Remix Documentation

Release 1

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Sep 08, 2022

New Layout Intro

Remix IDE is used for the entire journey of smart contract development by users at every knowledge level. It requires no setup, fosters a fast development cycle and has a rich set of plugins with intuitive GUIs. The IDE comes in 2 flavors (web app or desktop app) and as a VSCode extension.

Remix Online IDE, see: https://remix.ethereum.org

Supported browsers: Firefox, Chrome, Brave. We do not support Remix's use on tablets or mobile devices.

Remix Desktop IDE, see releases: https://github.com/ethereum/remix-desktop/releases

Ethereum-Remix a VSCode extension, see here. The documentation for the VSCode extension is located here.

CHAPTER 1

Remix Project

Remix IDE is part of the Remix Project which also includes the Remix Plugin Engine and Remix Libraries: low-level tools for wider use.

Remix-IDE is available at remix.ethereum.org and more information can be found in these docs. Our IDE tool is available at our GitHub repository.

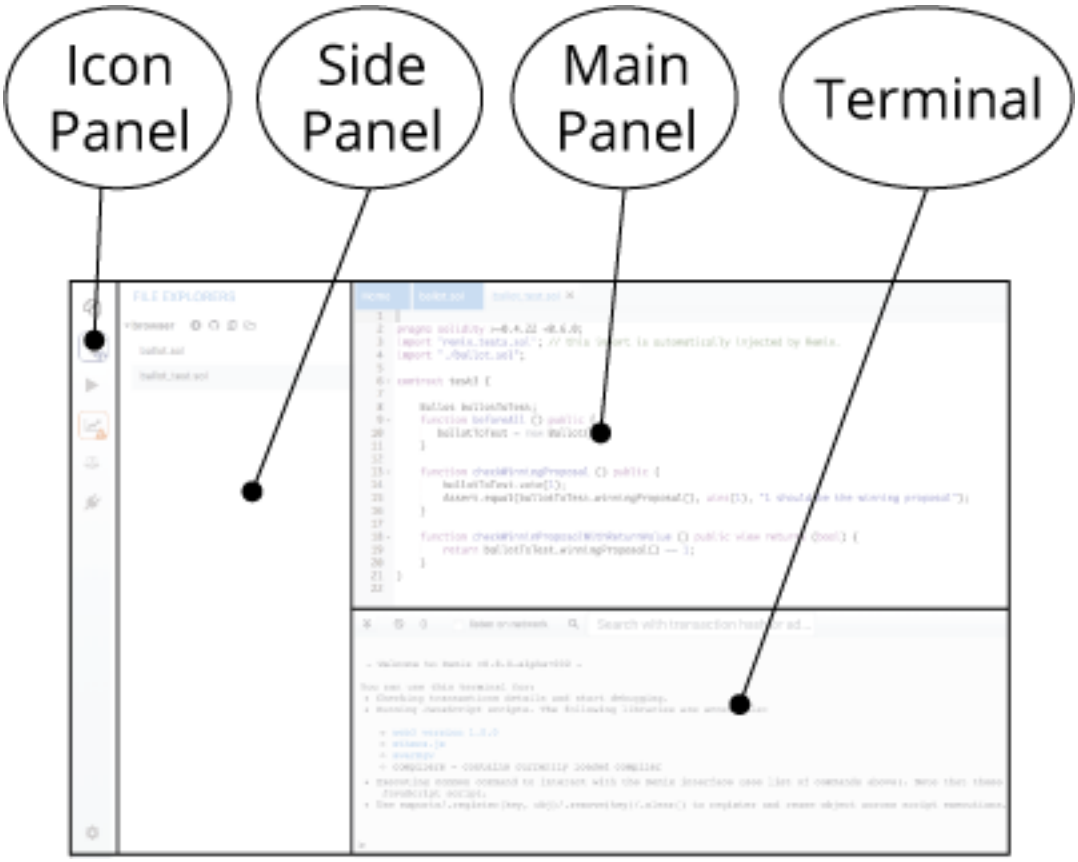
This set of documents covers instructions on how to use Remix. Additional information can be found in our blog and in our tutorial tool, LearnEth located inside of Remix IDE.

Useful links:

- Solidity documentation
- Remix alpha - The version where we test new Remix release (not stable!).
- Remix Desktop - Remix Desktop's release page.
- Remix on Github
- Remix on Medium
- Remix on Twitter
- Our Gitter support channel
- Ethereum.org's Developer resources

1.1 Remix-IDE Layout

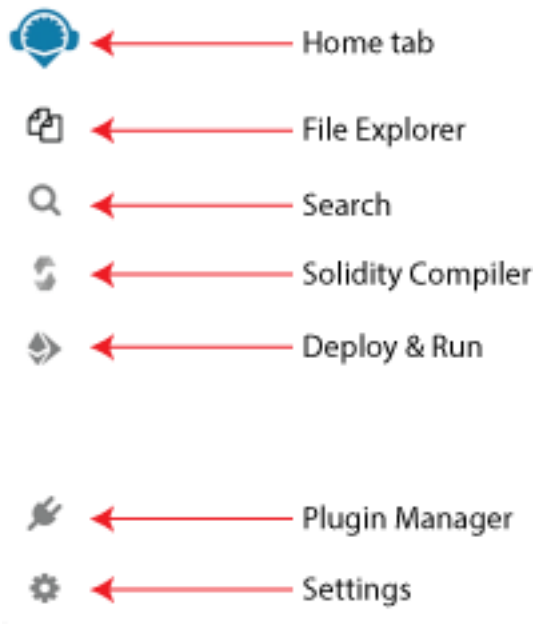
1.1.1 The new structure



1. Icon Panel - click to change which plugin appears in the Side Panel
2. Side Panel - Most but not all plugins will have their GUI here.
3. Main Panel - In the old layout this was just for editing files. In the tabs can be plugins or files for the IDE to compile.
4. Terminal - where you will see the results of your interactions with the GUI's. Also you can run scripts here.

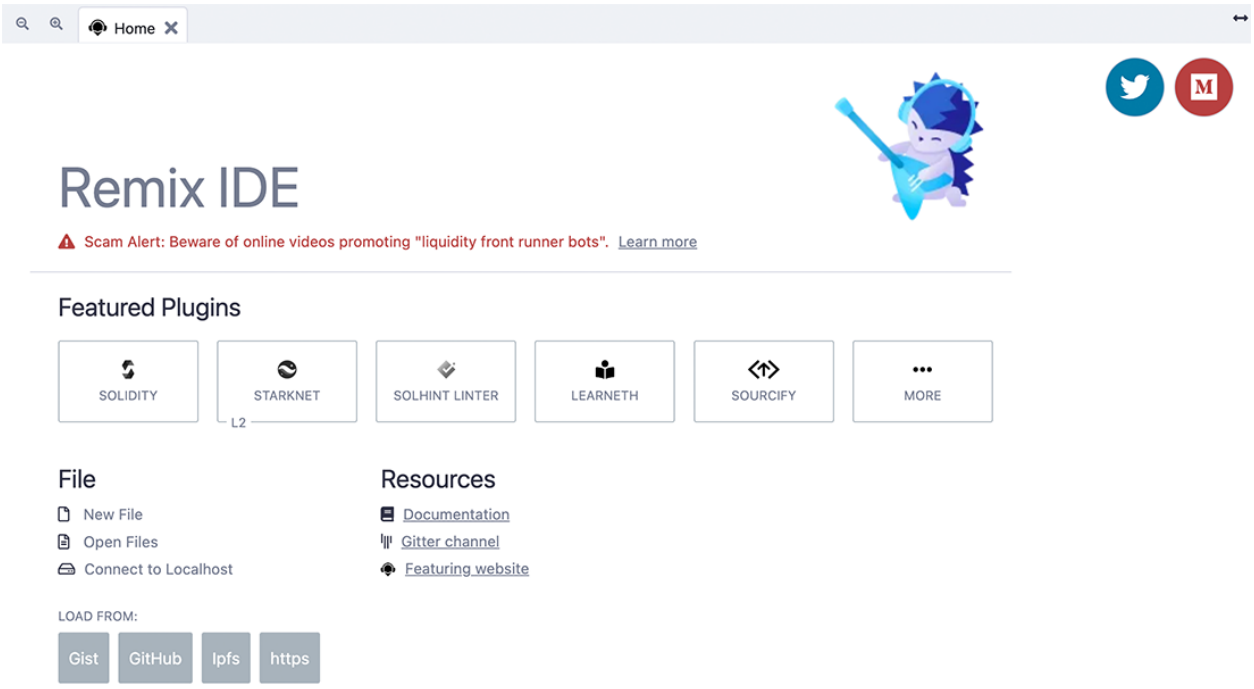
1.1.2 Icon Panel at Page Load

When you load remix - the icon panel show these icons by default.



Everything in Remix is a plugin... so the ***Plugin Manager*** is very important.

1.1.3 Home tab



The home tab is located in the Main Panel. It can be closed. You can also access it (even if closed) by clicking the Remix logo at the top of the icon panel.

The hometab contains links to resources - including links to these docs as well as our Twitter feed, our Medium blog, gitter chat and more. There are also shortcuts for loading files into Remix.

Solidity Environment

Clicking the **Solidity button** in the featured plugins section of the home tab will activate **Solidity Static Analysis** and **Solidity Unit Testing** as well as the Solidity Compiler and Deploy & Run (which are there by default).

To see all the plugins go to the **Plugin Manager** - by selecting the plug in the icon panel.  You can also get there by clicking the **More** button in the featured plugin list.

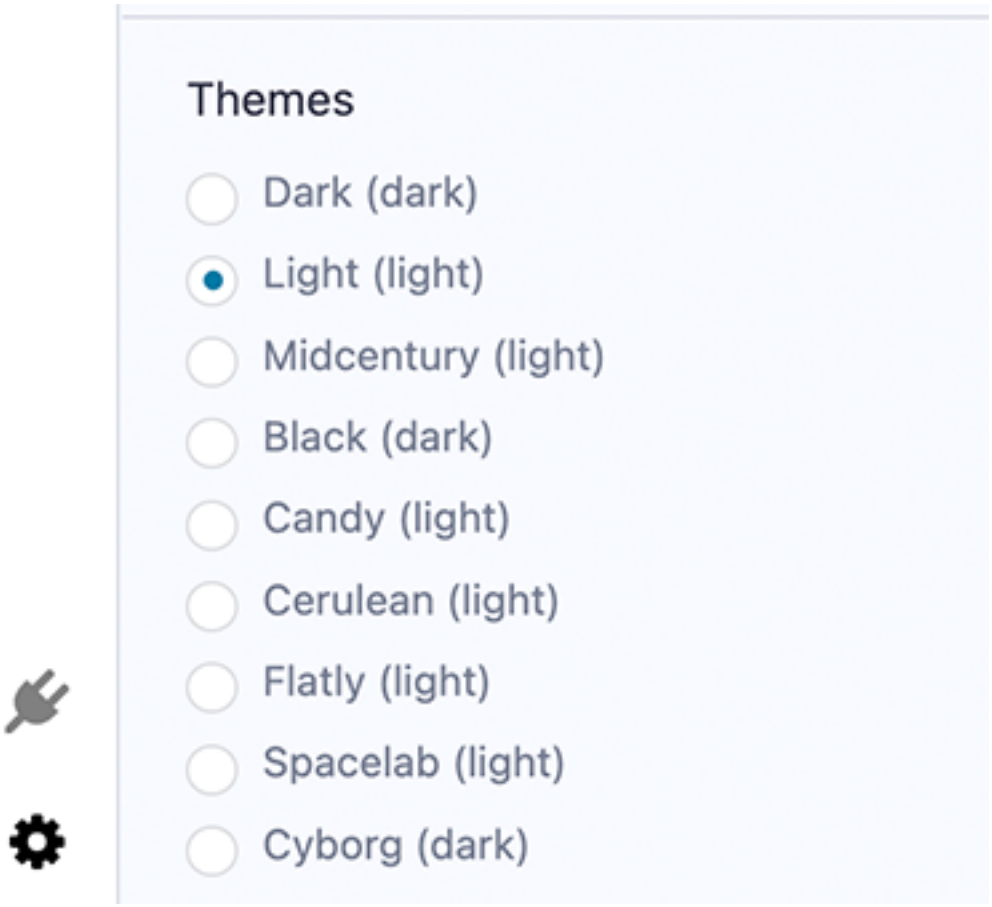
1.1.4 Plugin Manager

In Remix, you only need to load the functionality you need - and the Plugin Manger is where you manage what plugins are turned off or on.

The Plugin Manager is also the place you go when you are creating your own plugin and you want to load your local plugin into Remix. In that case you'd click on the "Connect to a Local Plugin" link at the top of the Plugin Manager panel.

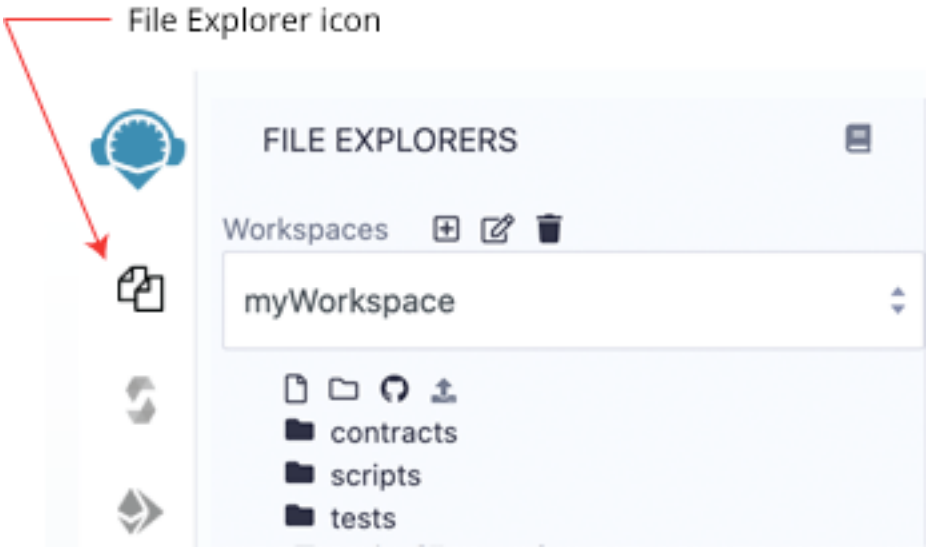
1.1.5 Themes

So you want to work on Remix with a dark theme or a light theme or just a different theme than the one you are currently looking at? At the bottom of the **Settings** plugin is where you can choose a theme. These are bootstrap based themes. The Dark and Light theme have been the most customized for Remix.



1.2 File Explorer

To get to the File Explorer module - click the File Explorer icon.



The File Explorer is for managing Workspaces and files. There is also a context menu that pops up when you right click on a file or folder.

1.2.1 File Storage

By default, Remix IDE stores files in **IndexedDB**.

Coding in Remix IDE Online is different from writing in a Google doc. Yes, both are written in a browser but a Google doc saves your work to Google's servers, and Remix—out of the box—only saves your code to your browser's storage. So tread carefully, browser storage is not permanent!

Important Note: Clearing the browser storage & IndexedDB will **permanently delete** all the files stored there.

1.2.2 File Storage outside of the browser and Version Control

If you want to use browser storage, but also to save a git repo on IPFS, use the **DGIT** plugin.

If you want to store files on your computer's filesystem, use **Remixd** or use the **desktop version of Remix IDE**. Remixd enables you to have access to a selected folder on your hard drive. Remix Desktop is a version of Remix IDE in an Electron app.

Also see this article about securing your files in Remix

1.2.3 File Explorer Tour

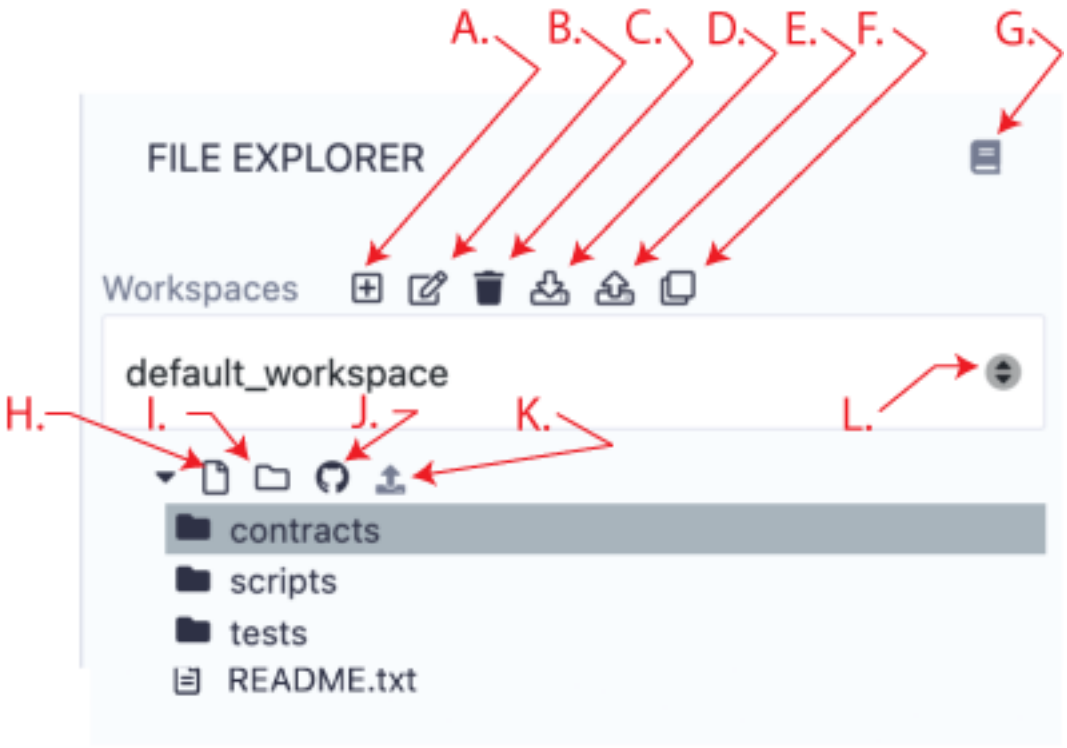


Fig. 1

The book icon - **G.** is the link to the documentation (this page).

Workspaces

Workspaces help to organize your files by allowing you to separate your projects. Here are the basic operations of managing a Workspace. The letters in bold below refer to the labels in fig. 1.

- **A.** Add a Workspace
- **B.** Rename a Workspace
- **C.** Delete a Workspace
- **D.** Download all Workspaces This will create a .zip file with all the files of all the Workspaces. The zip file will have a folder called **.workspaces** that will contain a folder of each workspace. Depending on your OS, you may need to change the preferences on .workspaces folder to make it visible.
- **E.** Upload the Workspaces backup made from the previous icon.
- **F.** Clone a repo from Git repository
- **G.** Link to documentation
- **J.** Publish the Workspace to a GIST
- **L.** Choose a Workspace

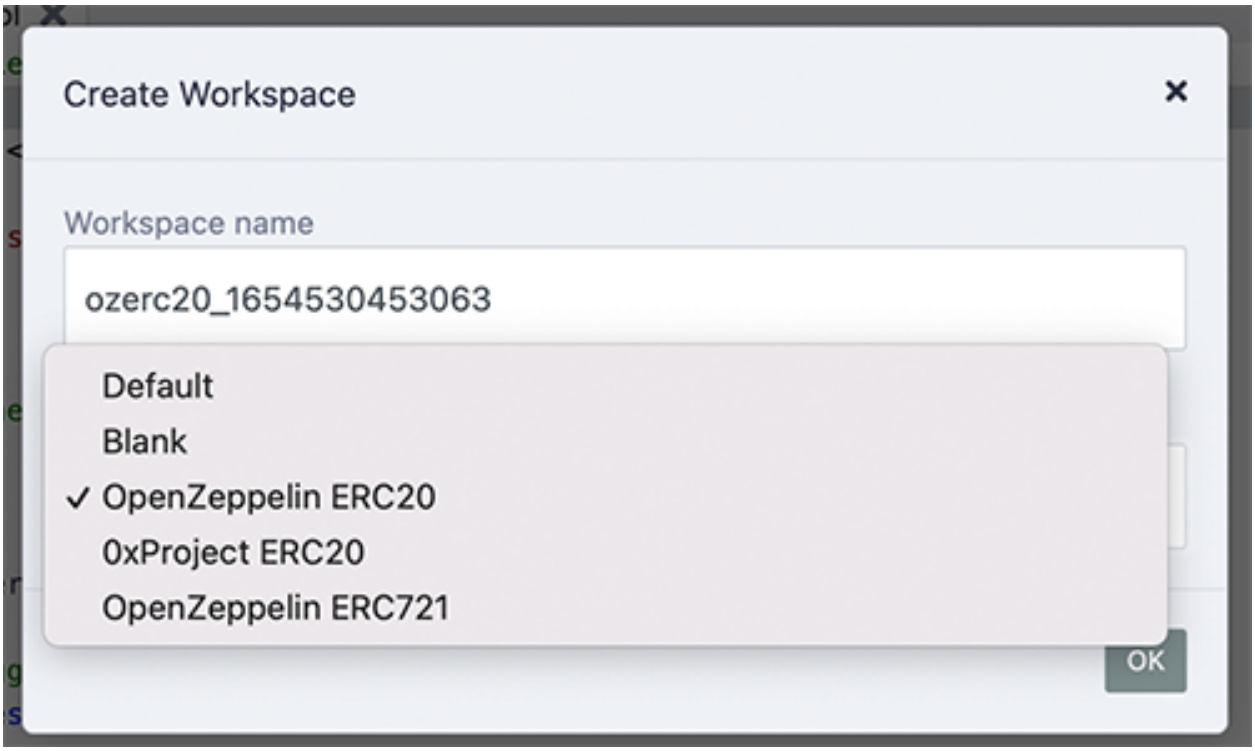
File Manipulation

The letters in bold below refer to the labels in fig. 1.

- **H.** Create a file
- **I.** Create a folder
- **K.** Load a local file into the current Workspace

1.2.4 Workspaces with Templates

When you create a new Workspace, a modal comes up where you choose which template of files to include.

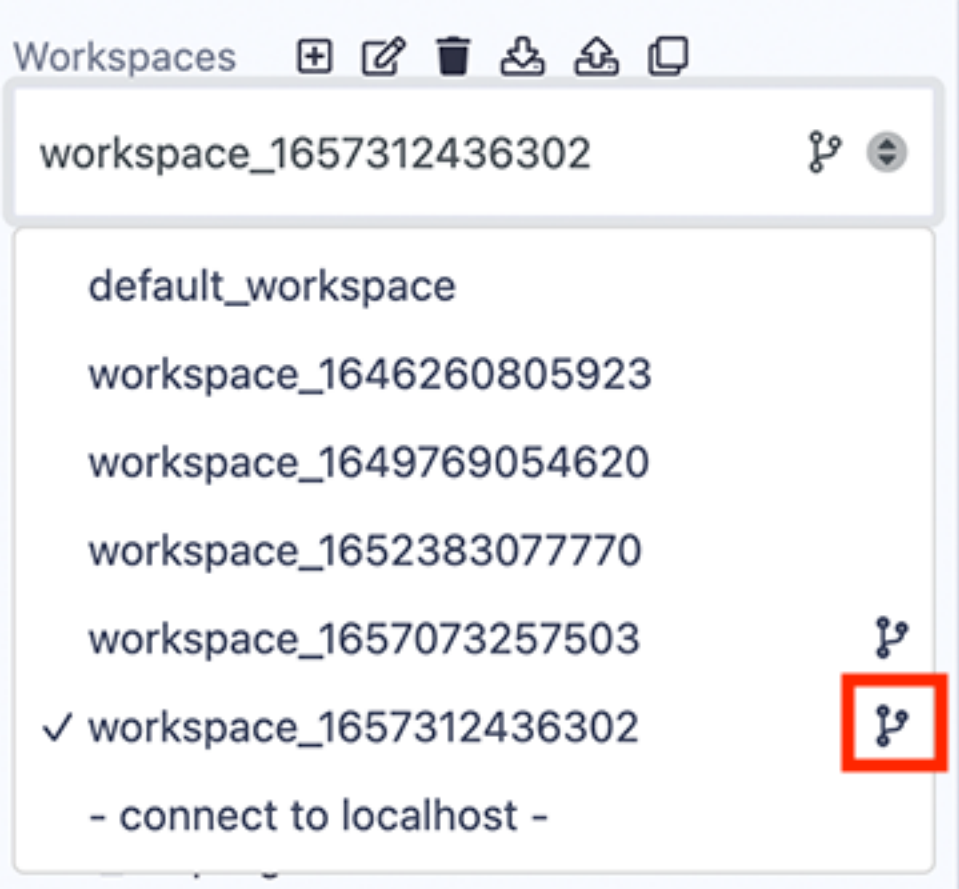


1.2.5 Workspaces & cloning a repo

When you click the **clone** icon (**F.** in fig.1), you'll be asked for the url of the repo. A new workspace will be created that will contain the cloned repo. To manage the Git repo, go to the DGIT plugin.

1.2.6 Workspaces with a Git repo

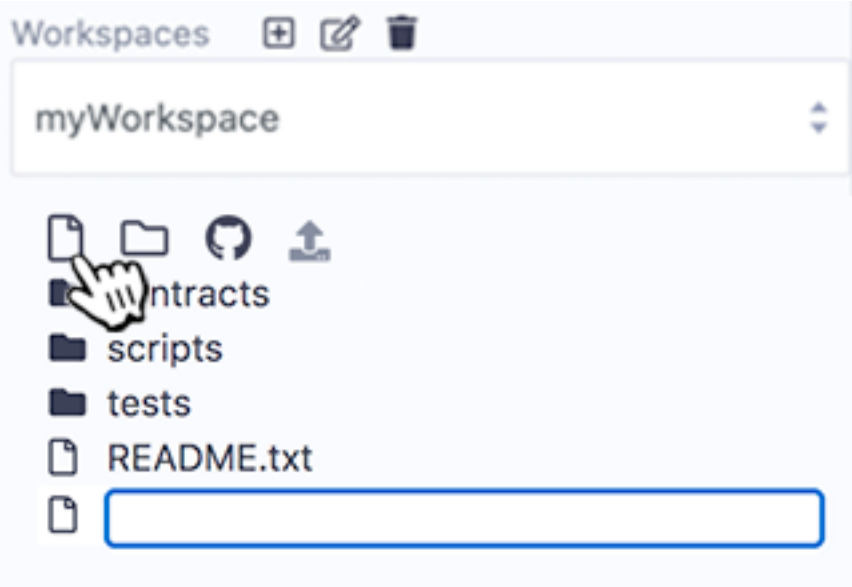
Workspaces with an associated Git will have the Git icon next to them in the Workspaces select box.



1.2.7 Creating new files

There are 2 ways of creating files:

- The first is to click on the new file icon (**H.** in fig.1), then an input for the new file's name will appear in the **File Explorer**. Once a name is entered, a new empty file will open in the Editor. If the file's name is entered **without** a file extension, the extension **.sol** will be appended by default.



- The second way of creating a file is to right click on a file or folder to get a popup menu.

The new file will be placed in **the currently selected folder** of the Workspace. If a file and not a folder is selected, then the new file will be placed in that file's folder. And if nothing is selected, then the file will be placed in the root of the current workspace's folder. Or to be brief — just be mindful of what folder it lands in.

1.2.8 Publish to Gist

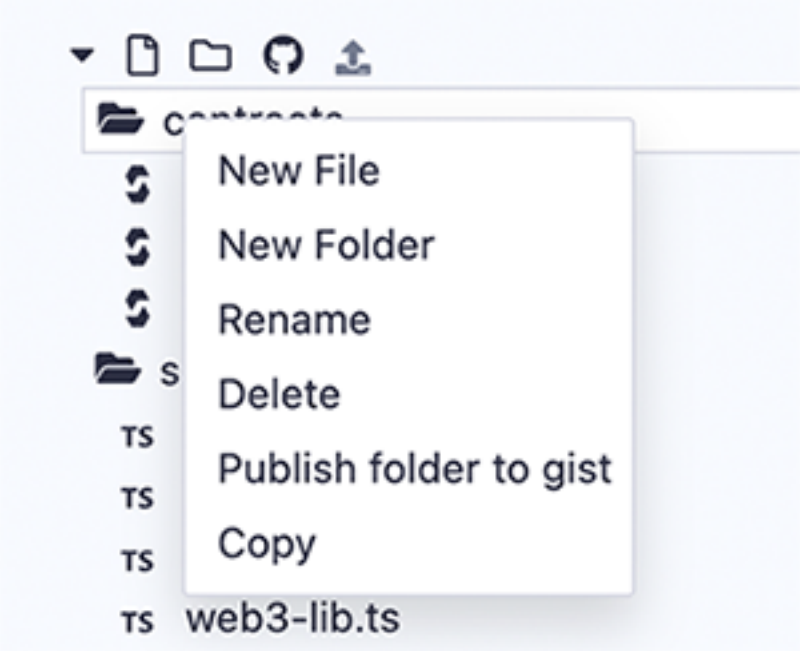
The icon (marked **J.** in fig.1) publishes all files from the current Workspace to a gist. **The Gist API requires users to be authenticated** to be able to publish a gist.

Click this link to Github tokens setup and select Generate new token. Then check the **Create gists** checkbox and generate a new token. Also make sure you check the box to enable the creation of Gists with this token.

Take the token and paste it in Remix's **Settings** module in the **Github Access Token** section. And then click Save.

You can also publish by right clicking on the file or folder.

1.2.9 Right-Click on a File or Folder



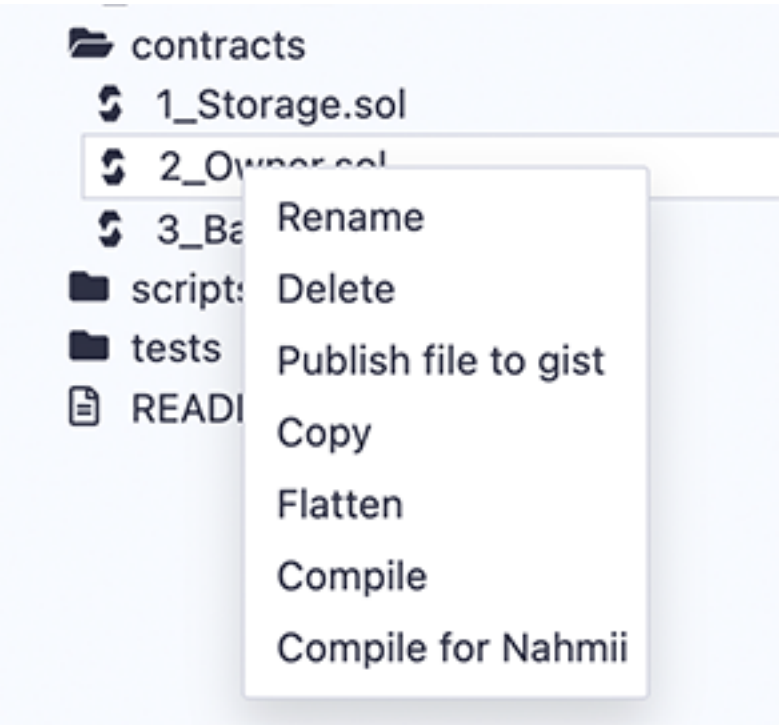
Right-clicking on a file or folder will bring a context menu — where you can create a folder or file within the same folder or to delete, rename, or publish the file or folder.

The functionality of the context menu also works with RemixD (which gives you have access to a folder on your hard drive).

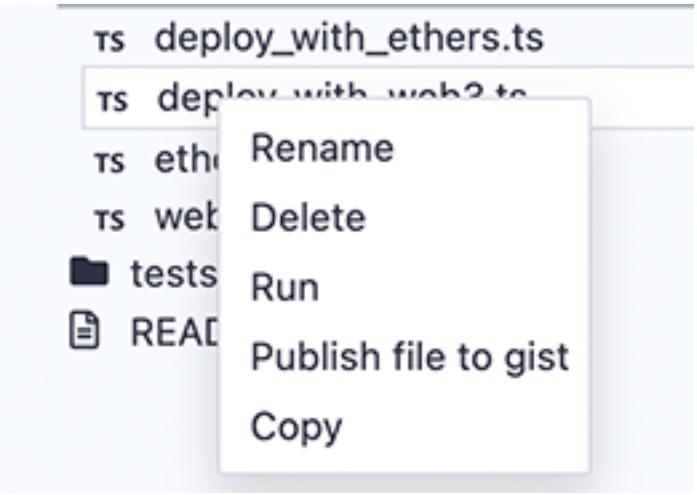
Note: When working with RemixD, and when adding files to the shared folder from your computer (and not from Remix), you'll need to open and close the containing folder or switch in and out of **localhost** workspace to refresh the view.

1.2.10 Right-Click on a Solidity file

Right-clicking on a file with a .sol extension will bring up an expanded context menu - which will also let you compile & flatten a file.



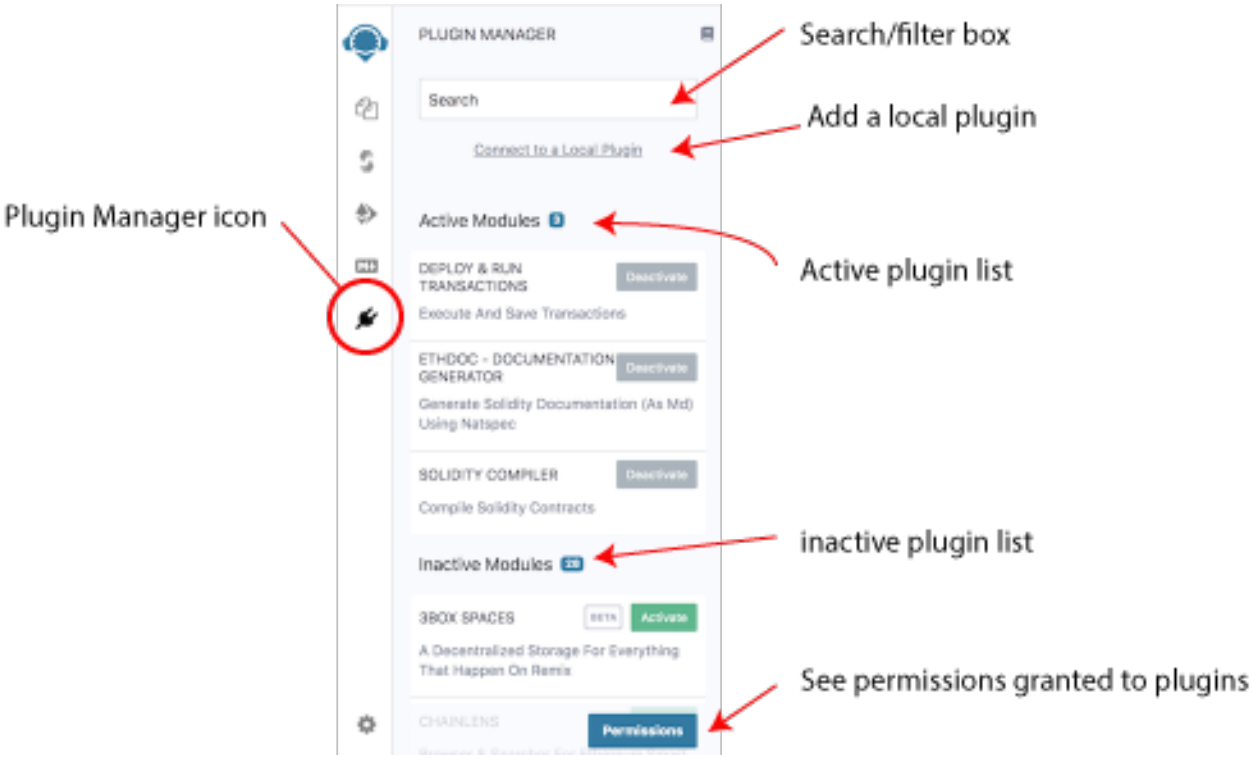
1.2.11 Right-Click on a Script



Right-click on any file with a .js or .ts extension to get the **Run** option in the context menu to run the script. The **Run** in the context menu is a shortcut. The other way to get a script to run is to:

1. Click on the script to make it the active tab in the editor
2. Input the command `remix.exeCurrent()` in the console.

1.3 Plugin Manager

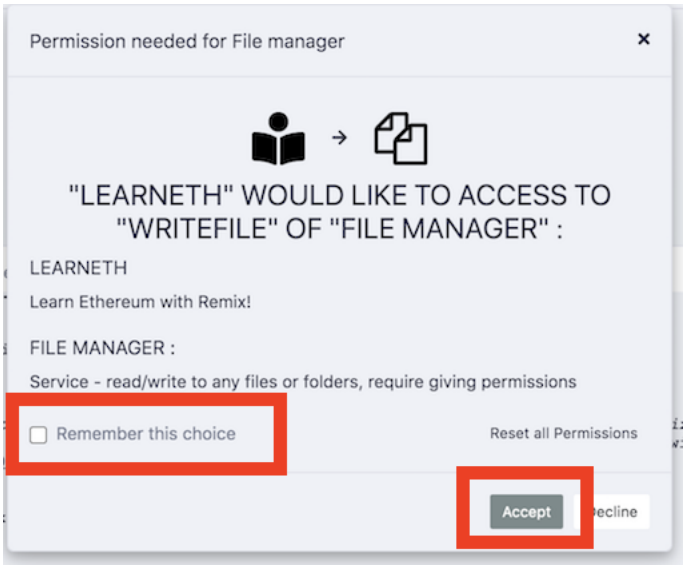


In Remix IDE you only load the functionality you need. Controlling which plugins are active or inactive happens in the **Plugin Manager**.

This plugin architecture has made it possible to integrate tools made by the Remix team with tools made by external teams. This architecture also allows Remix or just parts of Remix to be integrated into other projects.

1.3.1 Manage permissions

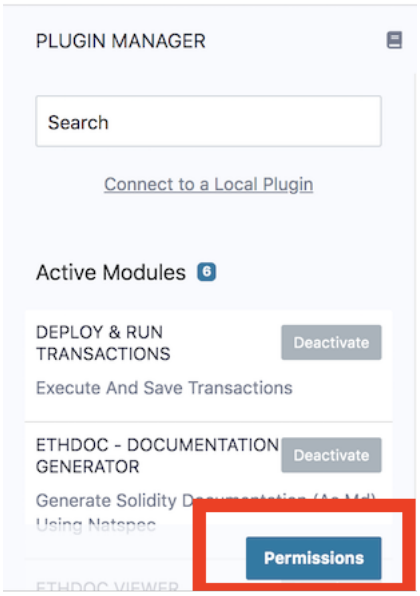
When plugins need to access other plugins for their operation, a modal will appear to ask you for permission.



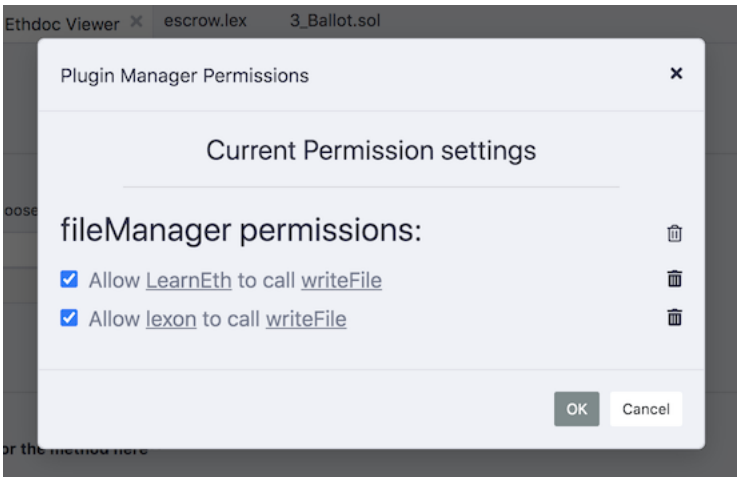
Often, the same plugin will want to do the same action multiple times. So when granting permission, its helpful to click the **Remember this choice** box. If you don't, you might get this modal repeatedly popping up.

1.3.2 View permissions

You can view the permissions that you have granted to plugins by clicking on the **Permissions** button at the bottom of the **Plugin Manager**.

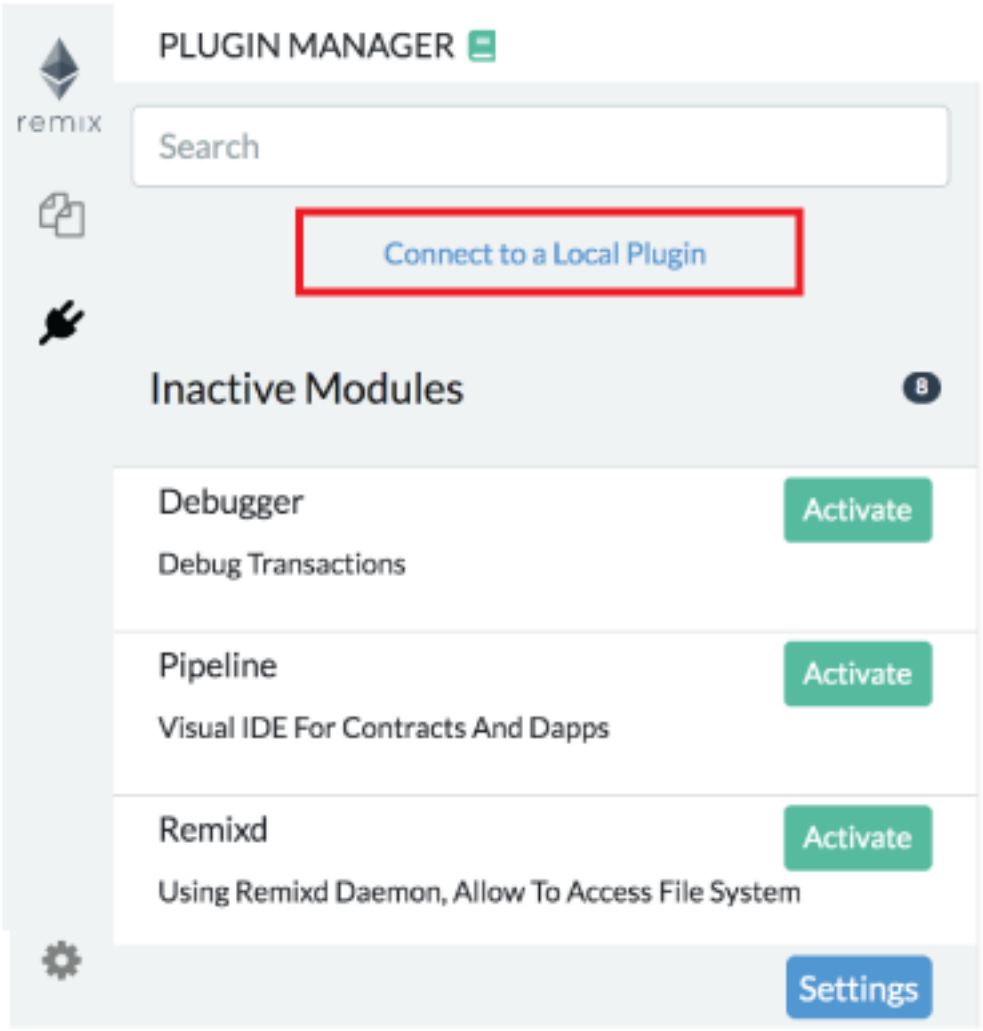


A modal will appear like the one below where you can view and erase the granted permission.



1.3.3 Plugin Devs: Load a local plugin

A plugin in development can be loaded into Remix IDE by clicking the "Connect to a Local Plugin" link at the top of the Plugin Manager panel.



To learn more about how to create your own plugin, go to the README of remix-plugin repo.

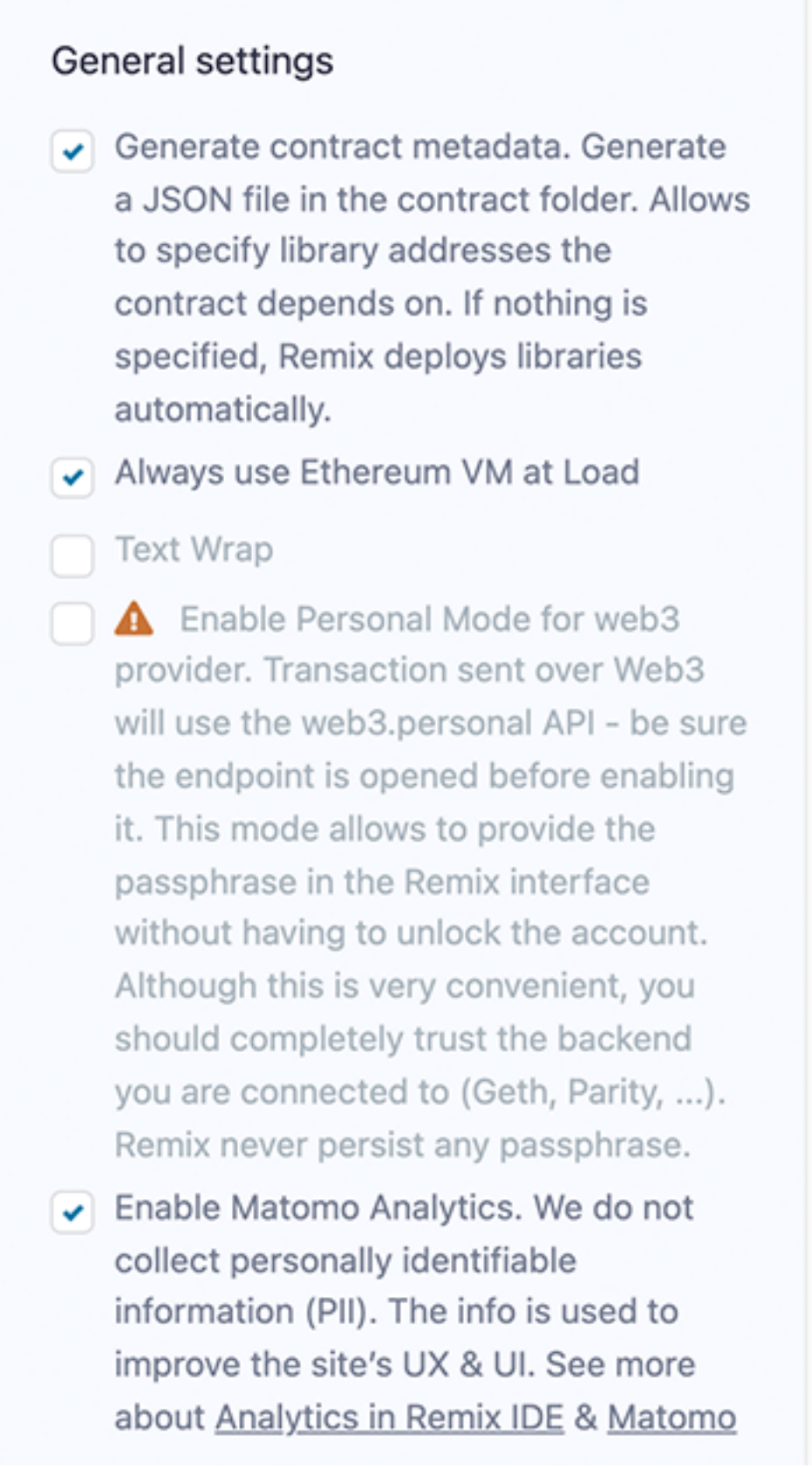
1.4 Settings

To get to **Settings** click the gear at the very bottom of the icon panel.

1.4.1 Reset Button

The Reset button at the top of the Setting panel will reset all of the settings back to the default.

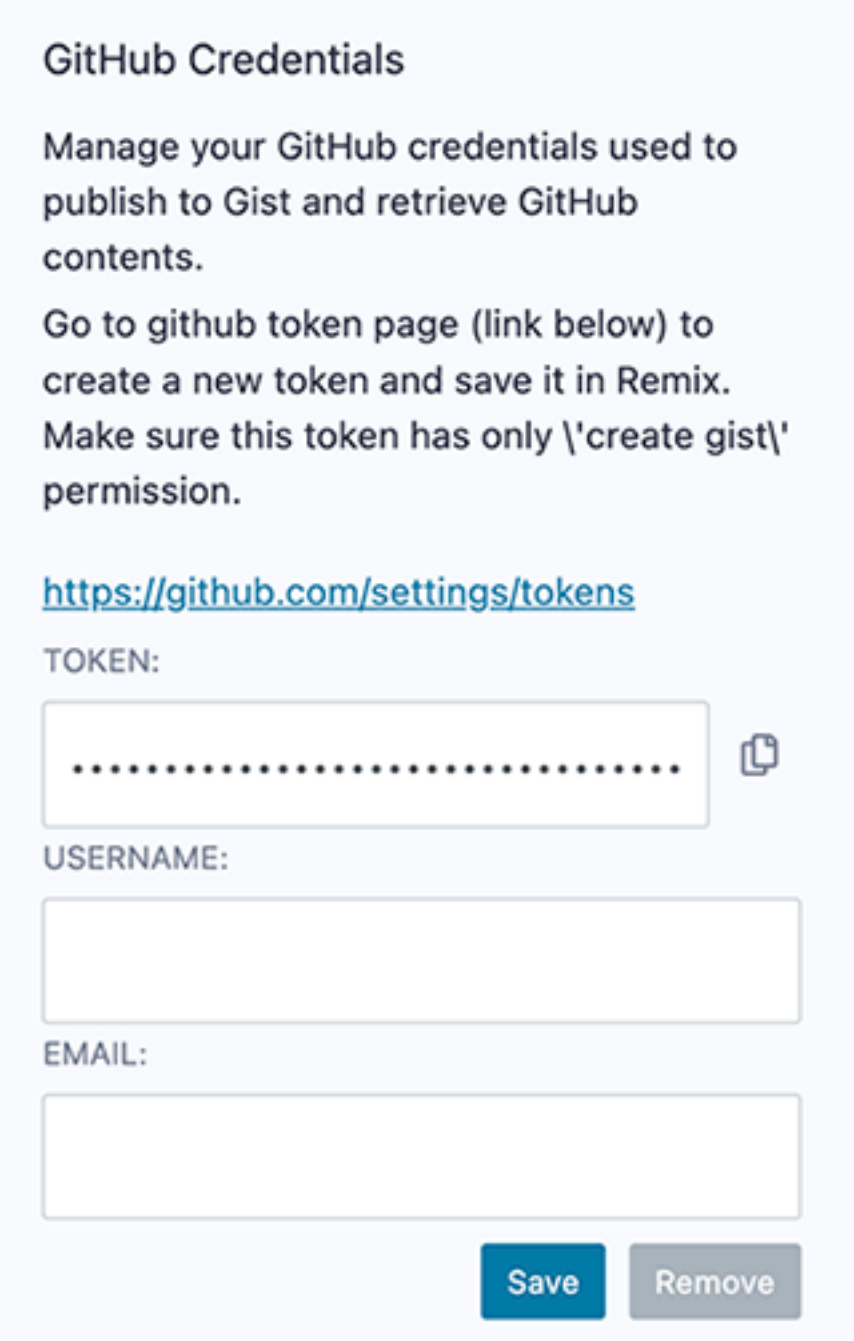
1.4.2 General Settings



- Generate contract metadata is used for deploying with libraries. See our blog post on the subject: Deploying with Libraries
- Always use Remix VM at Load: will make the Remix VM the selected **environment** when Remix loads.
- Text wrap: controls if the text in the editor should be wrapped.
- Personal mode: can be used when one is connecting to a **local node**. It is used to have Remix temporarily save the passphrase - so that you don't need to **unlock** the account in GETH. Remix will not persist the passphrase - so if you refresh your browser the passphrase will be gone.
- Matomo Analytics: This is where you can turn off and on your approval for us to use Matomo. We do not collect any personally identifiable information (PII) and our reports are public. See our blog post on the subject.

1.4.3 Github Access Token

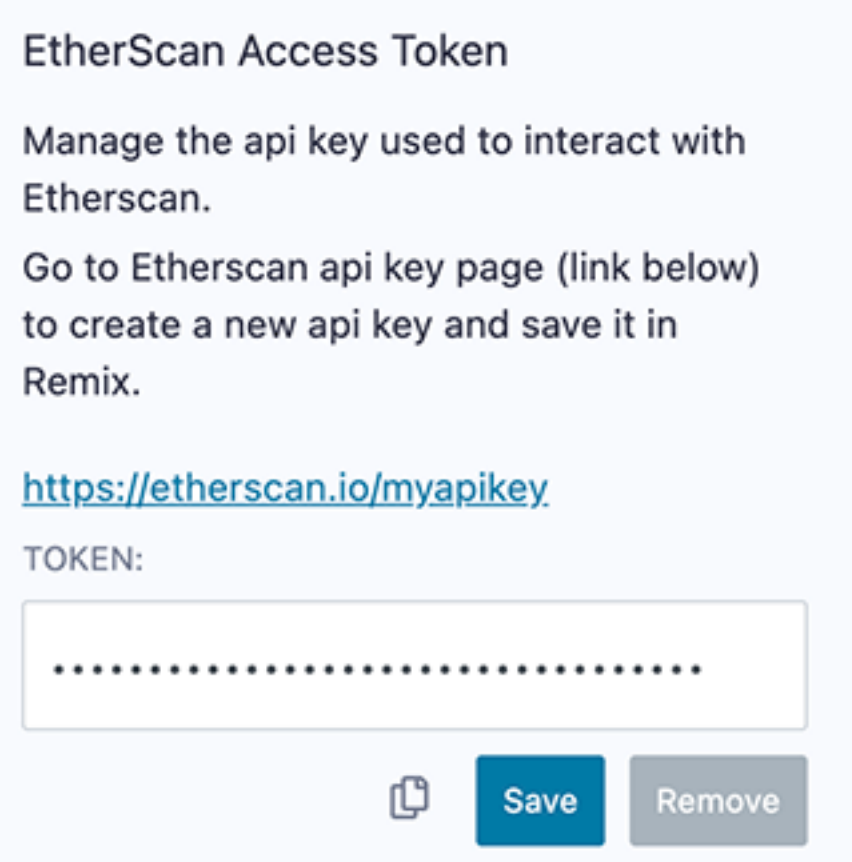
When performing Git operations on Github and when creating GISTs, it may be necessary to input an access token. This token has the specific permissions for your Git commands. Depending on the operation, you may also need to input your Github username & email address. Remix does not save your password info outside of your browser's localstorage. https://github.com/settings/tokens



1.4.4 Etherscan Access Token

You need to input your Etherscan access token when debugging verified contracts with the Remix Debugger. When verifying a contract with the Etherscan plugin, you need to put the API key in that plugin and not in the Settings panel.

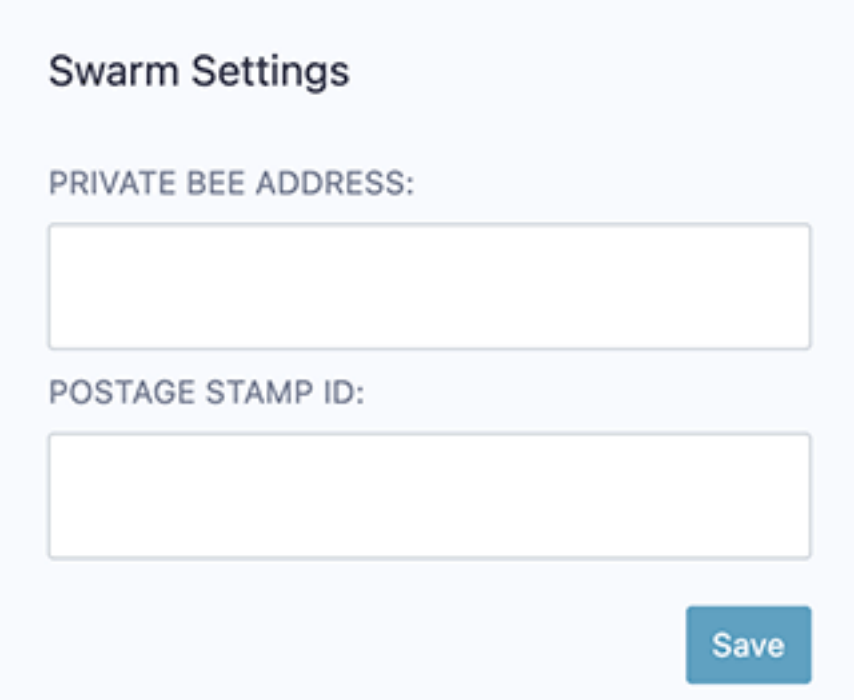
Click here to get your Etherscan API key.



1.4.5 Swarm Settings

In the Solidity Compiler, after the compilation is completed, there is a button to publish to Swarm.

Without putting in an address & postage stamp, you'll be using the public gateway, which may not persist you content as surely as if you put in your own info.



1.4.6 IPFS Settings

Just like the Swarm settings above, IPFS settings are for publishing your contracts to IPFS from the Solidity Compiler.

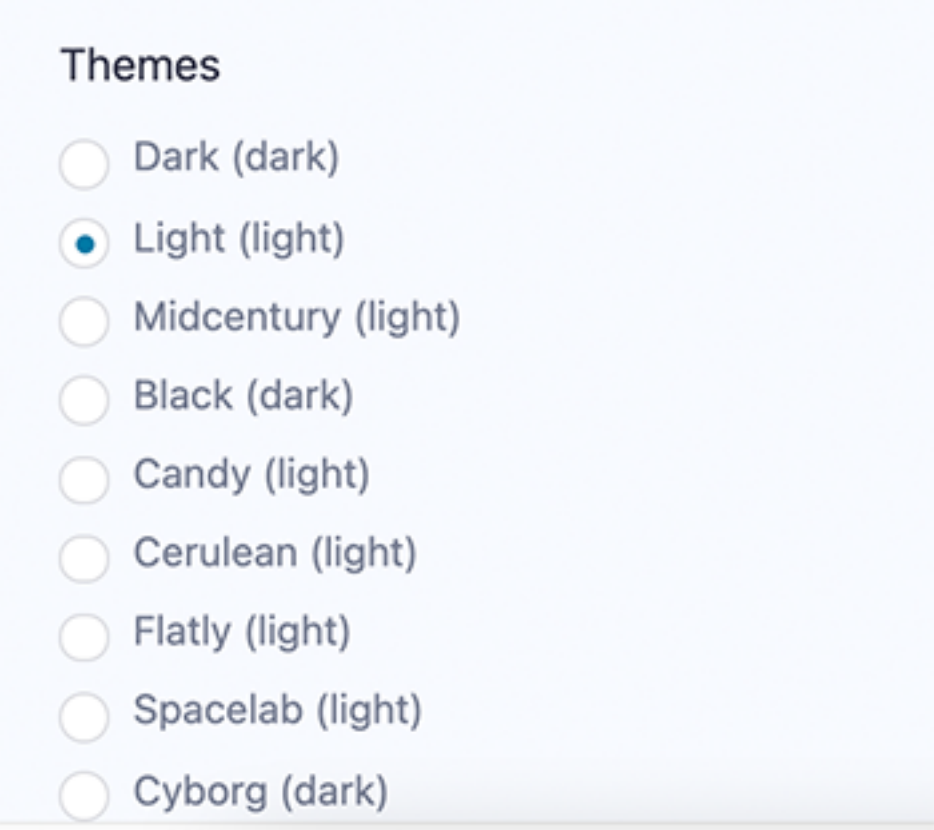
- If you do not put in any settings here, you will be using the public INFURA node. This will not guarantee your data will persist.

Other options are to:

- Use your own INFURA IPFS node. This requires a subscription. Learn more
- Use any external IPFS which doesn't require any authentification.
- Use your own local ipfs node (which usually runs under http://localhost:5001)

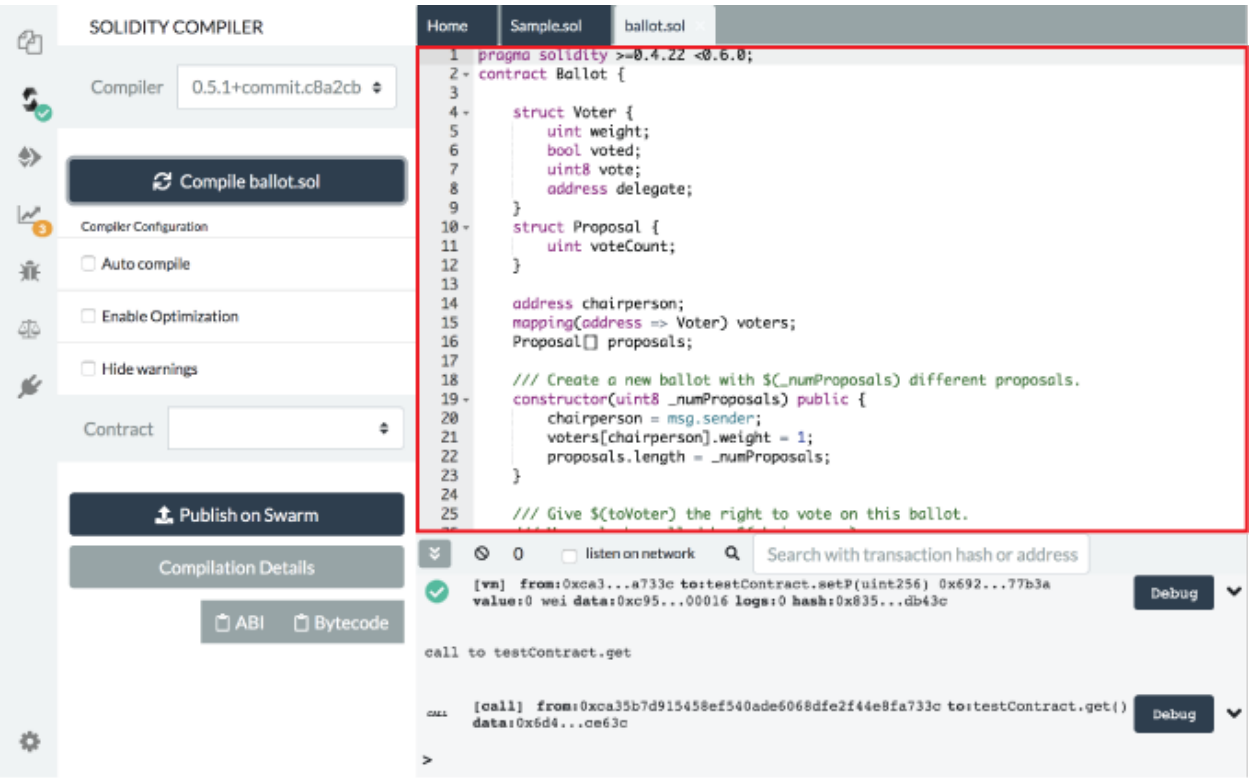
1.4.7 Themes

Choose themes here. The Dark & Light themes are the themes that the Remix team actively maintains.



1.5 Solidity Editor

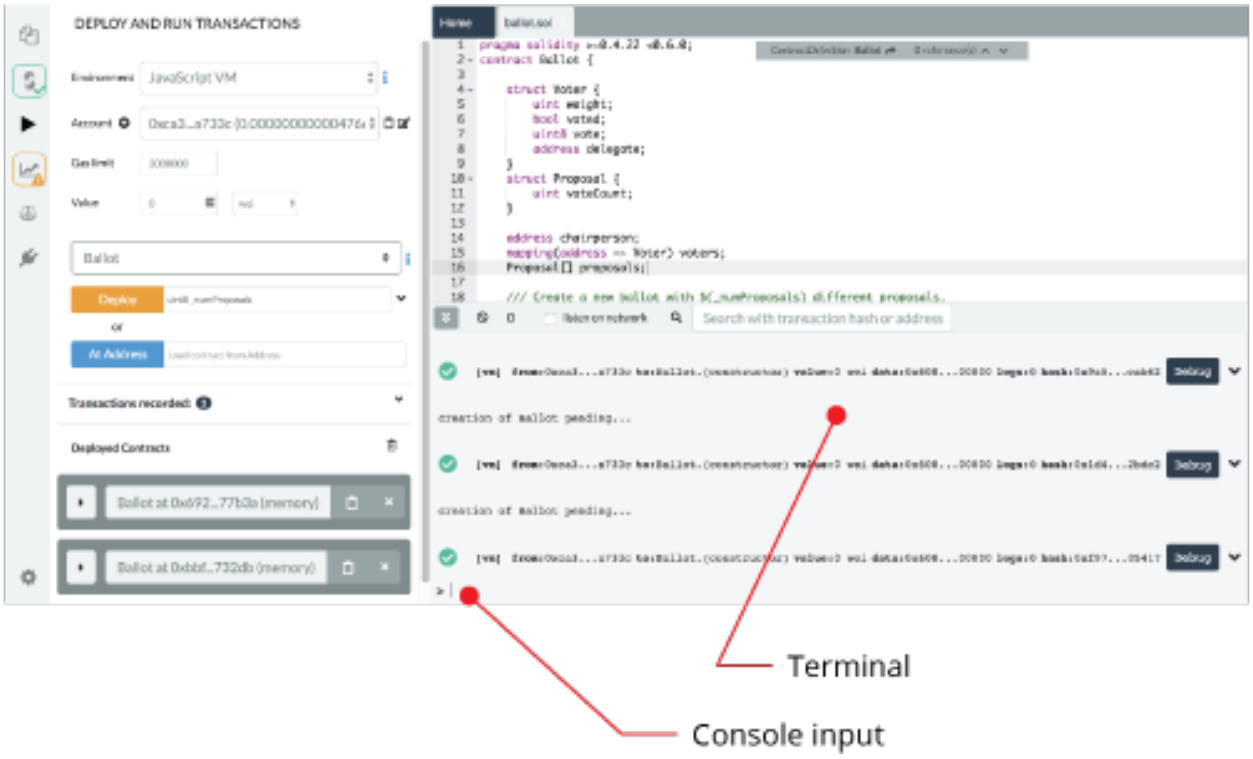
The Remix editor recompiles the code each time the current file is changed or another file is selected. It also provides syntax highlighting mapped to solidity keywords.



Here's the list of some important features:

- It display opened files as tabs.
- Compilation Warning and Error are displayed in the gutter
- Remix saves the current file continuously (5s after the last changes)
- +/- on the top left corner enable you to increase/decrease the font size of the editor

1.6 Terminal



Features, available in the terminal:

- It integrates a JavaScript interpreter and the `web3` object. It enables the execution of the JavaScript script which interacts with the current context. (note that `web3` is only available if the `web provider` or `injected provider` mode is selected).
- It displays important actions made while interacting with the Remix IDE (i.e. sending a new transaction).
- It displays transactions that are mined in the current context. You can choose to display all transactions or only transactions that refers to the contracts Remix knows (e.g transaction created from the Remix IDE).
- It allows searching for the data and clearing the logs from the terminal.
- You can run scripts by inputting them at the bottom after the >.

1.7 Solidity Compiler

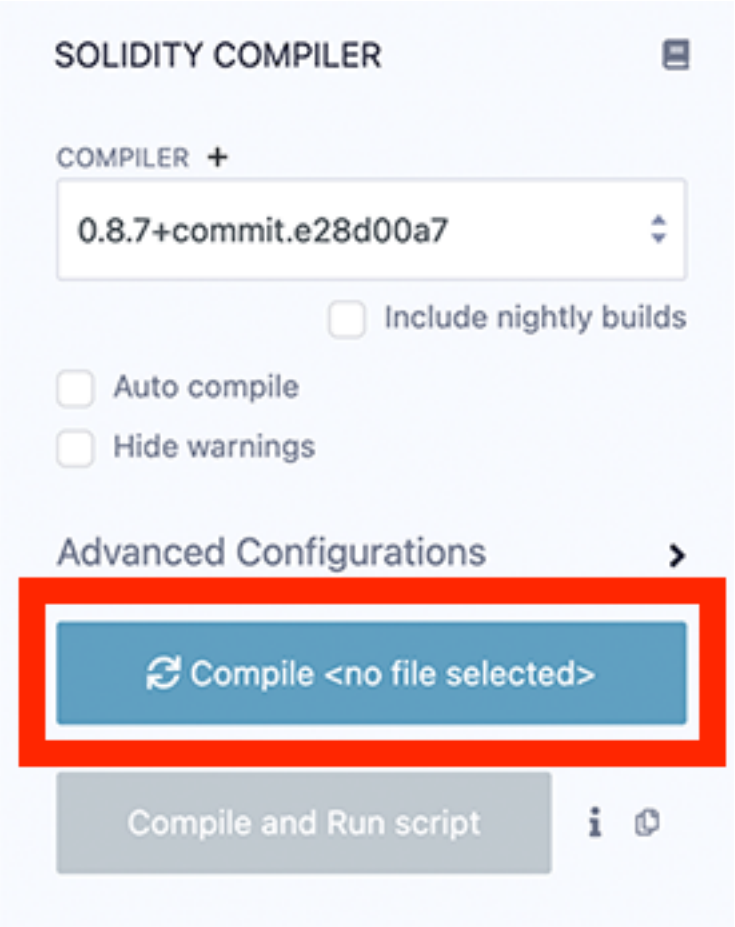
Clicking the Solidity icon in the icon panel brings you to the Solidity Compiler. The default view of the Solidity Compiler shows the basic configuration. To open the Advanced Configuration panel, click the **Advanced Configuration** button (**C. in fig. 1**). For details on advanced features - see below.

1.7.1 Solidity Compiler Basics

Selecting a contract to compile

To select a contract to compile, choose a file in the File Explorer. Or if there are several files open, make sure the one you want to compile is the active file in the Editor.

If there is not an active file in the editor or a file has not already been compiled, then the Solidity compiler will look like this:



Triggering compilation

Compiling is triggered when you:

- click the compile button (**D. in fig. 1 below**)
- use the shortcut `control + s`.
- right click on a file in the File Explorer and selecting **Compile** option

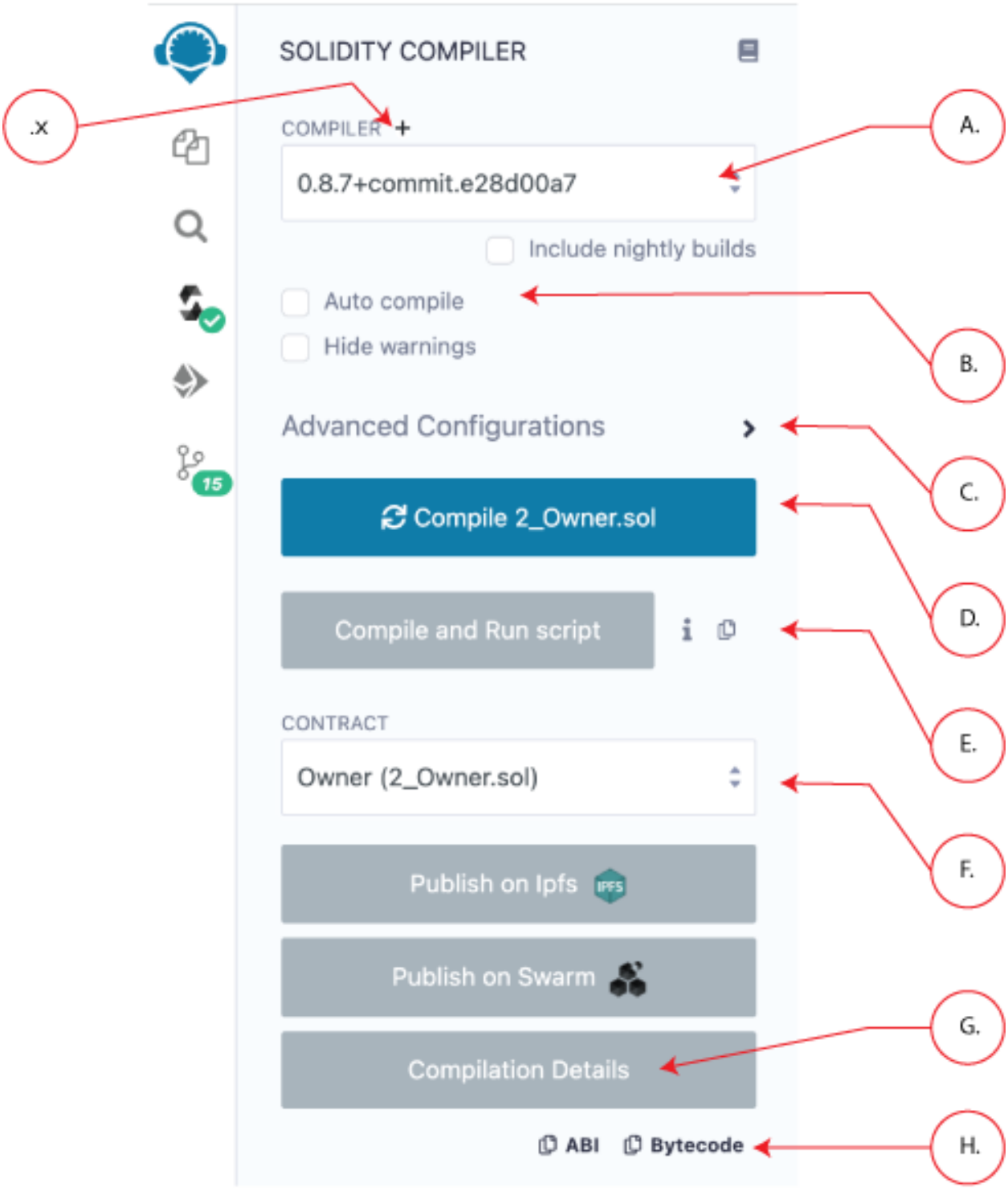

SOLIDITY COMPILER
.x
COMPILER
A.
0.8.7+commit.e28d00a7
Include nightly builds
Auto compile
Hide warnings
B.
Advanced Configurations
C.
Compile 2_Owner.sol
D.
Compile and Run script
CONTRACT
E.
Owner (2_Owner.sol)
F.
Publish on Ipfs
Publish on Swarm
G.
Compilation Details
ABI
Bytecode
H.

fig. 1

Auto Compile

If the auto compile checkbox (**B. in fig. 1 above**) is checked, compiliation will occur every few seconds (when the file is auto-saved) as well as when another file is selected. If a contract has a lot of dependencies, it can take a while to compile - so you use autocompilation at your discretion.

Solidity versions & Remix functionality

The compiler version is selected in the **COMPILER** dropdown list (**A. in fig. 1 above**).

You can compile (and deploy) contracts with versions of Solidity **older than 0.4.12**. However, the older compilers use a legacy AST — which we no longer support. Consequently, some plugins may not work and some functionality - e.g. source highlighting in the Editor may only be partially working.

Using the Contract select box

Because a Solidity file can include multiple contracts and because contracts can import other contracts, multiple contracts are often compiled. **However**, only 1 contract's compilation details can be retrieved at a time.

To select the desired contract, use the **Contract** select box (**F. in fig. 1**). Forgetting to select the right contract is a common mistake - so remember to verify that the contract you want is selected.

Compilation Details and Publishing

Using the publish button, you can upload your contract to **IPFS** or **Swarm** (only non abstract contracts can be published to Swarm).

When publishing a contract that imports other contracts, the main contract and all of its imported contracts will be published - each to their own address.

Published data contains the contract's metadata and the solidity source code.

After either **Publish on IPFS** or **Publish on Swarm** is clicked a modal will pop up. This modal contains the contract's address as well as the addreses of the contracts that it imported and the address of the contract's **metadata**.

When the "Compilation Details" button is clicked (**G. in fig. 1**), a modal opens displaying detailed information about the current selected contract.

If you just want to get the **ABI** or the **Bytecode** - click the appropriate button see **H. in fig. 1**.

Passive Contract Verification

When you publish your metadata to IPFS and deploy your code to the mainnet or a public testnet, the contract verification service **Sourcify**, will verifiy your contracts without you needing to do anything.

Compile and Run script

The Compile and Run script button (**E. in fig. 1**) is for compiling and then immediately running a script. It's a time saver so that you can write some code, automatically run script that sets state of the contract - thus allowing you to quickly understand how the code is working. (more about Compile & Run)

Compilation Errors and Warning

Compilation Errors and Warning are displayed below the contract section. At each compilation, the static analysis tab builds a report.

It is important to address reported issues even if the compiler doesn't complain. (more about static analysis)

1.7.2 Advanced Compiler Configurations

Clicking on Advanced Compiler Configurations will open this panel (**M. in fig. 2 below**).

fig. 2

There is a radio button to choose whether to configure the compiler through the interface (**N. in fig 2**) or to use a JSON file for the cofiguration (**R. in fig 2**).

Solidity or YUL

Since the Solidity version `0.5.7`, it is possible to compile `Yul` files. Please read the (solidity documentation about Yul) which contain some code examples. You can use the language dropdown (**O. in fig 2**) to switch the language. **This dropdown list is only available for versions greater than or equal to `0.5.7`.**

Select an EVM version

The EVM dropdown list (**P. in fig 2**) allows to compile code against a specific **Ethereum hard fork**. The `compiler default` corresponds to the default hard fork used by a specific version.

To see the name of the hard fork used in the current compilation, click the "Compilation Details" button and in the `Metadata` section there will be a sub-section called **settings**. Open up the **settings** to see the EVM version's name.

Enable optimization

According to the the Solidity Docs, "the optimizer tries to simplify complicated expressions, which reduces both code size and execution cost, i.e., it can reduce gas needed for contract deployment as well as for external calls made to the contract."

For recent versions of Solidity, it is recommended to enable optimization .

To learn more about optimization, (**Q. in the fig 2**) visit the Solidity docs on the optimizer.

To the right of the **Enable optimization** checkbox is the box to input the number of Optimization runs. The default value is 200.

You may ask — "What is the right number of runs for my contract?" And the Solidity docs say:

> If you want the initial contract deployment to be cheaper and the later function executions to be more expensive, set it to –optimize-runs=1. If you expect many transactions and do not care for higher deployment cost and output size, set –optimize-runs to a high number.

To learn more about the optimization runs, visit the Solidity docs about Optimizer options.

JSON file for Compiler configuration

Selecting the radio button next to **Use configuration file** will let you set the configuration using a JSON file (**T. in fig 2**). When you switch to **compile with a config file**, a sample compiler config file is created. This file can be edited with all the available options.

Clicking the config file's name will open it up in the Editor. To change the config file click the **Change** button. If you update the text box with a file name of a file that does not exist, a new file will be created containing the default file's contents.

There is no error checking when using the .json file for configuration settings, so make sure your config file is correct.

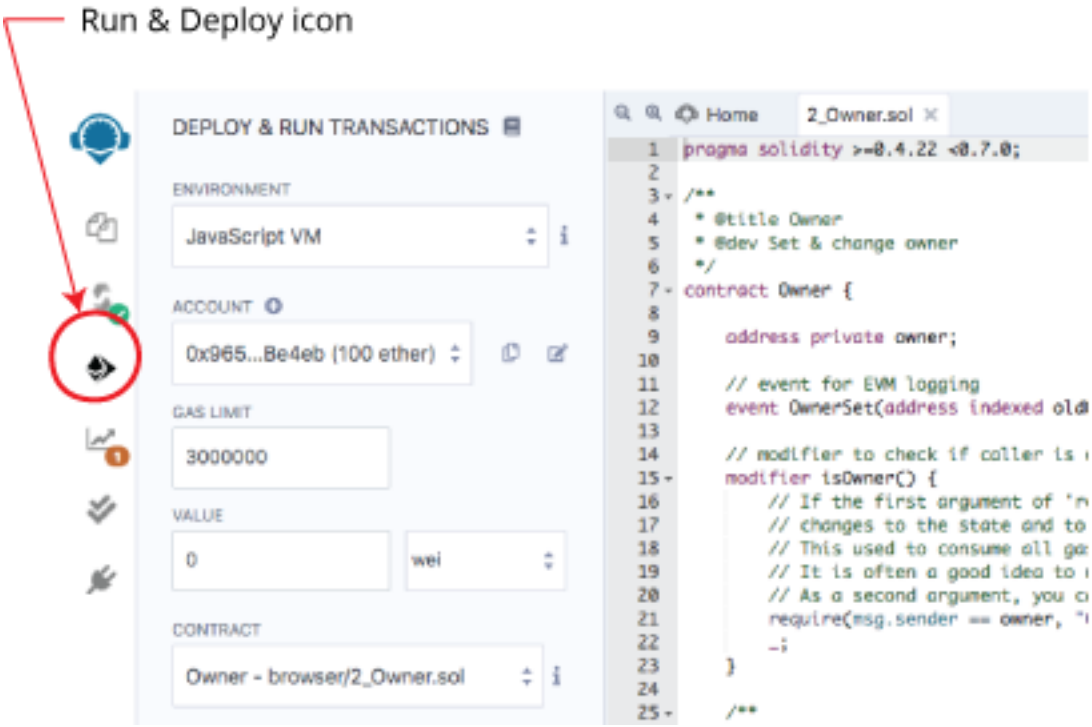
Use a Custom Solidity Compiler

For those writing your own custom solidity compiler, you can import that by clicking the **+** button (**X. in fig 1**) to open a modal where you can input the url of the compiler to be loaded.

1.8 Deploy & Run

The Deploy & Run module allows you to send transactions to the current environment.

To use this module, you need to have a contract compiled. So, if there is a contract name in the CONTRACT select box (the select box is under the VALUE input field), you can use this module. If nothing is there or you do not see the contract you want, you need to select a contract in the editor to make it active, go to a compiler module and compile it, and then come back to Deploy & Run.



1.8.1 Environment

- `Remix VM (London)` : For connecting to a sandbox blockchain in the browser. The Remix VM (previously called JavaScript VM) is its own "blockchain" and on each reload the old chain will be cleared and a new blockchain will be started. **The old one will not be saved**. The London refers to the London fork of Ethereum.
- `Remix VM (Berlin)` : Same as above except this chain is using the Berlin fork of Ethereum.
- `Injected Provider - provider name`: For connecting Remix to an injected web3 provider. The most common injected provider is `Metamask`.
- `Hardhat Provider`: For connecting Remix to a local Hardhat test chain.
- `Ganache Provider`: For connecting Remix to a local Truffle Ganache test chain.
- `Foundry Provider`: For connecting Remix to a local Foundry Anvil test chain.
- `WalletConnect`: For using the WalletConnect allowing you to approve transactions on a mobile device.
- `External HTTP Provider`: Remix will connect to a remote node. You will need to provide the URL to the selected provider: geth, parity or any Ethereum client. This was previously called **Web3 Provider**.

- `L2 - Optimism Provider`: For connecting Remix to an Injected Provider (usually Metamask) with the settings for the Optimism Network's mainnet.
- `L2 - Arbitrum One Provider`: For connecting Remix to an Injected Provider (usually Metamask) with the settings for the Arbitrum One network.

1.8.2 More about External HTTP Provider

If you are using Geth & https://remix.ethereum.org, please use the following Geth command to allow requests from Remix:

```
geth --http --http.corsdomain https://remix.ethereum.org
```

Also see Geth Docs about the http server

To run Remix using https://remix.ethereum.org & a local test node, use this Geth command:

```
geth --http --http.corsdomain="https://remix.ethereum.org" --http.api web3,eth,debug,
↪personal,net --vmdebug --datadir <path/to/local/folder/for/test/chain> --dev console
```

If you are using remix-alpha or a local version of remix - replace the url of the –http.corsdomain with the url of Remix that you are using.

To run Remix Desktop & a local test node, use this Geth command:

```
geth --http --http.corsdomain="package://a7df6d3c223593f3550b35e90d7b0b1f.mod" --http.
↪api web3,eth,debug,personal,net --vmdebug --datadir <path/to/local/folder/for/test/
↪chain> --dev console
```

Also see Geth Docs on Dev mode

The Web3 Provider Endpoint for a local node is **http://localhost:8545**

WARNING: Don't get lazy. It is a bad idea to use the Geth flag –http.corsdomain with a wildcard: `--http.corsdomain *`

If you put the wildcard `*`, it means everyone can request the node. Whereas, if you put a URL, it restricts the urls to just that one - e.g. `--http.corsdomain 'https://remix-alpha.ethereum.org'`

Only use `--http.corsdomain *` when using a **test chain** AND using only **test accounts**. For real accounts or on the mainchain **specify the url**.

1.8.3 Account:

- Account: the list of accounts associated with the current environment (and their associated balances). On the Remix VM, you have a choice of 5 accounts. If using Injected Web3 with MetaMask, you need to change the account in MetaMask.

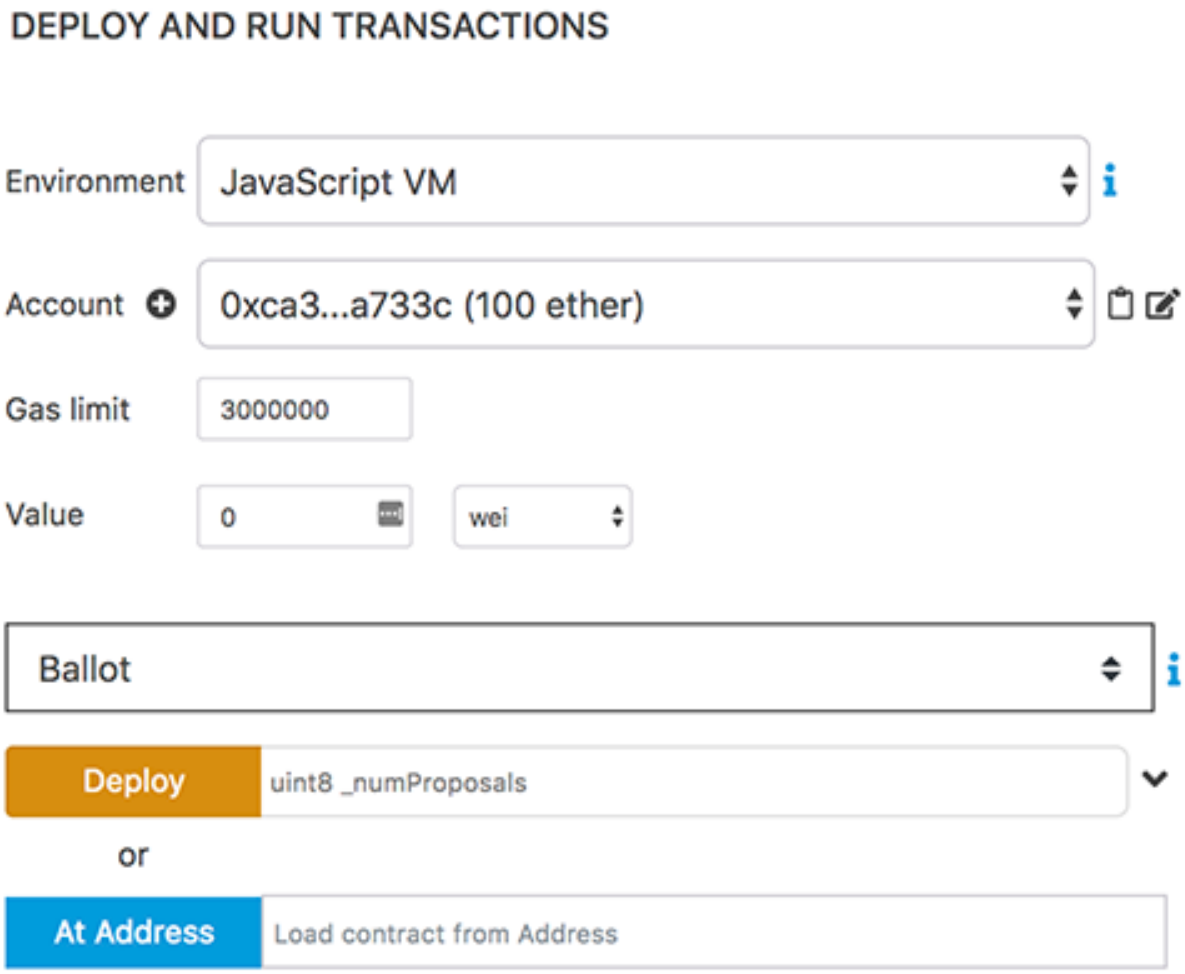
1.8.4 Gas Limit:

- This sets the maximum amount of gas that will be allowed for all the transactions created in Remix.

1.8.5 Value:

- This sets the amount of ETH, WEI, GWEI etc that is sent to a contract or a payable function. **Note:** payable functions have a red button.

The **Value** field is always reset to 0 after each transaction execution. The **Value** field is **NOT** for gas.



1.8.6 Deploy & AtAddress

- In the image above, the select box is set to **Ballot**. This select box will contain the list of compiled contracts.
- `Deploy` sends a transaction that deploys the selected contract. When the transaction is mined, the newly created instance will be added (this might take several seconds). **Note:** If the contract's constructor function has parameters, you need to specify them.
- `At Address` is used to access a contract that has already been deployed. Because the contract is already deployed, accessing a contract with **AtAddress** does not cost gas.

Note: When using AtAddress, be sure you trust the contract at that address.

To use **AtAddress**, you need to have the **source code** or **ABI** of the deployed contract **in the active tab** of the editor. When using the source code, it must be compiled with the same compilation settings as the deployed contract that you are trying access.

1.8.7 Using the ABI with AtAddress

The **ABI** is a JSON array which describes the contract's interface.

To interact with a contract using the ABI, create a new file in Remix with extension ***.abi** and copy the ABI content to it.

Make sure this file is the active tab in the editor. Then, in the field next to `At Address`, input the contract's address and click on `At Address`. If successful, an instance of the contract will appear below - in the list of **Deployed Contracts**.

Note: To generate the ABI, in the Solidity compiler, after a contract is compiled, click on the **Compilation Details** button. A modal will come up with that contains the ABI among other info.

1.8.8 Pending Instances

Validating a transaction takes several seconds. During this time, the GUI shows it in a pending mode. When the transaction is mined, the number of pending transactions is updated and the transaction is added to the log (see terminal).

1.8.9 Using the Recorder

The Recorder is a tool used to save a bunch of transactions in a JSON file and re-run them later either in the same environment or in another.

Saving to the JSON file (by default its called scenario.json) allows one to easily check the transaction list, tweak input parameters, change linked library, etc. . .

There are many use cases for the recorder.

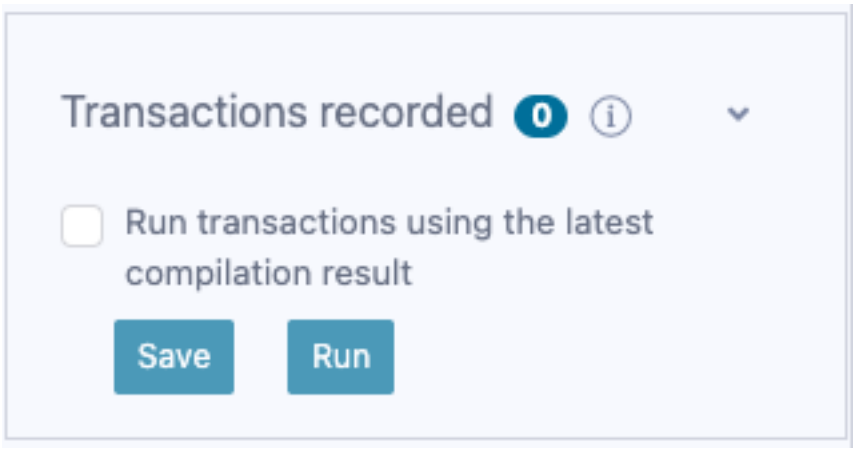
For instance:

- After having coded and tested contracts in a constrained environment (like the Remix VM), you could then change the environment and redeploy it to a more realistic environment like a public testnet or to a Geth node. By using the generated **scenario.json** file, you will be using all the same settings that you used in the Remix VM. And this means that you won't need to click the interface 100 times or whatever to get the state that you achieved originally. So the recorder could be a tool to protect your sanity.

  You can also change the settings in the scenario.json file to customize the playback.

- Deploying contract does often require more than creating one transaction and so the recorder will automate this deployment.

- Working in a dev environment often requires setting up the state in a first place.



When checked, the option `Run transactions using the last compilation result` allows you to develop a contract and easily set the state using **the latest compiled versions of the contracts.**

scenario.json

To create this file in the recorder, you first of course need to have run some transactions. In the image above - it has a `0` next to **Transactions Recorded**. So this isn't the right moment to save transactions because - well because there aren't any. Each time you make a transaction, that number will increment. Then when you are ready, click the floppy disk icon and the scenario.json file will be created.

The JSON file below is an example of the scenario.json file.

In it, 3 transactions are executed:

The first corresponds to the deployment of the lib `testLib`.

The second corresponds to the deployment of the contract `test` with the first parameter of the constructor set to 11. That contract depends on a library. The linkage is done using the property `linkReferences`. In that case we use the address of the previously created library : `created{1512830014773}`. The number is the id (timestamp) of the transaction that led to the creation of the library.

The third record corresponds to the call to the function `set` of the contract `test` (the property to is set to: `created{1512830015080}`) . Input parameters are `1` and `0xca35b7d915458ef540ade6068dfe2f44e8fa733c`

All these transactions are created using the value of the accounts `account{0}`.

```
{
"accounts": {
    "account{0}": "0xca35b7d915458ef540ade6068dfe2f44e8fa733c"
},
"linkReferences": {
    "testLib": "created{1512830014773}"
},
"transactions": [
    {
    "timestamp": 1512830014773,
    "record": {
        "value": "0",
        "parameters": [],
        "abi": "0xbc36789e7a1e281436464229828f817d6612f7b477d66591ff96a9e064bcc98a",
        "contractName": "testLib",
```

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```
        "bytecode":
↪"60606040523415600e57600080fd5b60968061001c6000396000f300606060405260043610603f576000357c0100000000
↪",
        "linkReferences": {},
        "type": "constructor",
        "from": "account{0}"
    }
    },
    {
    "timestamp": 1512830015080,
    "record": {
        "value": "100",
        "parameters": [
        11
        ],
        "abi": "0xc41589e7559804ea4a2080dad19d876a024ccb05117835447d72ce08c1d020ec",
        "contractName": "test",
        "bytecode":
↪"60606040526040516020806102b183398101604052808051906020019091905050806000819055505061027a806100376
↪_browser/ballot.sol:testLib____________
↪636d4ce63c60006040516020015260405181630fffffff167c0100000000000000000000000000000000000000000000000
↪",
        "linkReferences": {
        "browser/ballot.sol": {
            "testLib": [
            {
                "length": 20,
                "start": 511
            }
            ]
        }
        },
        "name": "",
        "type": "constructor",
        "from": "account{0}"
    }
    },
    {
    "timestamp": 1512830034180,
    "record": {
        "value": "1000000000000000000",
        "parameters": [
        1,
        "0xca35b7d915458ef540ade6068dfe2f44e8fa733c"
        ],
        "to": "created{1512830015080}",
        "abi": "0xc41589e7559804ea4a2080dad19d876a024ccb05117835447d72ce08c1d020ec",
        "name": "set",
        "type": "function",
        "from": "account{0}"
    }
    }
],
"abis": {
    "0xbc36789e7a1e281436464229828f817d6612f7b477d66591ff96a9e064bcc98a": [
    {
        "constant": true,
```


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```
        "inputs": [],
        "name": "get",
        "outputs": [
        {
            "name": "",
            "type": "uint256"
        }
        ],
        "payable": false,
        "stateMutability": "view",
        "type": "function"
    }
    ],
    "0xc41589e7559804ea4a2080dad19d876a024ccb05117835447d72ce08c1d020ec": [
    {
        "constant": true,
        "inputs": [],
        "name": "getInt",
        "outputs": [
        {
            "name": "",
            "type": "uint256"
        }
        ],
        "payable": false,
        "stateMutability": "view",
        "type": "function"
    },
    {
        "constant": true,
        "inputs": [],
        "name": "getFromLib",
        "outputs": [
        {
            "name": "",
            "type": "uint256"
        }
        ],
        "payable": false,
        "stateMutability": "view",
        "type": "function"
    },
    {
        "constant": true,
        "inputs": [],
        "name": "getAddress",
        "outputs": [
        {
            "name": "",
            "type": "address"
        }
        ],
        "payable": false,
        "stateMutability": "view",
        "type": "function"
    },
    {
```

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```
        "constant": false,
        "inputs": [
        {
            "name": "_t",
            "type": "uint256"
        },
        {
            "name": "_add",
            "type": "address"
        }
        ],
        "name": "set",
        "outputs": [],
        "payable": true,
        "stateMutability": "payable",
        "type": "function"
    },
    {
        "inputs": [
        {
            "name": "_r",
            "type": "uint256"
        }
        ],
        "payable": true,
        "stateMutability": "payable",
        "type": "constructor"
    }
    ]
}
}
```

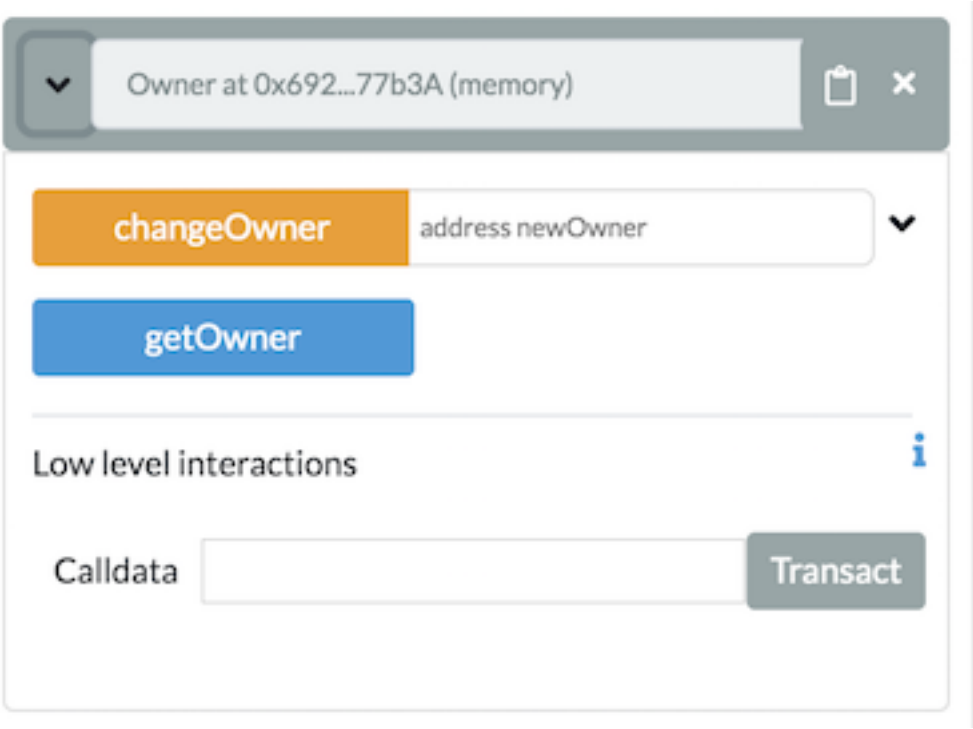
1.9 Deploy & Run (part 2)

1.9.1 Deployed contracts

This section in the Run tab contains a list of deployed contracts to interact with through autogenerated UI of the deployed contract (also called udapp).

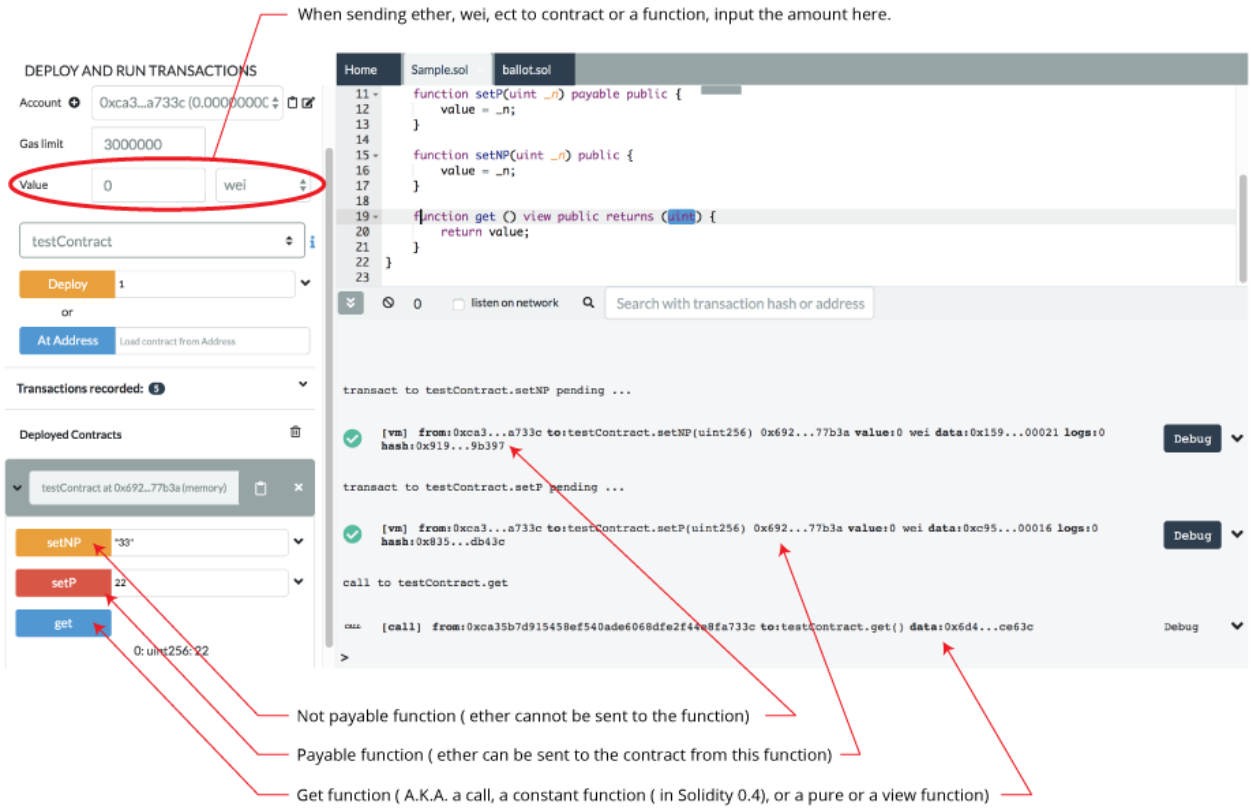
The deployed contract appears but is in its collapsed form.

Click the sideways caret to open it up.



You will see the functions in the contract. The functions buttons can have different color buttons.

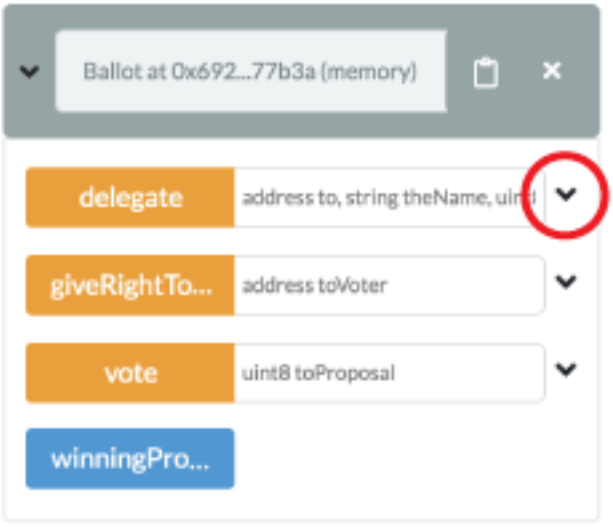
- Functions that are `constant` or `pure` functions in Solidity have a blue buttons. Clicking one of this type does not create a new transaction. So clicking will not cause state changes - it will only return a value stored in the contract - so it won't cost you anything in gas fees.
- Functions that change the state of the contract AND that do not accept Ether are called `non-payable` functions and have an orange button. Clicking on them will create a transaction and thus cost gas.
- Functions that have red buttons are `payable` functions in Solidity. Clicking one of these will create a new transaction and this transaction can accept a **value**. The **value** is put in in the Value field which is under the Gas Limit field.



See more information about Solidity modifiers in the Solidity docs. .

If a function requires input parameters, well.. you gotta put them in.

1.9.2 Inputting parameters



Inputting parameters in the collapsed view

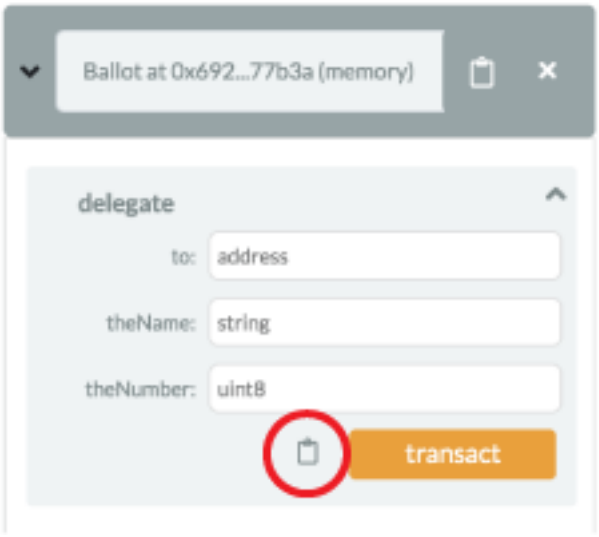
(Inputting all the parameters in a single input box)

- The input box tells you what type each parameter needs to be.
- Numbers and addresses do not need to be wrapped in double quotes.
- Strings do not need to be wrapped.
- Parameters are separated by commas.

In the example above the "delegate" function has 3 parameters.

Inputting parameters in the expanded view

Clicking the 'down' caret brings you to the *Multi-param Manager* - where you can input the parameters one at a time. **Much less confusing!**



In the expanded view, strings do not need to be wrapped.

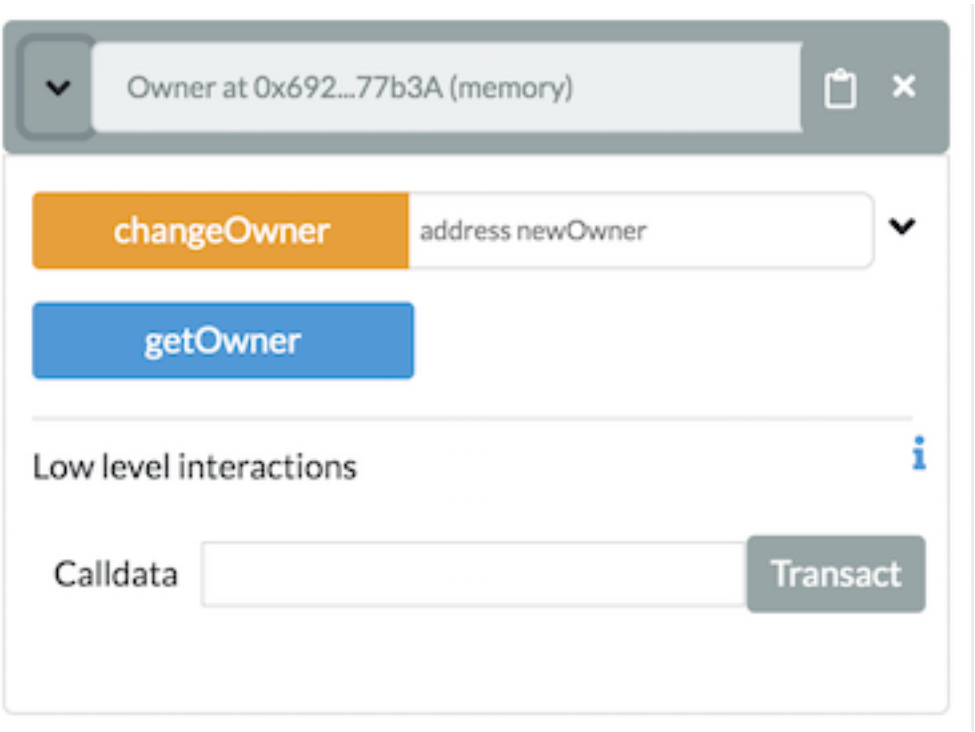
Clicking the clipboard icon will encode the inputs and will copy them. Only a valid set of inputs can be encoded.

So if you made a mistake and put a uint8 where an address should have been, clicking the clipboard here will give you an error.

1.9.3 Low level interactions

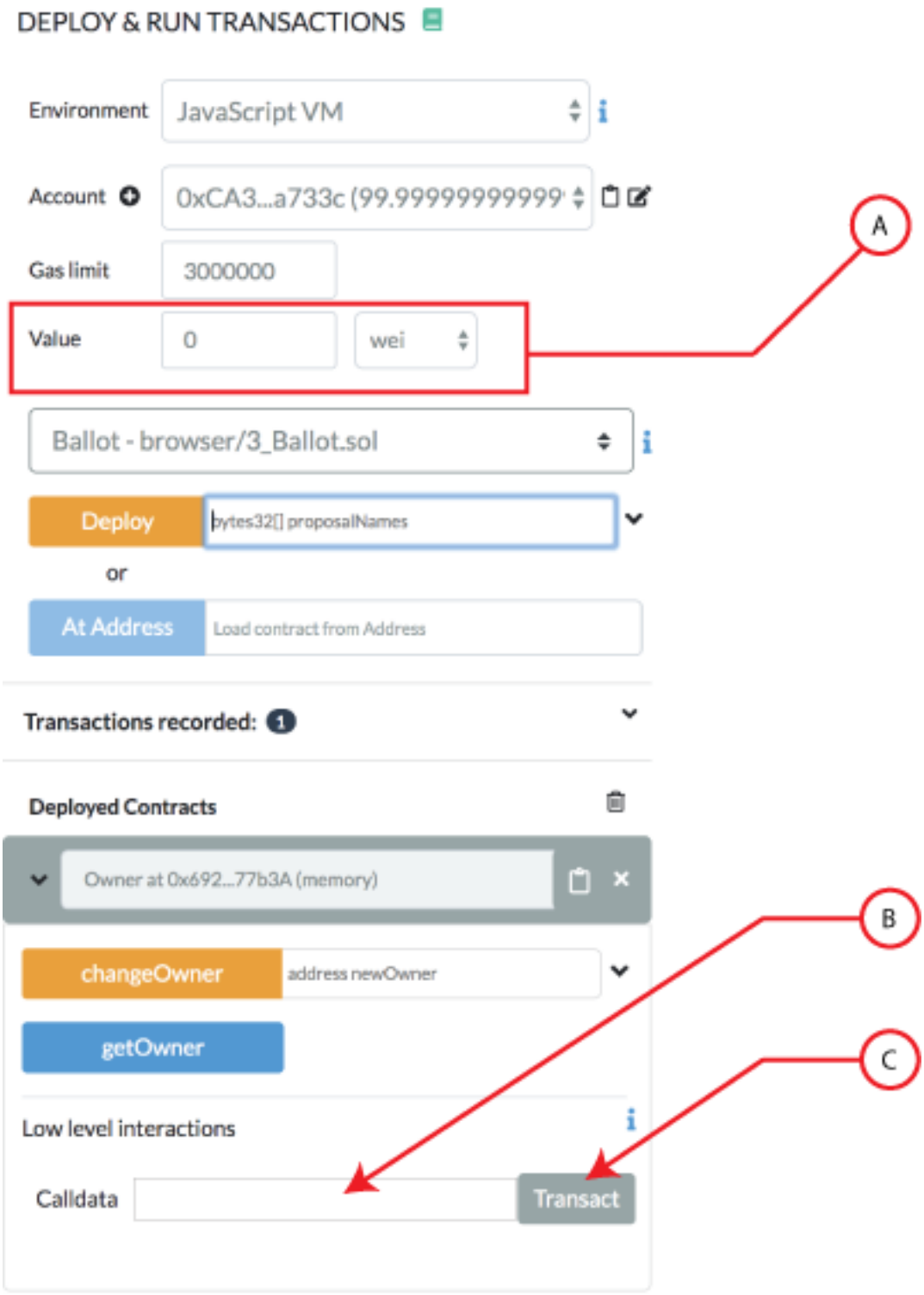
Low level interactions are used to send funds or calldata or funds & calldata to a contract through the **receive()** or **fallback()** function. Typically, you should only need to implement the fallback function if you are following an upgrade or proxy pattern.

The low level interactions section is below the functions in each deployed contract.



Please note the following:

- If you are executing a plain Ether transfer to a contract, you need to have the receive() function in your contract. If your contract has been deployed and you want to send it funds, you would input the amount of Ether or Wei etc. (see **A** in graphic below), and then input **NOTHING** in the calldata field of **Low level interactions** (see **B** in graphic) and click the Transact button (see **C** in graphic below).



- If you are sending calldata to your contract with Ether, then you need to use the fallback() function and have it with the state mutability of **payable**.
- If you are not sending ether to the contract but **are** sending call data then you need to use the fallback() function.
- If you break the rules when using the **Low level interactions** you will be slapped with a warning.

Please see the solidity docs for more specifics about using the **fallback** and **receive** functions.

Passing in a tuple or a struct to a function

To pass a tuple in, you need to put in an array [].

Similarly, to pass in a struct as a parameter of a function, it needs to be put in as an array []. Also note that the line `pragma experimental ABIEncoderV2;` needs to put in at the top of the solidity file.

Example of passing nested struct to a function

Consider a nested struct defined like this:

```
struct gardenPlot {
    uint slugCount;
    uint wormCount;
    Flower[] theFlowers;
}
struct Flower {
    uint flowerNum;
    string color;
}
```

If a function has the signature `fertilizer(Garden memory gardenPlot)` then the correct syntax is:

```
[1,2,[[3,"Petunia"]]]
```

To continue on this example, here's a sample contract:

```
pragma solidity >=0.4.22 <0.7.0;
pragma experimental ABIEncoderV2;

contract Sunshine {
    struct Garden {
      uint slugCount;
      uint wormCount;
      Flower[] theFlowers;
    }
    struct Flower {
        uint flowerNum;
        string color;
    }

    function picker(Garden memory gardenPlot) public {
        uint a = gardenPlot.slugCount;
        uint b = gardenPlot.wormCount;
        Flower[] memory cFlowers = gardenPlot.theFlowers;
        uint d = gardenPlot.theFlowers[0].flowerNum;
        string memory e = gardenPlot.theFlowers[0].color;
    }
}
```

After compiling, deploying the contract and opening up the deployed instance, we can then add the following input parameters to the function named **fertilizer** :

```
[1,2,[[3,"Black-eyed Susan"],[4,"Pansy"]]]
```

The function **fertilizer** accepts a single parameter of the type **Garden**. The type **Garden** is a **struct**. Structs are wrapped in **square brackets**. Inside **Garden** is an array that is an array of structs named **theFlowers**. It gets a set of brackets for the array and another set for the struct. Thus the double square brackets.

1.10 Deploy & Run Proxy Contracts

Remix IDE has functionality to assist in the handeling of proxy contracts that use the UUPS pattern.

A UUPS proxy contract is the implementation side of an ERC1967Proxy.

Once you have deployed a UUPS implementation contract, Remix will deploy a ERC1967 with your implementation contract's address.

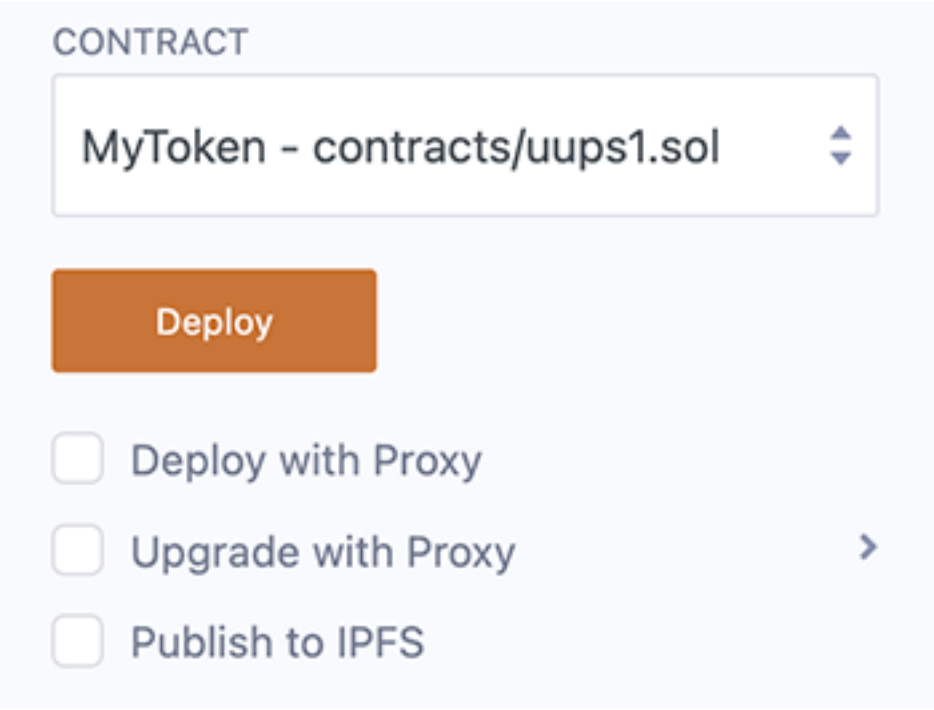
To interact with the functions in the **implementation contract**, use the deployed instance of the **ERC1967 instance** not on the implementation contract.

When its time to upgrade you contract, Remix has a UI for this.

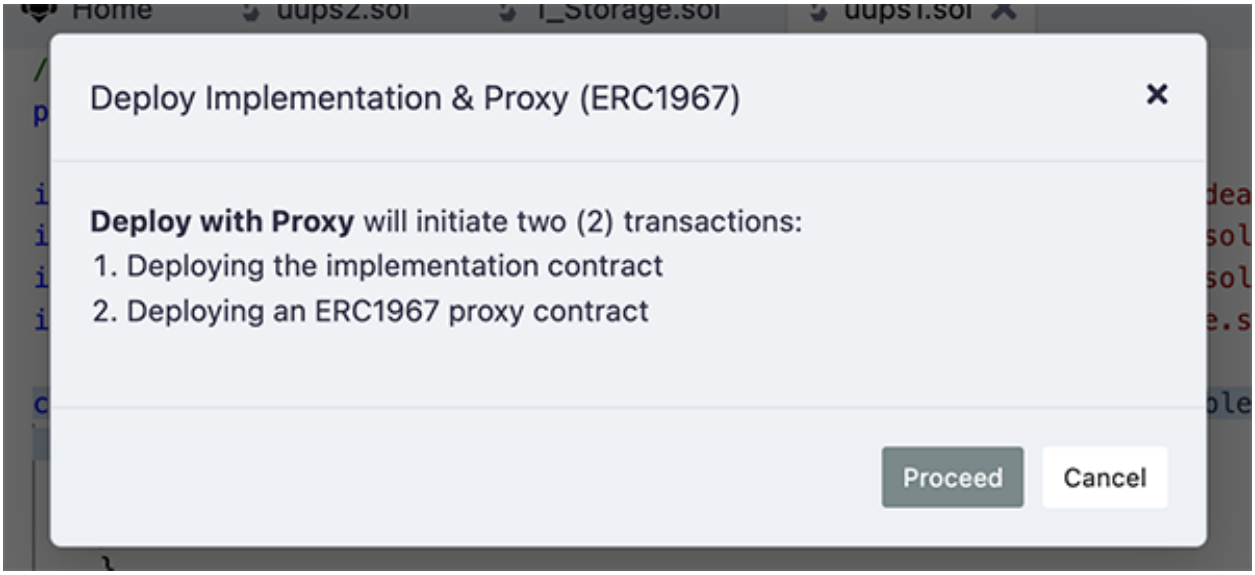
To try this out, you will need to get a proxy contract. Go to wizard.openzeppelin.com and select a contract. Then, in the Upgradeability section, check the UUPS option. Then, copy and paste the file into Remix. Compile the file and go to Deploy & Run.

1.10.1 Deploying

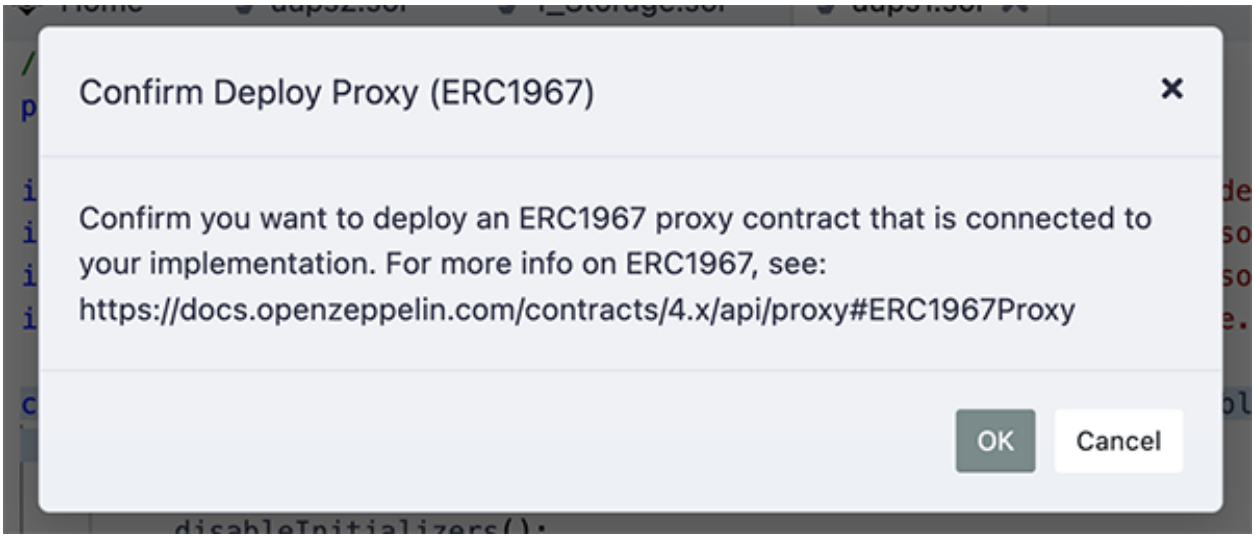
When a UUPS contract is selected in Deploy & Run's Contract select box, you'll see some checkboxes below the Deploy button:



Check the box for **Deploy with Proxy**. This will create two transactions: one for the implementation (your contract) and the other for the ERC1967 proxy contract. You will get two modals to check through:

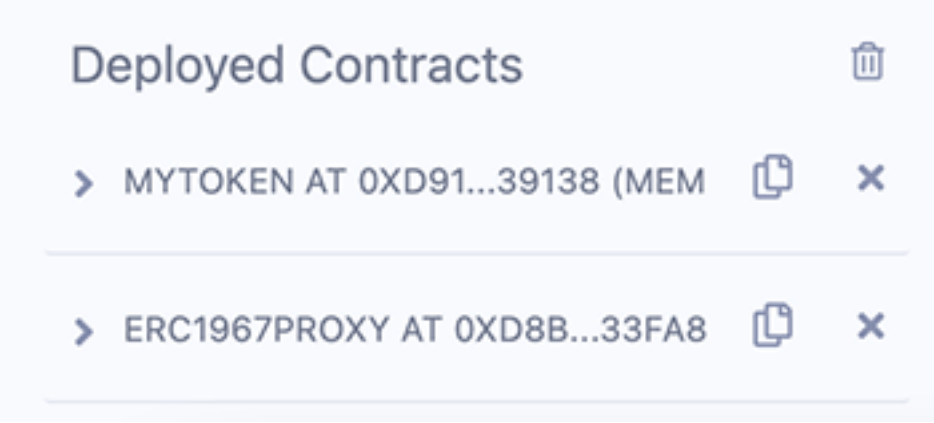


and then



If you are deploying to the **Remix VM**, these modals will appear one after the other. If you are connected to the mainnet or a public testnet, then the second modal will appear after the first transaction has gone through.

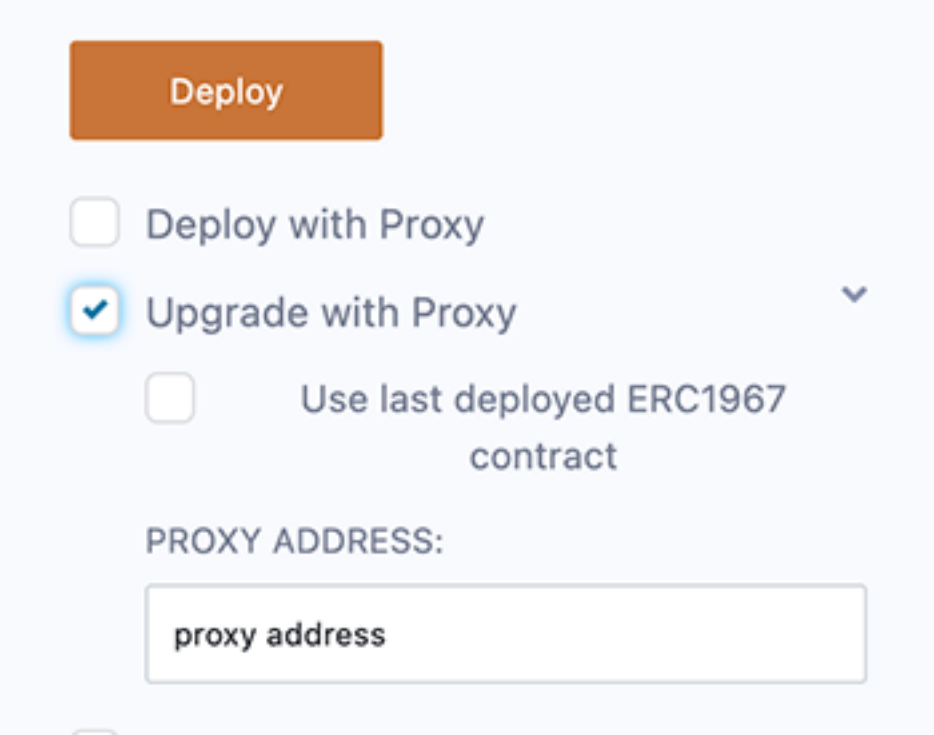
After the ERC1967 proxy contract is deployed, in the Deployed Contracts section, you'll see two deployed instances.



To interact with your implementation contract **DO NOT** use the instance of your contract. Instead, you should **use the ERC1967 Proxy**. The proxy will have all the functions of your implementation.

1.10.2 Upgrading

To upgrade, check the Upgrade with Proxy box and dial down the caret to see the options:



You'll either need to use the last deployed ERC1967 contract, or input the address of the ERC1967 contract that you want to use.

1.11 Debugger

The Debugger shows the contract's state while stepping through a transaction.

It can be used on transactions created on Remix or by providing a transaction's hash. The latter assumes that you have the contract's source code or that you have input the address of a verified contract.

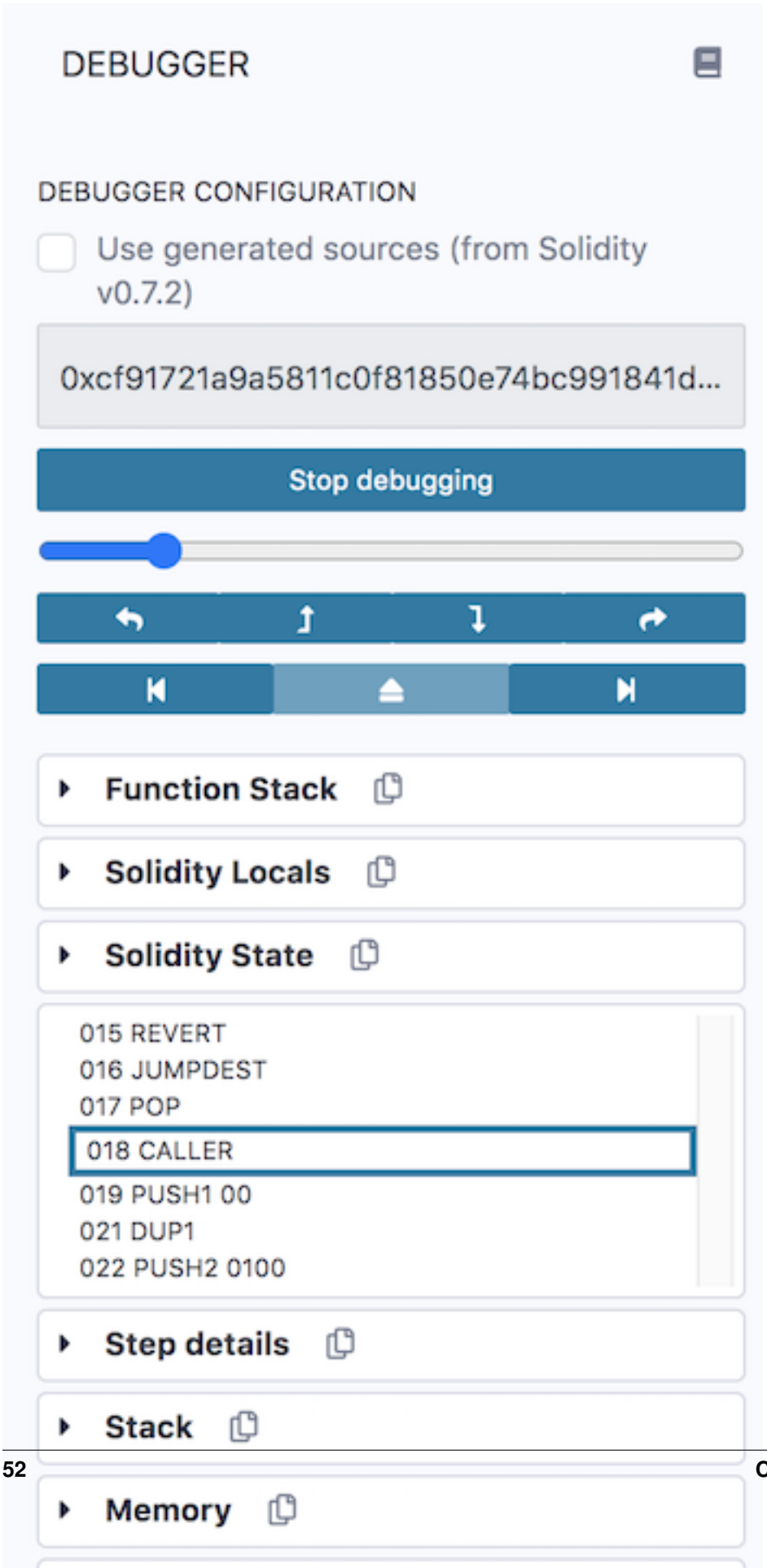
To start a debugging session either:

- **Click** the debug button in the Terminal when a successful or failed transaction appears there. The Debugger will be activated and will gain the focus in the **Side Panel**.
- **Activate** the Debugger in the Plugin Manager and then click the bug in the icon panel. To start the debugging session, input the address of a deployed transaction - while having the source code in the editor and then click the **Start debugging** button.

The debugger will highlight the relevant code in the Editor. If you want to go back to editing the code without the Debugger's highlights, then click the **Stop Debugging** button.

To learn more about how to use this tool go to the Debugging Transactions page.

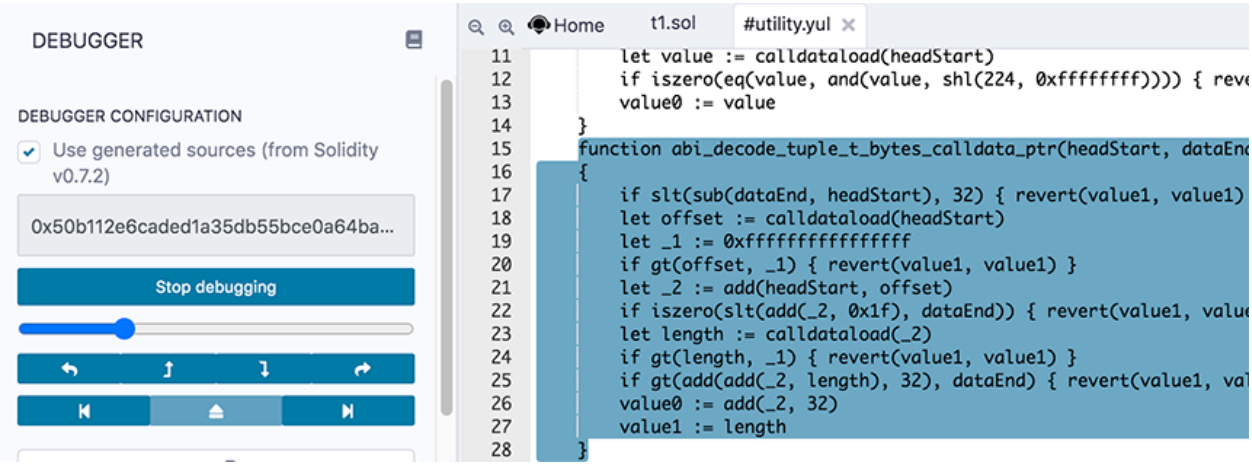
This page will go over the Debugger's *Use generated sources* option, its navigation and its panels.


DEBUGGER
DEBUGGER CONFIGURATION
Use generated sources (from Solidity v0.7.2)
0xcf91721a9a5811c0f81850e74bc991841d...
Stop debugging
Function Stack
Solidity Locals
Solidity State
015 REVERT
016 JUMPDEST
017 POP
018 CALLER
019 PUSH1 00
021 DUP1
022 PUSH2 0100
Step details
Stack
Memory

1.11.1 Use generated sources

This option is available for contracts using Solidity 0.7.2 or greater. See the solidity blog for more details about generated sourcess.

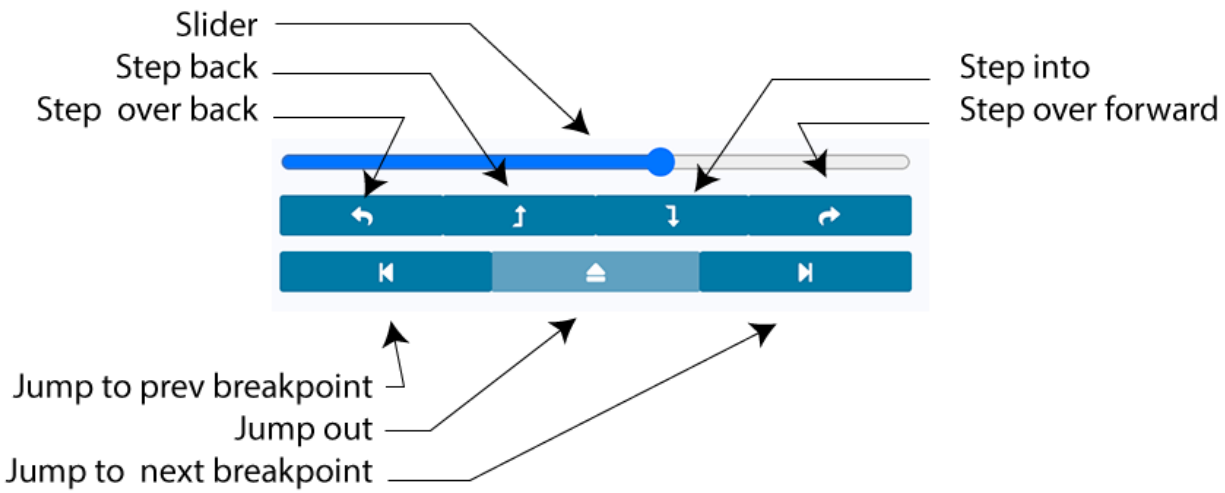
Using **generated sources** will make it easier to audit your contracts. When the option is checked, you can step into those compiler outputs — while debugging.



These compiler outputs will appear in a separate .yul file in the Remix editor.

1.11.2 The Debugger's Navigation

Slider & buttons



Slider

Moving the slider will highlight the relevant code in the **Editor**. On the most granular level, it scrolls through a transaction's opcodes (**see the opcode section below**). At each opcode, the transaction's state changes and these changes are reflected in the **Debugger's panels**.

Step over back

This button goes to the previous opcode. If the previous step involves a **function call**, function will not be entered.

Step back

This button steps back to the previous opcode.

Step into

This button advances to the next opcode. If the next line contains a function call, **Step into** will go into the function.

Step over forward

This button advances to the next opcode. If the next step involves a **function call**, function will not be entered.

Jump to the previous breakpoint

Breakpoints can be placed in the gutter of the Editor. If the current step in the call has passed a breakpoint, this button will move the slider to the most recently passed breakpoint.

Jump out

When you are in a call and click on this button, the slider will be moved to the end of the call.

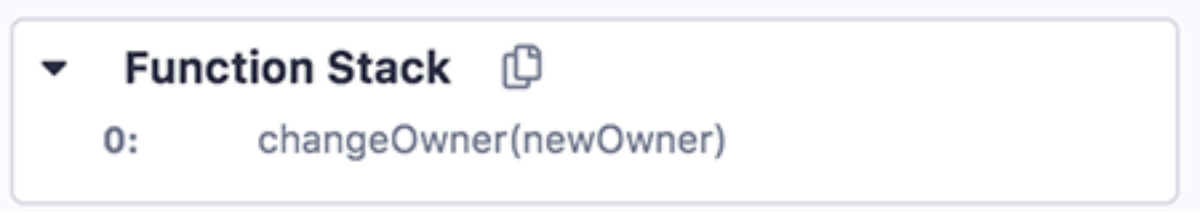
Jump to the next breakpoint

If a breakpoint is ahead in the code, this button will advance to that point.

1.11.3 The Debugger's Panels

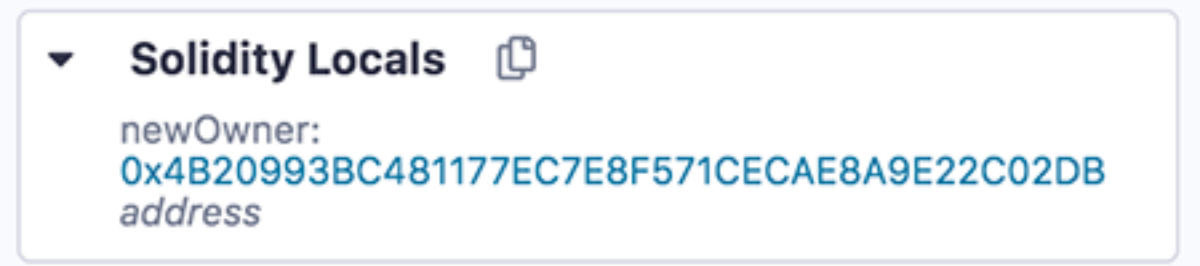
Function Stack

The Function stack lists the functions that the transaction is interacting with.



Solidity Locals

The Solidity Locals are the local variables inside a function.

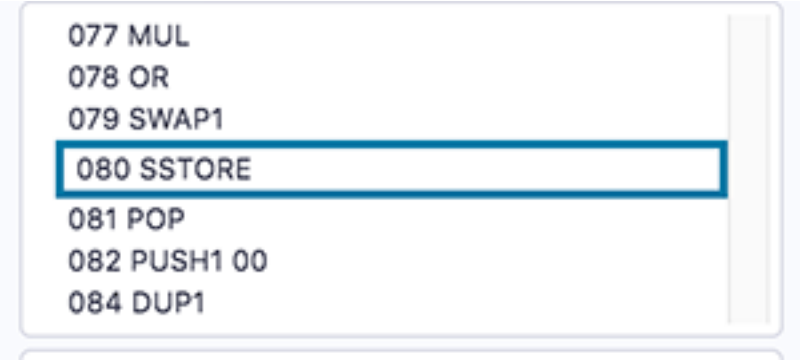


Solidity State

These are the state variables of the contract.

Opcodes

This panel shows the step number and the **opcode** that the debugger is currently on.



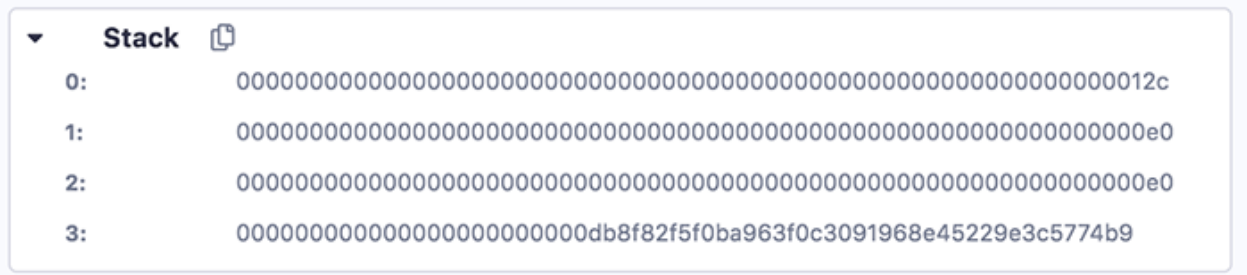
As you drag the **slider** (which is above the navigation buttons), the focussed step number & opcode changes.

Step details

Step details shows more info about the opcode step.

Stack

This panel shows the EVM Stack.



For more info about the stack.

Memory

Memory is cleared for each new message call. Memory is linear and can be addressed at byte level. **Reads** are limited to a width of 256 bits while **writes** can be either 8 bits or 256 bits wide.

The Memory panel consists of 3 columns. You might need to make Remix's side panel a bit wider to get the formatting to be correct. (Drag the border between the main panel and the side panel to the right).

The 1st column is the location in memory. The 2nd column is the hex encoded value. The 3rd column is the decoded value. If there is nothing, then the question marks (**?**) will show - like this:

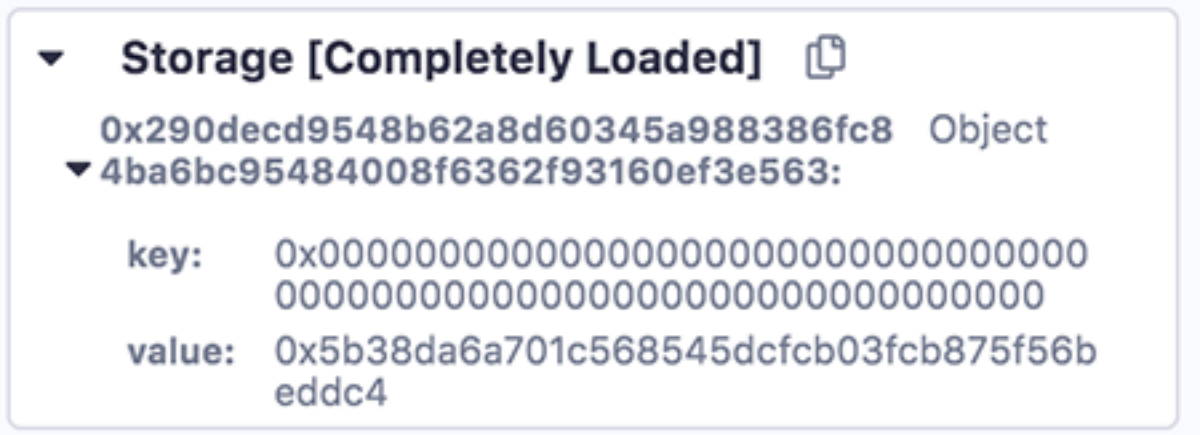
```
0x10: 00000000000000000000000000000000 ????????????????
```

Here is a full example of the **Memory** panel,

Some address slots have hex encoded values and those values are then decoded. For example, check position **0xa0** and **0x140**.

Storage

This is the persistant storage.



Call Stack

All computations are performed on a data array called the **call stack**. It has a maximum size of 1024 elements and contains words of 256 bits.

Call Data

The call data contains the functions parameters.

Return Value

The refers to the value that the function will return.

Full Storage Changes

This shows the persistant storage at the end of the function.

1.11.4 Breakpoints

Breakpoints can be placed in the gutter of the Editor to pause the debugger.

1.11.5 Additional Info

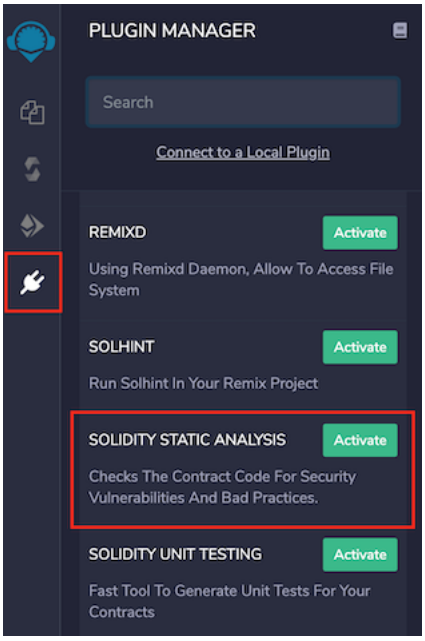
The debugger's granular information gives users detailed information about what is happening in a transaction - so not only is the debugger good for debugging, it is also an excellent teaching tool.

To learn about using the debugger, go to Debugging Transactions.

1.12 Solidity Static Analysis

Static code analysis is a process to debug the code by examining it and without actually executing the code.

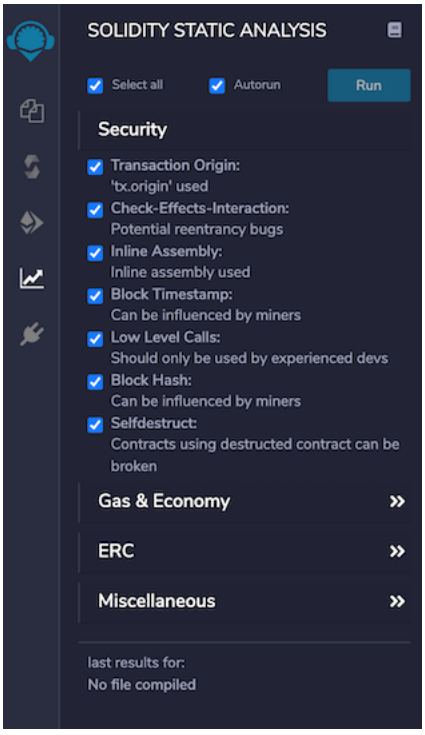
`Solidity Static Analysis` plugin performs static analysis on Solidity smart contracts once they are compiled. It checks for security vulnerabilities and bad development practices, among other issues. It can be activated from Remix `Plugin Manager`.



This plugin comes with `Solidity` environment of Remix IDE.

1.12.1 How to use

If you select this plugin, you will see a number of modules listed along with checkboxes, one `Auto run` checkbox and a `Run` button. `Run` button will be disabled as there is no compiled contract for now.



By default, all modules are selected for analysing a smart contract.

One can select/deselect the modules under which contract should be analyzed and can run the analysis for last compiled

contract by clicking on `Run`.

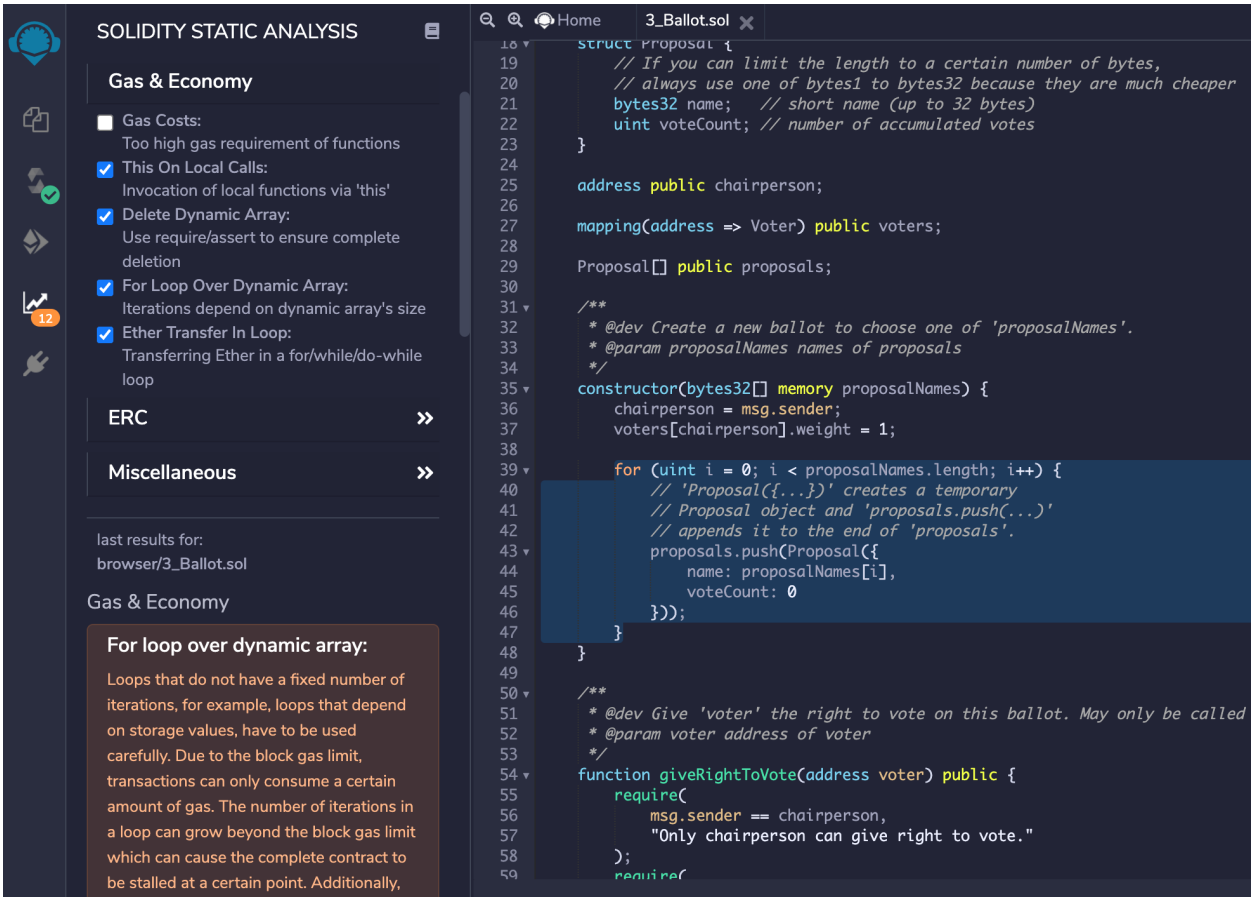
If `Auto run` checkbox is checked, analysis will be performed each time a contract is compiled. Uncheck the checkbox if you want to stop this behaviour.

1.12.2 Run

If `Auto run` checkbox is checked, analysis will be performed on compiling a contract and result will be shown as badge to the plugin icon. This number tells warnings count for the contract (e.g; `12` in attached image below) .

By visiting the plugin UI, the details of the warning can be seen along with the category name for each warning.

Clicking on warning details will highlight the relevant code in the editor.



1.12.3 Analysis Modules

Currently, with Remix IDE v0.10.1, there are 21 analysis modules listed under 4 categories. Categories are: `Security`, `Gas & Economy`, ERC & `Miscellaneous`.

Here is the list of modules under each category along with the example code which **should be avoided or used very carefully while development**:

Category: Security

- **Transaction origin: 'tx.origin' is used**

`tx.origin` is useful only in very exceptional cases. If you use it for authentication, you usually want to replace it by "msg.sender", because otherwise any contract you call can act on your behalf.

Example:

```
require(tx.origin == owner);
```

- **Check effects: Potential reentrancy bugs**

Potential Violation of Checks-Effects-Interaction pattern can lead to re-entrancy vulnerability.

Example:

```
// sending ether first
msg.sender.transfer(amount);

// updating state afterwards
balances[msg.sender] -= amount;
```

- **Inline assembly: Inline assembly used**

Use of inline assembly is advised only in rare cases.

Example:

```
assembly {
            // retrieve the size of the code, this needs assembly
            let size := extcodesize(_addr)
}
```

- **Block timestamp: Semantics maybe unclear**

`now` does not mean current time. `now` is an alias for `block.timestamp`. `block.timestamp` can be influenced by miners to a certain degree, be careful.

Example:

```
// using now for date comparison
if(startDate > now)
    isStarted = true;

// using block.timestamp
uint c = block.timestamp;
```

- **Low level calls: Semantics maybe unclear**

Use of low level `call`, `callcode` or `delegatecall` should be avoided whenever possible. `send` does not throw an exception when not successful, make sure you deal with the failure case accordingly. Use `transfer` whenever failure of the ether transfer should rollback the whole transaction.

Example:

```
x.call('something');
x.send(1 wei);
```

- **Blockhash usage: Semantics maybe unclear**

`blockhash` is used to access the last 256 block hashes. A miner computes the block hash by "summing up" the information in the current block mined. By summing up the information in a clever way a miner can try to influence the outcome of a transaction in the current block.

Example:

```
bytes32 b = blockhash(100);
```

- **Selfdestruct: Beware of caller contracts**

`selfdestruct` can block calling contracts unexpectedly. Be especially careful if this contract is planned to be used by other contracts (i.e. library contracts, interactions). Selfdestruction of the callee contract can leave callers in an inoperable state.

Example:

```
selfdestruct(address(0x123abc..));
```

Category: Gas & Economy

- **Gas costs: Too high gas requirement of functions**

If the gas requirement of a function is higher than the block gas limit, it cannot be executed. Please avoid loops in your functions or actions that modify large areas of storage

Example:

```
for (uint8 proposal = 0; proposal < proposals.length; proposal++) {
    if (proposals[proposal].voteCount > winningVoteCount) {
        winningVoteCount = proposals[proposal].voteCount;
        winningProposal = proposal;
    }
}
```

- **This on local calls: Invocation of local functions via 'this'**

Never use `this` to call functions in the same contract, it only consumes more gas than normal local calls.

Example:

```
contract test {

    function callb() public {
        address x;
        this.b(x);
    }

    function b(address a) public returns (bool) {}
}
```

- **Delete on dynamic Array: Use require/assert appropriately**

The `delete` operation when applied to a dynamically sized array in Solidity generates code to delete each of the elements contained. If the array is large, this operation can surpass the block gas limit and raise an OOG exception. Also nested dynamically sized objects can produce the same results.

Example:

```
contract arr {
    uint[] users;
    function resetState() public{
        delete users;
    }
}
```

- **For loop over dynamic array: Iterations depend on dynamic array's size**

Loops that do not have a fixed number of iterations, for example, loops that depend on storage values, have to be used carefully: Due to the block gas limit, transactions can only consume a certain amount of gas. The number of iterations in a loop can grow beyond the block gas limit which can stall the complete contract at a certain point. Additionally, using unbounded loops can incur in a lot of avoidable gas costs. Carefully test how many items at maximum you can pass to such functions to make it successful.

Example:

```
contract forLoopArr {
    uint[] array;

    function shiftArrItem(uint index) public returns(uint[] memory) {
        for (uint i = index; i < array.length; i++) {
            array[i] = array[i+1];
        }
        return array;
    }
}
```

- **Ether transfer in loop: Transferring Ether in a for/while/do-while loop**

Ether payout should not be done in a loop. Due to the block gas limit, transactions can only consume a certain amount of gas. The number of iterations in a loop can grow beyond the block gas limit which can cause the complete contract to be stalled at a certain point. If required, make sure that number of iterations are low and you trust each address involved.

Example:

```
contract etherTransferInLoop {
    address payable owner;

    function transferInForLoop(uint index) public  {
        for (uint i = index; i < 100; i++) {
            owner.transfer(i);
        }
    }

    function transferInWhileLoop(uint index) public  {
        uint i = index;
        while (i < 100) {
            owner.transfer(i);
            i++;
        }
    }
}
```

Category: ERC

- **ERC20: 'decimals' should be 'uint8'**

ERC20 Contracts `decimals` function should have `uint8` as return type.

Example:

```
contract EIP20 {
```

(continues on next page)

(continued from previous page)

```
    uint public decimals = 12;
}
```

Category: Miscellaneous

- **Constant/View/Pure functions: Potentially constant/view/pure functions**

It warns for the methods which potentially should be constant/view/pure but are not.

Example:

```
function b(address a) public returns (bool) {
        return true;
}
```

- **Similar variable names: Variable names are too similar**

It warns on the usage of similar variable names.

Example:

```
// Variables have very similar names voter and voters.
function giveRightToVote(address voter) public {
    require(voters[voter].weight == 0);
    voters[voter].weight = 1;
}
```

- **No return: Function with 'returns' not returning**

It warns for the methods which define a return type but never explicitly return a value.

Example:

```
function noreturn(string memory _dna) public returns (bool) {
       dna = _dna;
   }
```

- **Guard conditions: Use 'require' and 'assert' appropriately**

Use `assert(x)` if you never ever want x to be false, not in any circumstance (apart from a bug in your code). Use `require(x)` if x can be false, due to e.g. invalid input or a failing external component.

Example:

```
assert(a.balance == 0);
```

- **Result not used: The result of an operation not used**

A binary operation yields a value that is not used in the following. This is often caused by confusing assignment (=) and comparison (==).

Example:

```
c == 5;
or
a + b;
```

- **String Length: Bytes length != String length**

Bytes and string length are not the same since strings are assumed to be UTF-8 encoded (according to the ABI definition) therefore one character is not necessarily encoded in one byte of data.

Example:

```
function length(string memory a) public pure returns(uint) {
    bytes memory x = bytes(a);

    return x.length;
}
```

- **Delete from dynamic array: 'delete' on an array leaves a gap**

Using `delete` on an array leaves a gap. The length of the array remains the same. If you want to remove the empty position you need to shift items manually and update the length property.

Example:

```
contract arr {
    uint[] array = [1,2,3];

    function removeAtIndex() public returns (uint[] memory) {
        delete array[1];
        return array;
    }
}
```

- **Data Truncated: Division on int/uint values truncates the result**

Division of integer values yields an integer value again. That means e.g. 10 / 100 = 0 instead of 0.1 since the result is an integer again. This does not hold for division of (only) literal values since those yield rational constants.

Example:

```
function contribute() payable public {
    uint fee = msg.value * uint256(feePercentage / 100);
    fee = msg.value * (p2 / 100);
}
```

1.12.4 Remix-analyzer

`remix-analyzer` is the library which works underneath of remix-ide `Solidity Static Analysis` plugin.

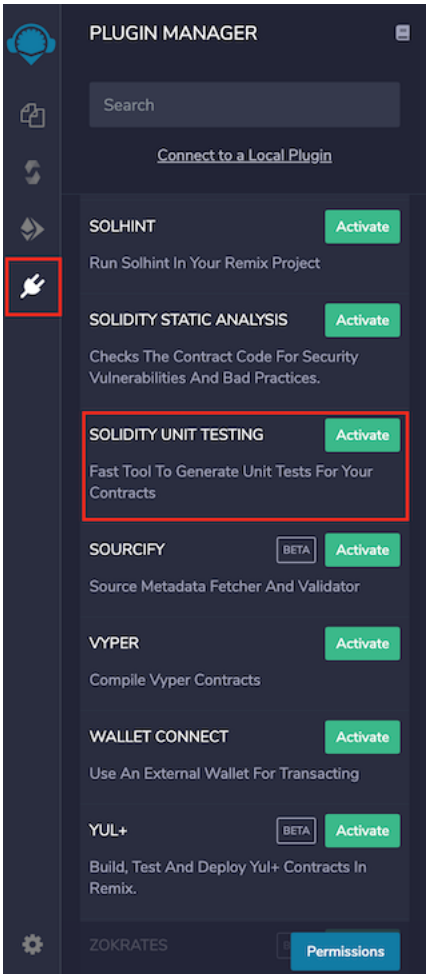
`remix-analyzer` is an NPM package. It can be used as a library in a solution supporting node.js. Find more information about this type of usage in the remix-analyzer repository

1.13 Unit Testing Plugin

Click the  (double check) icon from icon bar to move to the `Solidity Unit Testing` plugin.

If you haven't used this plugin before and are not seeing `double check` icon, you have to activate it from Remix plugin manager.

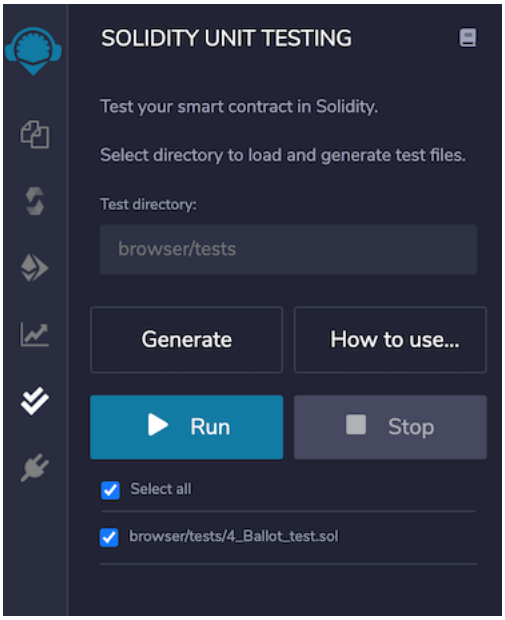
Go to the plugin manager by clicking the  (plug) icon and activate `Solidity Unit Testing` plugin.



Now `double check` icon will appear on the left side icon bar. Clicking on icon will load the plugin in the side panel.

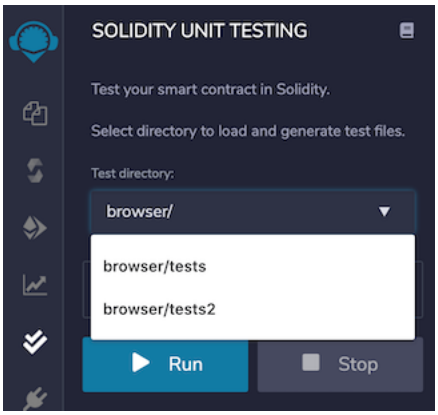
Alternatively, just select `Solidity` environment from Remix IDE `Home` tab. This will activate `Solidity Unit Testing` plugin along with `Solidity Compiler`, `Deploy & Run Transactions` & `Solidity Static Analysis` plugins.

After successful loading, plugin looks like this:



1.13.1 Test directory

Plugin asks you to provide a directory which will be your workspace only for this plugin. To select directory, as soon as you add / to the path, it shows the possible options.



Once selected, this directory will be used to load test files and to store newly generated test files.

Default test directory is `browser/tests`.

1.13.2 Generate

Select a solidity file which you want to test and click on the button `Generate`. It will generate a test file dedicated to selected file **in the test directory**.

If no file is selected, it will still create a file with generic name as `newFile_test.sol`.

This file contains sufficient information to give better understanding about developing tests for a contract.

Generic file looks as:

```
pragma solidity >=0.4.22 <0.8.0;
import "remix_tests.sol"; // this import is automatically injected by Remix.
import "remix_accounts.sol";
// Import here the file to test.

// File name has to end with '_test.sol', this file can contain more than one
↪testSuite contracts
contract testSuite {

    /// 'beforeAll' runs before all other tests
    /// More special functions are: 'beforeEach', 'beforeAll', 'afterEach' & 'afterAll
↪'
    function beforeAll() public {
        // Here should instantiate tested contract
        Assert.equal(uint(1), uint(1), "1 should be equal to 1");
    }

    function checkSuccess() public {
        // Use 'Assert' to test the contract,
        // See documentation: https://remix-ide.readthedocs.io/en/latest/assert_
↪library.html
        Assert.equal(uint(2), uint(2), "2 should be equal to 2");
        Assert.notEqual(uint(2), uint(3), "2 should not be equal to 3");
    }

    function checkSuccess2() public pure returns (bool) {
        // Use the return value (true or false) to test the contract
        return true;
    }

    function checkFailure() public {
        Assert.equal(uint(1), uint(2), "1 is not equal to 2");
    }

    /// Custom Transaction Context
    /// See more: https://remix-ide.readthedocs.io/en/latest/unittesting.html
↪#customization
    /// #sender: account-1
    /// #value: 100
    function checkSenderAndValue() public payable {
        // account index varies 0-9, value is in wei
        Assert.equal(msg.sender, TestsAccounts.getAccount(1), "Invalid sender");
        Assert.equal(msg.value, 100, "Invalid value");
    }
}
```

1.13.3 Write Tests

Write sufficient unit tests to ensure that your contract works as expected under different scenarios.

Remix injects a built-in `assert` library which can be used for testing. You can visit the library documentation *here*.

Apart from this, Remix allows usage of some special functions in the test file to make testing more structural. They are as:

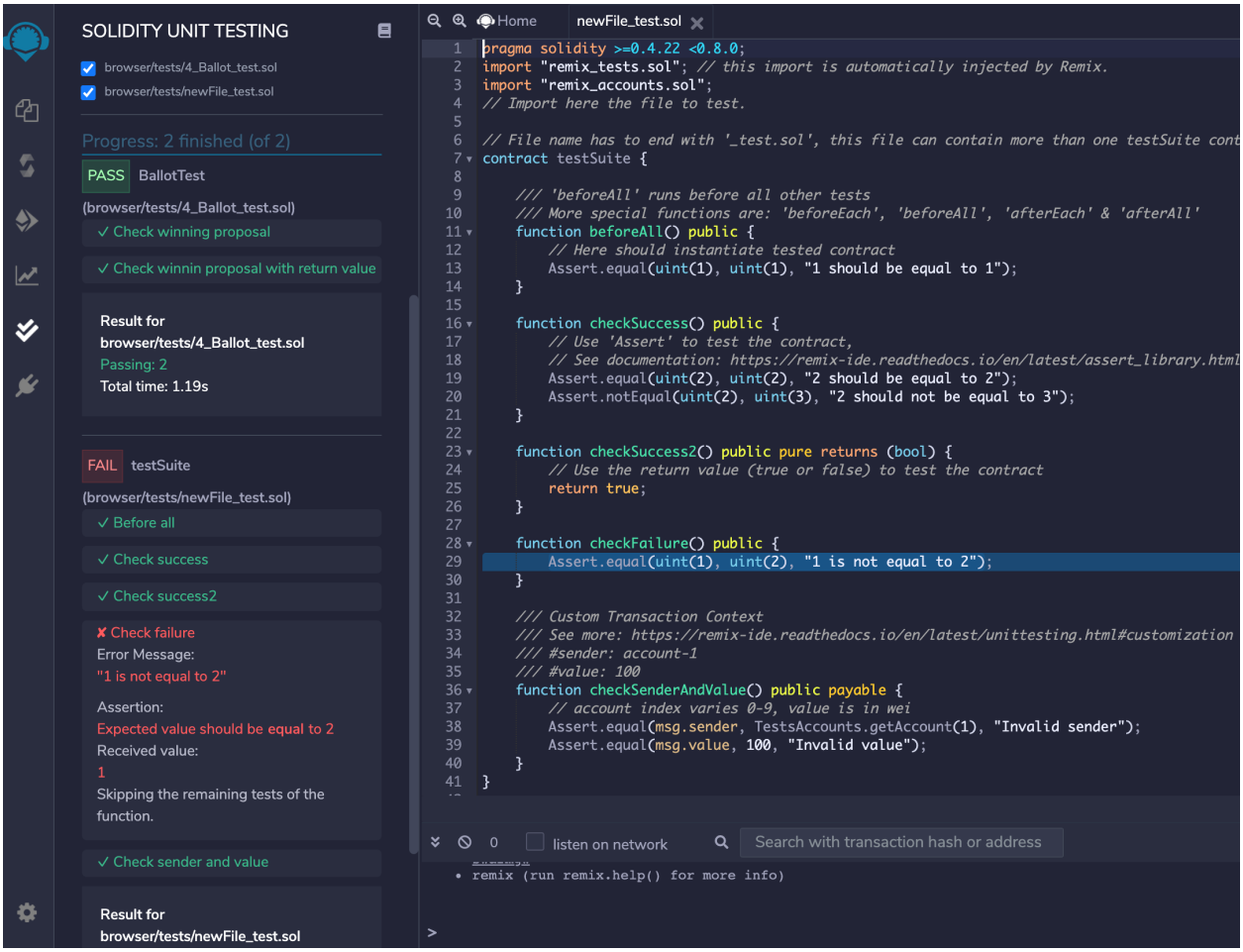
- `beforeEach()` - Runs before each test
- `beforeAll()` - Runs before all tests

- `afterEach()` - Runs after each test
- `afterAll()` - Runs after all tests

To get started, see this simple example.

1.13.4 Run

Once you are done with writing tests, select the file(s) and click on `Run` to execute the tests. The execution will run in a separate environment. After completing the execution of one file, a test summary will be show as below:



For failed tests, there will be more assertion details to analyze the issue. Clicking on failed test will highlight the relevant line of code in the editor.

1.13.5 Stop

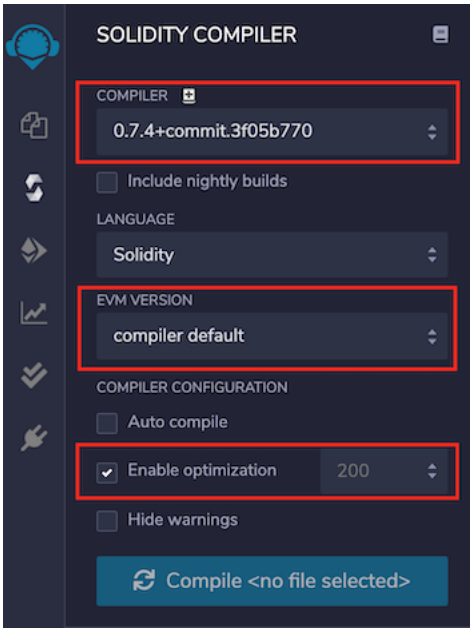
If you have selected multiple files to run the tests and want to stop the execution, click on `Stop` button. It will stop execution after running the tests for current file.

1.13.6 Customization

Remix facilitates users with various types of customizations to test a contract properly.

1. Custom Compiler Context

`Solidity Unit Testing` refers to the `Solidity Compiler` plugin for compiler configurations. Configure `Compiler`, `EVM Version`, `Enable Optimization` & `runs` in the `Solidity Compiler` plugin and this will be used in the `Solidity Unit Testing` plugin for contract compilation before running unit tests.



2. Custom Transaction Context

For interacting with a contract's method, the prime parameters of a transaction are `from` address, `value` & `gas`. Typically, a method's behaviour is tested with different values of these parameters.

One can input custom values for `msg.sender` & `msg.value` of transaction using NatSpec comments, like:

```
/// #sender: account-0
/// #value: 10
function checkSenderIs0AndValueis10 () public payable {
    Assert.equal(msg.sender, TestsAccounts.getAccount(0), "wrong sender in␣
↪checkSenderIs0AndValueis10");
    Assert.equal(msg.value, 10, "wrong value in checkSenderIs0AndValueis10");
}
```

Instructions to use:

1. Parameters must be defined in the method's NatSpec
2. Each parameter key should be prefixed with a hash (**#**) and end with a colon following a space (**:**) like `#sender:` & `#value:`
3. For now, customization is only available for parameters `sender` & `value`
4. Sender is the `from` address of a transaction which is accessed using `msg.sender` inside a contract method. It should be defined in a fixed format as '**account-**<account_index>'
5. `<account_index>` varies from `0-2` before remix-ide release v0.10.0 and `0-9` afterwards
6. `remix_accounts.sol` must be imported in your test file to use custom `sender`
7. Value is `value` sent along with a transaction in `wei` which is accessed using `msg.value` inside a contract method. It should be a number.

Regarding `gas`, Remix estimates the required gas for each transaction internally. Still if a contract deployment fails with `Out-of-Gas` error, it tries to redeploy it by doubling the gas. Deployment failing with double gas will show error: `contract deployment failed after trying twice: The contract code couldn't be stored, please check your gas limit`

Various test examples can be seen in *examples* section.

1.13.7 Points to remember

- A test contract cannot have a method with parameters. Having one such method will show error: `Method 'methodname' can not have parameters inside a test contract`
- Number of test accounts are `3` before remix-ide release v0.10.0 and `10` afterwards
- While a test file which imports `remix_accounts.sol` might not compile successfully with `Solidity Compiler` plugin, do not worry, this will have no bearing on its success with `Solidity Unit Testing` plugin.

1.14 Command Line Interface

1.14.1 remix-tests

`remix-tests` is a tool which can be used as a CLI (Command Line Interface) solution to run the solidity unit tests. This is the same tool which works as a library underneath Remix's `Solidity Unit Testing` plugin. It is available on NPM as `@remix-project/remix-tests`.

1.14.2 Get started

You can install it using NPM:

- As a dev dependency:

```
npm install --save-dev @remix-project/remix-tests
```

- As a global NPM module:

```
npm install -g @remix-project/remix-tests
```

To confirm installation, run:

```
$ remix-tests version
0.1.36
```

Version should be same as on NPM.

1.14.3 How to use

You can see all available options using `help` command.

```
$ remix-tests help
Usage: remix-tests [options] [command]

Options:
```

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```
  -V, --version            output the version number
  -c, --compiler <string>  set compiler version (e.g: 0.6.1, 0.7.1 etc)
  -e, --evm <string>       set EVM version (e.g: petersburg, istanbul etc)
  -o, --optimize <bool>    enable/disable optimization
  -r, --runs <number>      set runs (e.g: 150, 250 etc)
  -v, --verbose <level>    set verbosity level (0 to 5)
  -h, --help               output usage information

Commands:
  version                  output the version number
  help                     output usage information
```

General structure of a command is as:

`$ remix-tests <options> <file/directory path>`

To run all test files inside `examples` directory

```
$ remix-tests examples/
```

To run single test file named `simple_storage_test.sol` inside `examples` directory

```
$ remix-tests examples/simple_storage_test.sol
```

NOTE: `remix-tests` will assume that name of test(s) file ends with `"_test.sol"`. e.g `simple_storage_test.sol`

1.14.4 Example

Consider for a simple storage contract named `simple_storage.sol`:

```
pragma solidity >=0.4.22 <=0.8.0;

contract SimpleStorage {
  uint public storedData;

  constructor() public {
    storedData = 100;
  }

  function set(uint x) public {
    storedData = x;
  }

  function get() public view returns (uint retVal) {
    return storedData;
  }
}
```

Test file `simple_storage_test.sol` can be as:

```
pragma solidity >=0.4.22 <=0.8.0;
import "remix_tests.sol"; // injected by remix-tests
import "./simple_storage.sol";

contract MyTest {
```

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```
  SimpleStorage foo;

  function beforeAll() public {
    foo = new SimpleStorage();
  }

  function initialValueShouldBe100() public returns (bool) {
    return Assert.equal(foo.get(), 100, "initial value is not correct");
  }

  function initialValueShouldNotBe200() public returns (bool) {
    return Assert.notEqual(foo.get(), 200, "initial value is not correct");
  }

  function shouldTriggerOneFail() public {
    Assert.equal(uint(1), uint(2), "uint test 1 fails");
    Assert.notEqual(uint(1), uint(2), "uint test 2 passes");
  }

  function shouldTriggerOnePass() public {
    Assert.equal(uint(1), uint(1), "uint test 3 passes");
  }
}
```

Running `simple_storage_test.sol` file will output as:

```
$ remix-tests simple_storage_test.sol

                :: Running remix-tests - Unit testing for solidity ::

'creation of library remix_tests.sol:Assert pending...'

          MyTest
        ✓  Initial value should be100
        ✓  Initial value should not be200
          Should trigger one fail
        ✓  Should trigger one pass


3 passing (0.282s)
1 failing

  1) MyTest: Should trigger one fail

         error: uint test 1 fails
         expected value to be equal to: 2
         returned: 1
```

1.14.5 Custom compiler context

Most of the `remix-tests` options are there to define a custom compiler context. With an extended custom compiler context, execution of above test file will go as:

```
$ remix-tests --compiler 0.7.4 --evm istanbul --optimize true --runs 300 simple_
↪storage_test.sol

                :: Running remix-tests - Unit testing for solidity ::

[14:03:18] info: Compiler version set to 0.7.4. Latest version is 0.8.0
[14:03:18] info: EVM set to istanbul
[14:03:18] info: Optimization is enabled
[14:03:18] info: Runs set to 300
Loading remote solc version v0.7.4+commit.3f05b770 ...
'creation of library remix_tests.sol:Assert pending...'

          MyTest
        ✓  Initial value should be100
        ✓  Initial value should not be200
          Should trigger one fail
        ✓  Should trigger one pass


3 passing (0.316s)
1 failing

  1) MyTest: Should trigger one fail

         error: uint test 1 fails
         expected value to be equal to: 2
         returned: 1
```

Rememeber, custom compiler version will require internet connection to load compiler.

1.14.6 As a CI solution

`remix-tests` can also be used for continuous integration (CI) testing.

For implementation example, see Su Squares contract and Travis build that uses `remix-tests` for continuous integration.

1.15 Remix Assert Library

- *Assert.ok(value[, message])*
- *Assert.equal(actual, expected[, message])*
- *Assert.notEqual(actual, expected[, message])*
- *Assert.greaterThan(value1, value2[, message])*
- *Assert.lesserThan(value1, value2[, message])*

1.15.1 Assert

Assert.ok(value[, message])

- `value`: <bool>

- `message`: <string>

Tests if value is truthy. `message` is returned in case of failure.

Examples:

```
Assert.ok(true);
// OK
Assert.ok(false, "it\'s false");
// error: it's false
```

Assert.equal(actual, expected[, message])

- `actual`: <uint | int | bool | address | bytes32 | string>
- `expected`: <uint | int | bool | address | bytes32 | string>
- `message`: <string>

Tests if `actual` & `expected` values are same. `message` is returned in case of failure.

Examples:

```
Assert.equal(string("a"), "a");
// OK
Assert.equal(uint(100), 100);
// OK
foo.set(200)
Assert.equal(foo.get(), 200);
// OK
Assert.equal(foo.get(), 100, "value should be 100");
// error: value should be 100
```

Assert.notEqual(actual, expected[, message])

- `actual`: <uint | int | bool | address | bytes32 | string>
- `expected`: <uint | int | bool | address | bytes32 | string>
- `message`: <string>

Tests if `actual` & `expected` values are not same. `message` is returned in case of failure.

Examples:

```
Assert.notEqual(string("a"), "b");
// OK
foo.set(200)
Assert.notEqual(foo.get(), 200, "value should not be 200");
// error: value should not be 200
```

Assert.greaterThan(value1, value2[, message])

- `value1`: <uint | int>
- `value2`: <uint | int>
- `message`: <string>

Tests if `value1` is greater than `value2`. `message` is returned in case of failure.

Examples:

```
Assert.greaterThan(uint(2), uint(1));
// OK
Assert.greaterThan(uint(-2), uint(1));
// OK
Assert.greaterThan(int(2), int(1));
// OK
Assert.greaterThan(int(-2), int(-1), "-2 is not greater than -1");
// error: -2 is not greater than -1
```

Assert.lesserThan(value1, value2[, message])

- `value1`: <uint | int>
- `value2`: <uint | int>
- `message`: <string>

Tests if `value1` is lesser than `value2`. `message` is returned in case of failure.

Examples:

```
Assert.lesserThan(int(-2), int(-1));
// OK
Assert.lesserThan(int(2), int(1), "2 is not lesser than 1");
// error: 2 is not lesser than 1
```

1.16 Testing by Example

Here are some examples which can give you better understanding to plan your tests.

Note: Examples in this section are intended to give you a push for development. We don't recommend to rely on them without verifying at your end.

1.16.1 1. Simple example

In this example, we test setting & getting variables.

Contract/Program to be tested: `Simple_storage.sol`

```
pragma solidity >=0.4.22 <0.7.0;

contract SimpleStorage {
    uint public storedData;

    constructor() public {
        storedData = 100;
    }

    function set(uint x) public {
        storedData = x;
    }
```

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```
    function get() public view returns (uint retVal) {
        return storedData;
    }
}
```

Test contract/program: `simple_storage_test.sol`

```
pragma solidity >=0.4.22 <0.7.0;
import "remix_tests.sol";
import "./Simple_storage.sol";

contract MyTest {
    SimpleStorage foo;

    // beforeEach works before running each test
    function beforeEach() public {
        foo = new SimpleStorage();
    }

    /// Test if initial value is set correctly
    function initialValueShouldBe100() public returns (bool) {
        return Assert.equal(foo.get(), 100, "initial value is not correct");
    }

    /// Test if value is set as expected
    function valueIsSet200() public returns (bool) {
        foo.set(200);
        return Assert.equal(foo.get(), 200, "value is not 200");
    }
}
```

1.16.2 2. Testing a method involving `msg.sender`

In Solidity, `msg.sender` plays a great role in access management of a smart contract methods interaction. Different `msg.sender` can help to test a contract involving multiple accounts with different roles. Here is an example for testing such case:

Contract/Program to be tested: `Sender.sol`

```
pragma solidity >=0.4.22 <0.7.0;
contract Sender {
    address private owner;

    constructor() public {
        owner = msg.sender;
    }

    function updateOwner(address newOwner) public {
        require(msg.sender == owner, "only current owner can update owner");
        owner = newOwner;
    }

    function getOwner() public view returns (address) {
        return owner;
```

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```
    }
}
```

Test contract/program: `Sender_test.sol`

```
pragma solidity >=0.4.22 <0.7.0;
import "remix_tests.sol"; // this import is automatically injected by Remix
import "remix_accounts.sol";
import "./Sender.sol";

// Inherit 'Sender' contract
contract SenderTest is Sender {
    /// Define variables referring to different accounts
    address acc0;
    address acc1;
    address acc2;

    /// Initiate accounts variable
    function beforeAll() public {
        acc0 = TestsAccounts.getAccount(0);
        acc1 = TestsAccounts.getAccount(1);
        acc2 = TestsAccounts.getAccount(2);
    }

    /// Test if initial owner is set correctly
    function testInitialOwner() public {
        // account at zero index (account-0) is default account, so current owner␣
↪should be acc0
        Assert.equal(getOwner(), acc0, 'owner should be acc0');
    }

    /// Update owner first time
    /// This method will be called by default account(account-0) as there is no␣
↪custom sender defined
    function updateOwnerOnce() public {
        // check method caller is as expected
        Assert.ok(msg.sender == acc0, 'caller should be default account i.e. acc0');
        // update owner address to acc1
        updateOwner(acc1);
        // check if owner is set to expected account
        Assert.equal(getOwner(), acc1, 'owner should be updated to acc1');
    }

    /// Update owner again by defining custom sender
    /// #sender: account-1 (sender is account at index '1')
    function updateOwnerOnceAgain() public {
        // check if caller is custom and is as expected
        Assert.ok(msg.sender == acc1, 'caller should be custom account i.e. acc1');
        // update owner address to acc2. This will be successful because acc1 is␣
↪current owner & caller both
        updateOwner(acc2);
        // check if owner is set to expected account i.e. account2
        Assert.equal(getOwner(), acc2, 'owner should be updated to acc2');
    }
}
```

1.16.3 3. Testing method execution

With Solidity, one can directly verify the changes made by a method in storage by retrieving those variables from a contract. But testing for a successful method execution takes some strategy. Well that is not entirely true, when a test is successful - it is usually obvious why it passed. However, when a test fails, it is essential to understand why it failed.

To help in such cases, Solidity introduced the `try-catch` statement in version `0.6.0`. Previously, we had to use low-level calls to track down what was going on.

Here is an example test file that use both **try-catch** blocks and **low level calls**:

Contract/Program to be tested: `AttendanceRegister.sol`

```
pragma solidity >=0.4.22 <0.7.0;
contract AttendanceRegister {
    struct Student{
            string name;
            uint class;
        }

    event Added(string name, uint class, uint time);

    mapping(uint => Student) public register; // roll number => student details

    function add(uint rollNumber, string memory name, uint class) public returns
↪(uint256){
        require(class > 0 && class <= 12, "Invalid class");
        require(register[rollNumber].class == 0, "Roll number not available");
        Student memory s = Student(name, class);
        register[rollNumber] = s;
        emit Added(name, class, now);
        return rollNumber;
    }

    function getStudentName(uint rollNumber) public view returns (string memory) {
        return register[rollNumber].name;
    }
}
```

Test contract/program: `AttendanceRegister_test.sol`

```
pragma solidity >=0.4.22 <0.7.0;
import "remix_tests.sol"; // this import is automatically injected by Remix.
import "./AttendanceRegister.sol";

contract AttendanceRegisterTest {

    AttendanceRegister ar;

    /// 'beforeAll' runs before all other tests
    function beforeAll () public {
        // Create an instance of contract to be tested
        ar = new AttendanceRegister();
    }

    /// For solidity version greater or equal to 0.6.0,
    /// See: https://solidity.readthedocs.io/en/v0.6.0/control-structures.html#try-
↪catch
    /// Test 'add' using try-catch
```

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```
    function testAddSuccessUsingTryCatch() public {
        // This will pass
        try ar.add(101, 'secondStudent', 11) returns (uint256 r) {
            Assert.equal(r, 101, 'wrong rollNumber');
        } catch Error(string memory /*reason*/) {
            // This is executed in case
            // revert was called inside getData
            // and a reason string was provided.
            Assert.ok(false, 'failed with reason');
        } catch (bytes memory /*lowLevelData*/) {
            // This is executed in case revert() was used
            // or there was a failing assertion, division
            // by zero, etc. inside getData.
            Assert.ok(false, 'failed unexpected');
        }
    }

    /// Test failure case of 'add' using try-catch
    function testAddFailureUsingTryCatch1() public {
        // This will revert on 'require(class > 0 && class <= 12, "Invalid class");'␣
↪for class '13'
        try ar.add(101, 'secondStudent', 13) returns (uint256 r) {
            Assert.ok(false, 'method execution should fail');
        } catch Error(string memory reason) {
            // Compare failure reason, check if it is as expected
            Assert.equal(reason, 'Invalid class', 'failed with unexpected reason');
        } catch (bytes memory /*lowLevelData*/) {
            Assert.ok(false, 'failed unexpected');
        }
    }

    /// Test another failure case of 'add' using try-catch
    function testAddFailureUsingTryCatch2() public {
        // This will revert on 'require(register[rollNumber].class == 0, "Roll number␣
↪not available");' for rollNumber '101'
        try ar.add(101, 'secondStudent', 11) returns (uint256 r) {
            Assert.ok(false, 'method execution should fail');
        } catch Error(string memory reason) {
            // Compare failure reason, check if it is as expected
            Assert.equal(reason, 'Roll number not available', 'failed with unexpected␣
↪reason');
        } catch (bytes memory /*lowLevelData*/) {
            Assert.ok(false, 'failed unexpected');
        }
    }

    /// For solidity version less than 0.6.0, low level call can be used
    /// See: https://solidity.readthedocs.io/en/v0.6.0/units-and-global-variables.html
↪#members-of-address-types
    /// Test success case of 'add' using low level call
    function testAddSuccessUsingCall() public {
        bytes memory methodSign = abi.encodeWithSignature('add(uint256,string,uint256)
↪', 102, 'firstStudent', 10);
        (bool success, bytes memory data) = address(ar).call(methodSign);
        // 'success' stores the result in bool, this can be used to check whether␣
↪method call was successful
        Assert.equal(success, true, 'execution should be successful');
```

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```
        // 'data' stores the returned data which can be decoded to get the actual␣
↪result
        uint rollNumber = abi.decode(data, (uint256));
        // check if result is as expected
        Assert.equal(rollNumber, 102, 'wrong rollNumber');
    }

    /// Test failure case of 'add' using low level call
    function testAddFailureUsingCall() public {
        bytes memory methodSign = abi.encodeWithSignature('add(uint256,string,uint256)
↪', 102, 'duplicate', 10);
        (bool success, bytes memory data) = address(ar).call(methodSign);
        // 'success' will be false if method execution is not successful
        Assert.equal(success, false, 'execution should be successful');
    }
}
```

1.16.4 4. Testing a method involving `msg.value`

In Solidity, ether can be passed along with a method call which is accessed inside contract as `msg.value`. Sometimes, multiple calculations in a method are performed based on `msg.value` which can be tested with various values using Remix's Custom transaction context. See the example:

Contract/Program to be tested: `Value.sol`

```
pragma solidity >=0.4.22 <0.7.0;
contract Value {
    uint256 public tokenBalance;

    constructor() public {
        tokenBalance = 0;
    }

    function addValue() payable public {
        tokenBalance = tokenBalance + (msg.value/10);
    }

    function getTokenBalance() view public returns (uint256) {
        return tokenBalance;
    }
}
```

Test contract/program: `Value_test.sol`

```
pragma solidity >=0.4.22 <0.7.0;
import "remix_tests.sol";
import "./Value.sol";

contract ValueTest{
    Value v;

    function beforeAll() public {
        // create a new instance of Value contract
        v = new Value();
    }
```

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```
    /// Test initial balance
    function testInitialBalance() public {
        // initially token balance should be 0
        Assert.equal(v.getTokenBalance(), 0, 'token balance should be 0 initially');
    }

    /// For Solidity version greater than 0.6.1
    /// Test 'addValue' execution by passing custom ether amount
    /// #value: 200
    function addValueOnce() public payable {
        // check if value is same as provided through devdoc
        Assert.equal(msg.value, 200, 'value should be 200');
        // execute 'addValue'
        v.addValue{gas: 40000, value: 200}(); // introduced in Solidity version 0.6.2
        // As per the calculation, check the total balance
        Assert.equal(v.getTokenBalance(), 20, 'token balance should be 20');
    }

    /// For Solidity version less than 0.6.2
    /// Test 'addValue' execution by passing custom ether amount again using low␣
↪level call
    /// #value: 100
    function addValueAgain() public payable {
        Assert.equal(msg.value, 100, 'value should be 100');
        bytes memory methodSign = abi.encodeWithSignature('addValue()');
        (bool success, bytes memory data) = address(v).call.gas(40000).
↪value(100)(methodSign);
        Assert.equal(success, true, 'execution should be successful');
        Assert.equal(v.getTokenBalance(), 30, 'token balance should be 30');
    }
}
```

1.16.5 5. Testing a method involving `msg.sender` and `msg.value`

In the following test, we will be emulating multiple accounts making deposits in a smart contract to the same recipient and finally having the recipient withdraw the lump sum of all donations. We are also verifying that the donations match the expected amounts. This example really drives home how could you switch between different accounts, while using a set of different msg.value amounts.

Contract/Program to be tested: `Donations.sol`

```
// SPDX-License-Identifier: GPL-3.0
pragma solidity ^0.8.4;

contract donations{
    struct Donation {
        uint id;
        uint amount;
        string donor;
        string message;
        uint timestamp; //seconds since unix start
    }
    uint amount = 0;
    uint id = 0;
```

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```
    mapping(address => uint) public balances;
    mapping(address => Donation[]) public donationsMap;

    function donate(address _recipient, string memory _donor, string memory _msg)␣
↪public payable {
        require(msg.value > 0, "The donation needs to be >0 in order for it to go␣
↪through");
        amount = msg.value;
        balances[_recipient] += amount;
        donationsMap[_recipient].push(Donation(id++,amount,_donor,_msg,block.
↪timestamp));
    }

    function withdraw() public {  //whole thing by default.
        amount = balances[msg.sender];
        balances[msg.sender] -= amount;
        require(amount > 0, "Your current balance is 0");
        (bool success,) = msg.sender.call{value:amount}("");
        if(!success){
            revert();
        }
    }

    function balances_getter(address _recipient) public view returns (uint){
            return balances[_recipient];
    }

    function getBalance() public view returns(uint) {
            return msg.sender.balance;
    }
}
```

Test contract/program: `Donations_test.sol`

```
// SPDX-License-Identifier: GPL-3.0

pragma solidity >=0.4.22 <0.9.0;
import "remix_tests.sol";
import "remix_accounts.sol";
import "../donations.sol";

contract testSuite is donations {
    address acc0 = TestsAccounts.getAccount(0); //owner by default
    address acc1 = TestsAccounts.getAccount(1);
    address acc2 = TestsAccounts.getAccount(2);
    address acc3 = TestsAccounts.getAccount(3);
    address recipient = TestsAccounts.getAccount(4); //recipient

    /// #value: 1000000000000000000
    /// #sender: account-1
    function donateAcc1AndCheckBalance() public payable{
        Assert.equal(msg.value, 1000000000000000000, 'value should be 1 Eth');
        donate(recipient, "Mario", "Are you a bird?");
        Assert.equal(balances_getter(recipient), 1000000000000000000, 'balances␣
↪should be 1 Eth');
    }
```

(continues on next page)

(continued from previous page)

```
    /// #value: 1000000000000000000
    /// #sender: account-2
    function donateAcc2AndCheckBalance() public payable{
        Assert.equal(msg.value, 1000000000000000000, 'value should be 1 Eth');
        donate(recipient, "Tom", "Are you a plane?");
        Assert.equal(balances_getter(recipient), 2000000000000000000, 'balances␣
↪should be 2 Eth');
    }

    /// #value: 2000000000000000000
    /// #sender: account-3
    function donateAcc3AndCheckBalance() public payable{
        Assert.equal(msg.value, 2000000000000000000, 'value should be 1 Eth');
        donate(recipient, "Maria", "Are you a car?");
        Assert.equal(balances_getter(recipient), 4000000000000000000, 'balances␣
↪should be 4 Eth');
    }

    /// #sender: account-4
    function withdrawDonations() public payable{
        uint initialBal = getBalance();
        withdraw();
        uint finalBal = getBalance();
        Assert.equal(finalBal-initialBal, 4000000000000000000, 'balances should be 4␣
↪Eth');
    }
}
```

1.17 Hardhat

(Supported since Remix IDE v0.12.0 and Remixd v0.3.6)

1.17.1 Remixd and Hardhat

Note: If you have not used `remixd` before, read more about it here

If `remixd` is running locally on your device and shared folder is a **Hardhat project**, an additional websocket plugin will be listening on port `65522`. According to its documentation,

> *Hardhat projects are npm projects with the hardhat package installed and a hardhat.config.js or hardhat.config.ts file.*

Remixd looks for the `hardhat.config.js` or `hardhat.config.ts` file in shared folder, and if it finds the file, the Hardhat websocket listener will run.

The Hardhat websocket listener is a websocket plugin similar to `remixd` and is used to perform Hardhat specific actions with Remix IDE.

It doesn't need any separate installation as it is shipped with remixd NPM module.

```
[INFO] you are using the latest version 0.3.5
[WARN] You can only connect to remixd from one of the supported origins.
[WARN] Any application that runs on your computer can potentially read from and write to all files in the directory.
[WARN] Symbolic links are not forwarded to Remix IDE

[INFO] Fri Jun 04 2021 10:47:44 GMT+0530 (India Standard Time) remixd is listening on 127.0.0.1:65520
[INFO] Fri Jun 04 2021 10:47:44 GMT+0530 (India Standard Time) hardhat is listening on 127.0.0.1:65522
```

1.17.2 Enable Hardhat Compilation

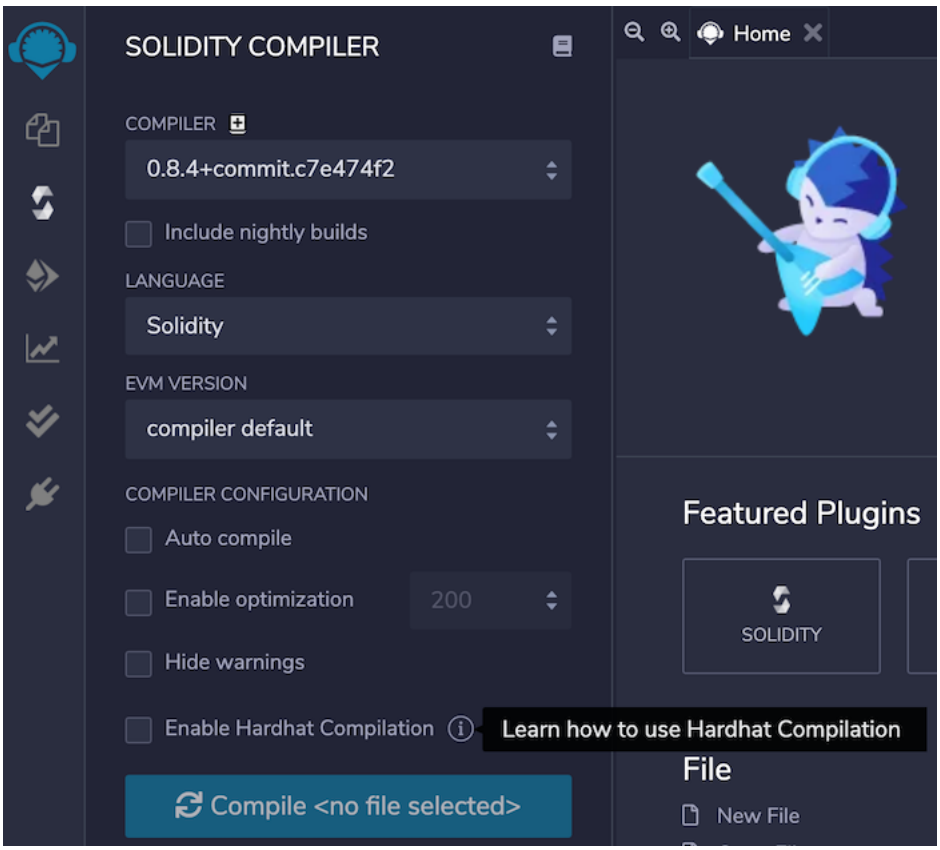
Prerequisites

To use Hardhat compilation with Remix IDE efficiently:

1. **Hardhat** should be installed locally on the system https://hardhat.org/getting-started/#installation
2. Shared folder should be a Hardhat project containing `hardhat.config.js` or `hardhat.config.ts`
3. `Remixd` Hardhat websocket listener should be running at `65522`

How to use

If a hardhat project is shared through remixd and `localhost` workspace is loaded in Remix IDE, there will be an extra checkbox shown in `Solidity Compiler` plugin with the label `Enable Hardhat Compilation`.

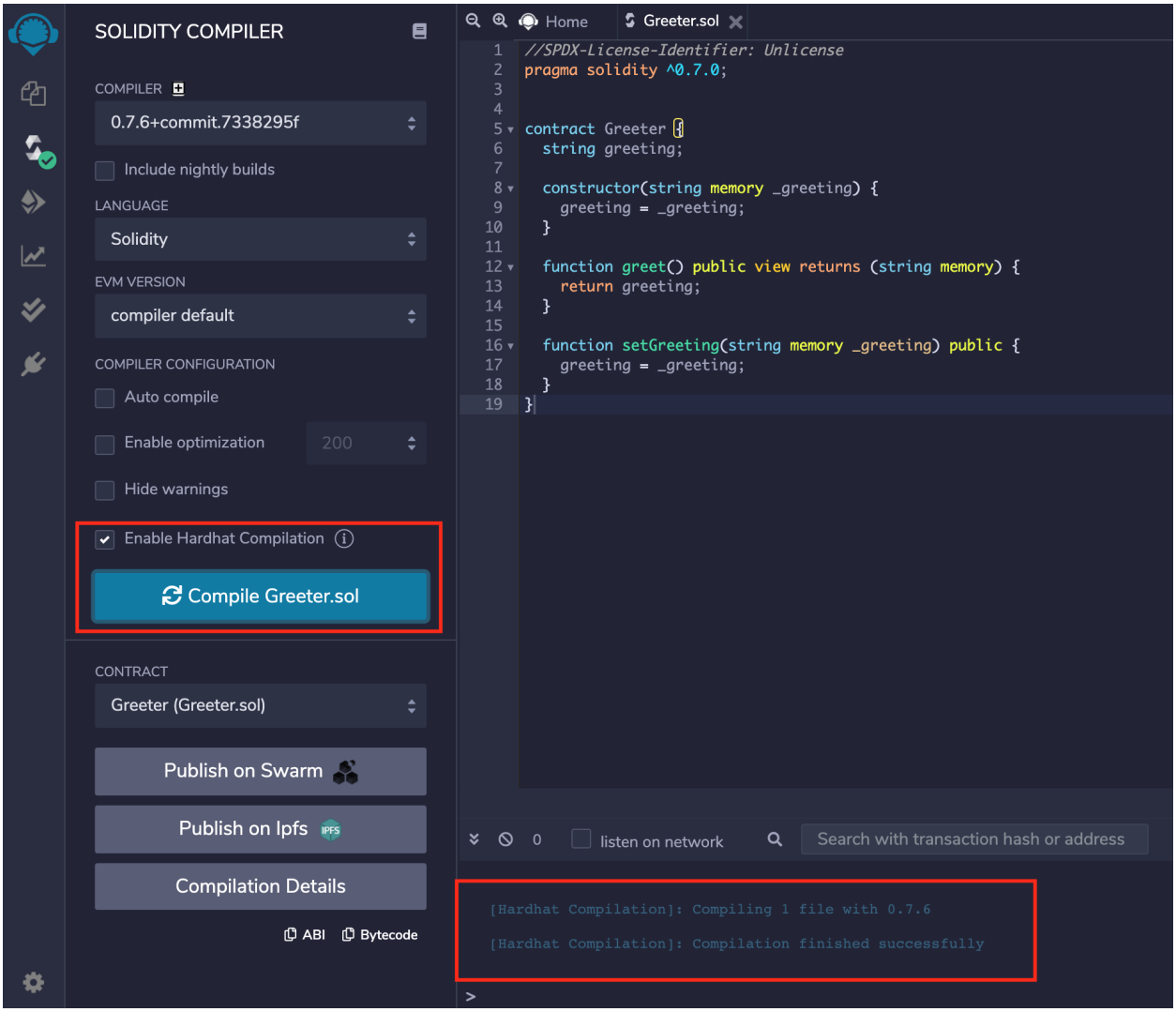


There is an info icon along side the label which redirects to a specific section of Remix official documentation that explains how to use Hardhat compilation.

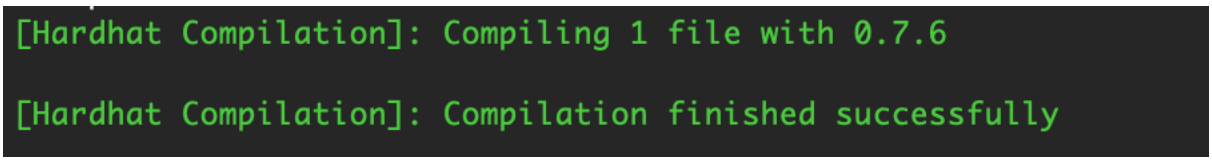
One can check the `Enable Hardhat Compilation` box to run the compilation for Hardhat along with the Remix using the compiler configuration in `Solidity Compiler` plugin.

On clicking `Compile` button, a file with `remix-compiler.config.js` will be created on the project root which will be storing compiler configuration set in Remix's `Solidity Compiler` plugin. It is passed to Hardhat for compilation.

The result of the compilation will be shown in the Remix IDE terminal



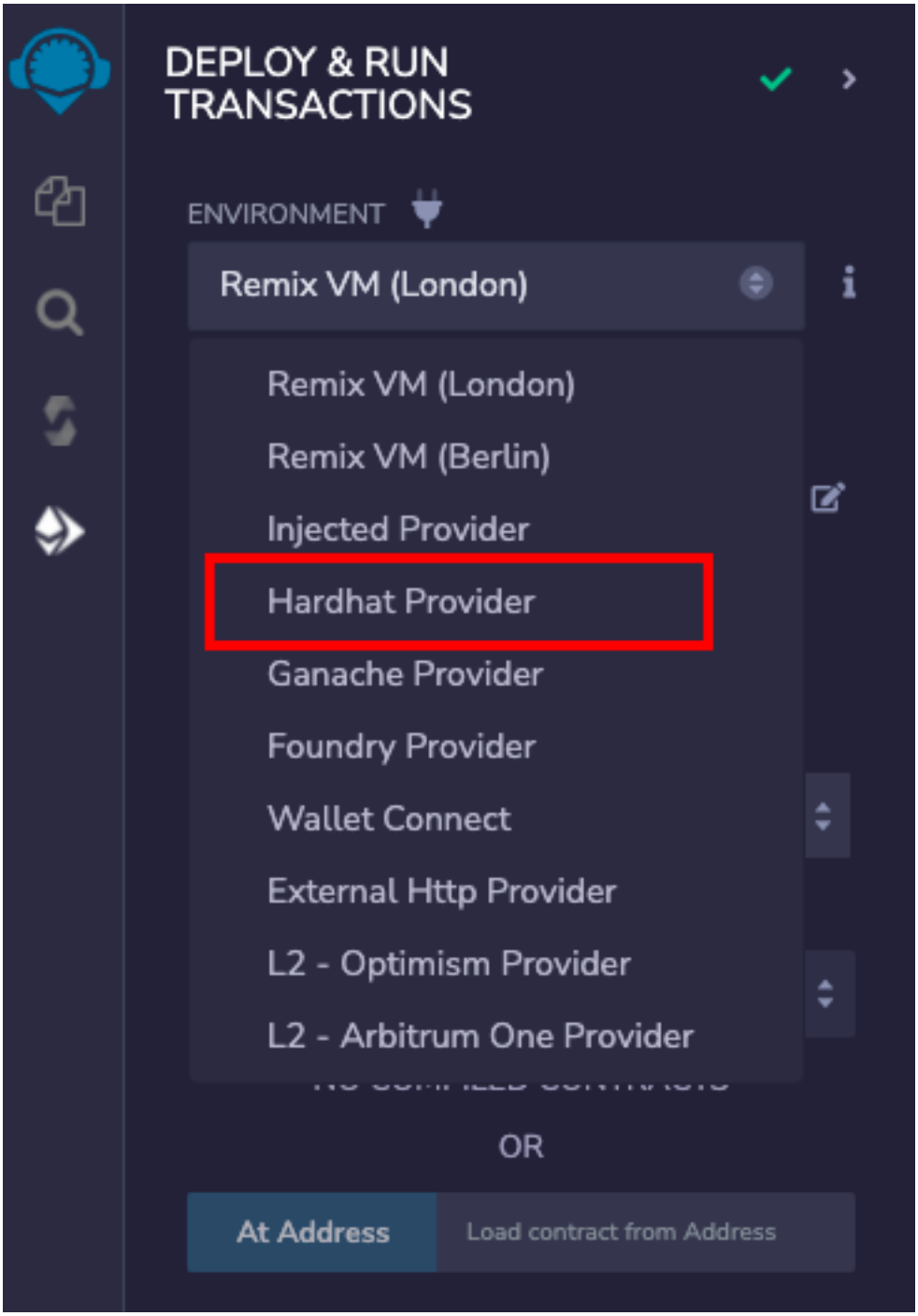
and also in the **remixd** terminal.



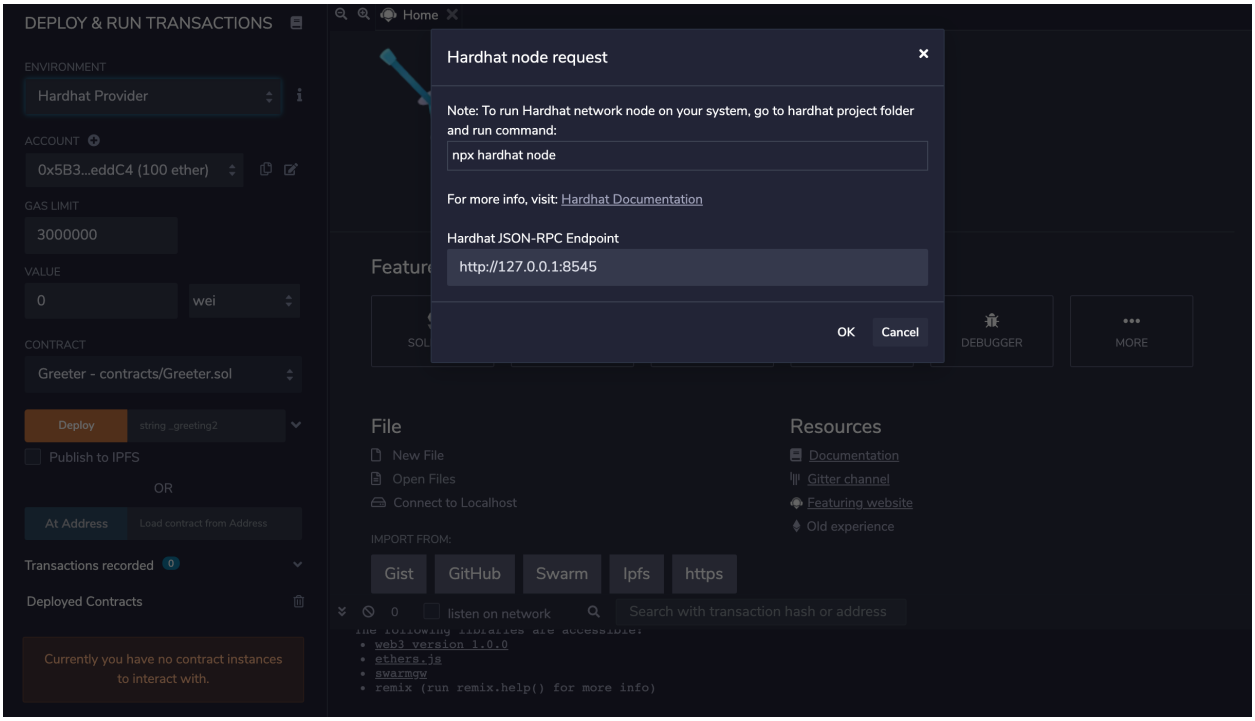
1.17.3 Hardhat Provider

In Hardhat, contracts are deployed by starting a local node. Read more about it in Hardhat documentation

Hardhat Provider is a plugin on Remix IDE which enables users to deploy the contract to the Hardhat 'localhost' network. This can be chosen from the `ENVIRONMENT` dropdown of `Deploy and Run Transactions` plugin.

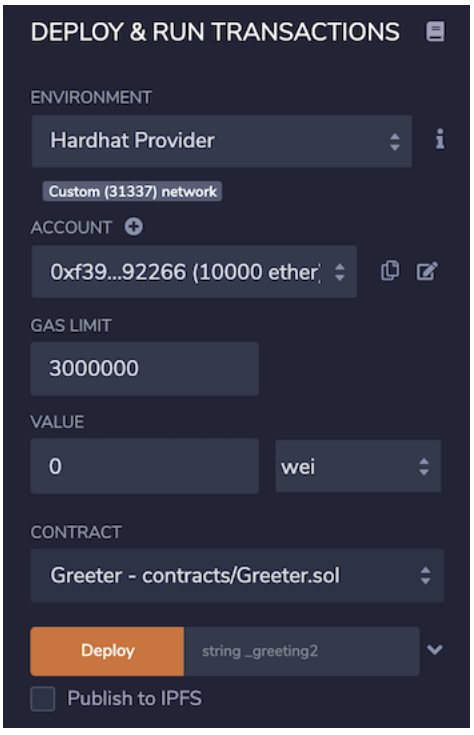


As soon as you select `Hardhat Provider`, a modal is opened asking for the `Hardhat JSON-RPC Endpoint`.



If Hardhat node is running with default options, then the default endpoint value in modal will not need any change. In case, Hardhat node host and port are different, JSON-RPC endpoint should be updated in the modal text box.

Once the correct endpoint is filled in the modal, just click on `OK` and the accounts from the Hardhat node will be loaded in the `ACCOUNT` section. Network id will also be shown.



Now, one can start deploying the contract from Remix IDE to the Hardhat local node as usual.

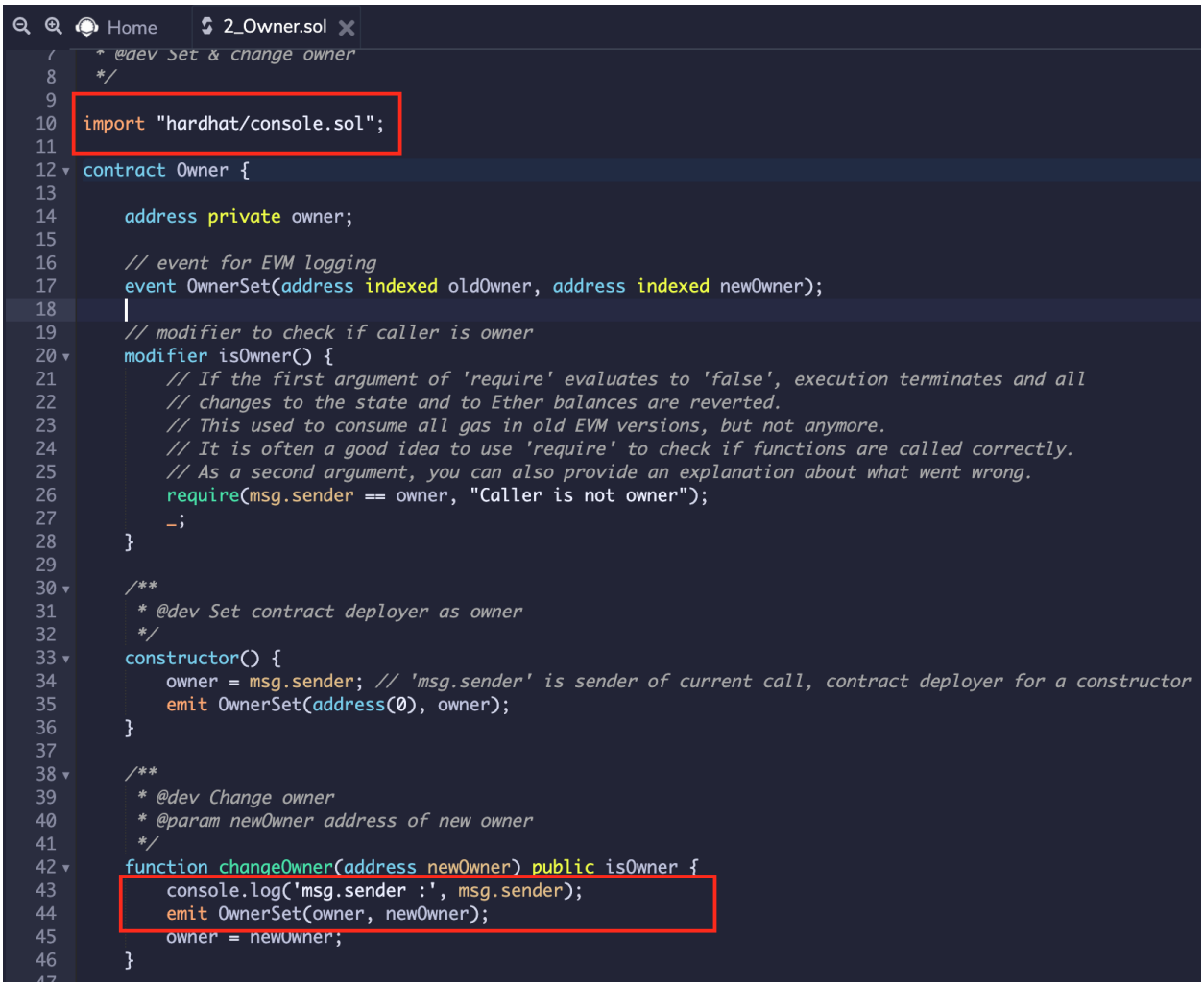
1.17.4 `console.log` in Remix IDE

(Supported since Remix IDE v0.17.0)

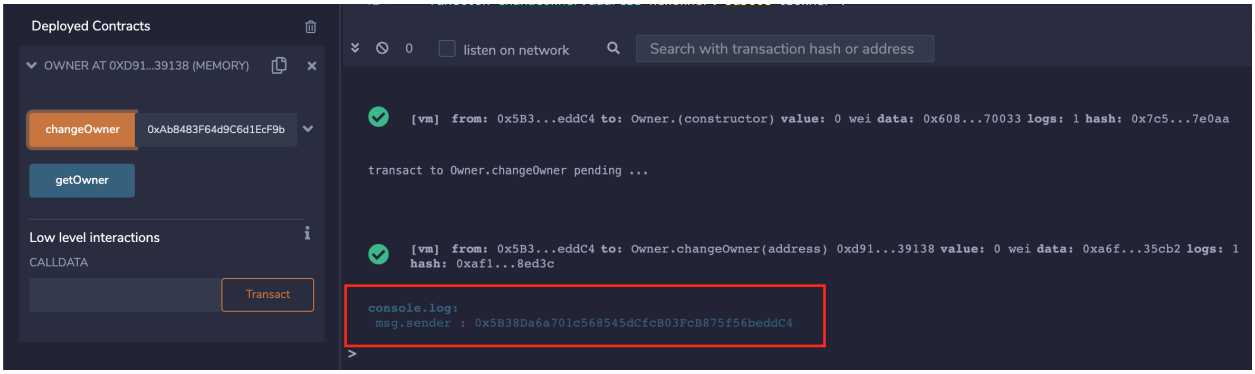
Remix IDE supports hardhat console library while using `Remix VM`. It can be used while making a transaction or running unit tests.

Deploy and Run Transactions

To try it out, you need to put an import statement and use `console.log` to print the value as shown in image.



Further, once you execute the `changeOwner` method, the value from console statement will be shown in Remix terminal after transaction details as below:

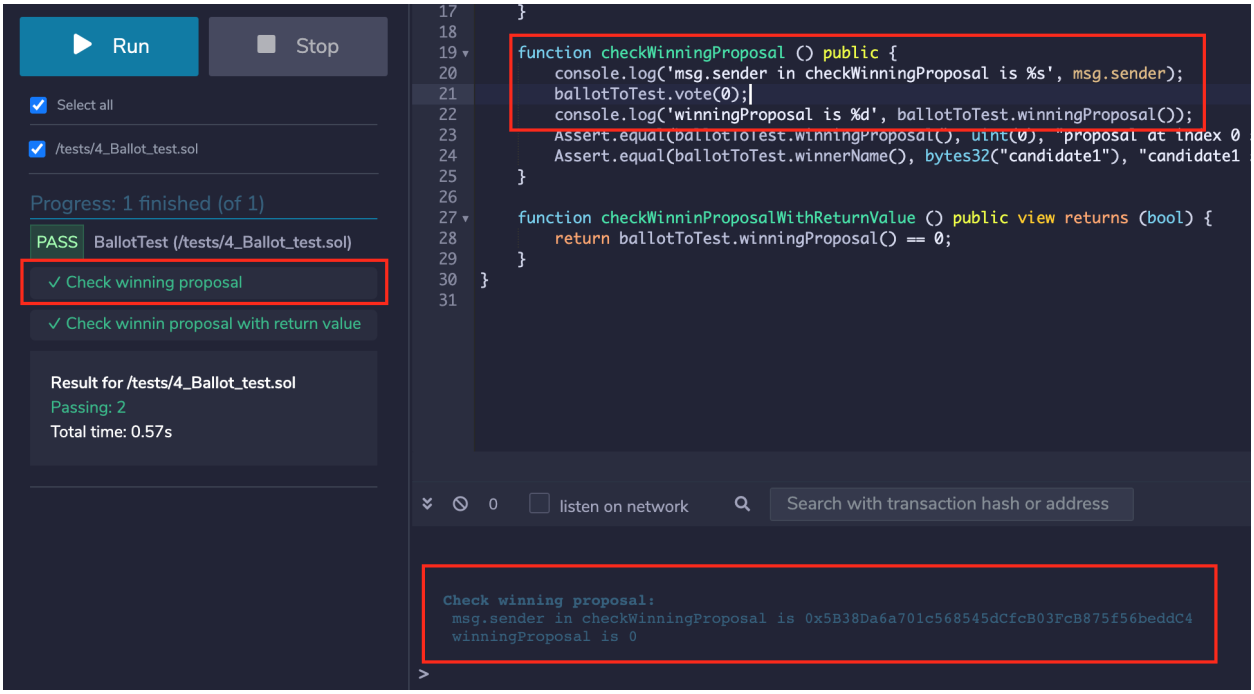


Solidity Unit Testing

Similarly, `console.log` can be used while running unit tests using Remix Solidity Unit Testing plugin. See image below.

```
// SPDX-License-Identifier: GPL-3.0

pragma solidity >=0.7.0 <0.9.0;
import "remix_tests.sol"; // this import is automatically injected by Remix.
import "../contracts/3_Ballot.sol";

import "hardhat/console.sol";

contract BallotTest {

    bytes32[] proposalNames;

    Ballot ballotToTest;
    function beforeAll () public {
        proposalNames.push(bytes32("candidate1"));
        ballotToTest = new Ballot(proposalNames);
    }

    function checkWinningProposal () public {
        console.log('msg.sender in checkWinningProposal is %s', msg.sender);
        ballotToTest.vote(0);
        console.log('winningProposal is %d', ballotToTest.winningProposal());
        Assert.equal(ballotToTest.winningProposal(), uint(0), "proposal at index 0 should be the winning proposal");
        Assert.equal(ballotToTest.winnerName(), bytes32("candidate1"), "candidate1 should be the winner name");
    }
```

For the tests including logging message, it will display in the Remix Terminal corresponding to test name.



1.18 Truffle

(Supported since Remix IDE v0.23.0 and Remixd v0.6.0)

1.18.1 Remixd and Truffle

Note: If you have not used `remixd` before, read more about it here

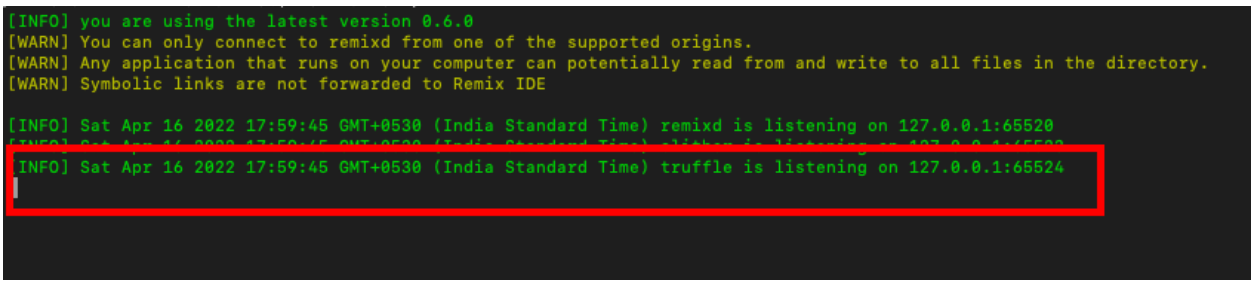
If `remixd` is running locally on your device and shared folder is a **Truffle project**, an additional websocket plugin will be listening on port `65524`. According to its documentation,

> *Truffle projects are projects with a truffle-config.js file.*

Remixd looks for the `truffle-config.js` file in shared folder. If found, the Truffle websocket listener will run.

The Truffle websocket listener is a websocket plugin similar to `remixd` and is used to perform Truffle specific actions with Remix IDE.

It doesn't need any separate installation as it is shipped with remixd NPM module.



1.18.2 Enable Truffle Compilation

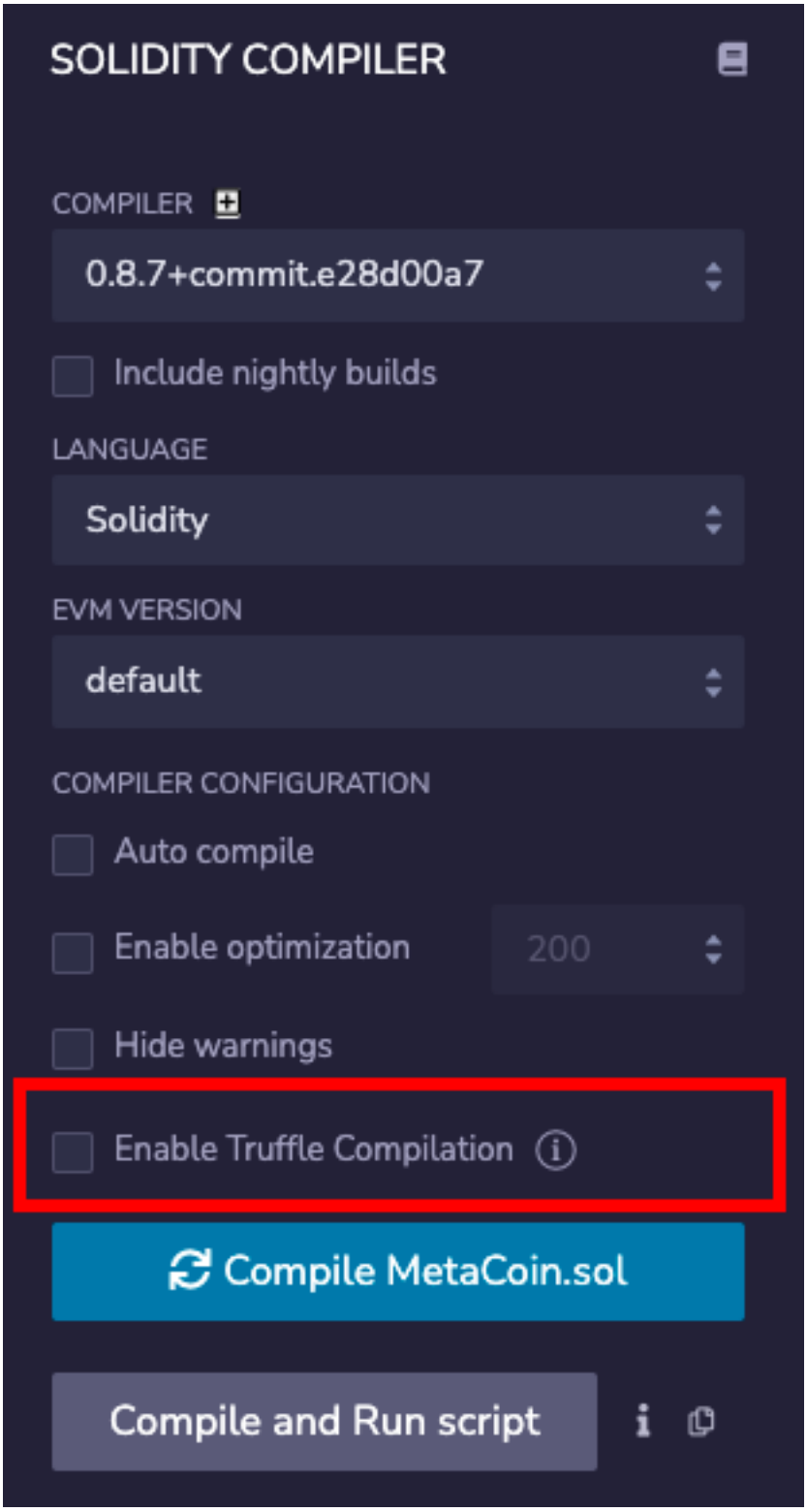
Prerequisites

To use Truffle compilation with Remix IDE efficiently:

1. **Truffle** should be installed locally on the system https://trufflesuite.com/docs/truffle/getting-started/installation/
2. Shared folder should be a Truffle project containing `truffle-config.js`
3. `Remixd` Truffle websocket listener should be running at `65524`

How to use

If a truffle project is shared through remixd and `localhost` workspace is loaded in Remix IDE, there will be an extra checkbox shown in `Solidity Compiler` plugin with the label `Enable Truffle Compilation`.

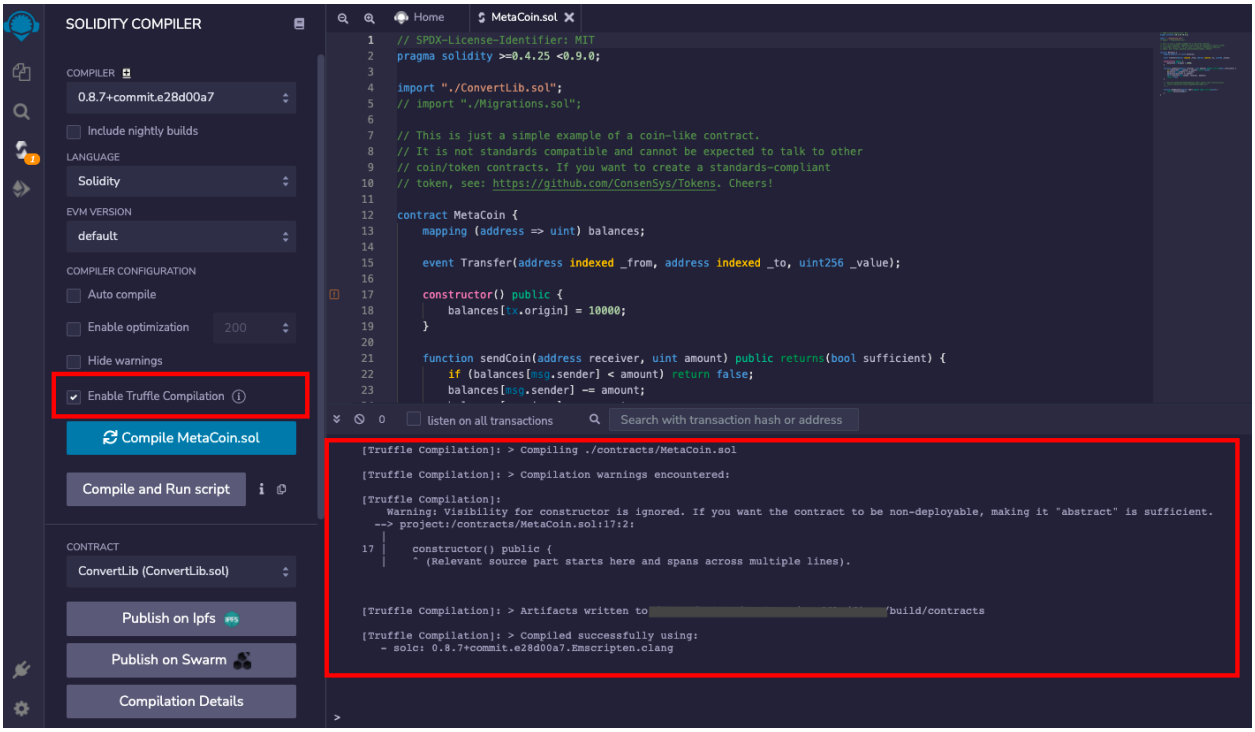


There is an info icon along side the label which redirects to a specific section of Remix official documentation that explains how to use Truffle compilation.

One can check the `Enable Truffle Compilation` box to run the compilation for Truffle along with the Remix using the compiler configuration in `Solidity Compiler` plugin.

On clicking `Compile` button, a file named as `remix-compiler.config.js` will be created on the project root which will be storing compiler configuration set in Remix's `Solidity Compiler` plugin. It is passed to Truffle for compilation.

The result of the compilation will be shown in the Remix IDE terminal

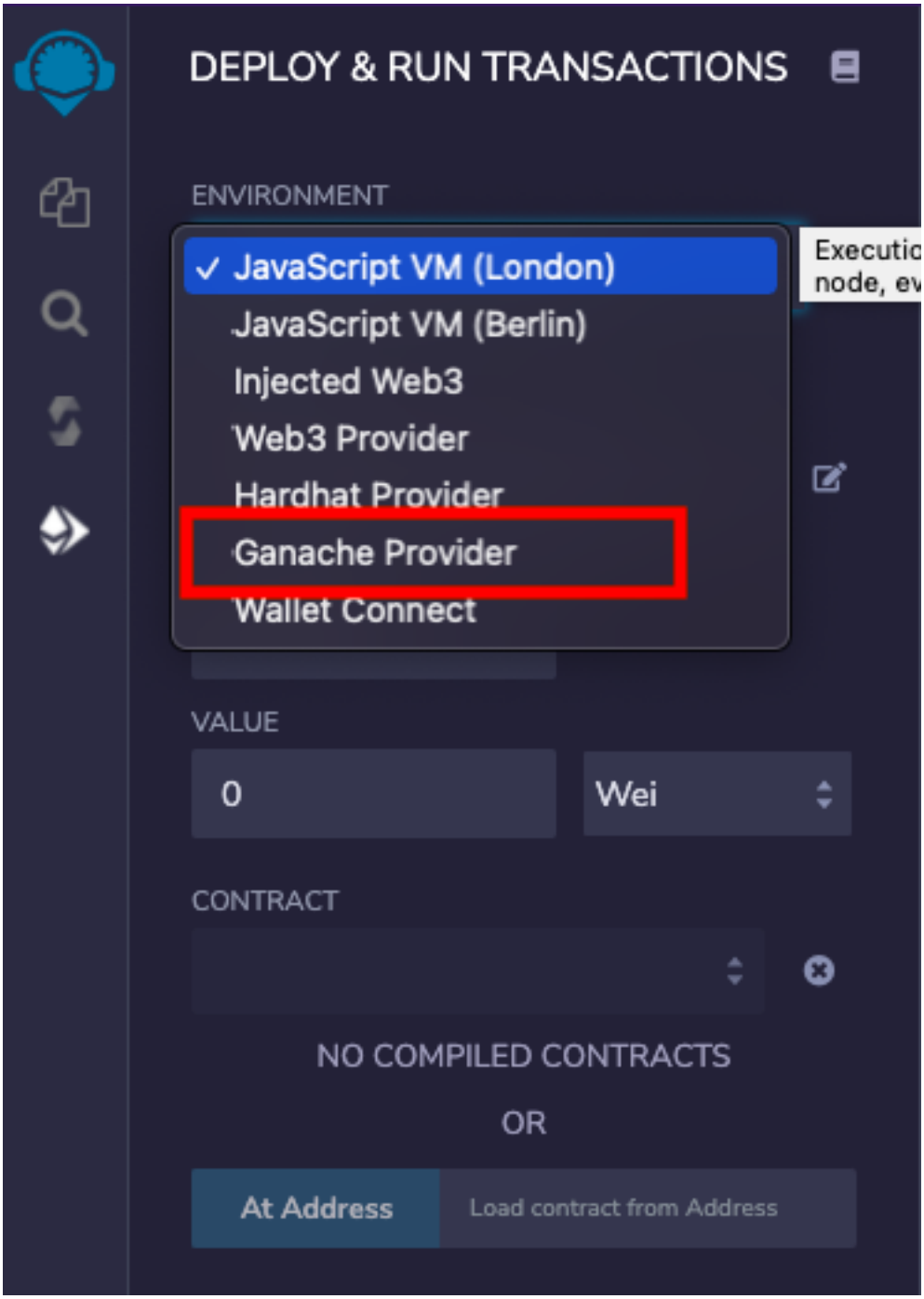


and also in the **remixd** terminal.

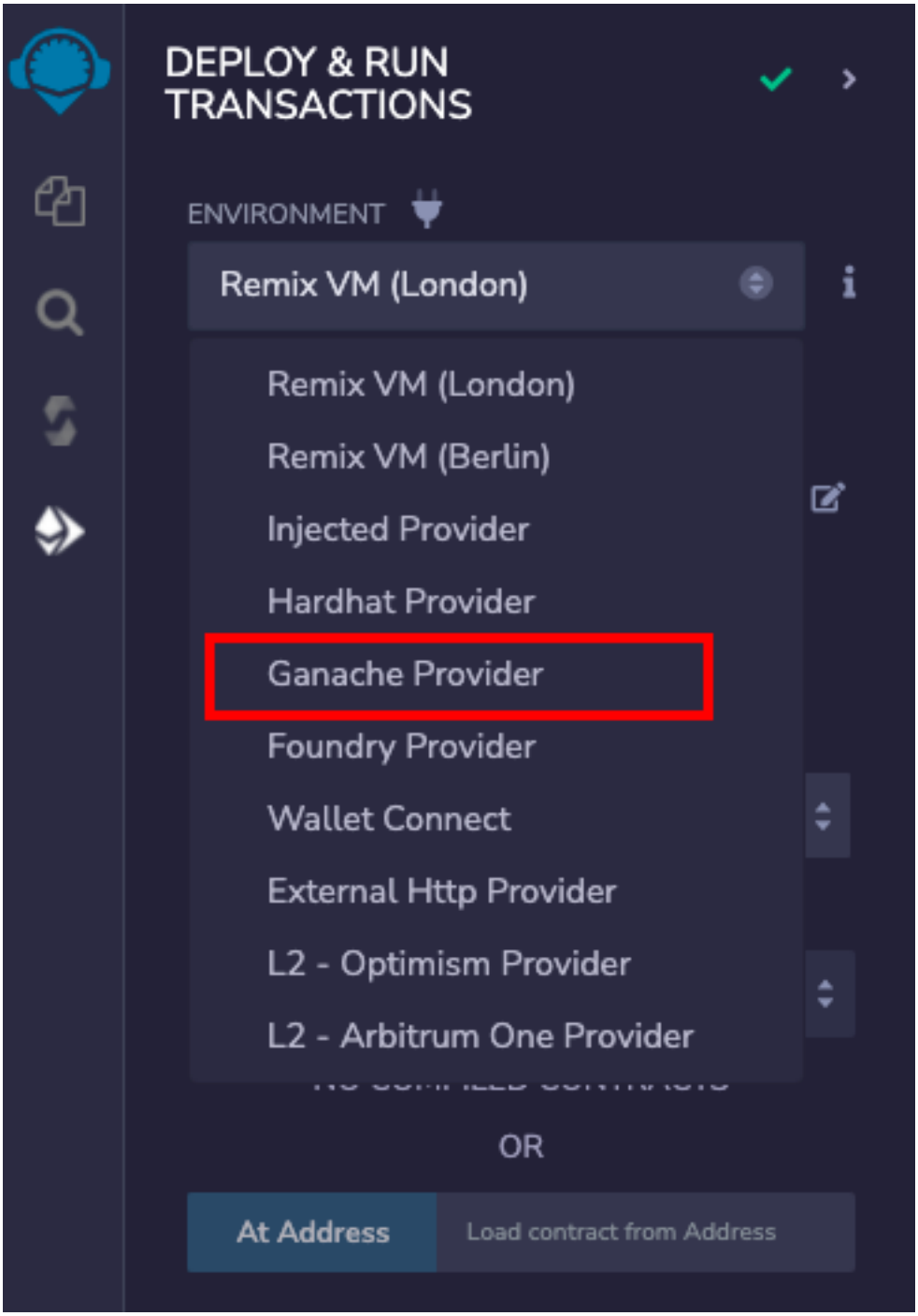
1.18.3 Ganache Provider

In Truffle, contracts are deployed by connecting to a built-in personal blockchain, i.e. Ganache. Read more about it in Truffle documentation

Ganache Provider is a plugin on Remix IDE which enables users to deploy the contract to the Truffle's built-in Ganache blockchain. `Ganache Provider` can be chosen from the list of environments in `Deploy & Run Transactions` plugin.

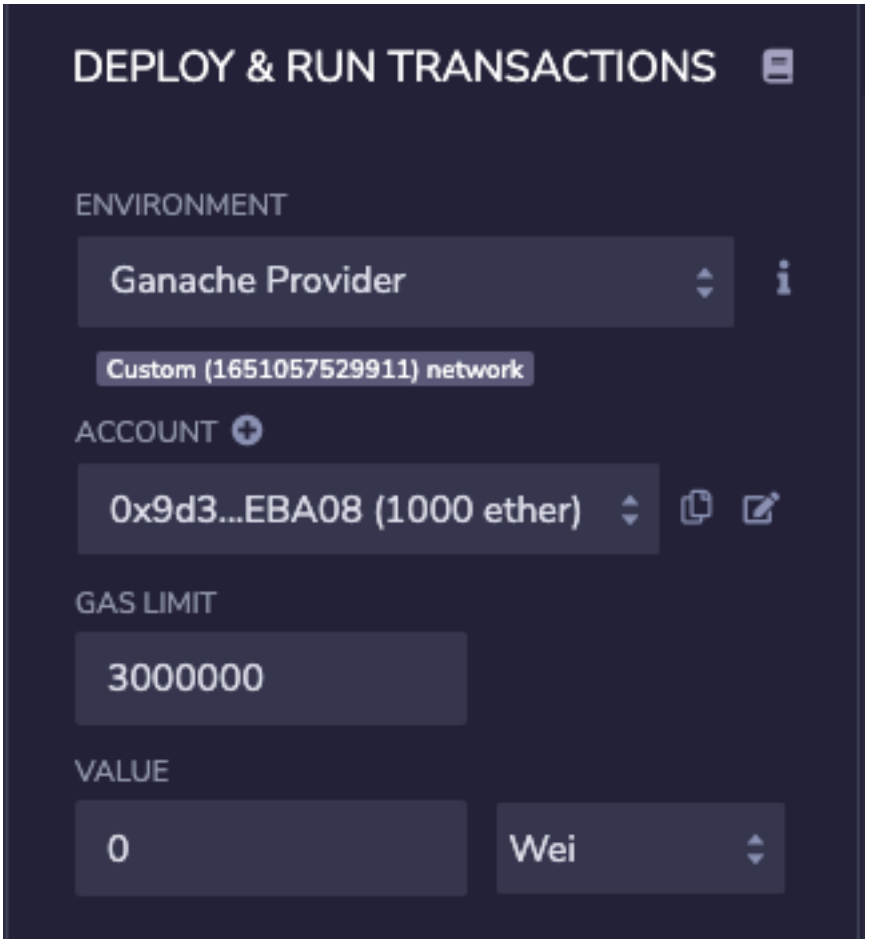


As soon as you select `Ganache Provider`, a modal is opened asking for the `Ganache JSON-RPC Endpoint`.



If Ganache node is running with default options, the default endpoint value in modal will not need any change. In case, Ganache node host and port are different, JSON-RPC endpoint should be updated in the modal text box.

Once the correct endpoint is filled in the modal, just click on `OK` and the accounts from the Ganache node will be loaded in the `ACCOUNT` section. Network id will also be shown.



Now, one can start deploying the contract from Remix IDE to the local Ganache node as usual.

1.19 Slither

(Supported since Remix IDE v0.15.0 and Remixd v0.5.0)

1.19.1 Remixd and Slither

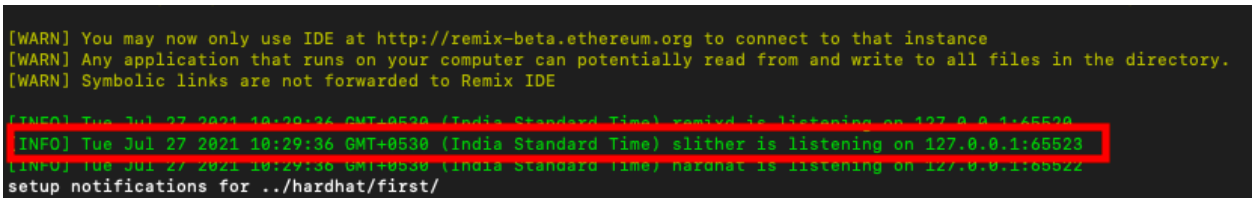
Note: If you have not used `remixd` before, read more about it here

When remixd NPM module is installed, it also installs Slither and solc-select and latest version of solc.

`Python3.6+ (pip3)` needs to already be installed on the System. In case of any discrepany, Slither can also installed along with other dependencies using command `remixd -i slither` *(This packaging of Slither with the remixd module is supported since Remixd `v0.6.3`)*

when `remixd` is running locally on your device, an additional websocket plugin will be listening on port `65523` which will be dedicated for Slither integration. (Supported since Remixd `v0.5.0`)

The remixd Slither listener is a websocket plugin similar to remixd and is used to perform Slither analysis with Remix IDE.



1.19.2 Enable Slither Analysis

Prerequisites

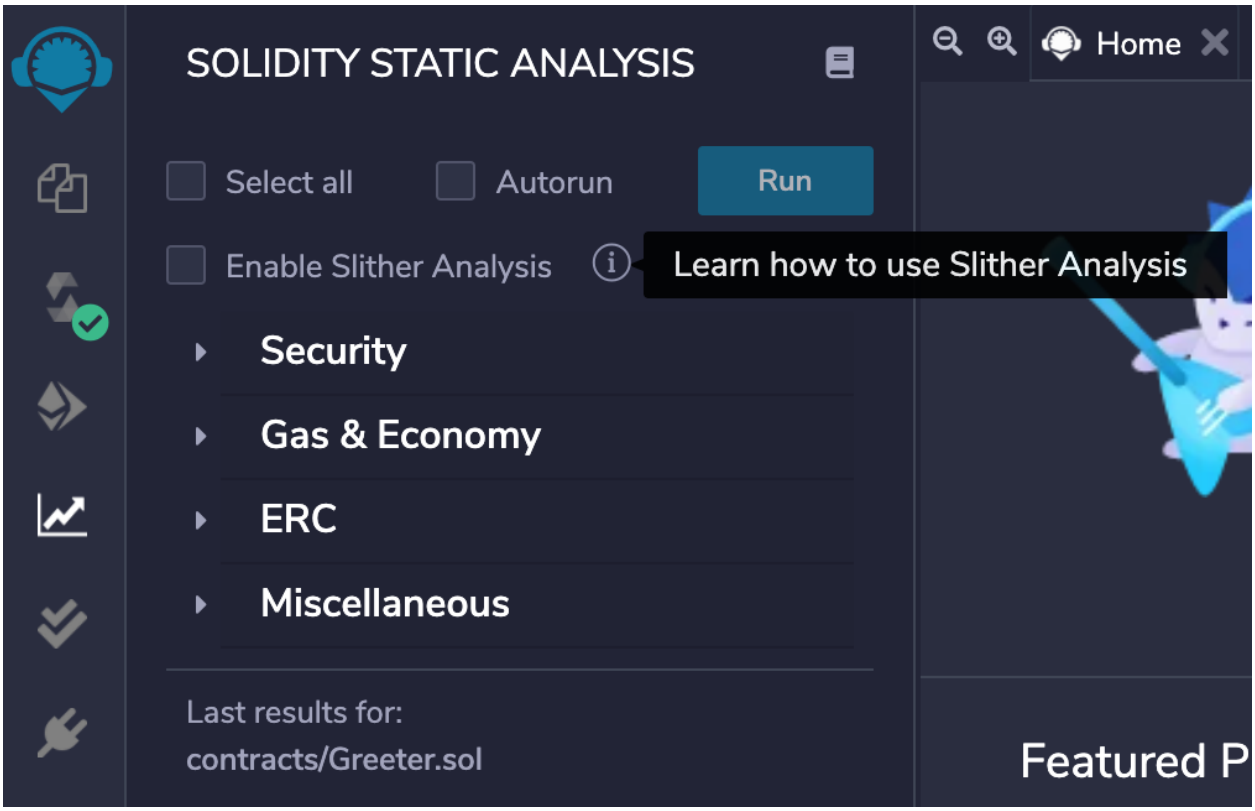
To use Slither analysis with Remix IDE efficiently, following tools should be installed locally on the system:

1. **Slither:** https://github.com/crytic/slither#how-to-install
2. **Solc:** https://docs.soliditylang.org/en/latest/installing-solidity.html
3. **Solc-select:** https://github.com/crytic/solc-select#quickstart

There are setup with remixd installation or can be done using `remixd -i slither` commmand.

How to use

If a project is shared through remixd and `localhost` workspace is loaded in Remix IDE, there will be an extra checkbox shown in `Solidity Static Analysis` plugin with the label `Enable Slither Analysis`.

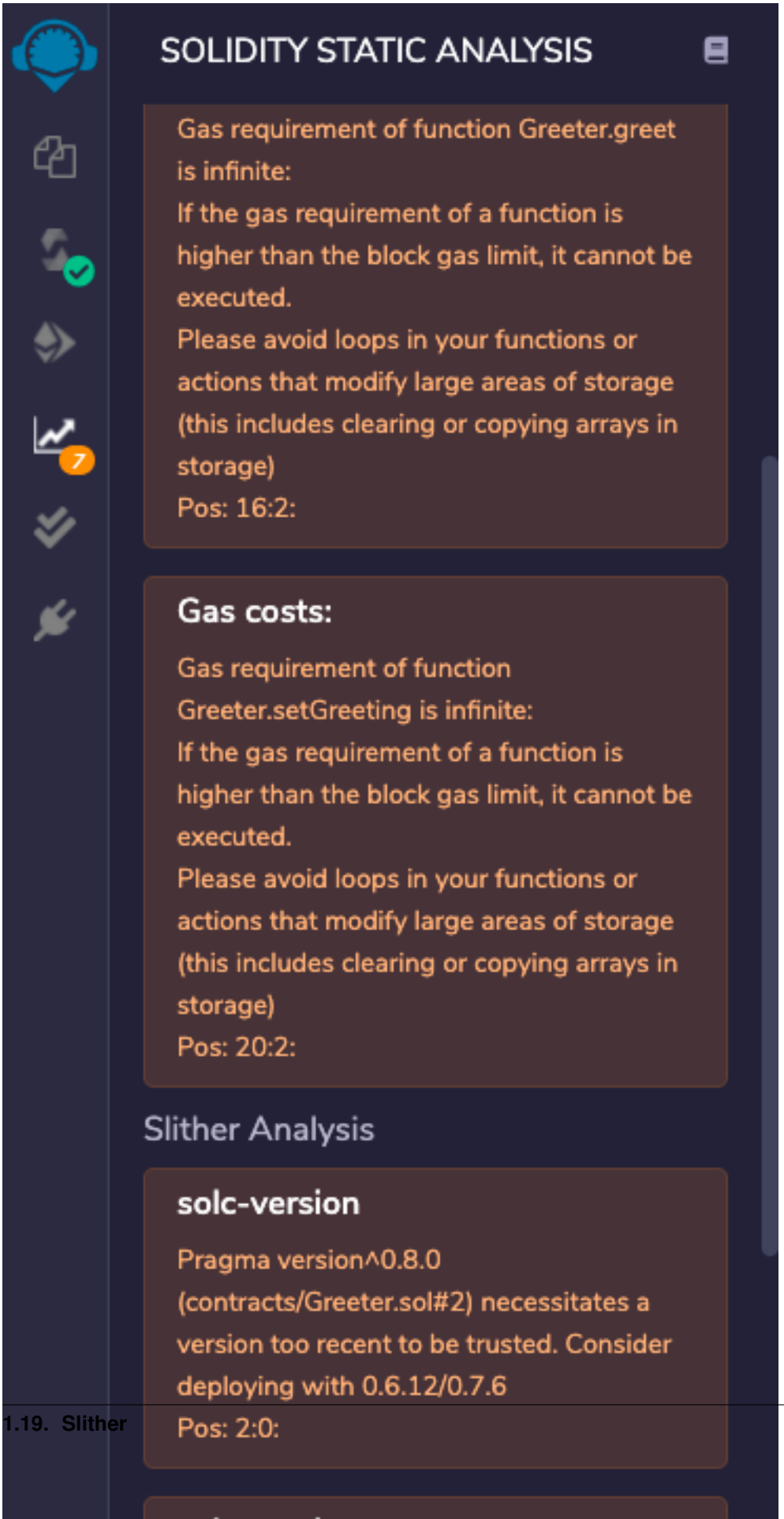


There is an info icon on the right side of the label which redirects to a specific section of Remix official documentation that explains how to use Slither Analysis and prerequisites for it.

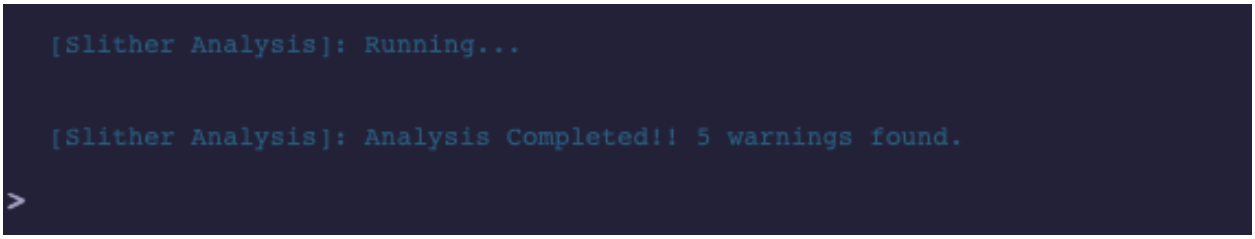
One can check the `Enable Slither Analysis` box to run the analysis using Slither along with the Remix's analysis library.

Latest report of Slither analysis will be stored locally on project root with a file named as `remix-slither-report.json`.

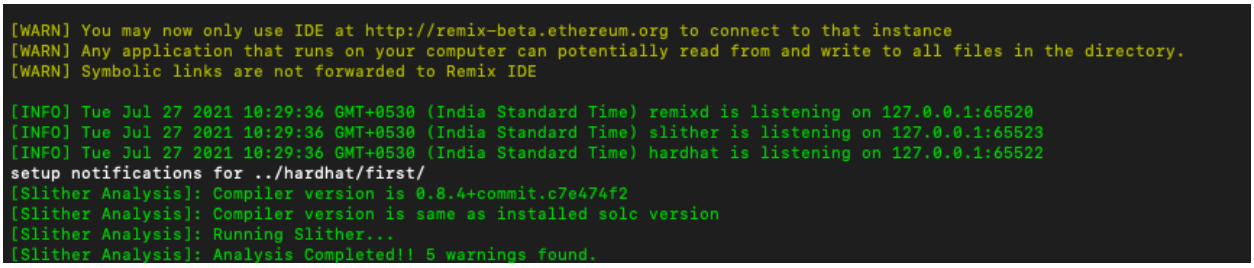
Slither Analysis report will also be displayed on the Remix IDE side after the Remix analysis report for better user readability.


SOLIDITY STATIC ANALYSIS
Gas requirement of function Greeter.greet is infinite:
If the gas requirement of a function is higher than the block gas limit, it cannot be executed.
Please avoid loops in your functions or actions that modify large areas of storage (this includes clearing or copying arrays in storage)
Pos: 16:2:
Gas costs:
Gas requirement of function Greeter.setGreeting is infinite:
If the gas requirement of a function is higher than the block gas limit, it cannot be executed.
Please avoid loops in your functions or actions that modify large areas of storage (this includes clearing or copying arrays in storage)
Pos: 20:2:
Slither Analysis
solc-version
Pragma version^0.8.0 (contracts/Greeter.sol#2) necessitates a version too recent to be trusted. Consider deploying with 0.6.12/0.7.6
Pos: 2:0:

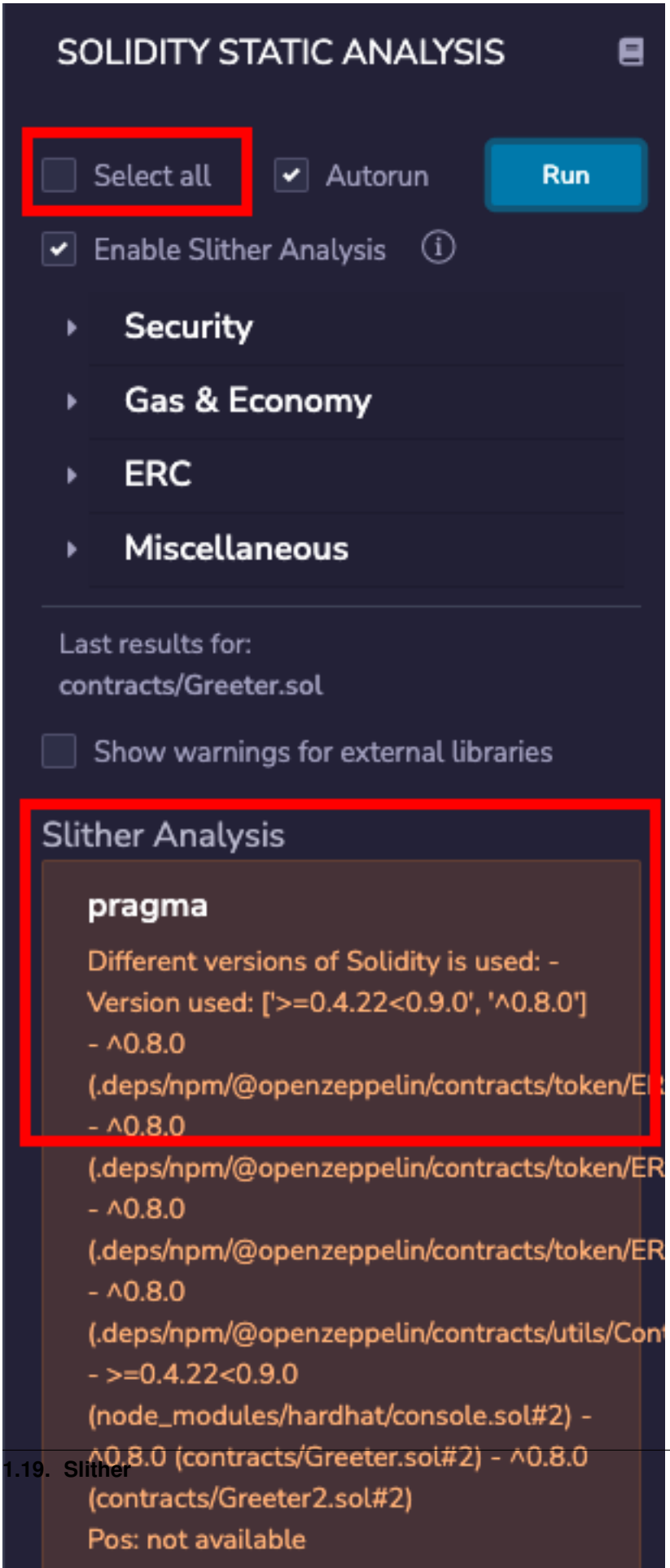
The result of the analysis will be shown in the Remix IDE terminal



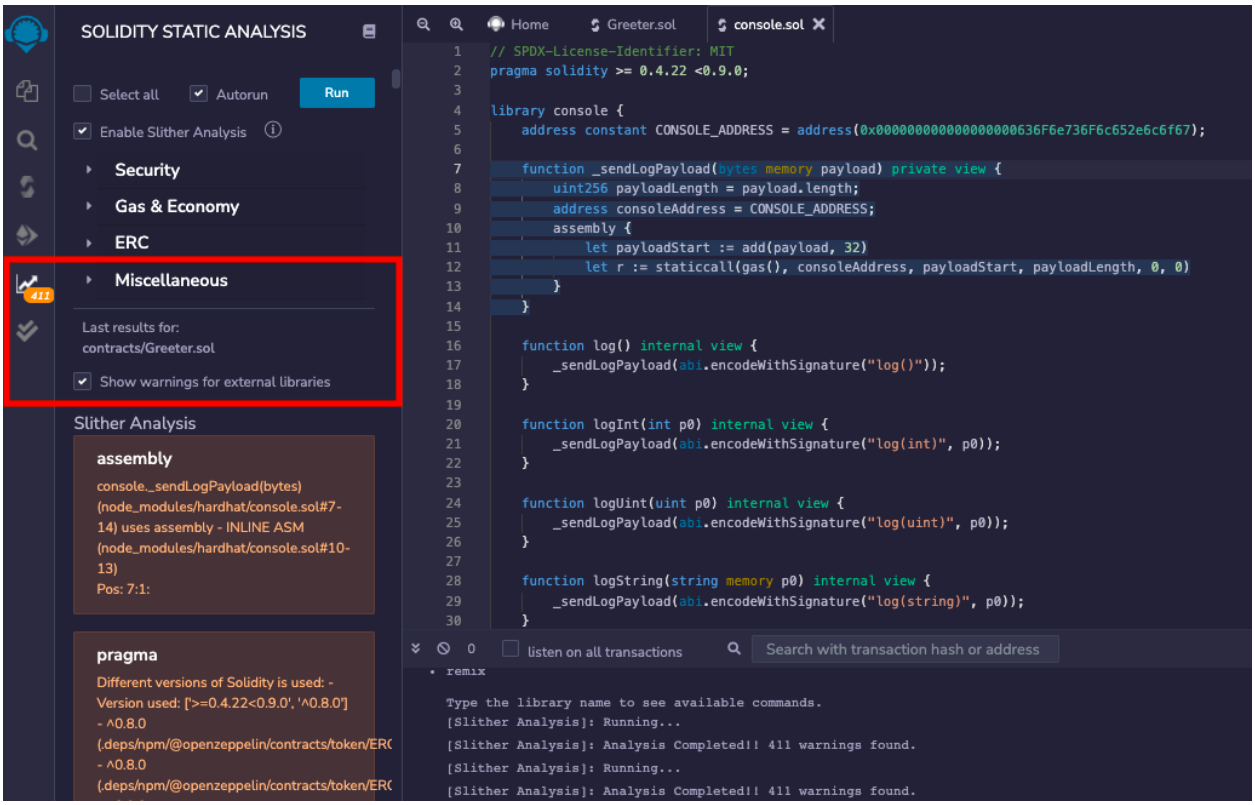
and also in the **remixd** console.



To only run Slither Analysis, deselect `Select all` checkbox and click on `Run`. Now it will show only the Slither Analysis report.


SOLIDITY STATIC ANALYSIS
Select all
Autorun
Run
Enable Slither Analysis
Security
Gas & Economy
ERC
Miscellaneous
Last results for:
contracts/Greeter.sol
Show warnings for external libraries
Slither Analysis
pragma
Different versions of Solidity is used: -
Version used: ['>=0.4.22<0.9.0', '^0.8.0']
- ^0.8.0
(.deps/npm/@openzeppelin/contracts/token/E
- ^0.8.0
(.deps/npm/@openzeppelin/contracts/token/ER
- ^0.8.0
(.deps/npm/@openzeppelin/contracts/token/ER
- ^0.8.0
(.deps/npm/@openzeppelin/contracts/utils/Con
- >=0.4.22<0.9.0
(node_modules/hardhat/console.sol#2) -
^0.8.0 (contracts/Greeter.sol#2) - ^0.8.0
(contracts/Greeter2.sol#2)
Pos: not available

By default, it doesn't show the warnings for external libraries like remix-tests.sol, hardhat/console.sol etc. To have a look on them, check the box with label `Show warnings for external libraries`.

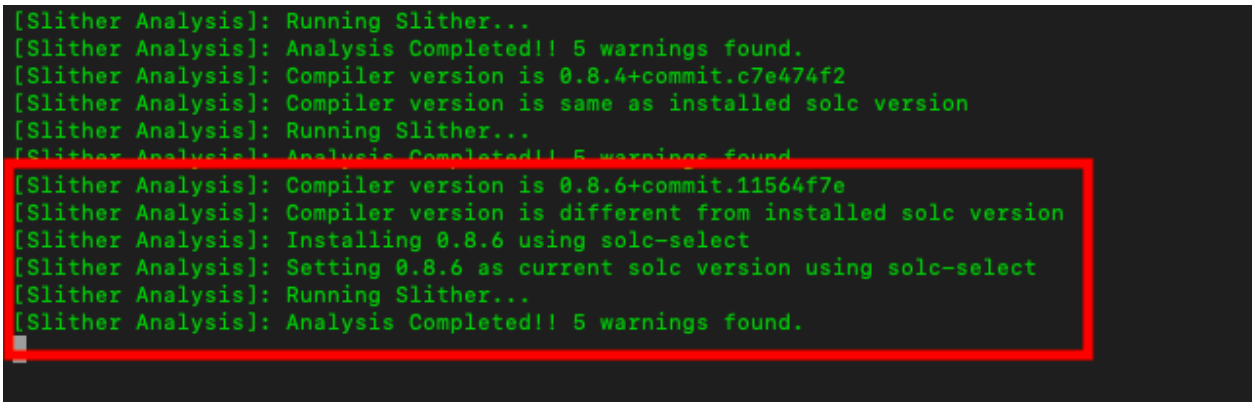


More Details

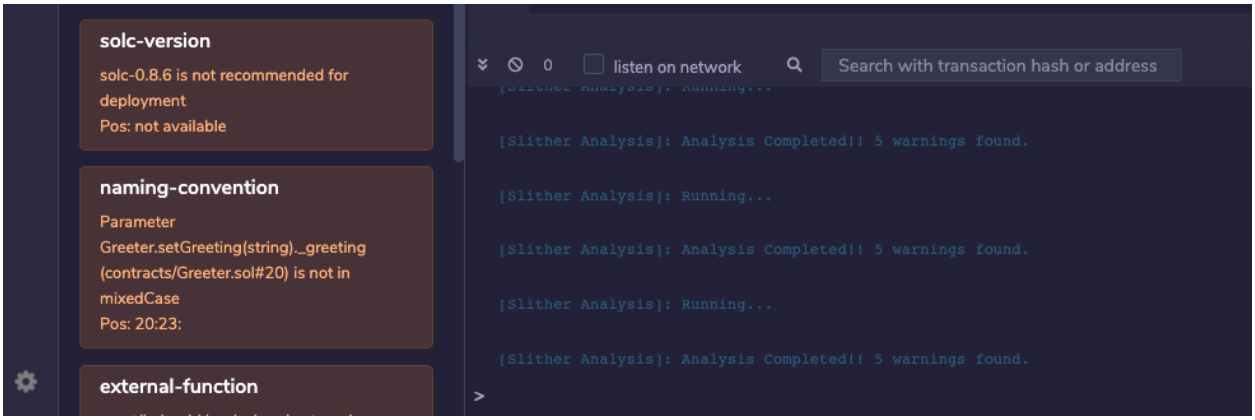
Analysis for Slither is run using the version set in `Solidity Compiler` plugin on Remix IDE. Slither is a CLI tool and requires `solc` to run the analysis. Before running the analysis, Slither websocket plugin checks if current version of solc is same as the version set in Remix IDE.

If the compiler version set in Solidity Compiler is different from current version of solc installed locally, the Slither websocket plugin will update the `solc` to be the same as the required version `solc-select`.

For example, if current `solc` version on the system is 0.8.4 and on the Remix IDE 0.8.6 is set, `remixd` logs explain remote solc version selection



After successful analysis run:

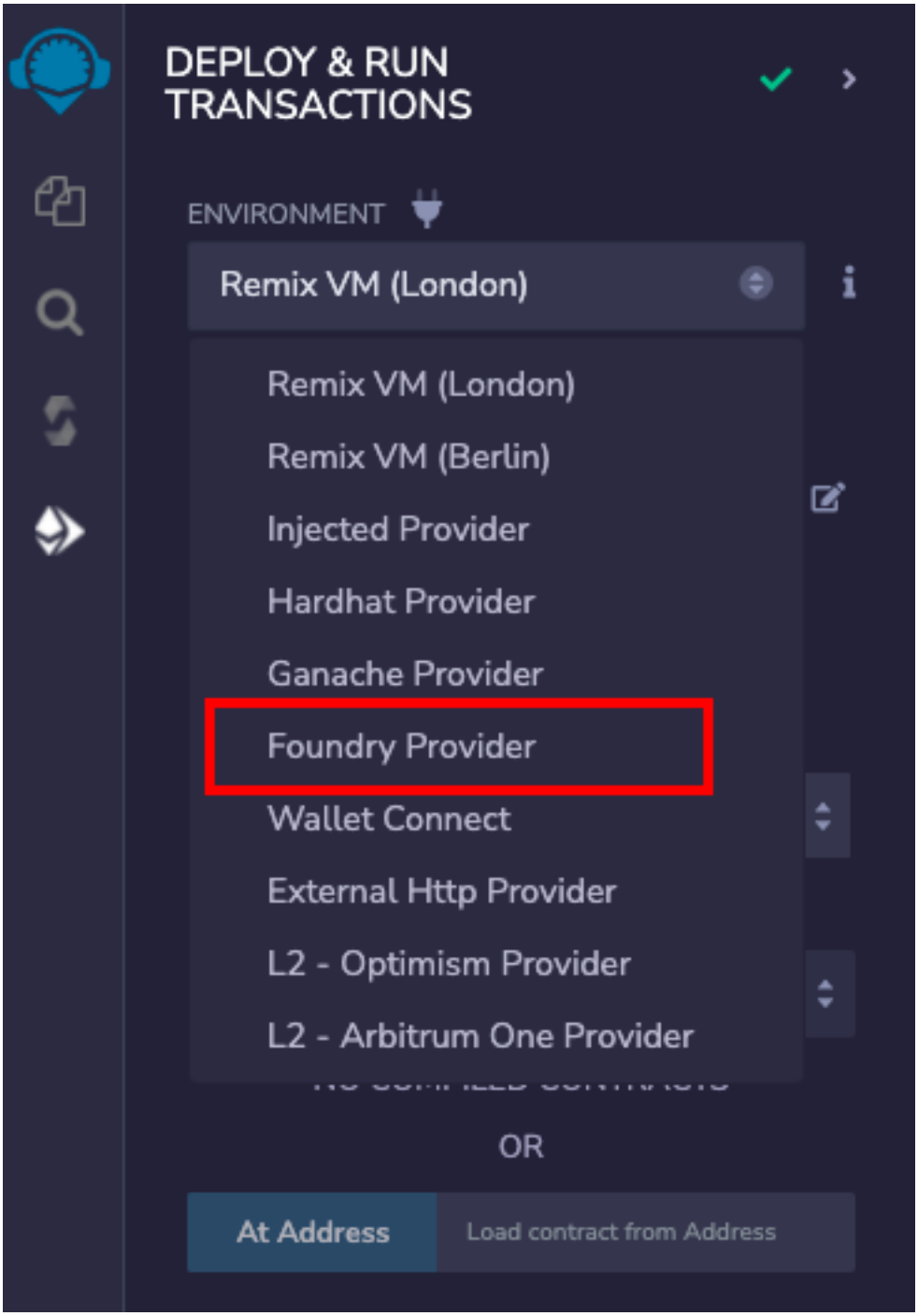


1.20 Foundry

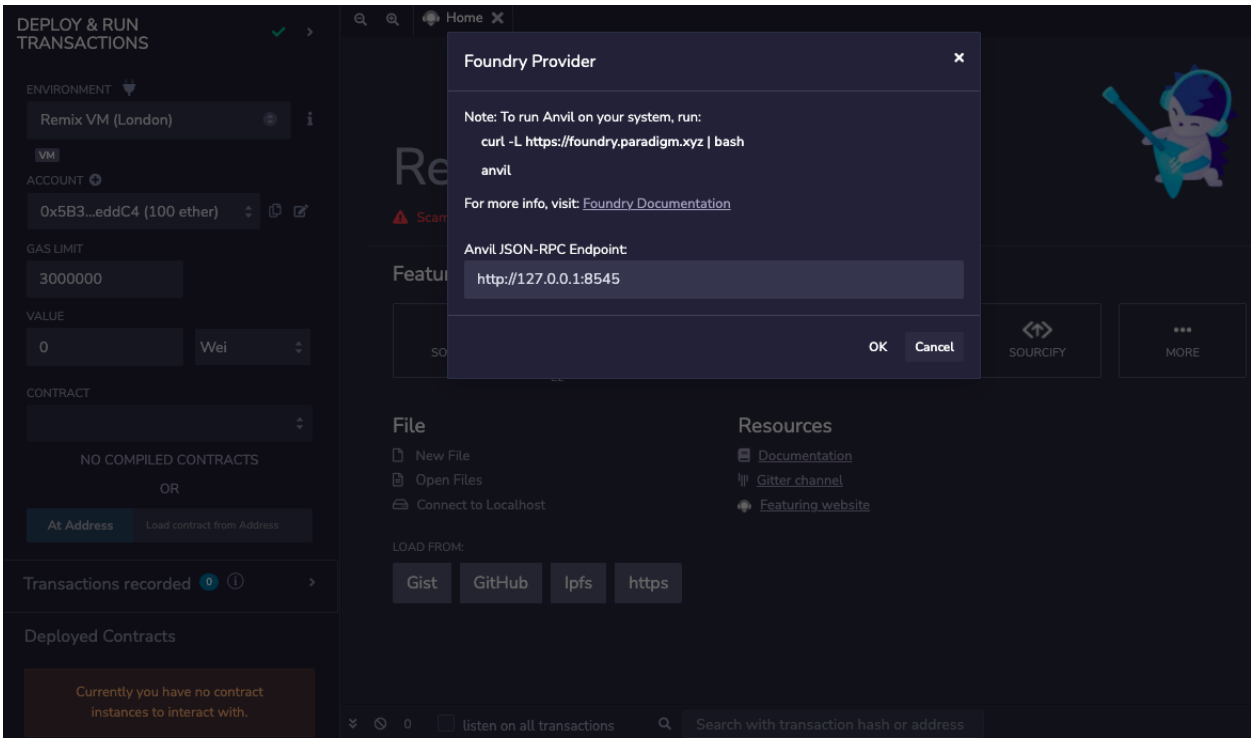
(Supported since Remix IDE v0.25.0)

1.20.1 Foundry Provider

Foundry Provider is a plugin on Remix IDE which enables users to deploy the contract to the Foundry's built-in **Anvil** blockchain. `Foundry Provider` can be chosen from the list of environments in `Deploy & Run Transactions` plugin.

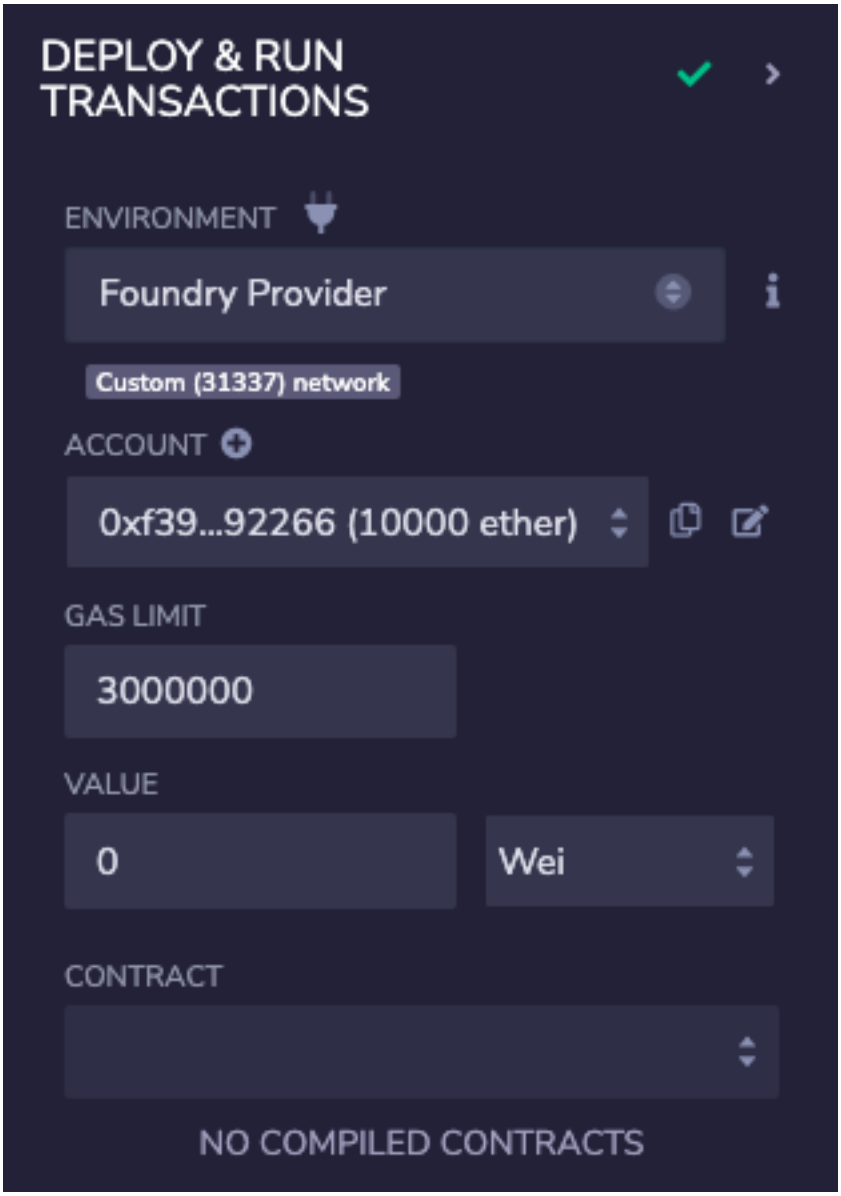


As soon as you select `Foundry Provider`, a modal is opened asking for the `Anvil JSON-RPC Endpoint`.



If Foundry Anvil node is running with default options, the default endpoint value in modal will not need any change. In case, Anvil node host and port are different, JSON-RPC endpoint should be updated in the modal text box.

Once the correct endpoint is filled in the modal, just click on `OK` and the accounts from the Anvil node will be loaded in the `ACCOUNT` section. Network id will also be shown.

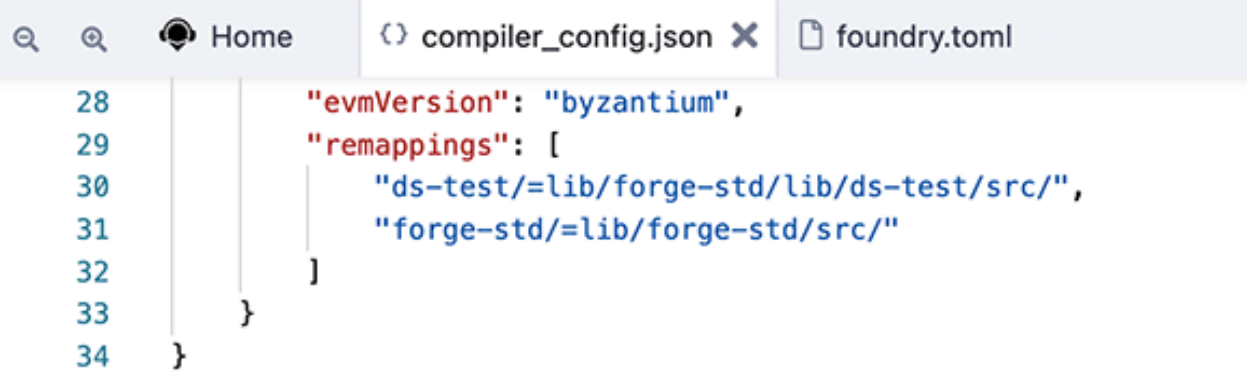


Now, one can start deploying the contract from Remix IDE to the local Anvil node as usual.

1.20.2 Foundry Remappings

Foundry manages dependencies using git submodules and can remap dependencies to make them easier to import. So import defined by remappings can have compilation errors on Remix IDE.

To support such compilation, Remix suggests running compilation using a compiler config file. Remix adds some default Forge remappings in the compiler config file when a Foundry project is loaded in Remix IDE using remixd.



Further, more remappings can be added manually, if required.

1.21 Generate Artifact

When a compilation for a Solidity file succeeds, Remix creates three JSON files for each compiled contract. Files can be seen in the `File Explorers plugin` as:

1. `artifacts/<contractName>.json`: contains the link to the libraries, the bytecode, the deployed bytecode, the gas estimation, the method identifiers, and the ABI. It is used for linking a library address to the file.
2. `artifacts/<contractName_metadata>.json`: contains the metadata from the output of Solidity compilation.
3. `artifacts/build-info/<dynamic_hash>.json`: contains info about `solc` compiler version, compiler input and output. This file is generated similar to the files generated through Hardhat compilation. You can also try Hardhat compilation from Remix.

Please note that in order to generate these artifact files, the **Generate contract metadata** box in the **General settings** section of the **Settings** module needs to be checked. By default, it is checked.

You can write scripts that can access either of these files.

1.21.1 Library Deployment with filename.json

By default Remix automatically deploys needed libraries.

When you open the metadata file for the libraries - **artifact/filename.json** you will see the following sections:

`linkReferences` contains a map representing libraries which depend on the current contract. Values are addresses of libraries used for linking the contract.

`autoDeployLib` defines if the libraries should be auto deployed by Remix or if the contract should be linked with libraries described in `linkReferences`

Note that Remix will resolve addresses corresponding to the current network. By default, a configuration key follows the form: `<network_name>:<networkd_id>`, but it is also possible to define `<network_name>` or `<network_id>` as keys.

Here is a sample metadata file for linking a library:

```
{
        "VM:-": {
                "linkReferences": {
                        "browser/Untitled.sol": {
                                "lib": "<address>",
                                "lib2": "<address>"
                        }
                },
                "autoDeployLib": true
        },
        "main:1": {
                "linkReferences": {
                        "browser/Untitled.sol": {
                                "lib": "<address>",
                                "lib2": "<address>"
                        }
                },
                "autoDeployLib": true
        },
        "ropsten:3": {
                "linkReferences": {
                        "browser/Untitled.sol": {
                                "lib": "<address>",
                                "lib2": "<address>"
                        }
                },
                "autoDeployLib": true
        },
        "rinkeby:4": {
                "linkReferences": {
                        "browser/Untitled.sol": {
                                "lib": "<address>",
                                "lib2": "<address>"
                        }
                },
                "autoDeployLib": true
        },
        "kovan:42": {
                "linkReferences": {
                        "browser/Untitled.sol": {
                                "lib": "<address>",
                                "lib2": "<address>"
                        }
                },
                "autoDeployLib": true
        },
        "data": {
                "bytecode": {
                        "linkReferences": {},
                        "object":
↪"608060405234801561001057600080fd5b506040516108723803806108728339818101604052602081101561003357600
↪",
                        "opcodes": "PUSH1 0x80 PUSH1 0x40 MSTORE CALLVALUE DUP1␣
↪ISZERO PUSH2 0x10 JUMPI PUSH1 0x0 DUP1 REVERT JUMPDEST POP PUSH1 0x40 MLOAD PUSH2␣
↪0x872 CODESIZE SUB DUP1 PUSH2 0x872 DUP4 CODECOPY DUP2 DUP2 ADD PUSH1 0x40 MSTORE␣
↪PUSH1 0x20 DUP2 LT ISZERO PUSH2 0x33 JUMPI PUSH1 0x0 DUP1 REVERT JUMPDEST DUP2 ADD␣
↪SWAP1 DUP1 DUP1 MLOAD SWAP1 PUSH1 0x20 ADD SWAP1 SWAP3 SWAP2 SWAP1 POP POP POP␣
↪CALLER PUSH1 0x0 DUP1 PUSH2 0x100 EXP DUP2 SLOAD DUP2 PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF MUL NOT AND SWAP1 DUP4 PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND MUL OR SWAP1 SSTORE POP PUSH1 0x1␣
↪DUP1 PUSH1 0x0 DUP1 PUSH1 0x0 SWAP1 SLOAD SWAP1 PUSH2 0x100 EXP SWAP1 DIV PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND DUP2 MSTORE PUSH1 0x20 ADD SWAP1␣
↪DUP2 MSTORE PUSH1 0x20 ADD PUSH1 0x0 KECCAK256 PUSH1 0x0 ADD DUP2 SWAP1 SSTORE POP␣
```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```
                        "sourceMap": "33:2130:0:-;;;382:163;8:9:-1;5:2;;;30:1;27;
↪20:12;5:2;382:163:0;;;;;;;;;;;;;;;13:2:-1;8:3;5:11;2:2;;;29:1;26;19:12;2:2;
↪382:163:0;;;;;;;;;;;;;;;446:10;432:11;;:24;;;;;;;;;;;;;;;;;;495:1;466:6;:19;473:11;
↪;;;;;;;;;;466:19;;;;;;;;;;;;;;;:26;;:30;;;;525:13;506:32;;:9;:32;;;;;;;:i;;;:-;;
↪382:163;33:2130;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;:i;;;:-;;;;;;;:o;;;:-;;;;;;;;;;;;;;;;
↪;;;;;;;;;;;;;;;:o;;;:-;;;;;;;"
                },
                "deployedBytecode": {
                        "linkReferences": {},
                        "object":
↪"608060405234801561001057600080fd5b506004361061004c5760003560e01c80635c19a95c1461005157806309ff1bc
↪",
                        "opcodes": "PUSH1 0x80 PUSH1 0x40 MSTORE CALLVALUE DUP1␣
↪ISZERO PUSH2 0x10 JUMPI PUSH1 0x0 DUP1 REVERT JUMPDEST POP PUSH1 0x4 CALLDATASIZE␣
↪LT PUSH2 0x4C JUMPI PUSH1 0x0 CALLDATALOAD PUSH1 0xE0 SHR DUP1 PUSH4 0x5C19A95C EQ␣
↪PUSH2 0x51 JUMPI DUP1 PUSH4 0x609FF1BD EQ PUSH2 0x95 JUMPI DUP1 PUSH4 0x9E7B8D61 EQ␣
↪PUSH2 0xB9 JUMPI DUP1 PUSH4 0xB3F98ADC EQ PUSH2 0xFD JUMPI JUMPDEST PUSH1 0x0 DUP1␣
↪REVERT JUMPDEST PUSH2 0x93 PUSH1 0x4 DUP1 CALLDATASIZE SUB PUSH1 0x20 DUP2 LT␣
↪ISZERO PUSH2 0x67 JUMPI PUSH1 0x0 DUP1 REVERT JUMPDEST DUP2 ADD SWAP1 DUP1 DUP1␣
↪CALLDATALOAD PUSH20 0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND SWAP1 PUSH1 0x20␣
↪ADD SWAP1 SWAP3 SWAP2 SWAP1 POP POP POP PUSH2 0x12E JUMP JUMPDEST STOP JUMPDEST␣
↪PUSH2 0x9D PUSH2 0x481 JUMP JUMPDEST PUSH1 0x40 MLOAD DUP1 DUP3 PUSH1 0xFF AND␣
↪PUSH1 0xFF AND DUP2 MSTORE PUSH1 0x20 ADD SWAP2 POP POP PUSH1 0x40 MLOAD DUP1 SWAP2␣
↪SUB SWAP1 RETURN JUMPDEST PUSH2 0xFB PUSH1 0x4 DUP1 CALLDATASIZE SUB PUSH1 0x20␣
↪DUP2 LT ISZERO PUSH2 0xCF JUMPI PUSH1 0x0 DUP1 REVERT JUMPDEST DUP2 ADD SWAP1 DUP1␣
↪DUP1 CALLDATALOAD PUSH20 0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND SWAP1 PUSH1␣
↪0x20 ADD SWAP1 SWAP3 SWAP2 SWAP1 POP POP POP PUSH2 0x4F9 JUMP JUMPDEST STOP␣
↪JUMPDEST PUSH2 0x12C PUSH1 0x4 DUP1 CALLDATASIZE SUB PUSH1 0x20 DUP2 LT ISZERO␣
↪PUSH2 0x113 JUMPI PUSH1 0x0 DUP1 REVERT JUMPDEST DUP2 ADD SWAP1 DUP1 DUP1␣
↪CALLDATALOAD PUSH1 0xFF AND SWAP1 PUSH1 0x20 ADD SWAP1 SWAP3 SWAP2 SWAP1 POP POP␣
↪POP PUSH2 0x5F6 JUMP JUMPDEST STOP JUMPDEST PUSH1 0x0 PUSH1 0x1 PUSH1 0x0 CALLER␣
↪PUSH20 0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND DUP2 MSTORE PUSH1 0x20 ADD SWAP1␣
↪DUP2 MSTORE PUSH1 0x20 ADD PUSH1 0x0 KECCAK256 SWAP1 POP DUP1 PUSH1 0x1 ADD PUSH1␣
↪0x0 SWAP1 SLOAD SWAP1 PUSH2 0x100 EXP SWAP1 DIV PUSH1 0xFF AND ISZERO PUSH2 0x18E␣
↪JUMPI POP PUSH2 0x47E JUMP JUMPDEST JUMPDEST PUSH1 0x0 PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND PUSH1 0x1 PUSH1 0x0 DUP5 PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND DUP2 MSTORE PUSH1 0x20 ADD SWAP1␣
↪DUP2 MSTORE PUSH1 0x20 ADD PUSH1 0x0 KECCAK256 PUSH1 0x1 ADD PUSH1 0x2 SWAP1 SLOAD␣
↪SWAP1 PUSH2 0x100 EXP SWAP1 DIV PUSH20 0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF␣
↪AND PUSH20 0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND EQ ISZERO DUP1 ISZERO␣
↪PUSH2 0x2BC JUMPI POP CALLER PUSH20 0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND␣
↪PUSH1 0x1 PUSH1 0x0 DUP5 PUSH20 0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND␣
↪PUSH20 0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND DUP2 MSTORE PUSH1 0x20 ADD␣
↪SWAP1 DUP2 MSTORE PUSH1 0x20 ADD PUSH1 0x0 KECCAK256 PUSH1 0x1 ADD PUSH1 0x2 SWAP1␣
↪SLOAD SWAP1 PUSH2 0x100 EXP SWAP1 DIV PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND EQ ISZERO JUMPDEST ISZERO PUSH2␣
↪0x32B JUMPI PUSH1 0x1 PUSH1 0x0 DUP4 PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND DUP2 MSTORE PUSH1 0x20 ADD SWAP1␣
↪DUP2 MSTORE PUSH1 0x20 ADD PUSH1 0x0 KECCAK256 PUSH1 0x1 ADD PUSH1 0x2 SWAP1 SLOAD␣
↪SWAP1 PUSH2 0x100 EXP SWAP1 DIV PUSH20 0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF␣
↪AND SWAP2 POP PUSH2 0x18F JUMP JUMPDEST CALLER PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND DUP3 PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND EQ ISZERO PUSH2 0x365 JUMPI POP␣
↪PUSH2 0x47E JUMP JUMPDEST PUSH1 0x1 DUP2 PUSH1 0x1 ADD PUSH1 0x0 PUSH2 0x100 EXP␣
↪DUP2 SLOAD DUP2 PUSH1 0xFF MUL NOT AND SWAP1 DUP4 ISZERO ISZERO MUL OR SWAP1 SSTORE␣
↪POP DUP2 DUP2 PUSH1 0x1 ADD PUSH1 0x2 PUSH2 0x100 EXP DUP2 SLOAD DUP2 PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF MUL NOT AND SWAP1 DUP4 PUSH20␣
↪0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND MUL OR SWAP1 SSTORE POP PUSH1 0x0␣
↪PUSH1 0x1 PUSH1 0x0 DUP5 PUSH20 0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND␣
↪PUSH20 0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF AND DUP2 MSTORE PUSH1 0x20 ADD␣
```

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```
                        "sourceMap": "33:2130:0:-;;;;8:9:-1;5:2;;;30:1;27;20:12;5:2;
↪33:2130:0;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;872:577;;;;;;13:2:-1;8:3;5:11;2:2;;;29:1;
↪26;19:12;2:2;872:577:0;;;;;;;;;;;;;;;;;;;;;;:::i;:::-;;1801:360;;;;;;i;:::-;;;;;;;;;;;;
↪;;;;;;;;;;;655:164;;;;;;13:2:-1;8:3;5:11;2:2;;;29:1;26;19:12;2:2;655:164:0;;;;;;;;;;
↪;;;;;;;;;;;:::i;:::-;;1509:286;;;;;;13:2:-1;8:3;5:11;2:2;;;29:1;26;19:12;2:2;
↪1509:286:0;;;;;;;;;;;;;;;;;;;;;;:::i;:::-;;872:577;919:20;942:6;:18;949:10;942:18;;;;;;
↪;;;;;;;;;919:41;;995:6;:12;;;;;;;;;;;;991:25;;;1009:7;;;991:25;1025:115;1063:1;
↪1032:33;;;6;:10;1039:2;1032:10;;;;;;;;;;;;;;;:19;;;;;;;;;;;;:33;;;;:70;;;;;1092:10;
↪1069:33;;;6;:10;1076:2;1069:10;;;;;;;;;;;;;;;:19;;;;;;;;;;;;:33;;;;1032:70;1025:115;
↪;;1121:6;:10;1128:2;1121:10;;;;;;;;;;;;;;;:19;;;;;;;;;;;;1116:24;;1025:115;;;
↪1160:10;1154:16;;;2;:16;;;1150:29;;;1172:7;;;1150:29;1203:4;1188:6;:12;;;;:19;;;;;;;;
↪;;;;;;;;;;1235:2;1217:6;:15;;;:20;;;;;;;;;;;;;;;;;;1247:24;1274:6;:10;1281:2;
↪1274:10;;;;;;;;;;;;;;;;1247:37;;1298:10;:16;;;;;;;;;;;;1294:148;;;1368:6;:13;;;
↪1328:9;1338:10;:15;;;;;;;;;;;;1328:26;;;;;;;;;;;;;;;;;:36;;;;:53;;;;;;;;;;;1294:148;;
↪;1429:6;:13;;;1408:10;:17;;;;:34;;;;;;;;;;;1294:148;872:577;;;;;;;:o;1801:360::-;
↪1849:22;1883:24;1910:1;1883:28;;1926:10;1939:1;1926:14;;1921:234;1949:9;:16;;;;
↪1942:4;:23;;;1921:234;;;2019:16;1991:9;2001:4;1991:15;;;;;;;;;;;;;;;;;:25;;;:44;
↪1987:168;;;2074:9;2084:4;2074:15;;;;;;;;;;;;;;;;;:25;;;2055:44;;2136:4;2117:23;;
↪1987:168;1967:6;;;;;;;1921:234;;;;1801:360;;;;:o;655:164::-;732:11;;;;;;;;;;;718:25;
↪;:10;:25;;;;:50;;;;747:6;:15;754:7;747:15;;;;;;;;;;;;;;;:21;;;;;;;;;;;718:50;
↪714:63;;;770:7;;714:63;811:1;786:6;:15;793:7;786:15;;;;;;;;;;;;;;;:22;;:26;;;;
↪655:164;;;;:o;1509:286::-;1558:20;1581:6;:18;1588:10;1581:18;;;;;;;;;;;;;;;1558:41;;
↪1613:6;:12;;;;;;;;;;;;;:46;;;;1643:9;:16;;;;1629:10;:30;;;;1613:46;1609:59;;;1661:7;;
↪;1609:59;1692:4;1677:6;:12;;;;:19;;;;;;;;;;;;;;;;;;1720:10;1706:6;:11;;;;:24;;;;;;;;;
↪;;;;;;;;1775:6;:13;;;1740:9;1750:10;1740:21;;;;;;;;;;;;;;;;;;:31;;;;:48;;;;;;;;;;;
↪1509:286;;;;;:o"
                },
                "gasEstimates": {
                        "creation": {
                                "codeDepositCost": "360800",
                                "executionCost": "infinite",
                                "totalCost": "infinite"
                        },
                        "external": {
                                "delegate(address)": "infinite",
                                "giveRightToVote(address)": "20997",
                                "vote(uint8)": "62215",
                                "winningProposal()": "infinite"
                        }
                },
                "methodIdentifiers": {
                        "delegate(address)": "5c19a95c",
                        "giveRightToVote(address)": "9e7b8d61",
                        "vote(uint8)": "b3f98adc",
                        "winningProposal()": "609ff1bd"
                }
        },
        "abi": [
                {
                        "constant": false,
                        "inputs": [
                                {
                                        "internalType": "address",
                                        "name": "to",
                                        "type": "address"
                                }
                        ],
```


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```
                "name": "delegate",
                "outputs": [],
                "payable": false,
                "stateMutability": "nonpayable",
                "type": "function"
        },
        {
                "constant": true,
                "inputs": [],
                "name": "winningProposal",
                "outputs": [
                        {
                                "internalType": "uint8",
                                "name": "_winningProposal",
                                "type": "uint8"
                        }
                ],
                "payable": false,
                "stateMutability": "view",
                "type": "function"
        },
        {
                "constant": false,
                "inputs": [
                        {
                                "internalType": "address",
                                "name": "toVoter",
                                "type": "address"
                        }
                ],
                "name": "giveRightToVote",
                "outputs": [],
                "payable": false,
                "stateMutability": "nonpayable",
                "type": "function"
        },
        {
                "constant": false,
                "inputs": [
                        {
                                "internalType": "uint8",
                                "name": "toProposal",
                                "type": "uint8"
                        }
                ],
                "name": "vote",
                "outputs": [],
                "payable": false,
                "stateMutability": "nonpayable",
                "type": "function"
        },
        {
                "inputs": [
                        {
                                "internalType": "uint8",
                                "name": "_numProposals",
                                "type": "uint8"
```

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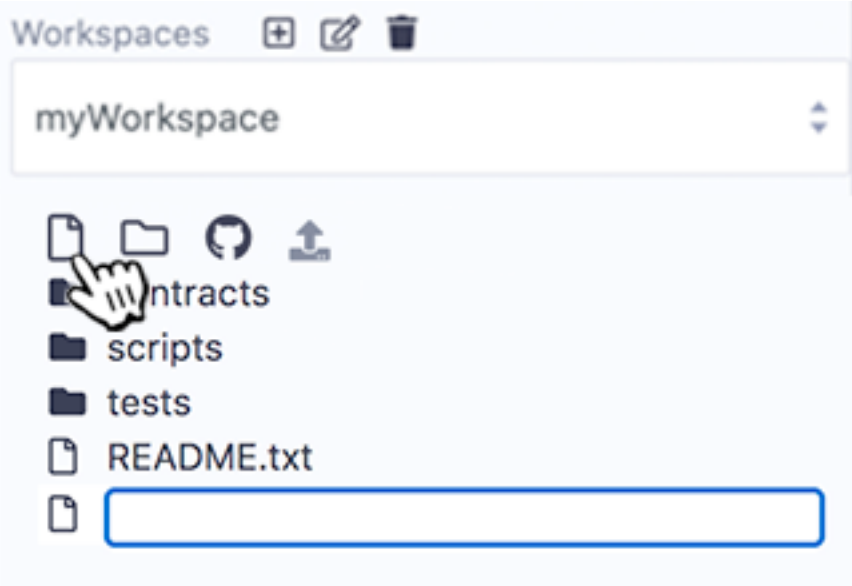
```
                                }
                            ],
                            "payable": false,
                            "stateMutability": "nonpayable",
                            "type": "constructor"
                    }
            ]

}
```

1.22 Creating and Deploying a Contract

This page contains the process of creating a contract, compiling it, deploying and then interacting with it.

1.22.1 A sample contract

This contract is very basic. The goal is to quickly start to create and to interact with a sample contract.



Go to the File Explorer, create a new file, name it and in the editor paste the contract below.

```
// SPDX-License-Identifier: GPL-3.0

pragma solidity ^0.7.6;

contract testContract {

    uint256 value;

    constructor (uint256 _p) {
        value = _p;
    }
```

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```
    function setP(uint256 _n) payable public {
        value = _n;
    }

    function setNP(uint256 _n) public {
        value = _n;
    }

    function get () view public returns (uint256) {
        return value;
    }
}
```

1.22.2 Compile the Contract

With the contract above as the active tab in the Editor, compile the contract.

For More Info see the docs on the (Solidity Compiler).

1.22.3 Deploy the contract

Go to the **Deploy & Run Transactions** plugin.

There are 3 type of environments Remix can be plugged to:

- Javascript VM
- Injected Web3
- Web3 Provider

(For details see Running transactions)

Both **Injected Web3** and **Web3 Provider** require the use of an external tool.

An external tool for **Injected provider** is Metamask. Some external tools used with **Web3 provider** are a Truffle Ganache-CLI, Hardhat node, or an Ethereum node itself.

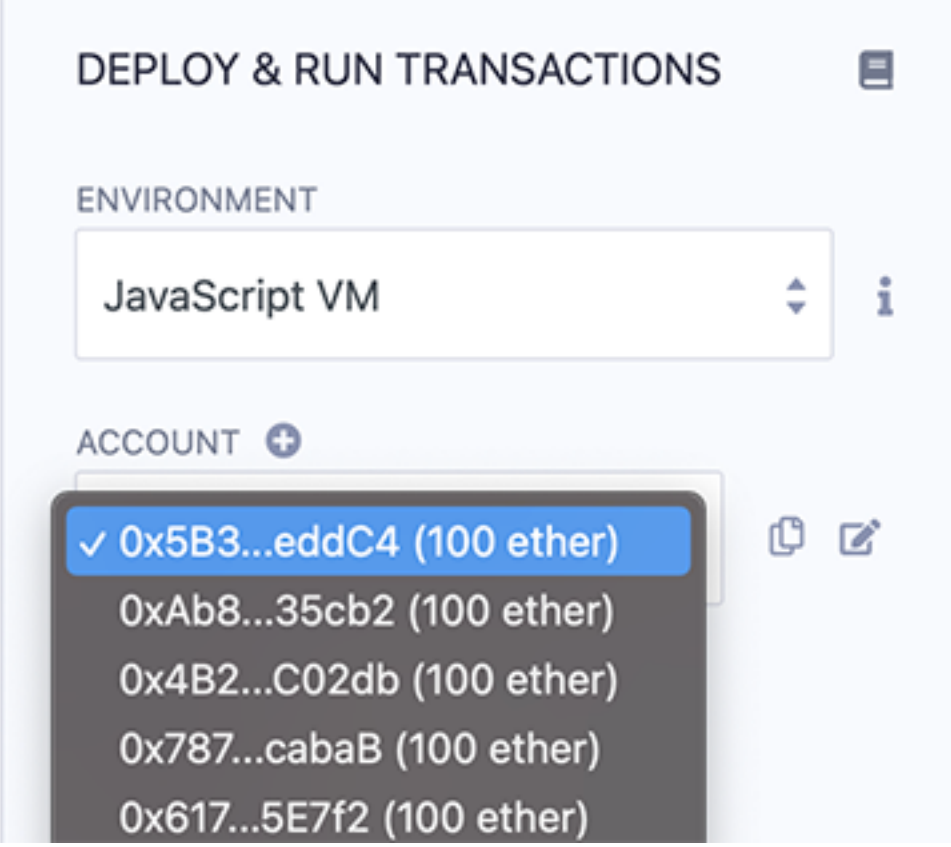
The **JavaScript VM** is convenient because it is a blockchain that runs in your browser and you don't need any other software or Ethereum node to run it.

NOTE: When you are in the **Javascript VM** and you reload the browser - the **Javascript VM** will restart to its fresh & default state.

For performance purposes (which is to say - for testing in an environment that is closest to the mainnet), it can be better to use an external node.

1.22.4 Select the VM environment

Make sure the VM mode is selected. All accounts displayed in **ACCOUNT** should have 100 ether.



1.22.5 Deploying a contract

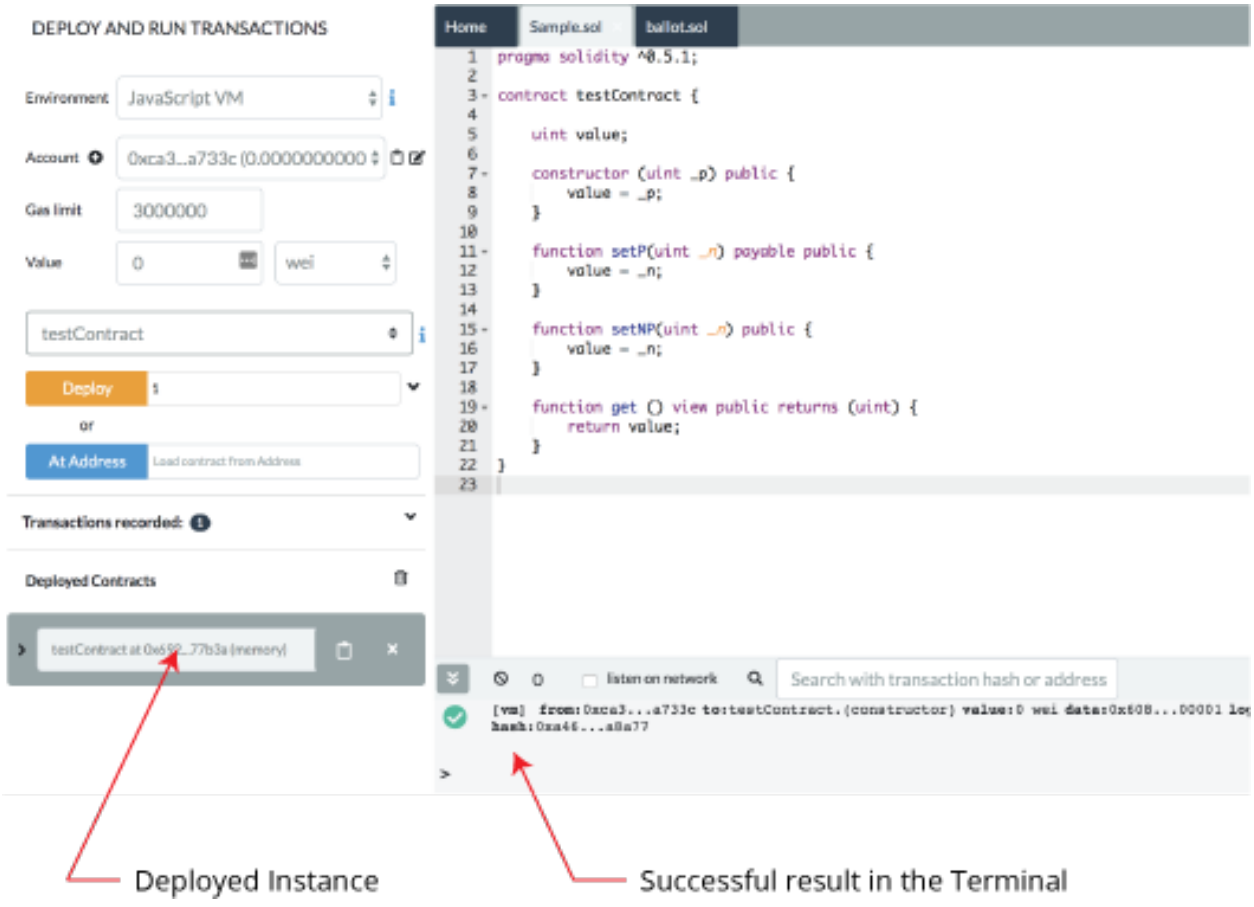
The constructor of `testContract` needs a parameter (of type `uint256`). Input a uint256 and click on `Deploy`.

The transaction is created which deploys the instance of `testContract` .

In a "normal" blockchain, you would have to wait for the transaction to be mined. However, because we are using the `JavaScript VM`, our execution is immediate.

The terminal will give information about the transaction.

The newly created instance is displayed in the **Deployed Contracts** section.



1.22.6 Interacting with an instance

Clicking on the caret to the left of the instance of TESTCONTRACT will open it up so you can see its function.

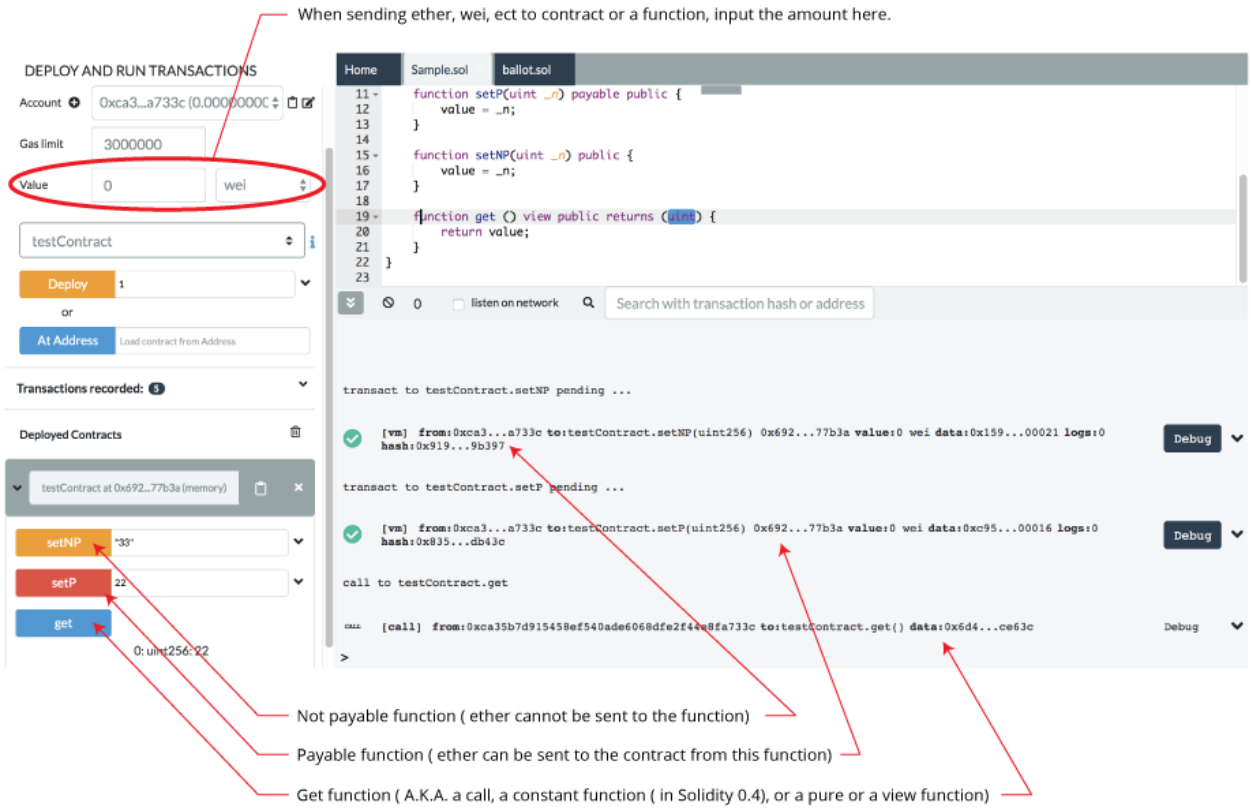
This new instance contains 3 actions which corresponds to the 3 functions (`setP`, `setPN`, `get`). Clicking on `setP` or `setPN` will create a new transaction.

Note that `setP` is `payable` (red button) : it is possible to send value (Ether) to the contract.

`setPN` is not payable (orange button - depending on the theme) : it is not possible to send value (Ether) to the contract.

Clicking on `get` will not execute a transaction (usually its a blue button - depending on the theme). It doesn't execute a transaction because a `get` does not modify the state (the variable `value`) of this instance.

Because `get` is a **view function**, you can see the return value just below the `get` button.



1.23 Debugging Transactions

(also see this page's companion: the Debugger Tour)

There are two ways to start a debugging session, each one corresponds to a different use case.

- Use Case 1: for debugging a transaction made in Remix - click the **Debug button** in the transaction log in Remix's Terminal.
- Use Case 2: for debugging a transaction where you have a **txn hash** from **verified contract** or where you have the txn hash and the compiled source code with the same compilation settings as the deployed contract.

1.23.1 Initiate Debugging from the transaction log in the Terminal

Let's start with a basic contract (or replace the contract below with your own)

```
pragma solidity >=0.5.1 <0.6.0;
contract Donation {
    address owner;
    event fundMoved(address _to, uint _amount);
    modifier onlyowner { if (msg.sender == owner) _; }
    address[] _giver;
    uint[] _values;

    constructor() public {
        owner = msg.sender;
    }
```

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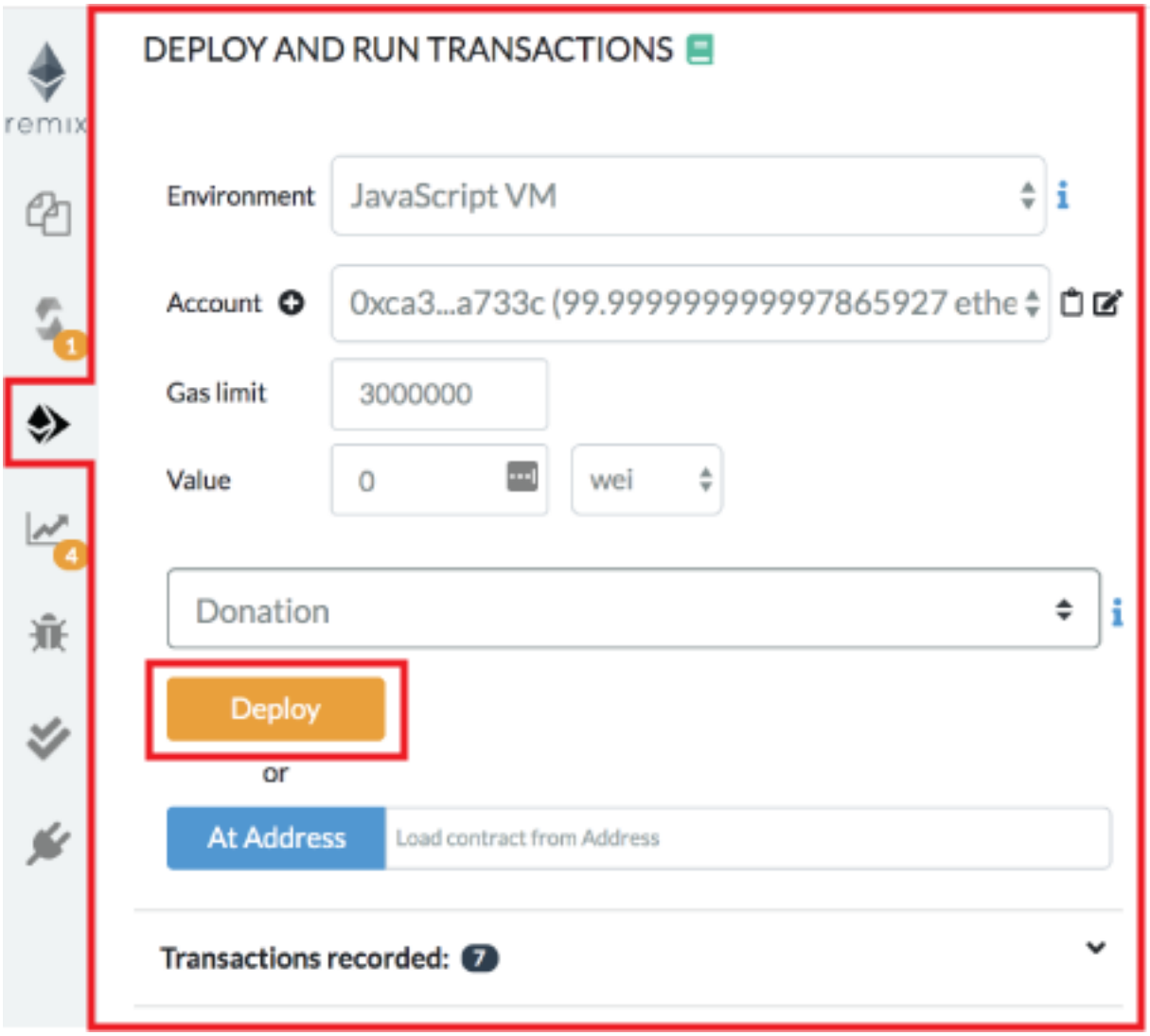
```
    function donate() public payable {
        addGiver(msg.value);
    }

    function moveFund(address payable _to, uint _amount) onlyowner  public {
        uint balance = address(this).balance;
        uint amount = _amount;
        if (amount <= balance) {
            if (_to.send(balance)) {
                emit fundMoved(_to, amount);
            } else {
               revert();
            }
        } else {
            revert();
        }
    }

    function addGiver(uint _amount) internal {
        _giver.push(msg.sender);
        _values.push(_amount);
    }
}
```

- Make a new file in Remix and copy the code above into it.
- Compile the code.
- Go to the Run & Deploy module.

For the purpose of this tutorial, we will run the `Remix VM`.

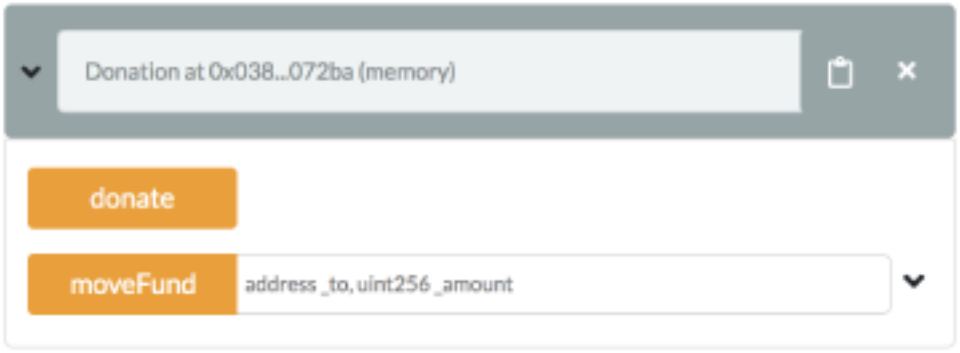
- Deploy the contract:

Click the `Deploy` button



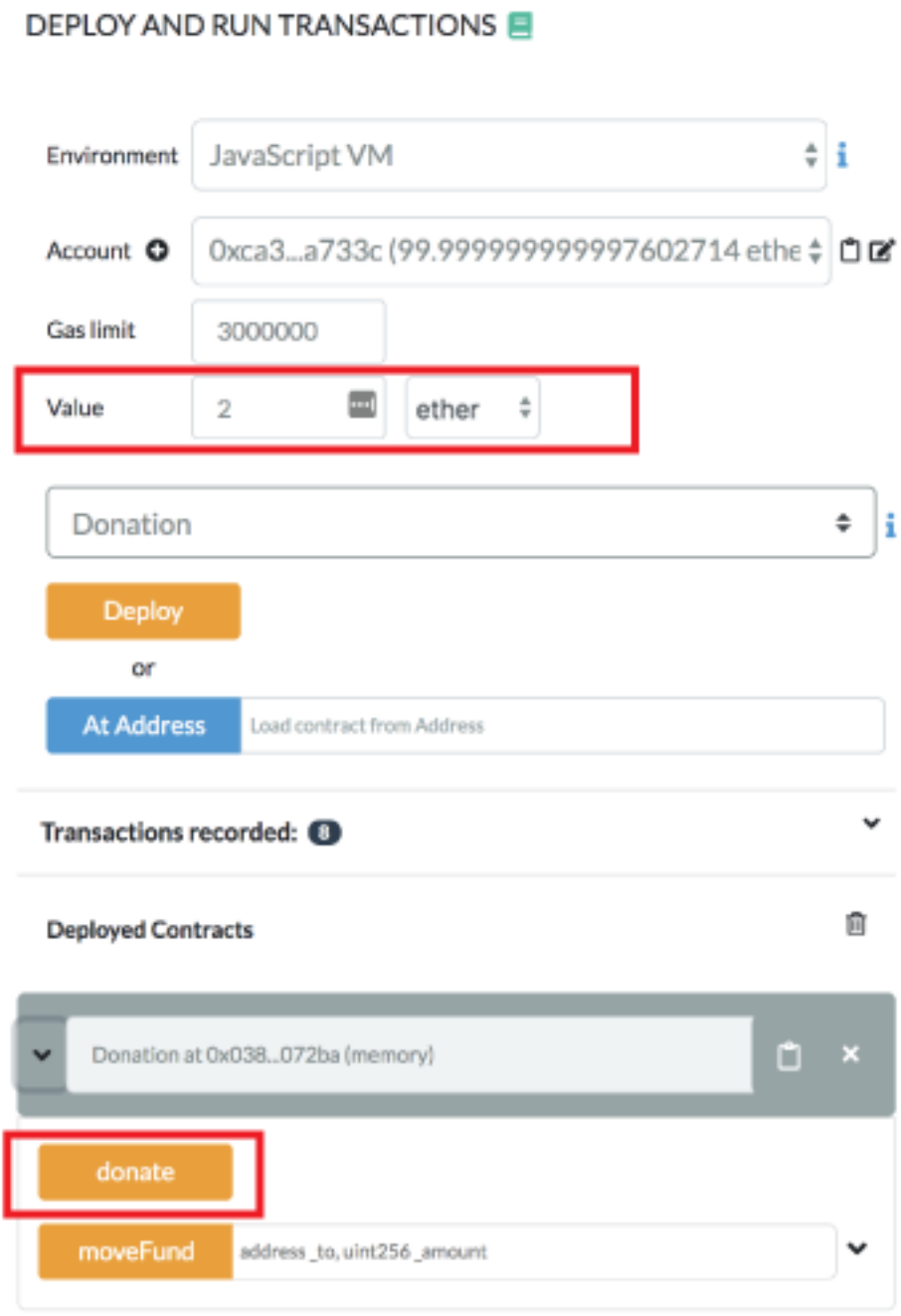
You'll see the deployed instance (AKA the udapp).

Then open it up (by clicking the caret).



We are going to call the `Donate` function and will send 2 Ethers.

To do this: in the value input box put in **2** and **select Ether** as the unit (DO NOT LEAVE THE DEFAULT unit as **gwei** or the change will be hard to detect).



Then click the `Donate` button.

This will send the Ether to the function.

Because we are using the `Remix VM`, everything happens almost instantly. (If we had been using Injected Web 3, then we would have to need to approve the transaction, pay for gas and wait for the transaction to get mined.)

Remix displays information related to each transaction result in the terminal.

Check in the **terminal** where the transaction you just made is logged.

Click the **debug button**.

But before we get to the actual debugging tool, the next section shows how to start a debugging session directly from the Debugger.

1.23.2 Initiate Debugging from the Debugger

Click the bug icon in the icon panel to get to the debugger in the side panel.

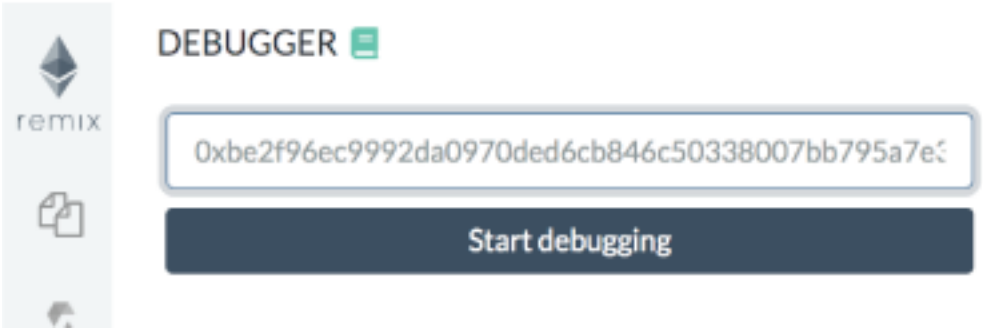
If you don't see the bug icon, go to the plugin manager and activate the debugger.

You can start a debug session by providing a `transaction hash`.

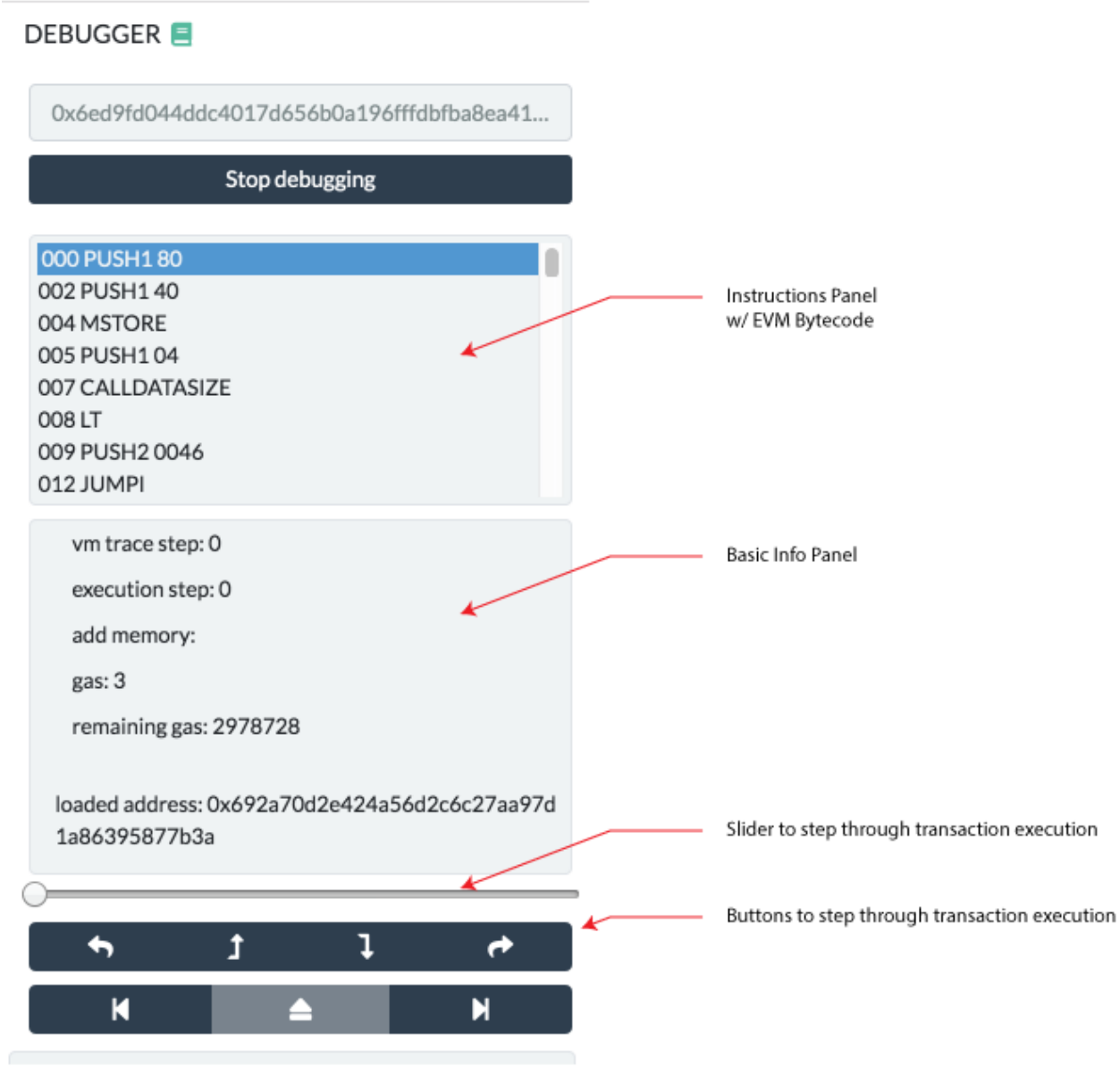
To find a transaction hash:

1. Go to a transaction in the terminal.
2. Click a line with a transaction - to expand the log.
3. The transaction hash is there - copy it.

Then click in the debugger paste the hash and click on the `Start debugging` button.



1.23.3 Using the debugger



The debugger allows one to see detailed informations about the transaction's execution. It uses the editor to display

the location in the source code where the current execution is.

The navigation part contains a slider and buttons that can be used to step through the transaction execution.

Explanation of Debugger button capabilities

1. Step Over Back Returns to the previous step, but ignores/steps over function calls: the debugger WILL NOT enter a function
2. Step Back Returns to the previous step. Does not ignore function calls: the debugger WILL enter any function along the way
3. Step Into Forwards to the next step. Does not ignore function calls: the debugger WILL enter any function along the way
4. Step Over Forward Forwards to the next step, but ignores/steps over function calls: the debugger WILL NOT enter a function
5. Jump to the Previous Breakpoint Sends the debugger to the last visited breakpoint. Note that breakpoints may be set by clicking the line number in source code
6. Jump Out Sends the debugger to the function's end
7. Jump to the Next Breakpoint Sends the debugger to the next breakpoint

1.23.4 11 panels give detailed information about the execution:

Instructions

The Instructions panel displays the bytecode of the current executing contract- with the current step highlighted.

Important note: When this panel is hidden, the slider will have a coarser granularity and only stop at *expression boundaries*, even if they are compiled into multiple EVM instructions. When the panel is displayed, it will be possible to step over every instruction, even those that refers to the same expression.

Solidity Locals

The Solidity Locals panel displays local variables associated with the current context.

Solidity State

The Solidity State panel displays state variables of the current executing contract.

Low level panels

These panels display low level informations about the execution:

- Stack
- Storages Changes
- Memory
- Call Data
- Call Stack

- Return Value (only if the current step is a RETURN opcode)
- Full Storages Changes (only at the end of the execution & it displays the all the storage changes)

Reverted Transaction

A transaction can be `reverted` (because of an *out of gas exception*, a Solidity `revert` statement or a low level exception).

It is important to be aware of the exception and to locate where the exception is in the source code.

Remix will warn you when the execution throws an exception. The `warning` button will jump to the last opcode before the exception happened.

Breakpoints

The two last buttons from the navigation area are used to jump either back to the previous breakpoint or forward to the next breakpoint.

Breakpoints can be added and removed by clicking on the line number in the **Editor**.

When using a debug session with breakpoints, the execution will jump to the first encountered breakpoint.

Important note: If you add a breakpoint to a line that declares a variable, it might be triggered twice: Once for initializing the variable to zero and a second time for assigning the actual value.

Here's an example of this issue. If you are debugging the following contract:

```
pragma solidity >=0.5.1 <0.6.0;

contract ctr {
    function hid() public {
        uint p = 45;
        uint m;
        m = 89;
        uint l = 34;
    }
}
```

And breakpoints are set for the lines

`uint p = 45;`

`m = 89;`

`uint l = 34;`

then clicking on the `Jump to the next breakpoint` button will stop at the following lines in the given order:

`uint p = 45;` (declaration of p)

`uint l = 34;` (declaration of l)

`uint p = 45;` (45 assigned to p)

`m = 89;` (89 assigned to m)

`uint l = 34;` (34 assigned to l)

1.24 Importing & Loading Source Files in Solidity

There are two main reasons for loading external files into Remix:

- **to import a library or dependency** (for files you will NOT be editing)
- **to load some files for manipulation, editing and play** (for files you might want to edit)

1.24.1 Importing a library or dependency

When importing from NPM, or a URL (like github, a IPFS gateway, or a Swarm gateway) you do not need to do anything more than use the `import` statement in your contract. The dependencies do not need to be "preloaded" into the File Explorer's current Workspace before the contract is compiled.

Files loaded from the import statement are placed in the **Files Explorer's** current Workspace's `.deps` folder.

Under the hood, Remix checks to see if the files are already loaded in the **.deps** directory. If not, it gets them via unpkg if it is an NPM lib.

Here are some example import statements:

Import from NPM

```
import "@openzeppelin/contracts/token/ERC20/ERC20.sol";
```

```
import "@openzeppelin/contracts@4.2.0/token/ERC20/ERC20.sol";
```

Note: In the example above, **@openzeppelin** is the name of the npm library. In the following example the library's name does not begin with an @ - but Remix will go and check npm for a library of that name.

```
import "solidity-linked-list/contracts/StructuredLinkedList.sol";
```

Import from a Github URL

```
import "https://github.com/OpenZeppelin/openzeppelin-contracts/blob/v2.5.0/contracts/
↪math/SafeMath.sol";
```

You should specify the release tag (where available), otherwise you will get the latest code in the master branch. For OpenZeppelin Contracts you should only use code published in an official release, the example above imports from OpenZeppelin Contracts v2.5.0.

Import from Swarm

```
import 'bzz-raw://5766400e5d6d822f2029b827331b354c41e0b61f73440851dd0d06f603dd91e5';
```

Import from IPFS

```
import 'ipfs://Qmdyq9ZmWcaryd1mgGZ4PttRNctLGUSAMpPqufsk6uRMKh';
```

Importing a local file not in .deps

To import a file NOT in the **.deps** folder, use a relative path (**./**). For example:

```
import "./myLovelyLovelyLib.sol";
```

Note: It is not possible to import across Workspaces.

Importing a file from your computer's filesystem

This method uses **remixd** - the remix daemon. Please go to the remixd docs for instructions about how to bridge the divide between the browser and your computers filesystem.

More about the import keyword

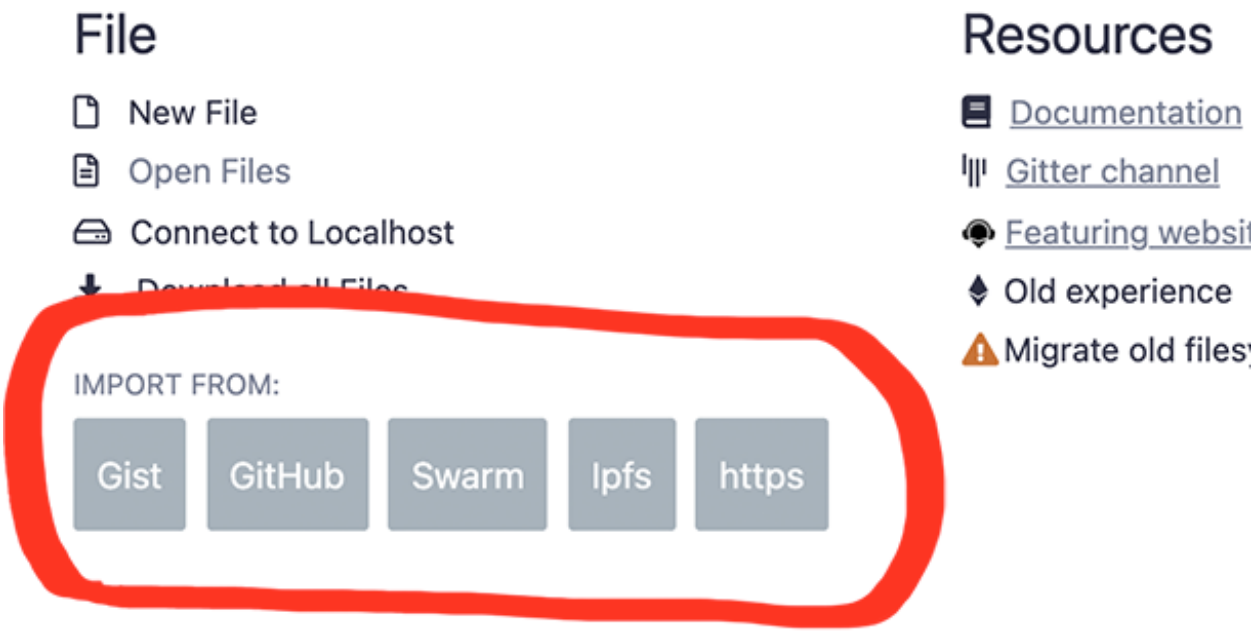
For a detailed explanation of the `import` keyword see the Solidity documentation

1.24.2 Importing a files for manipulation

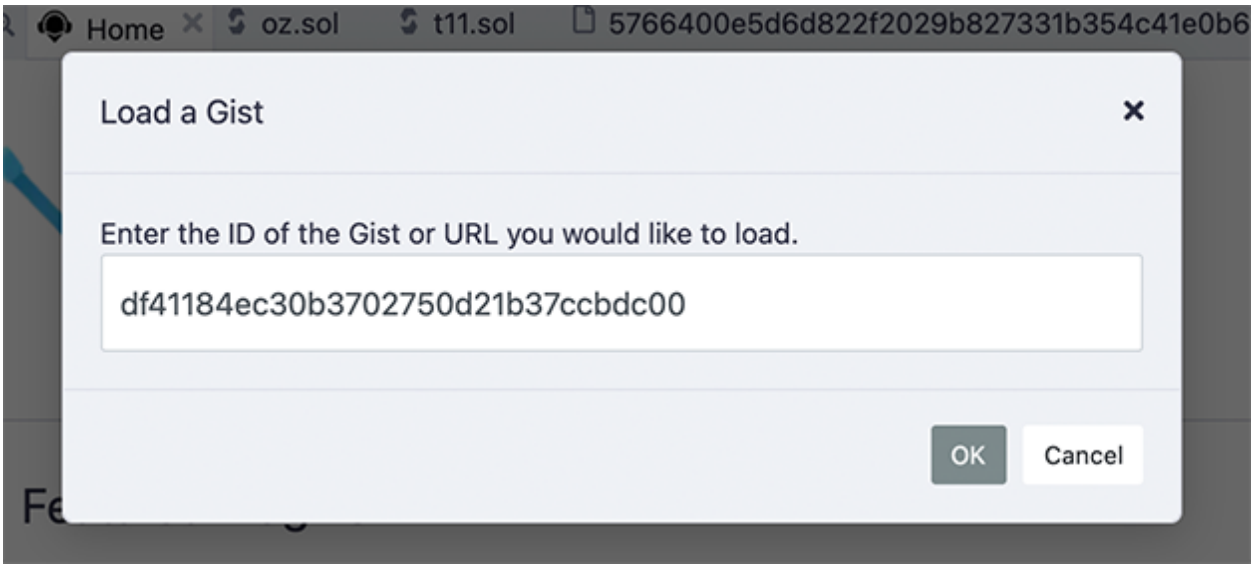
When importing from the home tab widgets or with a remix command in the console, the files are placed in the **root of the current Workspace** inside a folder the shows their source - eg github or gists.

Import buttons on the Remix home tab

The Gist, Github, Swarm, IPFS, & HTTPS buttons are to assist in getting files into Remix so you can explore.



Clicking on any of the Import buttons will bring up a modal like this one:



No need to wrap the input in quotes.

Loading with a remix command in the console

The 2 remix commands for loading are:

- remix.loadurl(url)
- remix.loadgist(id)

```
remix.loadurl('https://github.com/OpenZeppelin/openzeppelin-contracts/blob/v2.5.0/
↪contracts/math/SafeMath.sol')
```

```
remix.loadgist('5362adf2000afa4cbdd2c6d239e06bf5')
```

Accessing files loaded from the Home tab or from a remix command

When you load from github, a folder named `github` folder is created in the root of your current workspace. To import a file from the `github` folder, you would use a command like this:

```
import "github/OpenZeppelin/openzeppelin-contracts/contracts/math/SafeMath.sol";
```

Notice that this import statement doesn't include the version information that was in the remix.load(url) command. So it is recommended that you use the methods described at the top of this page for importing dependencies that you are not intending to edit.

Assume the .sol file that contained the import statement above is in the contracts folder. Notice that this import statement didn't need to traverse back to the github folder with a relative path like: **../github**.

1.25 Plugin List

Here is the list of Remix plugins that you will see in the Plugin Manager:

1.25.1 Core Plugins

File Explorer  The File Explorers is where you can see the files. profile name: **fileManager** Documentation

Remixd (No UI) Remixd (with an npm package running locally) connects a folder on your filesystem to the Remix website. Please see the docs for instructions. profile name: **remixd** Documentation

Solidity Compiler  Compiles Solidity & YUL. profile name: **solidity** Documentation

Deploy & Run  Deploy & interact with smart contracts on the in-browser chain (JSVM), local nodes, and public networks. profile name: **udapp** Documentation

Debugger  Insert breakpoints, step through a contract, check high level and low level parameters, and fetch & debug a transaction of a verified contract. profile name: **debugger** Documentation

Solidity Unit Testing  Run unit test written in Solidity. profile name: **solidityUnitTesting** Documentation

Solidity Static Analysis  Static code analysis is a process to debug the code by examining it and without actually executing the code. This plugin also has integrations with Slither. profile name: **solidityStaticAnalysis** Documentation

1.25.2 Additional Plugins

(sorted alphabetically)

Celo Compiler / Deployer  Compile & Deploy to the Celo blockchain. profile name: celo-remix-plugin Documentation Make an issue

Contract Deployer  Deploy a contract to multiple chains (1 at a time) with the same address. profile name: celo-remix-plugin Documentation Make an issue

Debug Tools for Remix  Not to be confused with the Debugger, this tool is for plugin devs to help test their plugins & their plugin's API. profile name: debugPlugin Documentation

Defi Explorer  The Defi Explorer loads the Uniswap V2 Protocol into the File Explorers. profile name: defiexplorer Documentation Make an issue

Defi Tutorials (main panel)  Learn about UMA. This plugin works with the UMA tutorials plugin. profile name: defiTutorials Make an issue

DGIT Version Control Clone repos from github & create GIT repos & use standard git commands. Also export/import to IPFS. profile name: dgit Documentation Make an issue

EthDoc Documentation Generator Creates the documentation of a soldity contract - generated from the Natspec comments in the code. The generated doc is placed in EthDoc viewer - which will be visible in an tab in the editor. profile name: ethdoc Documentation Make an issue

EthDoc Viewer (main panel) This plugin work with EthDoc Generator. It is automatically activated. profile name: ethdoc-viewer Documentation Make an issue

Etherscan Contract Verifier Verify a contract on Etherscan. profile name: etherscan Documentation Make an issue

Flattener Flattens compiled contracts profile name: flattener Make an issue

Gas Profiler Profile gas costs for every transaction you execute. Total execution costs as well as per line costs are displayed. profile name: gasProfiler Documentation Make an issue

Klaytn Deploy & interact with smart contracts to the Klaytn public network, local klaytn nodes. profile name: klaytn-remix-plugin Documentation Make an issue

Learneth Remix & Solidity Tutorials Tutorials that contain quizes that teach users Solidity and Remix features. profile name: learnEth Documentation Make an issue

Lexon Lexon is a language that reads like a legal contract and compile into Solidity (and then bytecode). This plugin allow you to take Lexon code and to profile name: lexon Documentation Make an issue

Moonbeam Compile and Deploy to the Moonbeam network profile name: moonbeam-remix-plugin Documentation Make an issue

Mythx Security Verification Free version and paid version for Mythx analysis. profile name: mythx Documentation Make an issue

Nahmii compiler Compile solidity contracts for the Nahmii network profile name: nahmii-compiler Make an issue

One Click Dapp Makes a basic front end for your contract once it is deployed on a public testnet.profile name: oneClickDapp Documentation Make an issue

Proveable Oracle Services  An oracle for the Remix VM environment. profile name: provable Documentation

Quorum Network  A Connection to Quorum profile name: quorum Documentation Make an issue

Solhint Linter  Solidity Linter providing both Security and Style Guide validations. profile name: solhint Documentation Make an issue

Solidity 2 UML  Generate UML diagrams from a compiled Solidity file profile name: sol2uml Documentation Make an issue

Sourcify  Verify you contracts and fetch verified contracts profile name: sourcify Documentation Make an issue

Starknet  Compile contracts written in Cairo to Starknet profile name: starkNet_compiler Documentation Make an issue

Tenderly  Verify Contracts. Import To Remix From your Tenderly project. profile name: tenderly Documentation Make an issue

UMA Playground (main panel) Learn about the UMA protocol. This plugin is loaded from the DEFI Tutorial plugin. profile name: umaPlayground Make an issue

UMA Tutorials (main panel) This plugin is activated by the DEFI Tutorials profile name: umaTutorials Make an issue

Vyper Compiler  Compile vyper code using local or remote Vyper compiler. profile name: vyper Documentation Make an issue

Wallet Connect (main panel) Approve transactions on your mobile device profile name: walletconnect Make an issue

YUL++  A low level language for Ethereum. profile name: yulp Make an issue

Zokrates  ZoKrates is a toolbox for zkSNARKs on Ethereum. profile name: ZoKrates Documentation Make an issue

1.26 Remix Commands

In the console, you can run the commands listed below. Once you start to type a command, there is *auto complete*. These commands are using the following libraries:

remix: Remix has a number of CLI commands for loading & executing file in a workspace. See the list below.

ethers: Remix IDE enables the use of ethersjs commands. See the Ethers docs for the full list.

web3: Remix IDE enable the use of web3js commands. See the Web3js docs for the full list.

swarmgw: This library can be used to upload/download files to Swarm via https://swarm-gateways.net/.

1.26.1 Remix Commands

remix.execute(filepath): Run the script specified by file path. If filepath is empty, script currently displayed in the editor is executed.

remix.exeCurrent(): Run the script currently displayed in the editor.

remix.getFile(path): Returns the content of the file located at the given path

remix.help(): Display this help message.

remix.loadgist(id): Load a gist in the file explorer.

remix.loadurl(url): Load the given url in the file explorer. The url can be of type github, swarm or ipfs.

1.26.2 A few Ethers JS examples

ethers.providers: A Provider abstracts a connection to the Ethereum blockchain, for issuing queries and sending state changing transactions.

ethers.utils: The utility functions exposed in both the ethers umbrella package and the ethers-utils. eg ethers.utils.formatBytes32String(text)

1.26.3 A few Web3 JS examples

web3.eth.abi: The web3.eth.abi functions let you de- and encode parameters to ABI (Application Binary Interface) for function calls to the EVM (Ethereum Virtual Machine).

web3.providers: Contains the current available providers.

web3.utils: This package provides utility functions for Ethereum dapps and other **web3.js packages.

1.26.4 A few Swarm examples examples (these will be updated soon)

swarmgw.get(url, cb): Download files from Swarm via https**://swarm-gateways.net/

swarmgw.put(content, cb): Upload files to Swarm via https**://swarm-gateways.net/

1.27 Running Scripts

JavaScript (JS) is a lightweight, interpreted, or just-in-time compiled programming language with first-class functions.

Remix IDE supports execution of JS scripts.

1.27.1 Write & Run a script

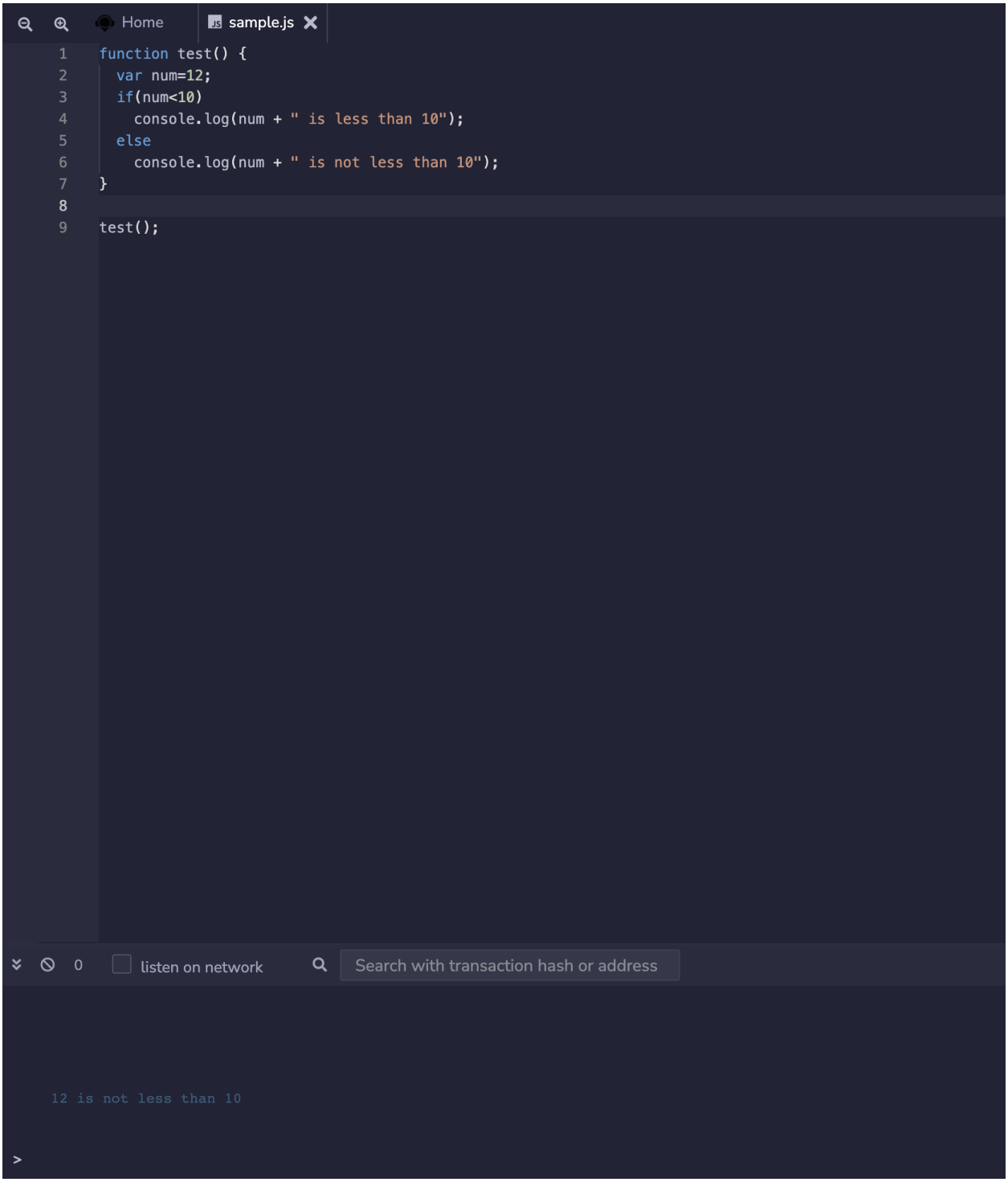
Create a file with `.js` extension and put your logic inside it. Once ready, there are two ways to run this script:

1. Make the script the active file in the editor and run `remix.exeCurrent()` from Remix terminal
2. Just right click on the script name in the `Files Explorers` plugin and click on the **Run** option. **ShortCut**: `Ctrl+Shift+S` when the script is displayed in the editor.

Here is a sample script:

```
function test() {
  var num=12;
  if(num<10)
    console.log(num + " is less than 10");
  else
    console.log(num + " is not less than 10");
}

test();
```

Running it using one of options mentioned above will show result in Remix terminal



1.27.2 Why run JavaScript Scripts in Remix?

- To mimic how the front-end of your dapp will use web3.js or ethers.js
- To quickly deploy and interact with a bunch of instances of a contract without going through the Remix GUI.
- To run some tests on a previous deployed contract.

1.27.3 Script to deploy a contract

Remix accepts async/await scripts to run web3.js or ethers.js commands. The script needs to be wrapped in a self executing function.

1.27.4 Setup

1. These scripts will need to access the contract's ABI. The ABI is located in the contract's metadata file. Make sure that this metadata file will be created by going to the **Settings** module and checking that the **Generate contract metadata** option is indeed **checked**.
2. Compile a Solidity file - to generate the contract metadata.
3. In the Deploy & Run plugin, choose the Environment.
    - Async/await scripts work on in all of the Environments: the Remix VM, Injected Provider (usually MetaMask), and External HTTP Provider.

1.27.5 JS Scripts in the File Explorers

In the **scripts** folder of a **workspace**, there are 2 example files: one using **web3.js** and the other using **ethers.js**.

1.27.6 Compile a contract and run a script on the fly

It is often convenient when drafting a contract to run a script just after the compilation succeeded.

That way one can quickly deploy and call several contracts in order to set them in a desired state for testing purpose.

Also if the script contains Mocha tests, those will also be run.

In order to do so, add the NatSpec tag `@custom:dev-run-script` to the contract followed by the absolute file path, like:

```
/**
 * @title ContractName
 * @dev ContractDescription
 * @custom:dev-run-script file_path
 */
contract ContractName {}
```

ShortCut: `Ctrl+Shift+S` , when editing a solidity file, will compile that file and then will run the script. In contrast, Ctrl+S will only start the compiling.

1.27.7 An Example Script

The example below deploys a solidity contract named **CustomERC20.sol**. This example is using the web3.js library. Ethers.js could also be used.

For more information about this example, please see: running async/await scripts

```
(async () => {
  try {
    console.log('deploy...')
```

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```
    // Note that the script needs the ABI which is generated from the compilation␣
↪artifact.
    const metadata = JSON.parse(await remix.call('fileManager', 'getFile', 'browser/
↪artifacts/CustomERC20.json'))
    const accounts = await web3.eth.getAccounts()

    let contract = new web3.eth.Contract(metadata.abi)

    contract = contract.deploy({
      data: metadata.data.bytecode.object,
      arguments: ["Mask", "N95"]
    })

    newContractInstance = await contract.send({
      from: accounts[0],
      gas: 1500000,
      gasPrice: '30000000000'
    })
    console.log(newContractInstance.options.address)
  } catch (e) {
    console.log(e.message)
  }
})()
```

For more script examples, please see Frequently Asked Scripts.

1.27.8 `require` in scripts at Remix

`require` statement is supported in a limited manner for Remix supported modules with Remix Scripts.

For now, modules supported by Remix are ethers, web3, swarmgw, chai, remix and hardhat only for hardhat.ethers object/plugin.

For unsupported modules, this error `<module_name> module require is not supported by Remix IDE` will be shown.

1.28 Testing using Chai & Mocha

(Supported since Remix IDE v0.22.0)

Remix supports testing of your files in JavaScript using assertion library Chai & test framework Mocha

Chai is a BDD / TDD assertion library for node and the browser that can be delightfully paired with any javascript testing framework.

Mocha is a feature-rich JavaScript test framework running on Node.js and in the browser, making asynchronous testing simple and fun.

1.28.1 Write tests

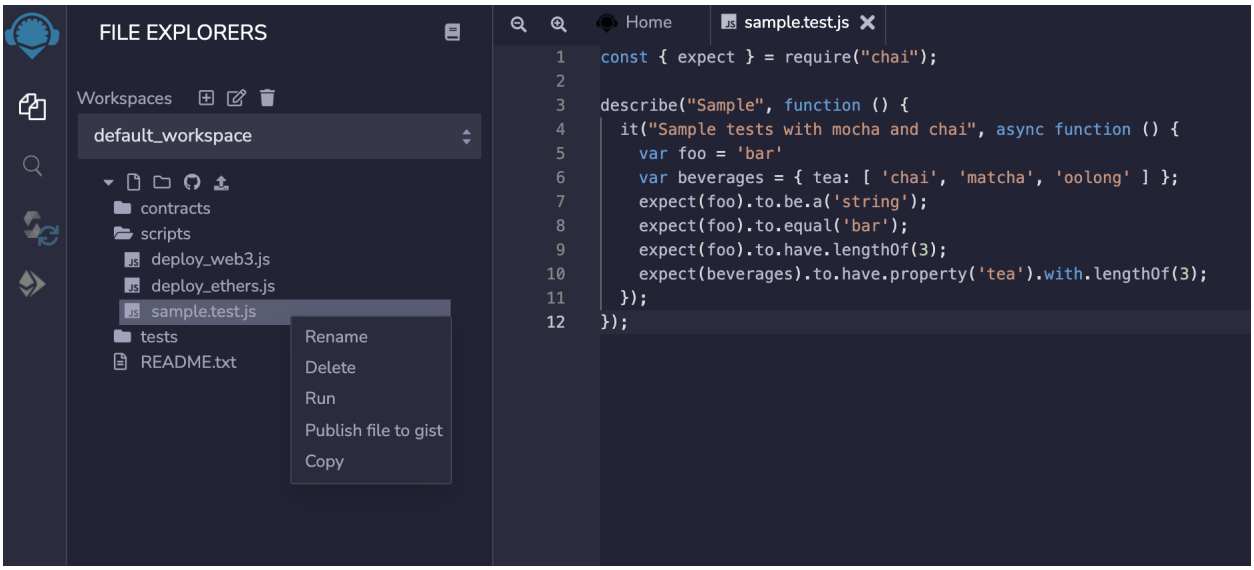
Create a js file in your project workspace. Better to create it inside `scripts` folder. Lets name it `sample.test.js`.

Write your tests in the file. Here is a sample:

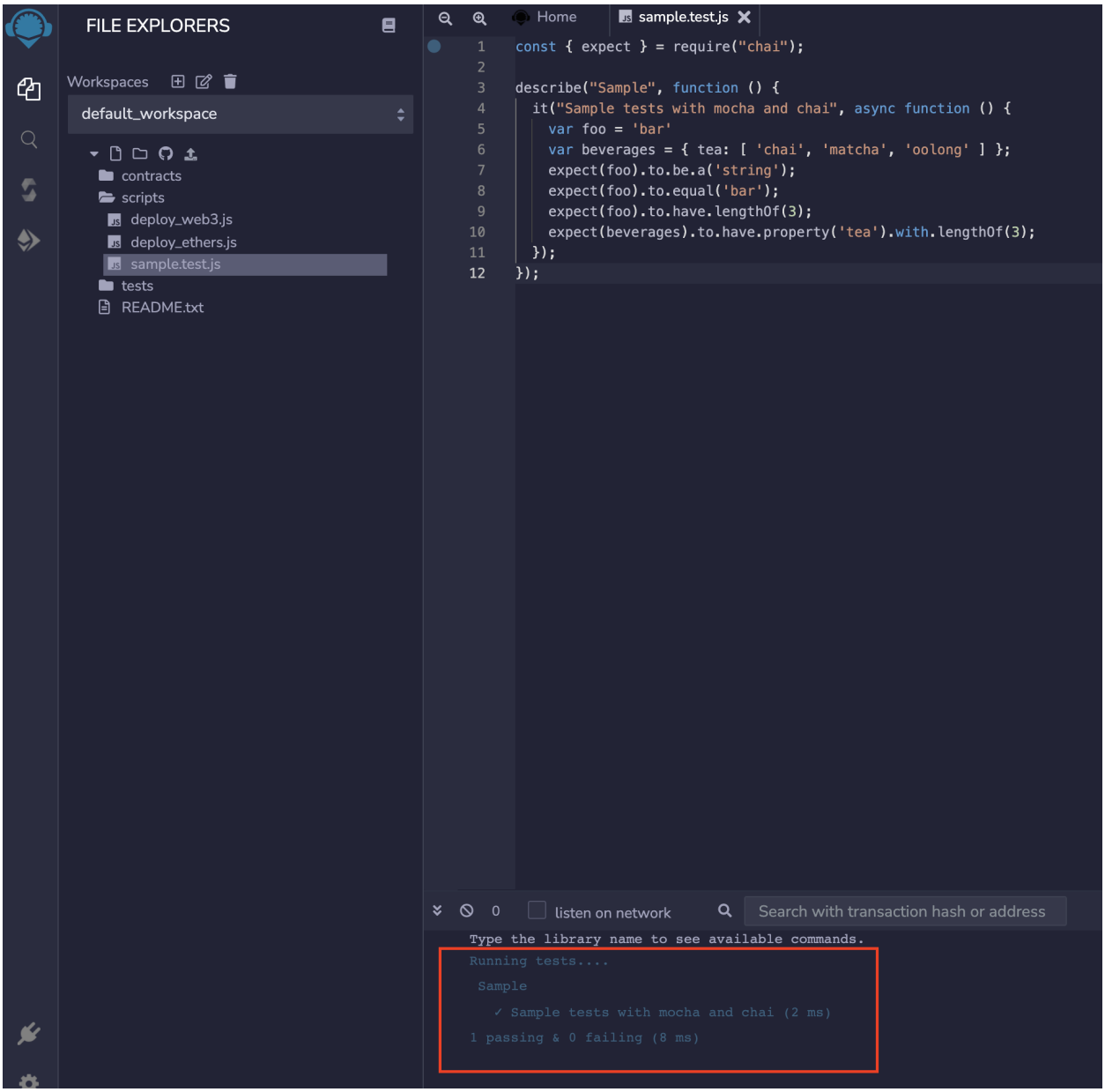
```
const { expect } = require("chai");

describe("Sample", function () {
  it("Sample tests with mocha and chai", async function () {
    var foo = 'bar'
    var beverages = { tea: [ 'chai', 'matcha', 'oolong' ] };
    expect(foo).to.be.a('string');
    expect(foo).to.equal('bar');
    expect(foo).to.have.lengthOf(3);
    expect(beverages).to.have.property('tea').with.lengthOf(3);
  });
});
```

1.28.2 Run tests

Once done with writing the tests, right click on file name in `File Explorers` plugin. It will show some options along with option to `Run`. This `Run` option is used to run the JS scripts



Click on `Run`, tests will be executed and result will be shown on Terminal.



1.28.3 Test a contract

Similarly unit tests can be written to test the functionality of a smart contract. An example to test default `1_Storage.sol` contract can be as:

```
const { expect } = require("chai");

describe("Storage", function () {
  it("test initial value", async function () {
    // Make sure contract is compiled and artifacts are generated
    const metadata = JSON.parse(await remix.call('fileManager', 'getFile', 'contracts/
↪artifacts/Storage.json'))
    const signer = (new ethers.providers.Web3Provider(web3Provider)).getSigner()
```

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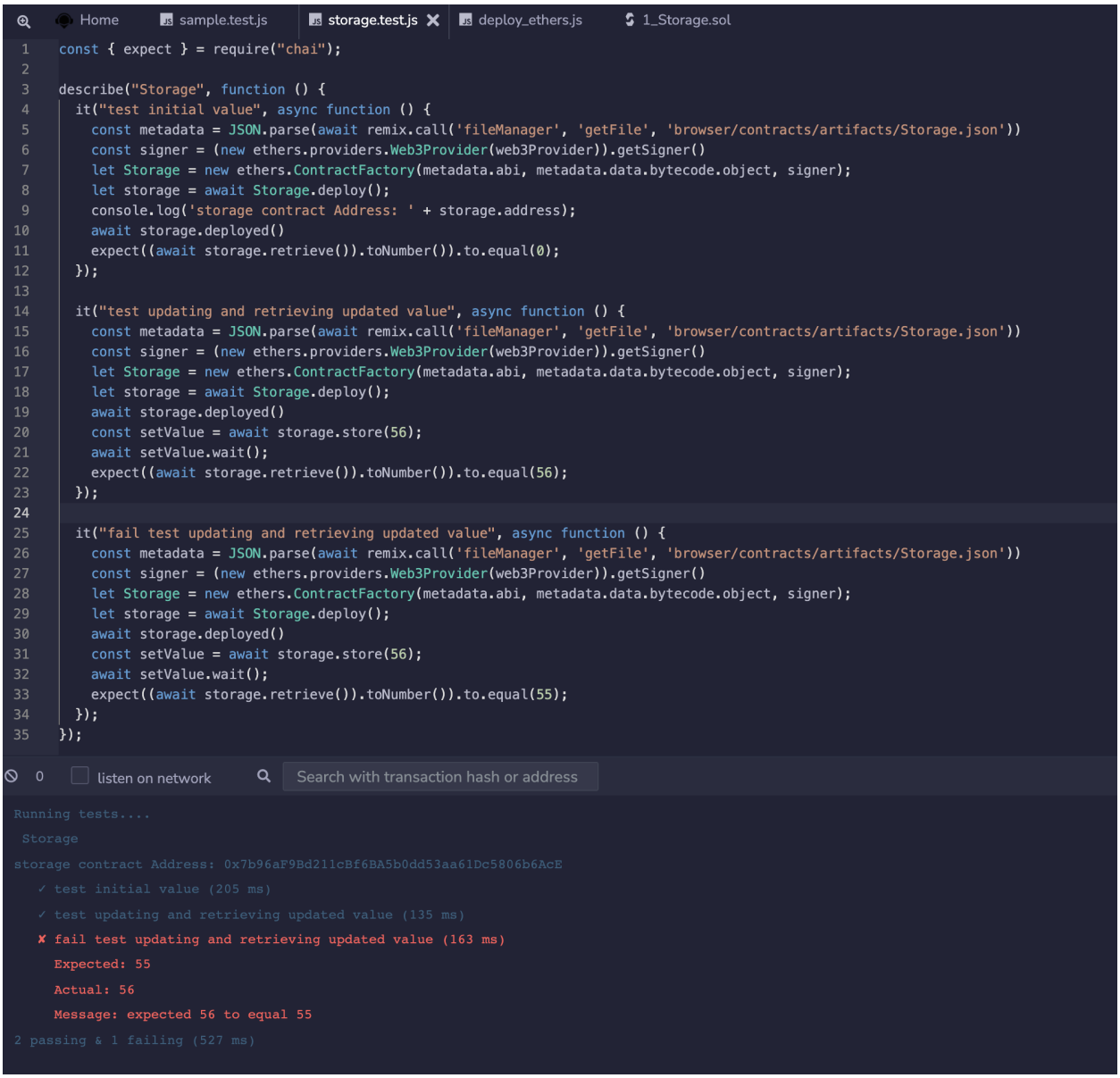
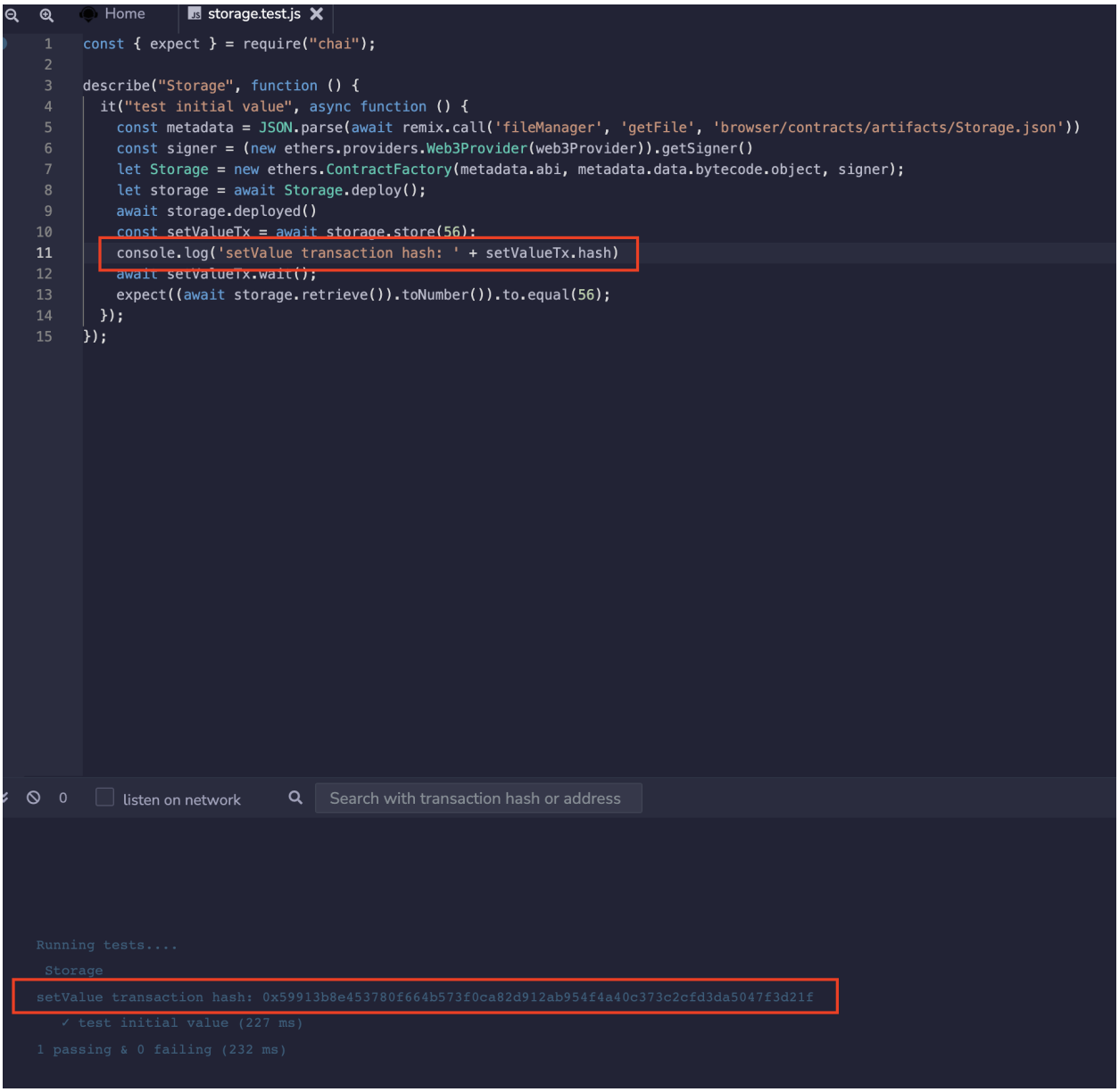
```
    let Storage = new ethers.ContractFactory(metadata.abi, metadata.data.bytecode.
↪object, signer);
    let storage = await Storage.deploy();
    console.log('storage contract Address: ' + storage.address);
    await storage.deployed()
    expect((await storage.retrieve()).toNumber()).to.equal(0);
  });

  it("test updating and retrieving updated value", async function () {
    const metadata = JSON.parse(await remix.call('fileManager', 'getFile', 'contracts/
↪artifacts/Storage.json'))
    const signer = (new ethers.providers.Web3Provider(web3Provider)).getSigner()
    let Storage = new ethers.ContractFactory(metadata.abi, metadata.data.bytecode.
↪object, signer);
    let storage = await Storage.deploy();
    await storage.deployed()
    const setValue = await storage.store(56);
    await setValue.wait();
    expect((await storage.retrieve()).toNumber()).to.equal(56);
  });

  it("fail test updating and retrieving updated value", async function () {
    const metadata = JSON.parse(await remix.call('fileManager', 'getFile', 'contracts/
↪artifacts/Storage.json'))
    const signer = (new ethers.providers.Web3Provider(web3Provider)).getSigner()
    let Storage = new ethers.ContractFactory(metadata.abi, metadata.data.bytecode.
↪object, signer);
    let storage = await Storage.deploy();
    await storage.deployed()
    const setValue = await storage.store(56);
    await setValue.wait();
    expect((await storage.retrieve()).toNumber()).to.equal(55);
  });
});
```

Result will be as:



1.28.4 Debugging a test transaction

To debug a transaction in one of the tests, print the transaction hash and input that in the Remix Debugger plugin.



1.28.5 Hardhat-ethers support

Remix also supports methods of hardhat-ethers plugin of Hardhat framework. Available methods under this plugin are:

```
interface Libraries {
  [libraryName: string]: string;
}

interface FactoryOptions {
  signer?: ethers.Signer;
  libraries?: Libraries;
}
```

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```
function getContractFactory(name: string, signer?: ethers.Signer): Promise<ethers.
↪ContractFactory>;

function getContractFactory(name: string, factoryOptions: FactoryOptions): Promise
↪<ethers.ContractFactory>;

function getContractFactory(abi: any[], bytecode: ethers.utils.BytesLike, signer?:␣
↪ethers.Signer): Promise<ethers.ContractFactory>;

function getContractAt(name: string, address: string, signer?: ethers.Signer): Promise
↪<ethers.Contract>;

function getContractAt(abi: any[], address: string, signer?: ethers.Signer): Promise
↪<ethers.Contract>;

function getSigners() => Promise<ethers.Signer[]>;

function getSigner(address: string) => Promise<ethers.Signer>;

function getContractFactoryFromArtifact(artifact: Artifact, signer?: ethers.Signer):␣
↪Promise<ethers.ContractFactory>;

function getContractFactoryFromArtifact(artifact: Artifact, factoryOptions:␣
↪FactoryOptions): Promise<ethers.ContractFactory>;

function getContractAtFromArtifact(artifact: Artifact, address: string, signer?:␣
↪ethers.Signer): Promise<ethers.Contract>;
```

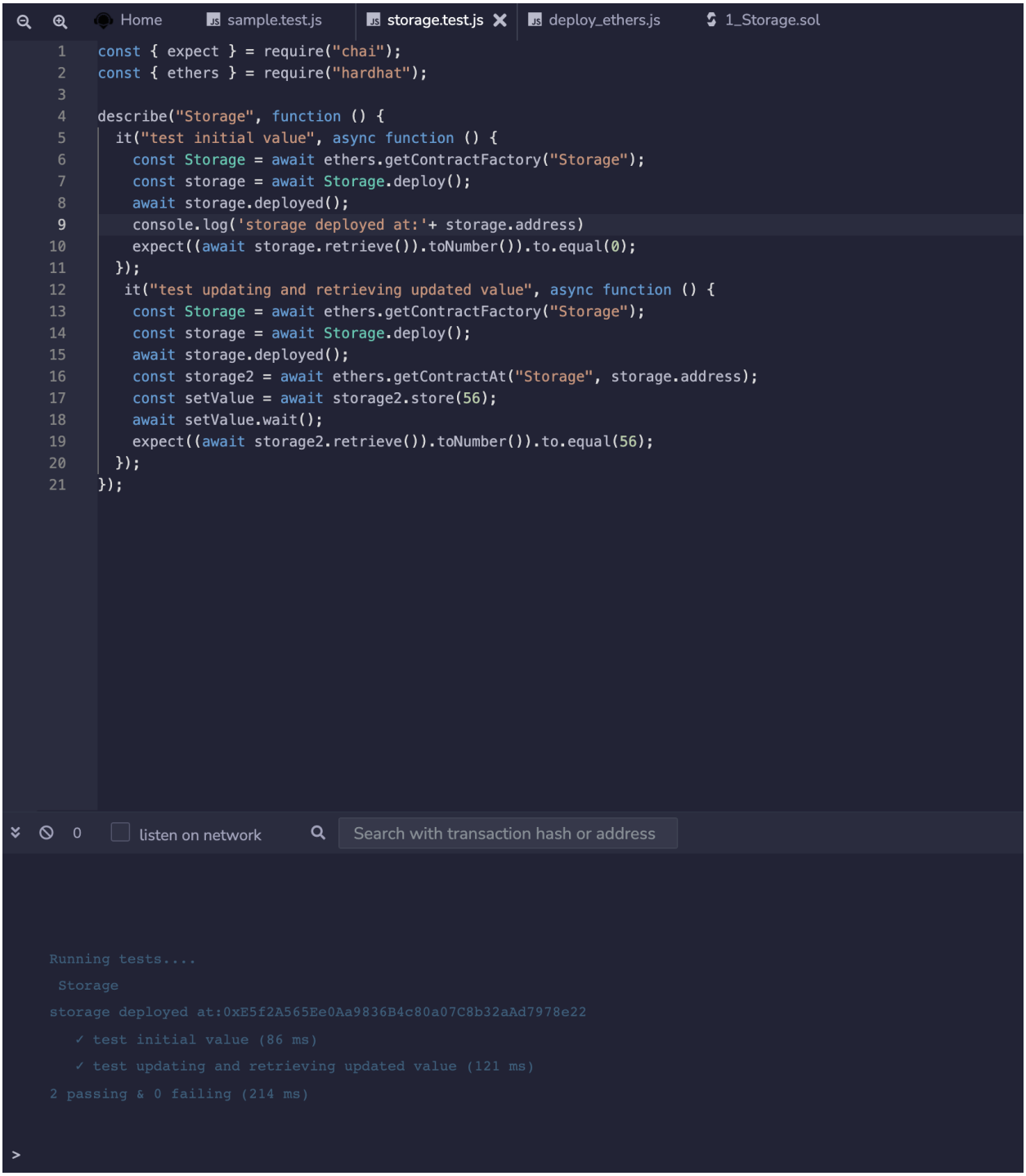
With this, one can run the tests for a hardhat project easily using Remix.

Example to test `Storage` contract with this plugin methods can be as:

```
const { expect } = require("chai");
const { ethers } = require("hardhat");

describe("Storage", function () {
  it("test initial value", async function () {
    const Storage = await ethers.getContractFactory("Storage");
    const storage = await Storage.deploy();
    await storage.deployed();
    console.log('storage deployed at:'+ storage.address)
    expect((await storage.retrieve()).toNumber()).to.equal(0);
  });
   it("test updating and retrieving updated value", async function () {
    const Storage = await ethers.getContractFactory("Storage");
    const storage = await Storage.deploy();
    await storage.deployed();
    const storage2 = await ethers.getContractAt("Storage", storage.address);
    const setValue = await storage2.store(56);
    await setValue.wait();
    expect((await storage2.retrieve()).toNumber()).to.equal(56);
  });
});
```

Result will be as:



1.29 Frequently Asked Scripts

Deploy with web3.js

```
(async () => {
  try {
```

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```
    console.log('deploy...')

    // Note that the script needs the ABI which is generated from the compilation_
↪artifact.
    const metadata = JSON.parse(await remix.call('fileManager', 'getFile', 'browser/
↪artifacts/CustomERC20.json'))
    const accounts = await web3.eth.getAccounts()

    let contract = new web3.eth.Contract(metadata.abi)

    contract = contract.deploy({
      data: metadata.data.bytecode.object,
      arguments: ["Mask", "N95"]
    })

    newContractInstance = await contract.send({
      from: accounts[0],
      gas: 1500000,
      gasPrice: '30000000000'
    })
    console.log(newContractInstance.options.address)
  } catch (e) {
    console.log(e.message)
  }
})()
```

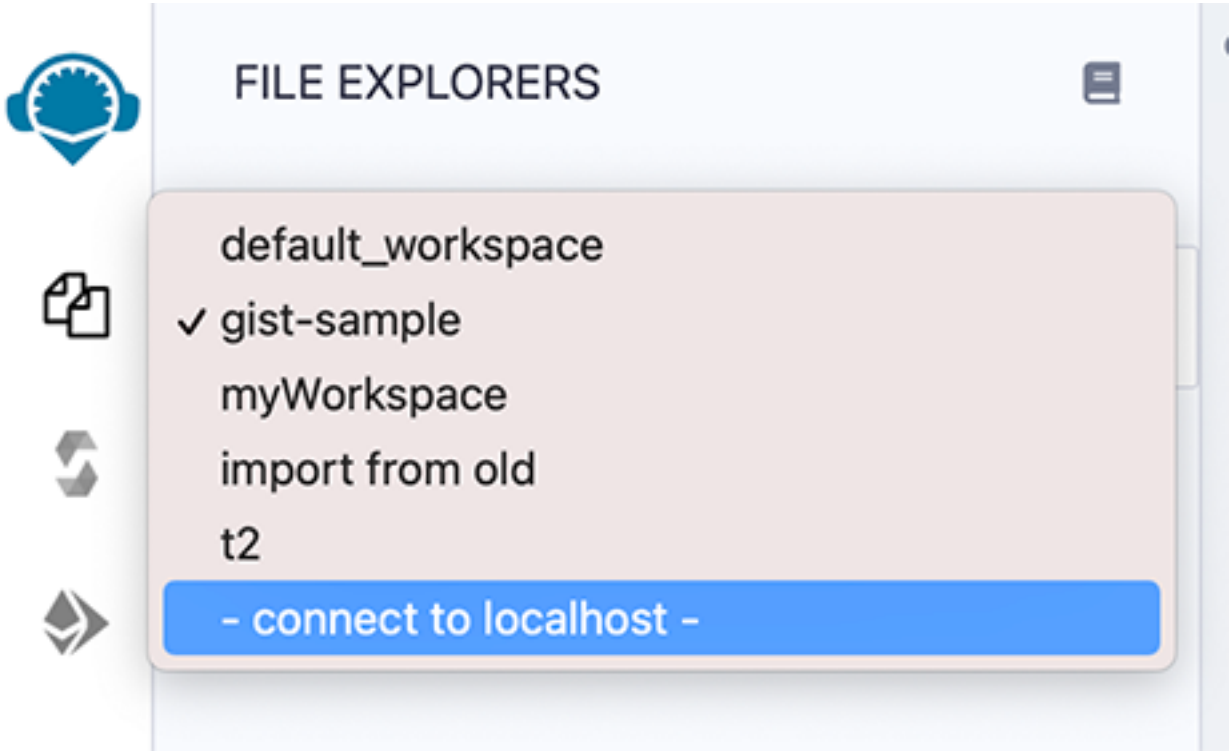
Deploy with Ethers

```
(async function() {
  try {
    const metadata = JSON.parse(await remix.call('fileManager', 'getFile', 'browser/
↪artifacts/CustomERC20.json'))
    // the variable web3Provider is a remix global variable object
    const signer = (new ethers.providers.Web3Provider(web3Provider)).getSigner()
    // Create an instance of a Contract Factory
    let factory = new ethers.ContractFactory(metadata.abi, metadata.data.bytecode.
↪object, signer);
    // Notice we pass the constructor's parameters here
    let contract = await factory.deploy('Mask', 'N95');
    // The address the Contract WILL have once mined
    console.log(contract.address);
    // The transaction that was sent to the network to deploy the Contract
    console.log(contract.deployTransaction.hash);
    // The contract is NOT deployed yet; we must wait until it is mined
    await contract.deployed()
    // Done! The contract is deployed.
    console.log('contract deployed')
  } catch (e) {
    console.log(e.message)
  }
})();
```

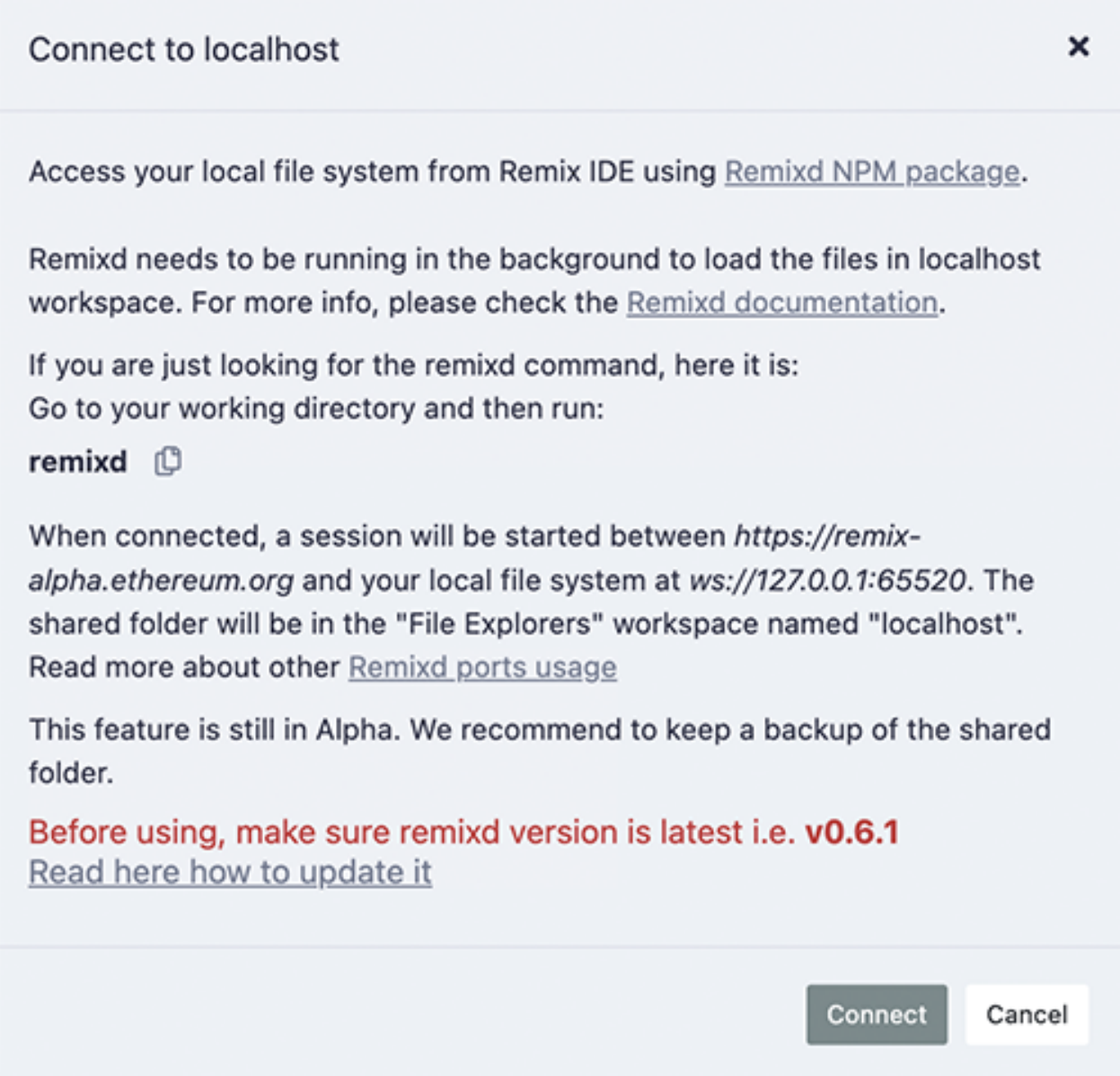
1.30 Remixd: Access your Local Filesystem

To give the Remix IDE (the web app) access to a folder on your computer, you need to use **Remixd** - the plugin along with **remixd** - the cli/npm module.

The **Remixd** plugin can be activated from the plugin manager or in the **File Explorer** - see the image below. The **connect to localhost** - will activate the **Remixd** plugin.



Once you click **connect to localhost** or activate Remixd from the **Plugin Manager**, a modal will come up:



The Remixd plugin is a **websocket plugin** and it has no UI other than this modal dialog box - so you won't see a Remixd icon in the icon panel.

Before you hit **Connect**, you need to install the remixd NPM module and run the **remixd** command.

The code of `remixd` is here .

1.30.1 remixd Installation

remixd is an NPM module and can be globally installed using the following command: `npm install -g @remix-project/remixd`

Or just install it in the directory of your choice by removing the -g flag: `npm install @remix-project/remixd`

NOTE: When the remixd NPM module is installed, it also installs Slither, solc-select and sets solc to latest version i.e. 0.8.15 currently.

ALSO NOTE: `Python3.6+ (pip3)` needs to already be installed on the System. (This packaging of Slither with the remixd module is supported since Remixd v0.6.3). In case of any discrepany, Slither can also installed along with other dependencies using command `remixd -i slither`

1.30.2 Find your version of remixd

The command: `remixd -v` or `remixd --version` will return your version number.

If this command does not work, then you have an outdated version!

1.30.3 Update to the latest remixd

Because **remixd** creates a bridge from the browser to your local filesystem, it is important that you have the latest version of script.

For users who had installed the version of remixd from the **VERY** old NPM address or for users who do not know which NPM address they had installed it from, run these 2 steps:

1. uninstall the old one: **npm uninstall -g remixd**
2. install the new: **npm install -g @remix-project/remixd**

For Most Users who know that they have a remixd version installed from @remix-project/remixd then just run:

npm install -g @remix-project/remixd

1.30.4 remixd command

The remixd command without options uses the terminal's current directory as the shared directory and the shared Remix domain will be `https://remix.ethereum.org`, `https://remix-alpha.ethereum.org`, or `https://remix-beta.ethereum.org`

The remixd command is: `remixd`

If you are using Remix from localhost or you are not running the command from your working directory, you'll need to use the command with flags.

remixd options

```
Usage: remixd [options]

Establish a two-way websocket connection between the local computer and Remix IDE for␣
↪a folder

Options:
  -v, --version               output the version number
  -u, --remix-ide  <url>      URL of remix instance allowed to connect
  -s, --shared-folder <path>  Folder to share with Remix IDE (Default: CWD)
  -i, --install <name>        Module name to install locally (Supported: ["slither"])
  -r, --read-only             Treat shared folder as read-only (experimental)
  -h, --help                  output usage information

Example:

    remixd -s ./shared_project -u http://localhost:8080
```

NOTE: `remixd -i slither` can be used to install Slither along with its dependencies

HTTP vs HTTPS in the remixd command

If your browser is on https://remix.ethereum.org (**secure http**) then use https in the command: `remixd -s <absolute-path-to-the-shared-folder> --remix-ide https://remix.ethereum.org`

Or if you are using **http** in the browser, then use **http** in the remixd command.

Read/Write permission & Read-only mode

The folder is shared using **a websocket connection** between `Remix IDE` and `remixd`.

Be sure the user executing `remixd` has read/write permission on the folder.

Alternatively, there is an option to run remixd in read-only mode, use `--read-only` flag.

1.30.5 Ports Usage

`remixd` functions by making websocket connections with Remix IDE on different ports. Ports are defined according to specific purpose. Port usage details are as:

- **65520** : For `remixd` websocket listener, to share local file system with Remix IDE. Shared folder will be loaded in the Remix IDE `File Explorers` workspace named `localhost`
- **65522** : For `hardhat` websocket listener, to enable the Hardhat Compilation using Remix IDE `Solidity Compiler` plugin, if shared folder is a Hardhat project.
- **65523** : For `slither` websocket listener, to enable the Slither Analysis using Remix IDE `Solidity Static Analysis` plugin
- **65524** : For `truffle` websocket listener, to enable the Truffle Compilation using Remix IDE `Solidity Compiler` plugin, if shared folder is a Truffle project.

Note: Please make sure your system is secured enough and these ports are not opened nor forwarded.

1.30.6 Warning!

- `remixd` **provides full read and write access** to the given folder **for any application** that can access the `TCP port 65520` on your local host.
- To minimize the risk, Remixd can **ONLY** bridge between your filesystem and the Remix IDE URLS - including:

```
https://remix.ethereum.org
https://remix-alpha.ethereum.org
https://remix-beta.ethereum.org
package://a7df6d3c223593f3550b35e90d7b0b1f.mod
package://6fd22d6fe5549ad4c4d8fd3ca0b7816b.mod
https://ipfsgw.komputing.org
```

(the package:// urls in the list above are for remix desktop)

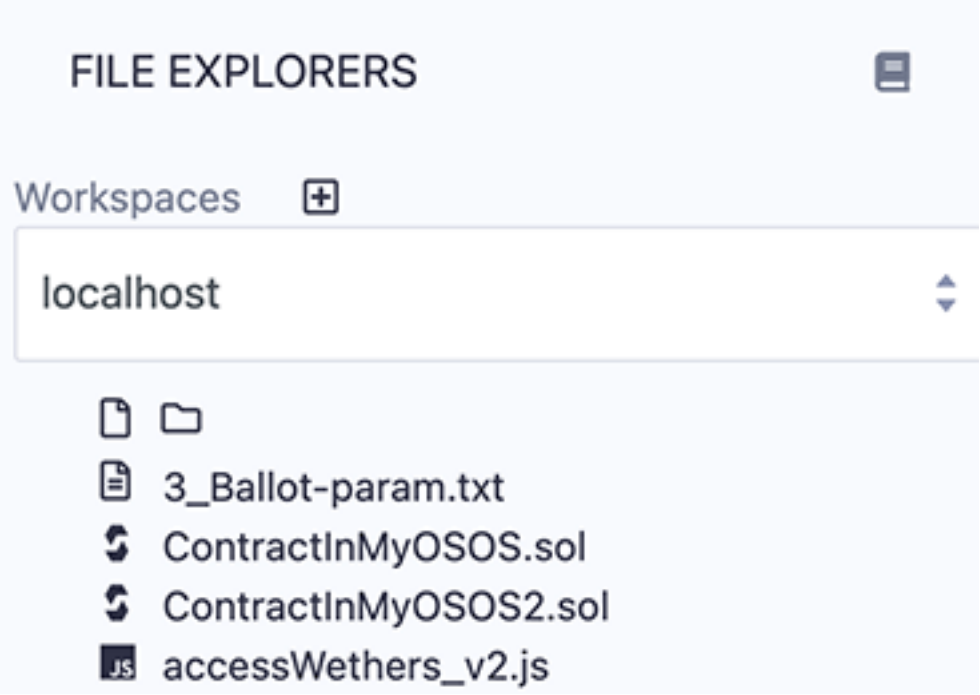
1.30.7 Clicking Connect on the modal.

Clicking on the **Connect** button on the Remixd modal (see the image above), will attempt to start a session where your browser can access the specified folder on your computer's filesystem.

If you do not have `remixd` running in the background - another modal will open up and it will say:

```
Cannot connect to the remixd daemon.
Please make sure you have the remixd running in the background.
```

Assuming you don't get the 2nd modal, your connection to the remixd daemon is successful. The shared folder will be visible in the File Explorer's workspace under **localhost**.



1.30.8 Creating & deleting folders & files

Clicking on the **new folder** or **new file** icon under **localhost** will create a new file or folder in the shared folder. Similarly, if you **right click** on a file or folder you can **rename** or **delete** the file.

1.30.9 Closing a remixd session

In the terminal where **remixd** is running, typing `ctrl-c` will close the session. Remix IDE will then put up a modal saying that **remixd** has stopped running.

1.31 Using Remix Safely

- It is dangerous to send transactions on contracts you don't understand (even if it's a get rich quick scheme that you've copied & pasted from a Discord DM or a youtube video and you really really want to get rich).
- Check our article on a current scam promoting "liquidity front runner bots".

- Always check that you are loading Remix over HTTPS unless you have a specific reason for accessing it with HTTP (e.g. for using Remix locally or for a connection you trust).
- Make sure all your imports include the **version number** otherwise you don't know what version of files you are getting and the builds are not reproducible.

So **do not** use an import like this: `import "@openzeppelin/contracts/token/ERC20/ERC20.sol";`

Rather, **use one** like this: `import "@openzeppelin/contracts@4.7.3/token/ERC20/ERC20.sol";`

- When connecting a contract to an existing deployment, ensure that the thing you are connecting to is correct AND is the correct version.
- Always be sure to address or understand every warning.
- Remix is a subdomain of ethereum.org - so the only valid Remix urls are:
  - remix.ethereum.org
  - remix-alpha.ethereum.org
  - remix-beta.ethereum.org

If you are directed to some site that looks like Remix but has a **similar but different URL** - it is NOT Remix and is likely a scam.

1.31.1 Remix's ease makes its users a target

Because Remix has no setup, it has a large community of noobies to smart contract development. This is great, but it provides a target audience for scammers exploit. Without Remix, the scammers would first need to instruct victims to set up a local dev environment, which would severely limit the success rate of the scam.

Scams lose their effectiveness when potential victims are educated about scams and about how to read and understand code. Learn Solidity and learn it well!

For Solidity Tutorials in Remix, go to the LearnEth plugin.

1.32 FAQ

1.32.1 Supported devices & Browsers

Q: What browsers will Remix work on?

A: We support Firefox, Chrome, and Brave. We do not test or look for errors in Safari, Edge or other browsers.

Q: Will Remix work on a tablet or mobile device?

A: We do not support the use of Remix on tablets or mobile phones.

1.32.2 General

Q: Are there keyboard shortcuts in Remix?

A: Yes - here is the list of keyboard shortcuts:

`Ctrl+Shift+F` : Opens the File Explorer

`Ctrl+Shift+A` : Opens the Plugin Manager

`Ctrl+S`: Compiles the active Solidity file

`Ctrl+Shift+S`: Compiles a Solidity file and runs a script when the script is displayed in the editor.(go here more info about this functionality)

1.32.3 Solidity compiler

Q: Error: compiler might be in a non-sane state

```
error: "Uncaught JavaScript exception: RangeError: Maximum call stack size exceeded.
The compiler might be in a non-sane state, please be careful and do not use further␣
↪compilation data to deploy to mainnet.
It is heavily recommended to use another browser not affected by this issue (Firefox␣
↪is known to not be affected)."
```

A: Old versions of solidity compiler had this problem with chrome. Please change the compiler version in Solidity Plugin to the newer one or use another browser.

Q: I'm getting an issue with Maximum call stack exceed and various other errors, can't compile.

A: Try a different browser or a newer solidity compiler version.

Q: How to verify a contract that imports other contracts?

A: The verification tool does not recursively go through the import statements in a contract. So can only verify a 'flattened' contract.

There is a plugin called `Flattener` which will stuff all the original code and the imported code into a single file.

1.32.4 Deploy & Run

Q: I am using an Infura endpoint in my app, but when I try to deploy against that endpoint in Remix IDE selecting "External HTTP Provider" and putting my endpoint in, it's telling me that it can't connect

A: If the endpoint you are using is http, it won't work.

Q: Where is deploy button?

A: Its in the Deploy & Run module. If you haven't activated that module, you should do that by clicking Deploy & Run module in the Plugin Manager. You could also activate everything you need to work with solidity on the landing page (click the remix logo at the top left for the screen) and click the "Solidity" button in the environment section.

Q: How to pass a tuple to a public function in Remix?

A: Pass it as an array [].

Q: How to input a struct as input to a parameter of a function in the Deploy & Run module?

A: For inputting a struct, just like a tuple, pass it in as an array []. Also you need to put in the line:

`pragma experimental ABIEncoderV2;` at the top of the solidity file.

For example, here's a solidity file with a struct is an input parameter.

```
pragma solidity >=0.4.22 <0.6.0;
pragma experimental ABIEncoderV2;

contract daPeeps {
    struct Peep {uint a; uint b;} // declaration of Peep type
    Peep peep; //declaration of an object of Peep type

    constructor () public
```

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```
    {
        peep.a = 0; // definition/initialisation of object
        peep.b = 0; //
    }

    function initPeepToPeep(Peep memory i) public payable {
        peep.a = i.a;
        peep.b = i.b;
    }
    function setPeep(uint a, uint b) public payable {
        peep.a = a;
        peep.b = b;
    }

    function getPeep() public view returns(Peep memory)
    {
        return peep;
    }
}
```

The input of initPeepToPeeps takes a struct. If you input `[1,2]` the transaction will go through.

1.32.5 Plugin Developers

Q: Where do plugin developers go with their questions?

A: The Gitter Remix plugin developers room https://gitter.im/ethereum/remix-dev-plugin

1.32.6 Analytics

Q: What information does Remix save when Matomo Analytics is enabled?

A: We want to know:

- Which plugins get activated & deactivated
- If users check the box to publish a contract's metadata when deploying
- Which themes are used/used most/not used at all
- The usage of the links to documentation
- On the homepage, which file importing buttons are used

Q: Is it opt-in or opt-out?

A: We use Matomo as an opt-in analytics platform.

Q: Where is the info stored? Is the info shared with 3rd parties?

A: All data collected through Matomo is stored on our own server.No data is given to third parties.

We respect your privacy and do not collect nor store any personally identifiable information (PII).

Q: What does Remix do with this info?

A: Our goal is to understand how many users we have, what plugins people are using, what is not getting used, what is not being used to its full potential.

With this understanding, we can make adjustments to the UI as well as providing more tips and documentation. It's a way of getting constant anonymous feedback from our users.

Q: After I agree opt-in, can I change my mind?

A: You can turn off or on Matomo in the Settings panel. There are no consequences for not opting-in or opting-out.

1.33 Remix URLs & Links with Parameters

1.33.1 Main Remix URLs

- Remix IDE Online is located at https://remix.ethereum.org.
- The alpha version of remix is located at https://remix-alpha.ethereum.org. This is not a stable version.
- Github repo: https://github.com/ethereum/remix-project. The README contains instructions for running Remix-IDE locally.
- Remix Desktop is an Electron App. Here is the release page.
- Remix has a VSCode extension called Ethereum Remix.
- The Remix twitter account is EthereumRemix.
- The Remix Project Medium publication is: https://medium.com/remix-ide.
- The Remix Project website introduces the different facets of our project.
- The Remix Gitter Channel is a forum to post your questions about Remix.

1.33.2 Customize Remix with URL Parameters

There are many ways to customize Remix IDE by using url parameters. Here are some options:

- Activate or deactivate a **list of plugins to be activated** - and specify which plugin gains the "focus". *SEE MORE*
- Send **commands to a plugin** - once the plugin loads. *SEE MORE*
- *Load a GIST*, *a file via a url* or a *base64 encoded string* into Remix's Editor.
- Specify **the theme** (Dark or Light). *SEE MORE*
- Specify which panels should be **minimized** - useful when embedding Remix in your site. *SEE MORE*
- Select the **version of the Solidity** compiler, enable/disable the **optimizer**, turn on auto compile or choose the language for the Solidity compiler. *SEE MORE*
- Load **verified contracts from Etherscan** using contract address *SEE MORE*

Activating a list of plugins

The following example contains the url parameter **activate** followed by **a comma separated list of plugins**.

The last plugin in the list will gain the focus.

When you use the activate list, all other plugins that a user had loaded will be deactivated. This does not apply to the file explorer, the plugin manager, and the settings modules because these are never deactivated.

```
https://remix.ethereum.org/?#activate=solidity,solidityUnitTesting,defiexplorer
```

Note: a plugin is called by its **name** as specified in its profile. There are 3 types of plugins:

1. **Native Mandatory Plugins** that are always loaded (so you don't need to activate them using the url parameter **activate**). These include: **fileManager**, **settings**, **manager** (the plugin manager), and **udapp** (deploy & run).
2. **Native Optional Plugins** that are loaded on demand: **debugger**, **hardhat-provider**, **solidity**, **solidityStaticAnalysis**, **solidityUnitTesting**, and **vyper**
3. **External Plugins** to get these plugins' names, please go to https://github.com/ethereum/remix-plugins-directory/tree/master/plugins.

Deactiving a list of plugins

```
https://remix.ethereum.org/?#deactivate=debugger
```

Minimizing Remix panels

The following URL will **close everything except the main panel & the icon panel** (the side and terminal are minimized).

```
https://remix.ethereum.org/?#embed=true
```

To minimize just the side panel, use this URL:

```
https://remix.ethereum.org/?#minimizesidepanel=true
```

To minimize just the terminal, use this URL:

```
https://remix.ethereum.org/?#minimizeterminal=true
```

Specifying a theme

To link to Remix with a theme specified use this url:

```
**https://remix.ethereum.org/?#theme=Dark**
```

A URL example combining multiple parameters

To link to Remix with the a list of plugins activated and with:

- the Learneth gaining the side panel's focus (because it is the last in the list)
- the Light theme loaded
- the terminal minimized
- optimize off

use this url:

```
https://remix.ethereum.org/?#activate=solidity,solidityUnitTesting,LearnEth&
↪theme=Light&minimizeterminal=true&optimize=false&evmVersion=null&version=soljson-v0.
↪6.6+commit.6c089d02.js
```

1.33.3 Pass commands to a plugin's API via a url param

The URL parameter to issue a command is `call`. Following the `call` is a // (double slash) separated list of arguments.

```
call=plugin_name//function//parameter1//paremeter2
```

An example using call

The URL below uses `activate` & `call`. It **activates** a number of plugins and **calls** the File Explorers to tell it to load one of the default Remix files:

```
https://remix.ethereum.org/?#activate=defiexplorer,solidity&call=fileManager//open//
↪contracts/3_Ballot.sol
```

Load a specific tutorial in the LearnEth plugin:

```
https://remix.ethereum.org/?#activate=solidityUnitTesting,solidity,LearnEth&
↪call=LearnEth//startTutorial//ethereum/remix-workshops//master//proxycontract
```

Make calls to a number of different plugins' APIs

Use the `calls` parameter to call a series of plugins. Use `///` to separate the calls.

For example, this command, after activating a list of plugins, calls the LearnEth plugin's API and then calls the File Explorer's API.

```
https://remix.ethereum.org/?#activate=solidityUnitTesting,solidity,LearnEth&
↪calls=LearnEth//startTutorial//ethereum/remix-workshops//master//proxycontract///
↪fileManager//open//contracts/3_Ballot.sol
```

1.33.4 Load a file via a URL into the Editor

The `url` parameter takes a URL, loads it into the Editor and saves it into the code-sample workspace of the File Explorer:

```
https://remix.ethereum.org/#url=https://github.com/ethereum/remix-project/blob/master/
↪apps/remix-ide/contracts/app/solidity/mode.sol
```

1.33.5 Load an encoded base64 string into a .sol file in the Editor

The `code` parameter takes an encoded base64 string and loads it into the Editor as a .sol file and saves to the code-sample workspace of the File Explorer:

```
https://remix.ethereum.org/?
↪#code=Ly8gU1BEWC1MaWNlbnNlLUlkZW50aWZpZXI6IE1JVAoKcHJhZ21hIHNvbGlkaXR5IDAuOC40OwoKLyoqCiAqIEB0aXRs
```

1.33.6 Load contracts from Etherscan via address

The `address` parameter takes an address, loads all the **verified contracts** found for the address on different Ethereum networks and saves them into the `etherscan-code-sample` workspace of the File Explorer:

```
https://remix.ethereum.org/#address=0xdac17f958d2ee523a2206206994597c13d831ec7
```

1.33.7 Load a Solidity contract from Github

With a github url of a Solidity contract like this one:

```
https://github.com/ethereum/remix-project/blob/master/apps/remix-ide/contracts/app/
↪solidity/mode.sol
```

Then delete the **github** part and type in **remix.ethereum.org** in its place, like this:

```
https://remix.ethereum.org/ethereum/remix-project/blob/master/apps/remix-ide/
↪contracts/app/solidity/mode.sol
```

Remix will fetch the Solidity file and open it up in the File Explorer in a Workspace named **code-sample**.

1.33.8 Load a GIST

The URL parameter here is `gist`.

```
https://remix.ethereum.org/?gist=0fe90e825327ef313c88aedfe66ec142
```

Load a GIST and have it be visible in the Editor:

Using both `gist` & `call`

```
https://remix.ethereum.org/?#activate=solidity,debugger&
↪gist=0fe90e825327ef313c88aedfe66ec142&call=fileManager//open//browser/gists/
↪0fe90e825327ef313c88aedfe66ec142/gridMix4.sol
```

Load a GIST, have it be visible in the Editor & load a list of plugins:

```
https://remix.ethereum.org/?#activate=solidity,LearnEth&
↪gist=0fe90e825327ef313c88aedfe66ec142&call=fileManager//open//browser/gists/
↪0fe90e825327ef313c88aedfe66ec142/gridMix4.sol
```

1.33.9 Load a specific version of the Solidity compiler:

```
https://remix.ethereum.org/?#version=soljson-v0.6.6+commit.6c089d02
```

Note: you need to specify both the Solidity version and the commit.

1.33.10 Load a custom Solidity compiler:

```
https://remix.ethereum.org/#version=https://solidity-blog.s3.eu-central-1.amazonaws.
↪com/data/08preview/soljson.js
```

1.33.11 Turn on autoCompile:

```
https://remix.ethereum.org/#autoCompile=true
```

1.33.12 Select the language for the Solidity Compiler

Choose YUL or Solidity with the language parameter.

```
https://remix.ethereum.org/#language=Yul
```

1.34 Remix as code viewer

1.34.1 Through Etherscan

Verified contracts on Etherscan can be viewed in Remix by making a simple change to the URL. Mostly for a mutiple part contract verification, Remix provides a quick way to load all the contracts.

A typical Etherscan URL for a contract address looks like this:

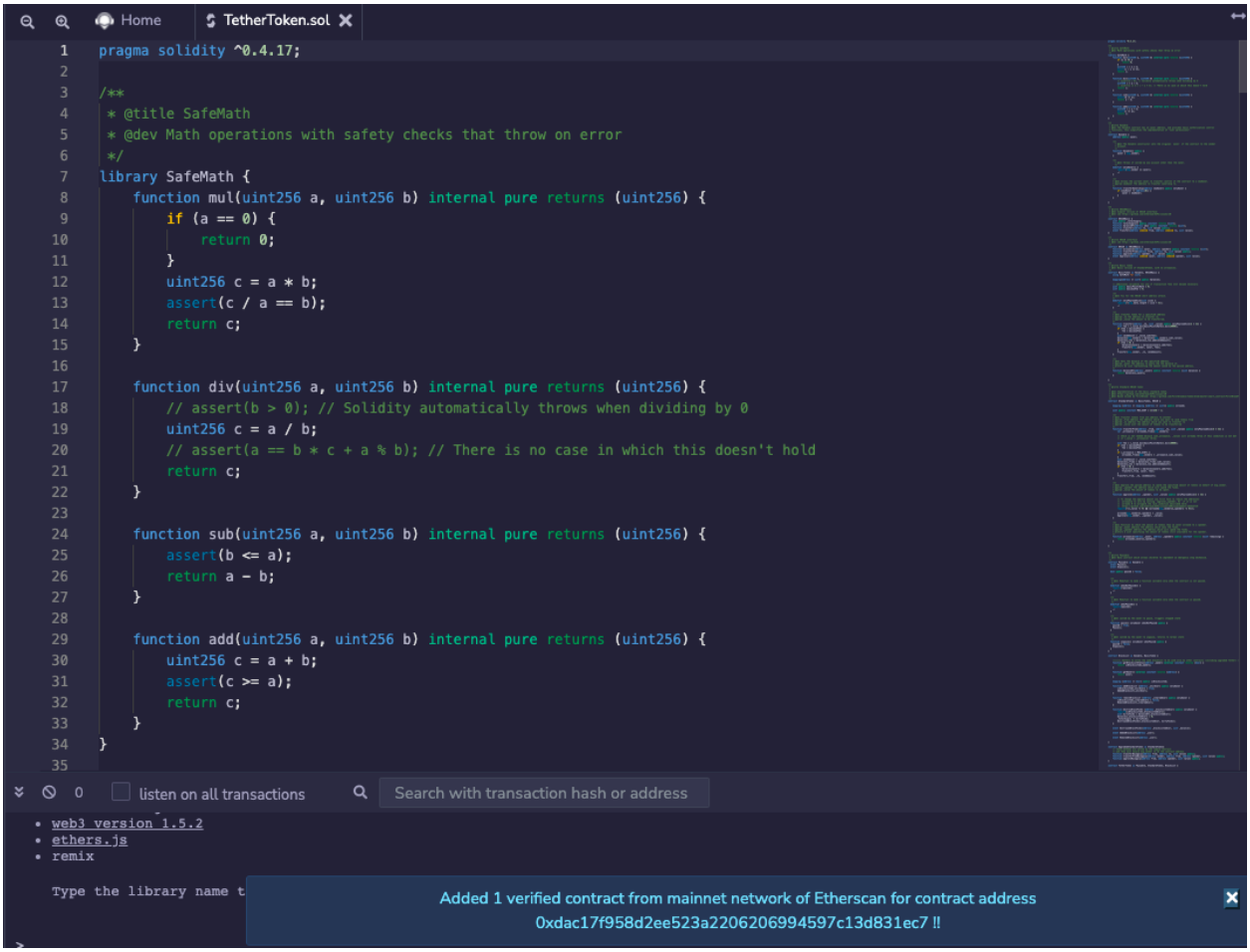
`https://etherscan.io/address/0xdac17f958d2ee523a2206206994597c13d831ec7`

In the URL, change `etherscan.io` to `remix.ethereum.org`

`https://remix.ethereum.org/address/0xdac17f958d2ee523a2206206994597c13d831ec7`

and reload. It will fetch the contracts verified on Etherscan.

Contracts verified on Ethereum mainnnet and on other test networks (Ropsten, Rinkeby, Kovan & Goerli) will be loaded in respective directories under `etherscan-code-sample` workspace.



Tihs works for Etherscan testnet URLs `https://ropsten.etherscan.io`, `https://goerli.etherscan.io/` etc. If they are similarly updated, contracts will be loaded in Remix.

1.34.2 Through GitHub

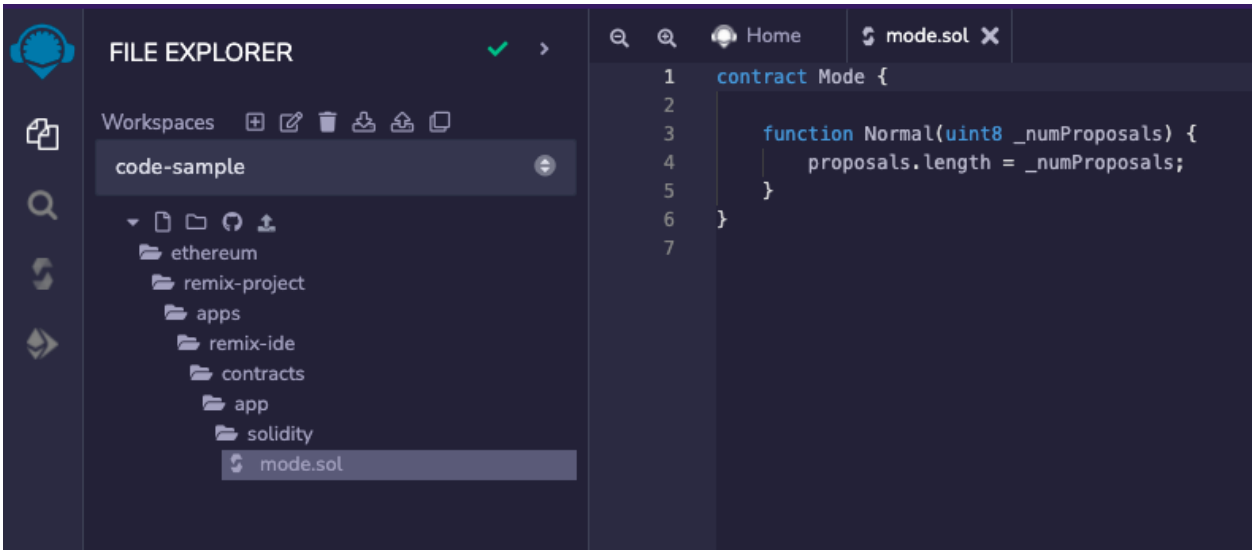
Solidity files in GitHub can be loaded on Remix with a similar tweak. For a file with URL like:

`https://github.com/ethereum/remix-project/blob/master/apps/remix-ide/contracts/app/solidity/mode.sol`

change `github.com` to `remix.ethereum.org` like:

`https://remix.ethereum.org/ethereum/remix-project/blob/master/apps/remix-ide/contracts/app/solidity/mode.sol`

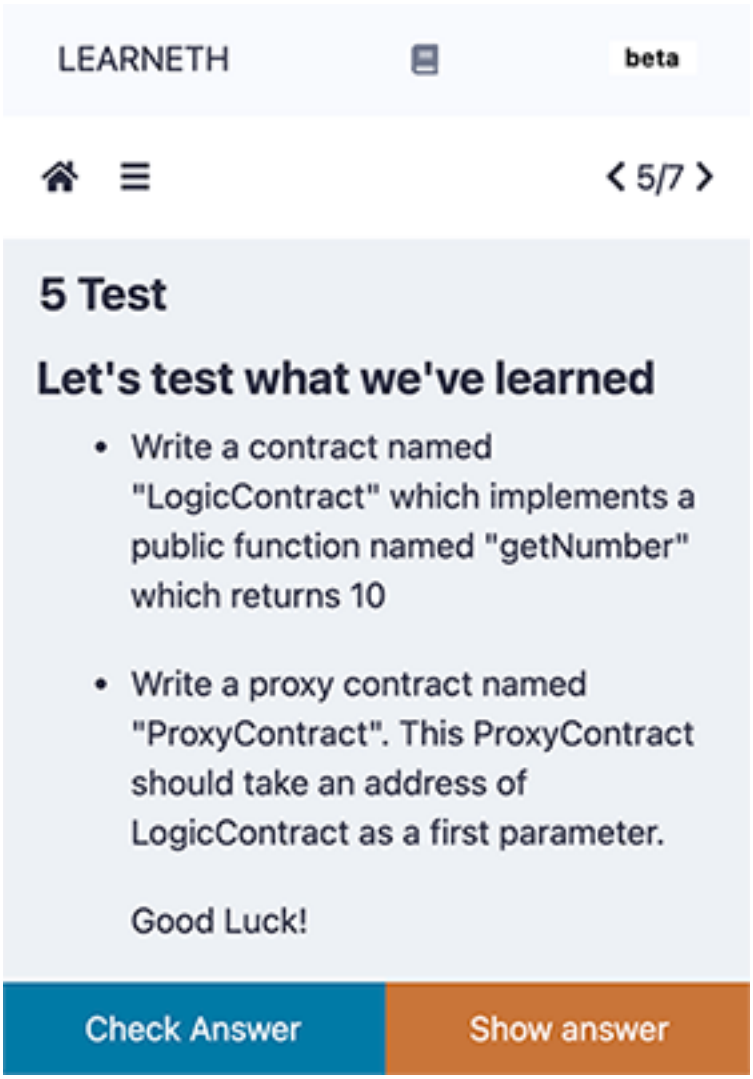
and reload. It will open the same file in Remix IDE.



1.35 Remix Tutorials with Learneth

Learneth is a tutorial platform integrated into Remix.

Tutorials can contain quizzes for testing students' work. These quizzes are run by Solidity Unit Tests.



We have a growing set of tutorials on our repo- but anyone can build tutorials on their own repos and have their students load them up!

The tutorials contain .md files for instructions and can also contain example files, Solidity Unit Test files for quizzes, as well as answer files for quizzes.

1.35.1 Opening Learneth & associated links

Learneth is a plugin - so to access it, you need to activate the Learneth plugin in the Plugin Manager. Alternatively - this link will active it: click this link.

```
https://remix.ethereum.org/?#activate=udapp,solidity,LearnEth
```

This link will activate Learneth and then will open a specific tutorial - in this case it will load the **proxy contract** tutorial:

```
https://remix.ethereum.org/?#activate=udapp,solidity,LearnEth&call=LearnEth//
↪startTutorial//ethereum/remix-workshops//master//proxycontract
```

NOTE: For other tricks about Remix URLs with parameters, go here: locations.

1.35.2 Learneth Tutorials

Here is the current list of Learneth Tutorials

Beginner

```
Remix Basics
Intro to Solidity
```

Intermediate

```
Basic Use of web3.js
The Recorder
```

Advanced

```
All About Proxy Contracts
Deploy with Libraries
Opcodes in the Debugger
```

1.35.3 Learneth & Tutorial Repos

The code for the Learneth plugin is located here: https://github.com/bunsenstraat/remix-learneth-plugin/blob/master/docs/index.rst

Documentation for creating your own tutorials is located here: https://remix-learneth-plugin.readthedocs.io/en/latest/index.html

Remix maintains and curates this repo of Learneth tutorials: https://github.com/ethereum/remix-workshops

1.36 Code Contribution Guide

Remix is an open source tool and we encourage everyone to help us improve it. Please opening issues, give feedback or contribute by a pulling request to our codebase.

The Remix application is built with JavaScript and it doesn't use any frameworks. We rely on a selected set of npm modules, like `yo-yo`, `csjs-inject` and among others. Check out the `package.json` files in the Remix submodules to learn more about the stack.

To learn more, please visit our GitHub page.

1.37 Community Support

We know that blockchain ecosystem is very new and that lots of information is scattered around the web. That is why we created a community support channel where we and other users try to answer your questions if you get stuck using Remix. Please, join the community and ask for help.

For anyone who is interested in developing a custom plugin for Remix or who wants to contribute to the codebase, we opened a contributors' channel especially for developers working on Remix tools.

We would kindly ask you to respect the space and to use it for getting help with your work and the developers' channel for discussions related to working on Remix codebase. If you have ideas for collaborations or you want to promote your project, try to find some more appropriate channels to do so. Or you can contact the main contributors directly on Gitter or Twitter.