string memory _albumTitle, uint _tracks) public {
        artist = _artist;
        albumTitle = _albumTitle;
        tracks = _tracks;
    } // setAlbum

} // Album
```

Recompile and Deploy

Recompile and redeploy the updated contract. Use the UI to call getAlbum() and setAlbum() to verify behavior.



Adding and Raising an Event

Defining an Event

Begin by adding the following code to define your new event, albumEvent. Define the event after your local state variables but before your constructor.

```
// Event which will be raised anytime the current album information is updated.
    event albumEvent(string albumEvent_Artist, string albumEvent_Title, uint albumEvent_Tracks);
```

Raising an Event

Add the following code to the setAlbum function. This will raise the event anytime the current album information is changed.

```
// Raise the albumEvent to let any event subscribers know the current album information has changed.
        emit albumEvent(_artist, _albumTitle, _tracks);
```

Adding Access Control

- We will be adding function modifier to our SC which will only allow the contract's owner to update the currrent album information.

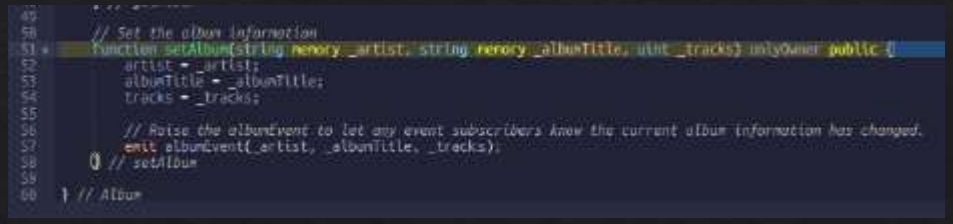
To start, we'll need a variable to store the account number of the contract's owner. Declare a new variable, owner, using the address data type using the code below.

```
// The owner of the current instance of this smart contract
    address owner;
```

```
// Set the owner property of this contract instance to the constructor of this
contract deployment
        owner = msg.sender;
```

Modifier

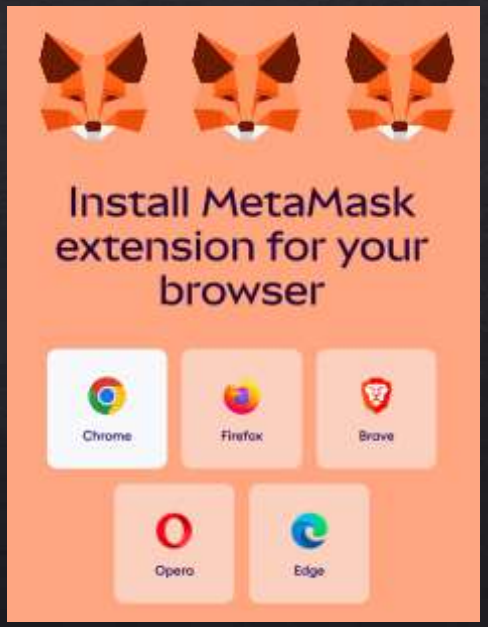
```
// This function modifier ensures that the initiator of any transaction
   //   it is attached to matches the address of the contract's owner.
   // Use this function modifier for functions that should only
   //   be performed by the owner of this contract instance.
   modifier onlyOwner {
      if (msg.sender != owner) {
         // The initiator of this transaction is NOT the contract instance's owner!
      } else {
         _;
      } // else
   } // modifier onlyOwner
```



Connecting the digital wallet MetaMask

Begin by opening a browser and navigate to:

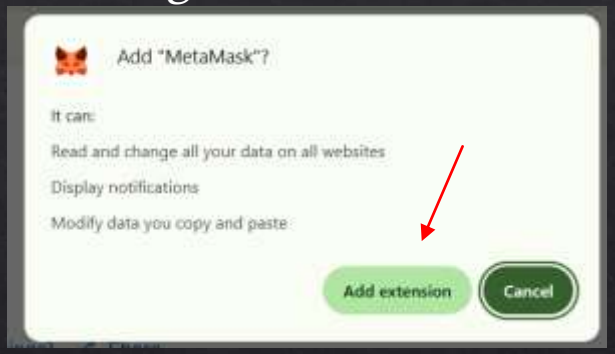
https://metamask.io/download



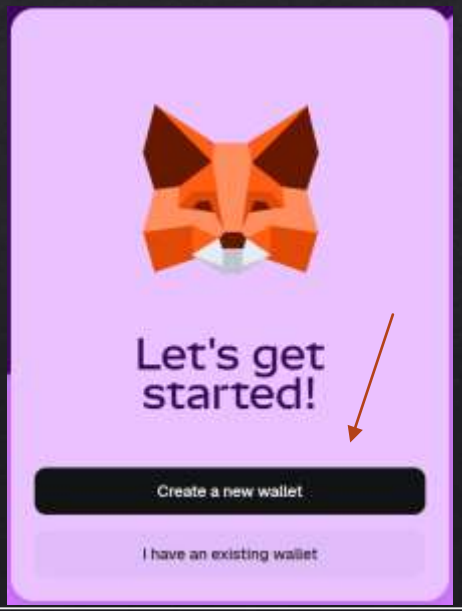
Installing and Setting up MetaMask

1. Click “Add to Chrome” to install the MetaMask browser extension.

2. Confirm the installation by selecting “Add extension.”

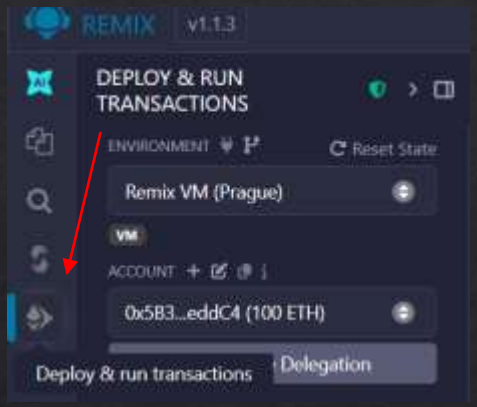


3. Select “Create a new wallet.

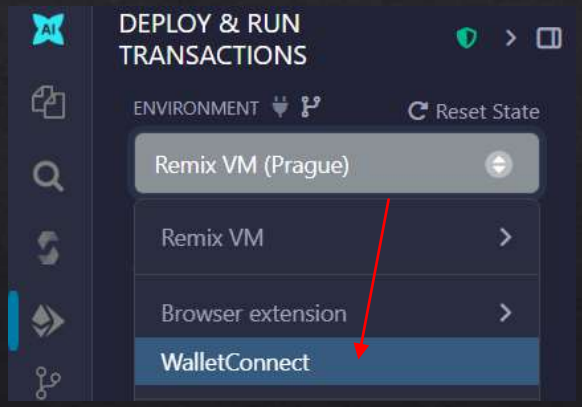


Connecting MetaMask to Remix IDE

1. Open Remix and navigate to the Deploy & Run Transactions panel.

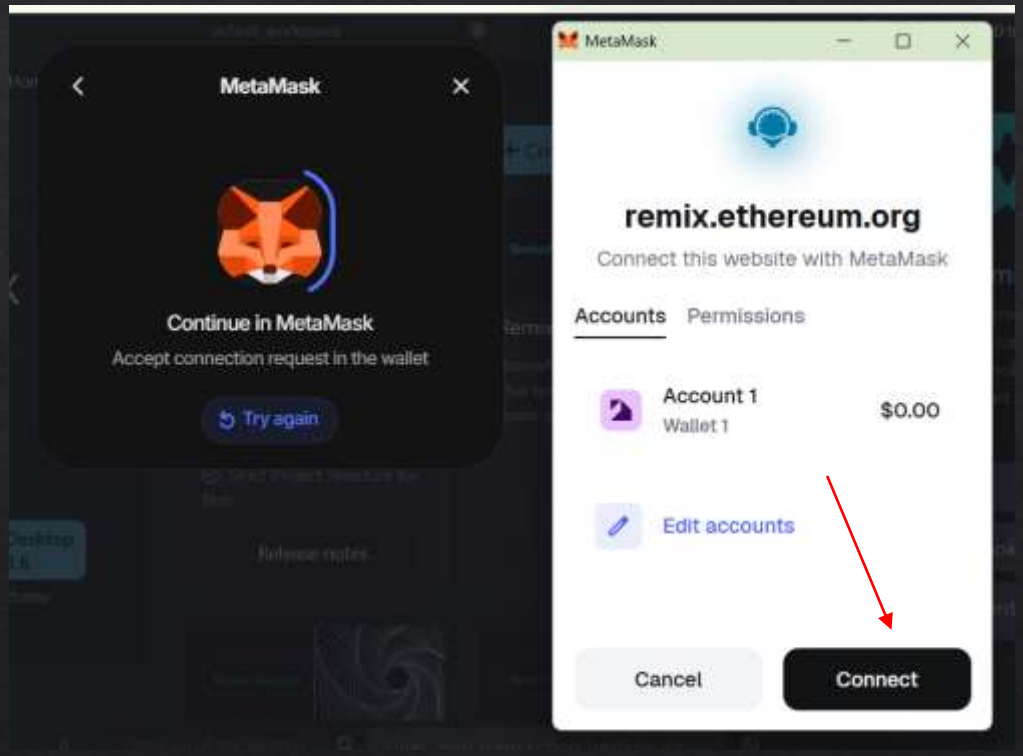


2. Choose Injected Provider MetaMask or WalletConnect from the list.



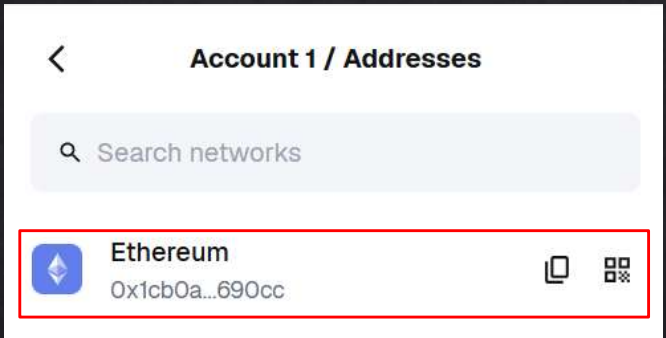
Signing Transactions with MetaMask

Confirm the wallet connection request that appears from remix.ethereum.org. Click Connect to authorize Remix to use your MetaMask account.



Confirming MetaMask Connection

1. Check your MetaMask account address.



2. Verify the same address in Remix.

Installing Node.js and Web3.js on Windows

1. Right-click on the Start Menu → Windows PowerShell → Run as Administrator.

2. Install Node.js and npm (Node Package Manager)

```
npm install -g node
```

3. Check Node.js and npm installation

```
node -v
npm -v
```

4. Install Web3.js library:

```
npm install web3
```

Connecting the SC with the UI

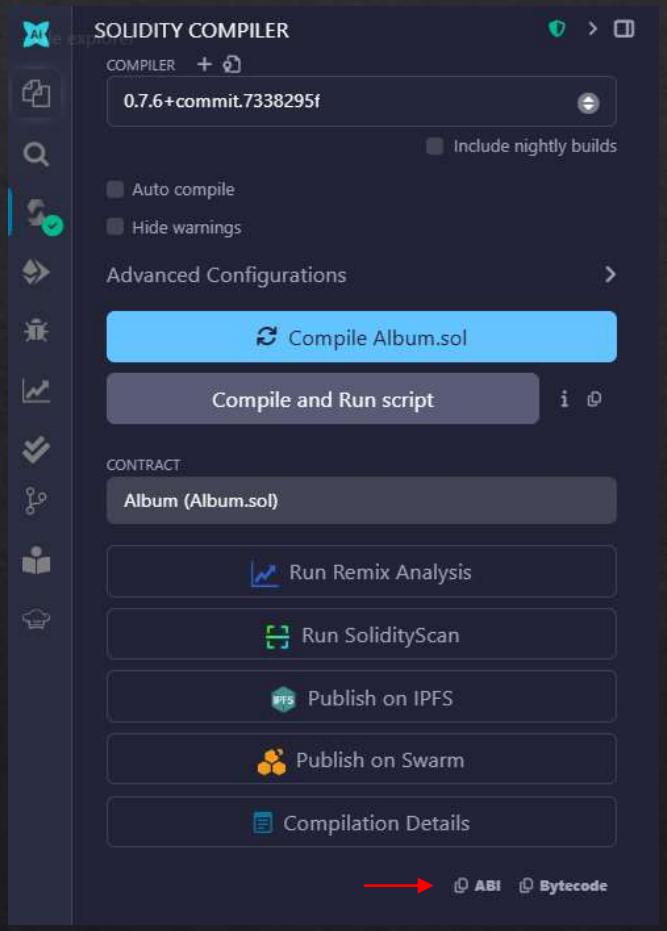
For the frontend we need an html and a css file

index.html

```
// Update these variables with YOUR account number and contract address
var myAccountNumber = 'PASTE YOUR ACCOUNT NUMBER HERE (FROM GANACHE)';
var myContractAddress = 'PASTE YOUR DEPLOYED CONTRACT ADDRESS HERE (FROM GANACHE)';
```

```
// Create a new web3 reference
//This syntax uses Web3's Http. This doesn't support sunscriptions
//web3 = new Web3(new Web3.providers.HttpProvider("http://localhost:7545"));

// The syntax below uses Web3's WebsocketProvider instead of the HttpProvider. This provider DOES support event subscriptions.
let web3 = new Web3(new Web3.providers.WebsocketProvider('ws://localhost:7545'))
```

Inserting the ABI



Copy ABI from the compiler tab in Remix and paste it in the *index.html* file

```
// Build a reference to the smart contract.
var albumContract = new web3.eth.Contract('PASTE YOUR ABI HERE (without the quotes)');
albumContract.options.address = myContractAddress;
```

Keep in mind that every time you recompile the SC you need to adjust the settings in the html file

Resources

Resources:

- Solidity Documentation
- Remix IDE Tutorials
- Ethereum Developer Portal