PREDA-Toolchain (PREDA Language Preview Toolchain) is a local toolkit developed for PREDA. It provides the ability for programmers to compile, deploy, and conduct performance tests for their smart contracts.

Quick start

Welcome to PREDA-Toolchain. Before learning how to use it, please refer to the Installation Guide document to install PREDA-Toolchain.

After installing the PREDA-Toolchain, it is important to become familiar with it, including how to write a smart contract, compile the smart contract, and write a test script to test the smart contract, by going through the following contents:

- Write a smart contract
- Compile the smart contract
- Write a test script to test the smart contract

Write a smart contract

There are some example smart contracts and test scripts in the installation package for learning and reference.

Next, we will take the *Ballot.prd* as an example to demonstrate.

Ballot.prd is a voting smart contract written in PREDA language, it implements voting in parallel on a shard blockchain, of course, we still have a lot of questions for a real practical voting system, but at least we showed how to implement voting logic through PREDA. It has the following functions:

- Initialize proposals
- Vote
- Collect votes

Initialize proposals

```
@address function init(array<string> names) export {
    //__debug.assert(controller == __transaction.get_self_address());
    __debug.assert(!is_voting());
    relay@global (^names){
        __debug.print("global: ", names);
        for (uint32 i = 0u; i < names.length(); i++) {
            Proposal proposal;
            proposal.name = names[i];
            proposal.totalVotedWeight = 0u64;
            proposals.push(proposal);
        }
        current_case++;
        last_result.case = 0u;
        last_result.topVoted = "";
    }
    __debug.print("EOC init: ", names);
}
```

> A relay statement is similar to a function call, except that the call is asynchronous. The call data is packaged in a so-called "relay transaction" and relayed to the target address for execution. The relay statement itself returns immediately.

vote

```
@address function bool vote(uint32 proposal_index, uint32 case_num) export {
    if(case_num == current_case && case_num > voted_case && proposal_index<proposals.length())
    {
        voted_case = case_num;
        __debug.print("Vote: ", proposal_index);

        /*
        relay@global (^case_num, ^proposal_index, ^weight) {
            if(case_num == current_case)
                proposals[proposal_index].totalVotedWeight += weight;
        }*/
        votedWeights.set_length(proposals.length());
        votedWeights[proposal_index] += weight;
        return true;
    }

    __debug.print("Vote: ", proposal_index, " failed");
    return false;
}
```

Collect votes

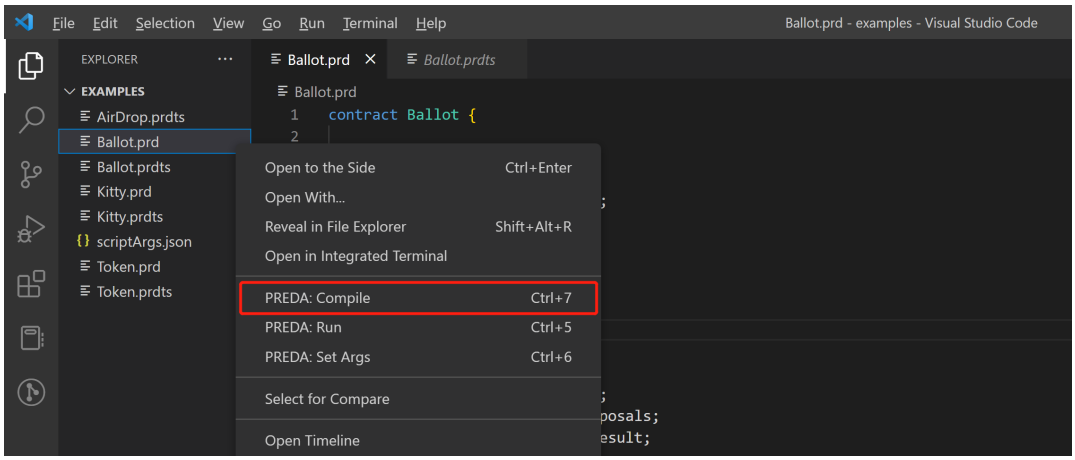
```
@address function finalize() export {
    //__debug.assert(controller == __transaction.get_self_address());
    __debug.assert(is_voting());
    relay@global (){
        // ... maybe do something else before scatter-gathering
        __debug.print("In global");
```

```
        shardGather_reset();
        relay@shards (){
            // ... maybe do something in each shard
            __debug.print("Shard Vote: ", votedWeights);
            relay@global(auto shardVotes = votedWeights) {
                //BEGIN: code for scattering
                for(uint32 i=0u; i<shardVotes.length(); i++)
                {
                    proposals[i].totalVotedWeight += uint64(shardVotes[i]);
                }
                //END

                if(shardGather_gather())
                {
                    __debug.print("votes: ", proposals);
                    //BEGIN: code for gathering
                    last_result.case = current_case;
                    uint64 w = 0u64;
                    for(uint32 i=0u; i<proposals.length(); i++)
                    {
                        if(proposals[i].totalVotedWeight > w)
                        {
                            last_result.topVoted = proposals[i].name;
                            w = proposals[i].totalVotedWeight;
                        }
                    }

                    __debug.print("result: ", last_result);
                    //END
                }
            }
        }
    }
}
```

For more syntax details, please refer to PREDA Language Specification document.

Compile the smart contract

Right click on the contract file, select the `PREDA:Compile` command to compile the smart contract, this process will check the contract syntax.



Write a test script to test the smart contract

PREDA-toolchain provides a scripting language for testing smart contracts easily, it mainly includes the following functions:

- deploy smart contract
- set on-chain states
- call a smart contract function
- smart contract performance testing
- chain info visualization

Now we will take the *Ballot.prdts* as an example to demonstrate.

Write a test script

This is the code details of *Ballot.prdts*

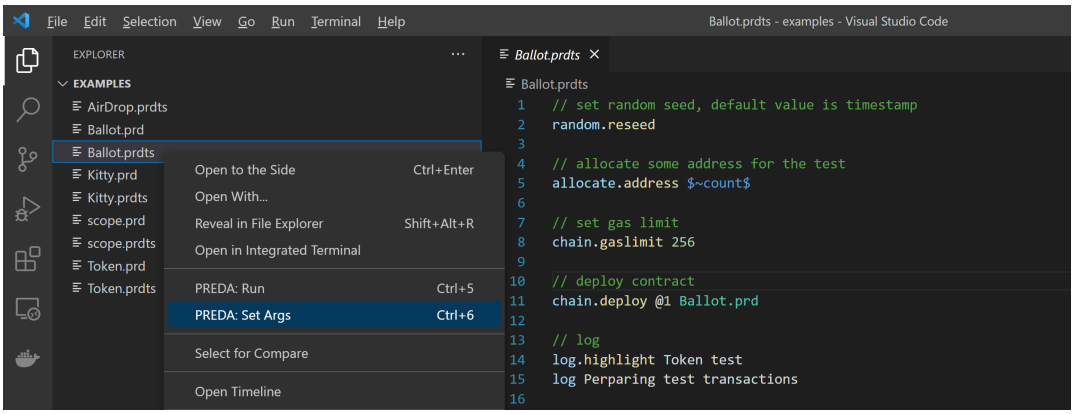
```
// set random seed, default value is timestamp
random.reseed

// allocate some address for the test
allocate.address $~count$
```

```
// set gas limit
chain.gaslimit 256

// deploy contract
chain.deploy @1 Ballot.prd

// log
log.highlight Token test
log Perparing test transactions

// set state, prepare for the test
state.set Ballot.address @all { weight:$random(1, 20)$, voted_case:0 }

log.highlight Ballot test: Step 1

// call Ballot.init at address_0
txn1 = Ballot.init @0 { names: ["Spring", "Yarn", "Combat"] }

// run the chain
chain.run
// print chain info
chain.info

log.highlight Ballot test: Step 2
// call Ballot.vote at all address
txn2[] = Ballot.vote @all { proposal_index: $random(0,2)$, case_num: 1 }
// print chain info
chain.info

log.highlight Ballot test: Step 3
// call Ballot.finalize at address_0 to collect votes
txn3 = Ballot.finalize @0 {}

chain.info
log Executing

// start stopwatch
stopwatch.restart
// run the chain to excute transactions
chain.run
// stop stopwatch to report performance
stopwatch.report

chain.info

// address visualization
viz.addr @random
viz.addr @3 Ballot
viz.addr @all

// txn visualization
viz.txn txn1
viz.txn txn2[0]

viz.section Finalize
// trace visualization
viz.trace txn3

// profiling visualization
viz.profiling
```

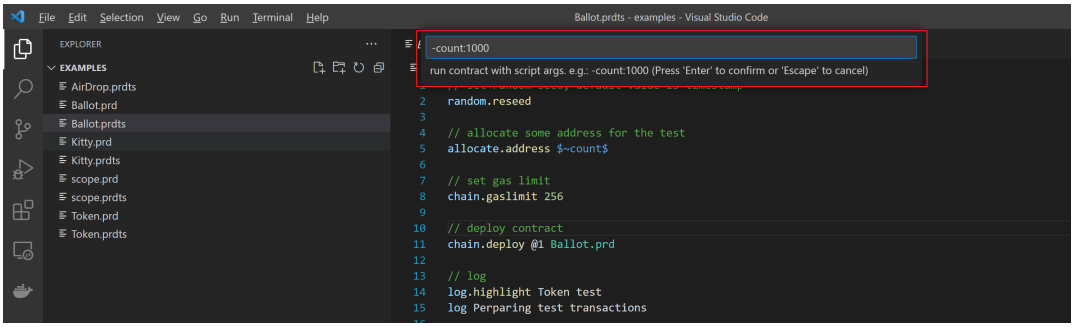
For more syntax details, please refer to PREDA test script syntax Chapter.

Set input parameters of the test script

Right-click on the scipt file, and select `PREDA: Set Args`

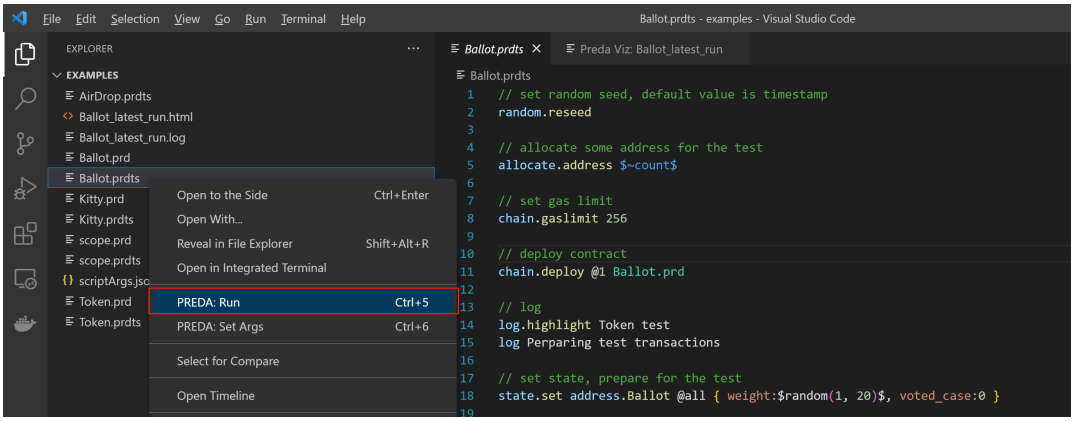


Enter the parameters in the pop-up box and confirm, PREDA-toolchain will execute the script with the set input parameters.



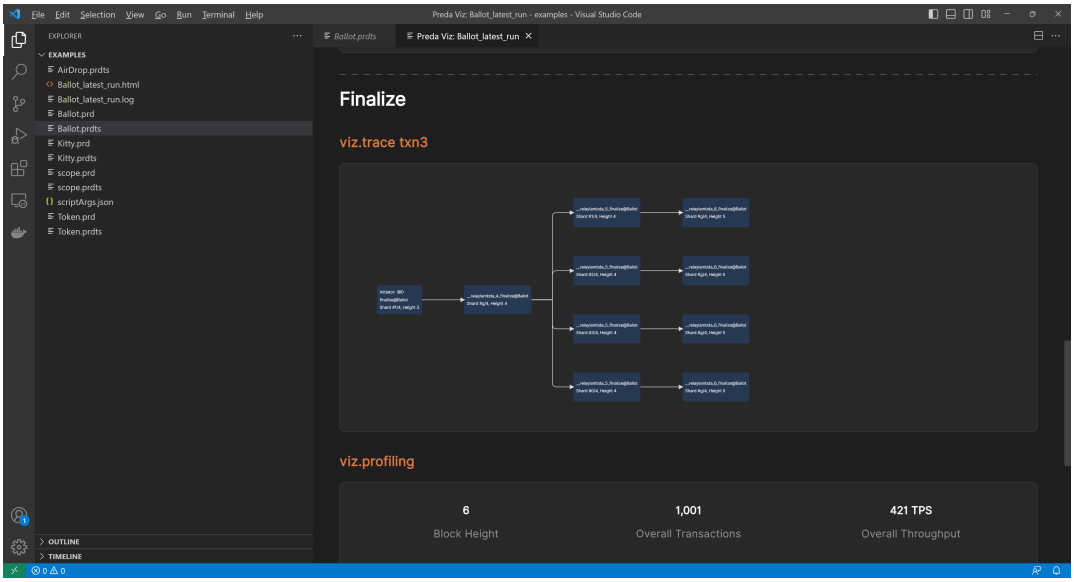
Run the test script

Right click on the script file, and select `PREDA:Run`, PREDA-toolchain will execute the test script.



Chain info visualization

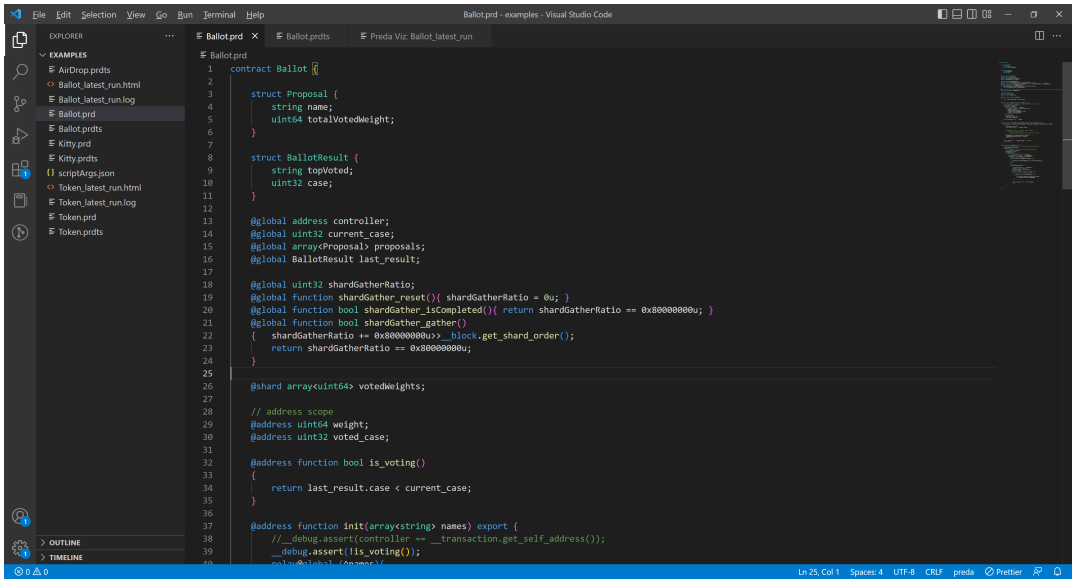
The PREDA-toolchain will provide a visual interface for chain information after execute the test script.

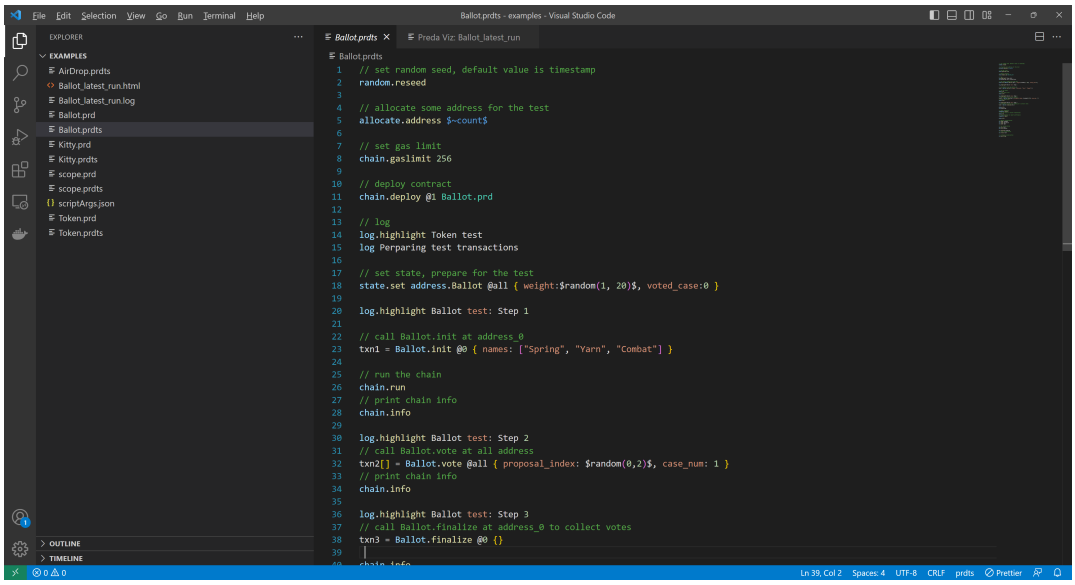


PREDA-Toolchain features

Code highlighting

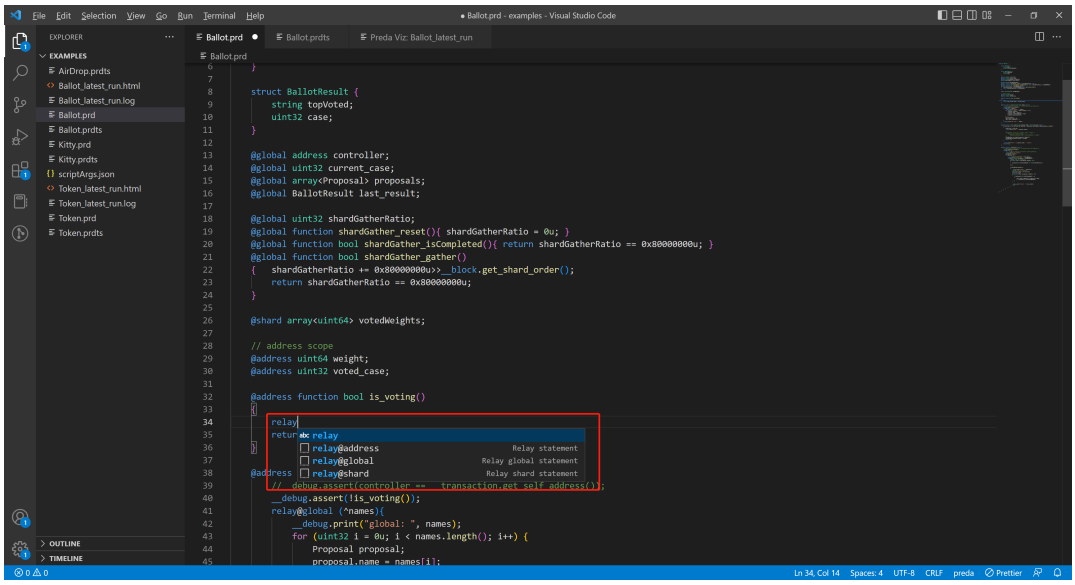
PREDA-Toolchain provide syntax highlighting for *.prd* and *.prdts*.

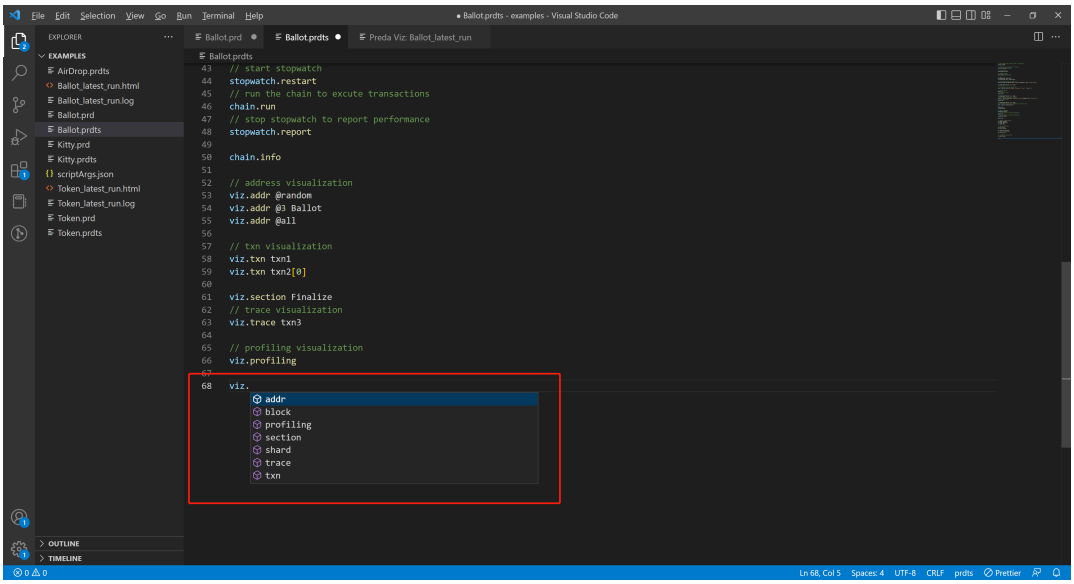




Code auto-completion

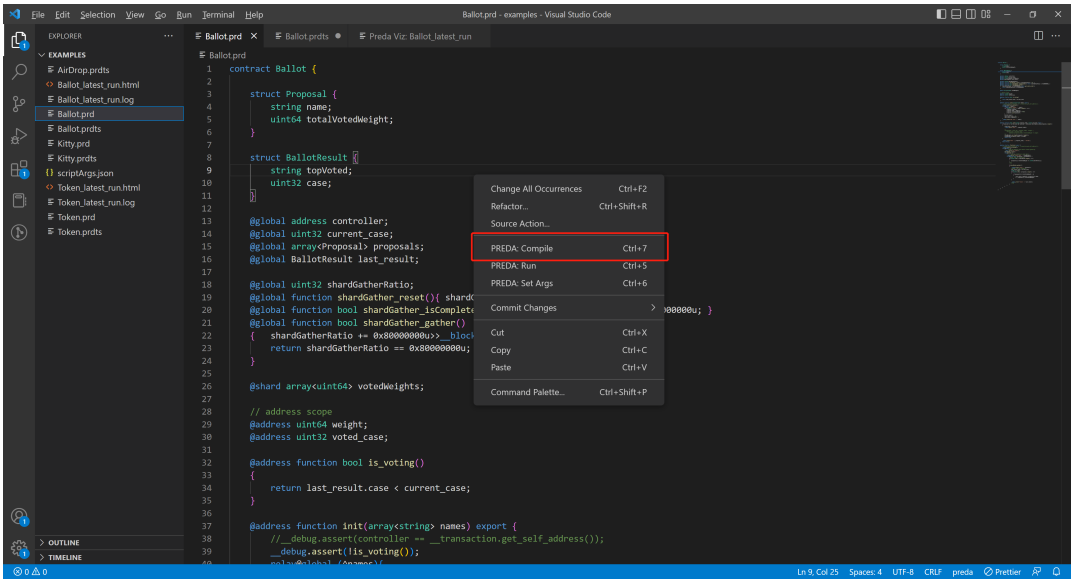
PREDA-Toolchain provide code auto-completion for *.prd* and *.prdts*.





Compile the contract

Right-click on the contract file, and select `PREDA:Compile`, PREDA-Toolchain will check the contract syntax.



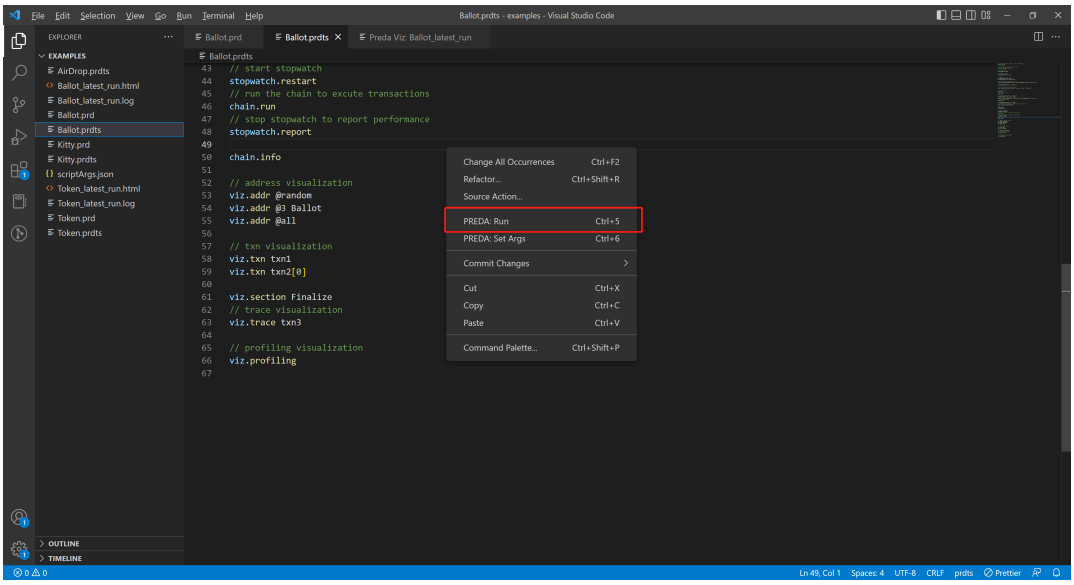
Set Compile Args

Right-click on the contract file, and select `PREDA:Set Compile Args`,PREDA-Toolchain will pop up an input box at the top for entering parameters. We can set compile arguments such as contract dependences:

```
./IToken.prd
```

Run the script

Right click on the test script file, and select `PREDA:Run`, PREDA-Toolchain will execute the commands in the test script and output a visual report.

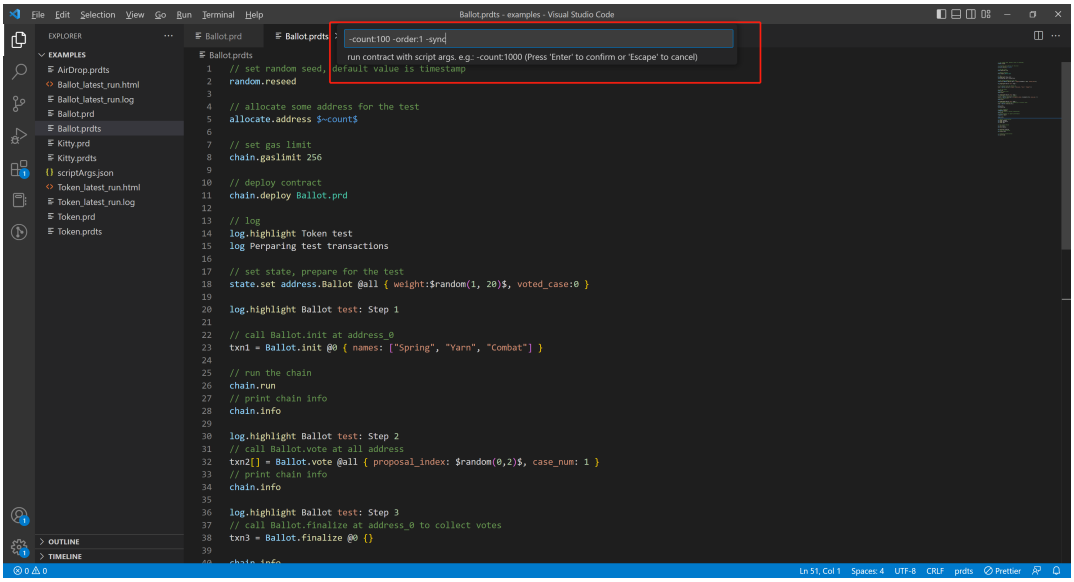


Set input parameters of the script

Right-click on the script file, and select `PREDA:Set Args`, PREDA-Toolchain will pop up an input box at the top for entering parameters. The parameter format is as follows:

```
-count:100 -order:1 -sync
```

The script input parameters will be saved in the scriptArgs.json file.



Built-in parameters

-order:n

The default value of order is 2, is means the blockchain will has 2^{order} shards, the max value of order is 16.

-sync/-async

The sharding mode describes the working mode between shards, when the sharding mode is sync, each shard will output blocks synchronously and the block height will be the same; while when the sharding mode is async, each shard will output blocks asynchronously and the block height may be different.

-perftest

By default, PREDA-toolchain will print logs when executing contract calls, which can consume intensive capability during performance testing. Under this circumstance, you can turn on the performance mode by this parameter.

Custom parameters

Users can use custom parameters in test scripts, such as:

```
allocate.address $~count$
```

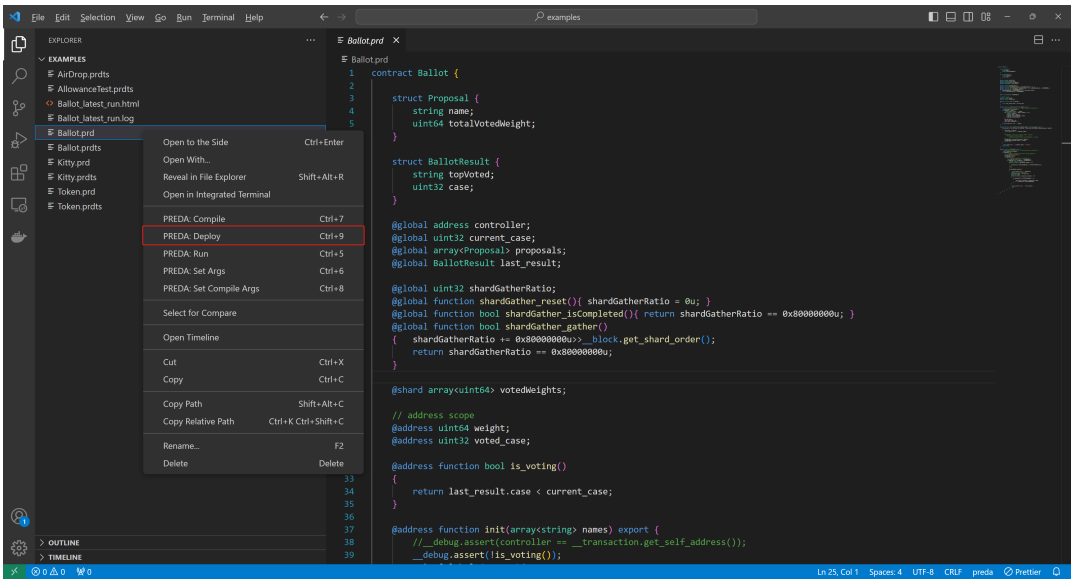
The `$~count$` defines a parameter used to apply for the specified number of addresses, then the user can set the value of this parameter in the pop-up box.

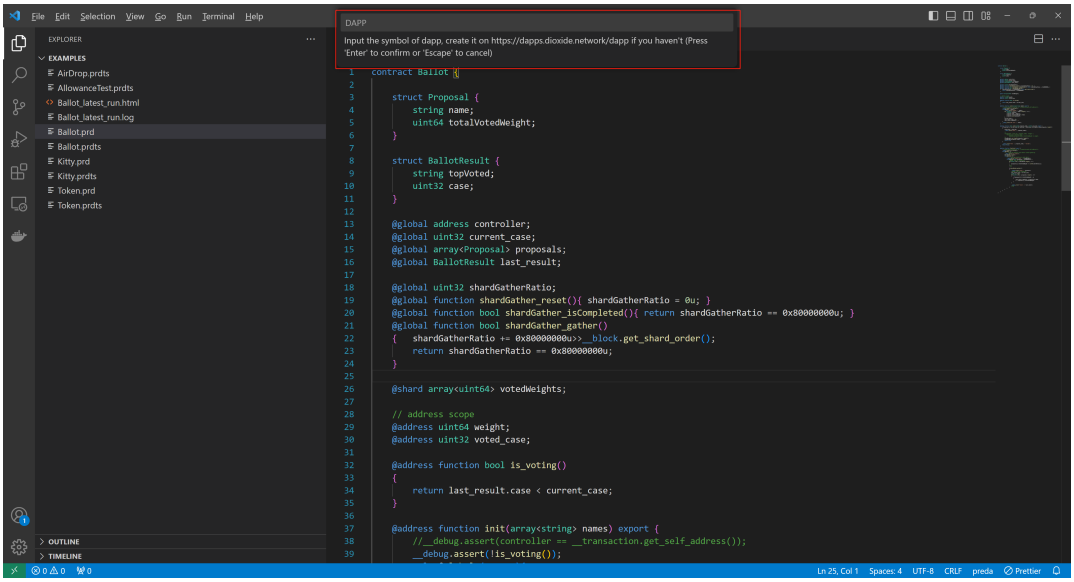
```
-count:100
```

Deploy the contract

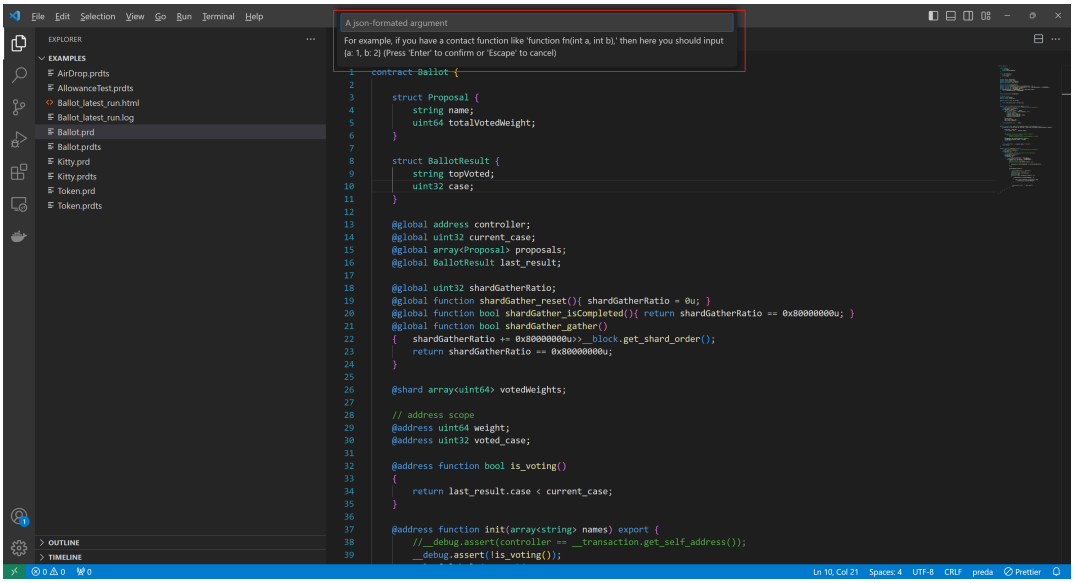
> **Precondition:**
>
> ```
> 1. Install the DioWallet
> 2. Create your DApp
> ```

Right-click on the contract file, and select `PREDA:Deploy`, PREDA-Toolchain will pop up an input box at the top for entering your dapp name.

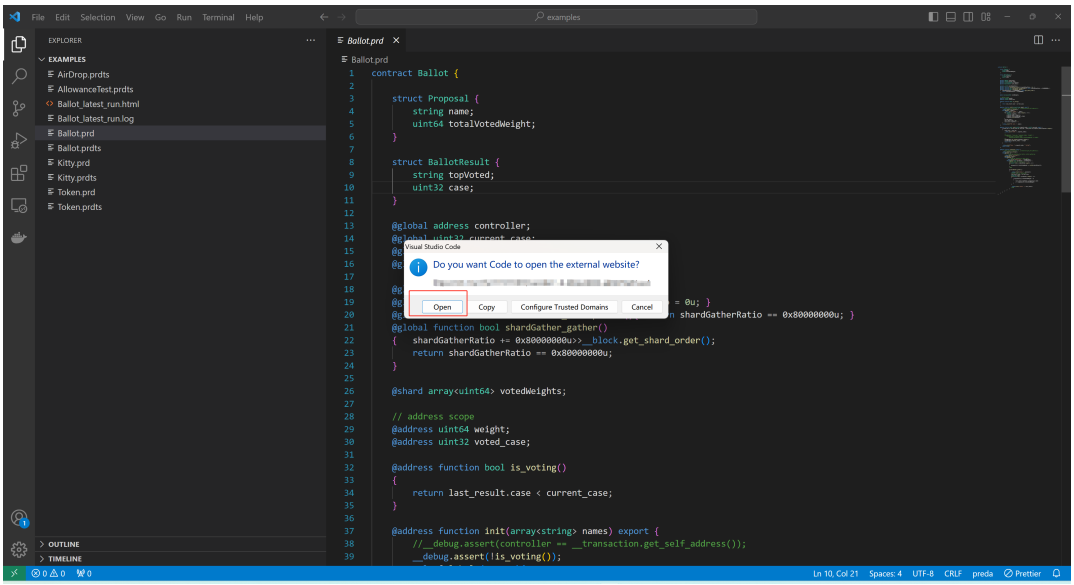




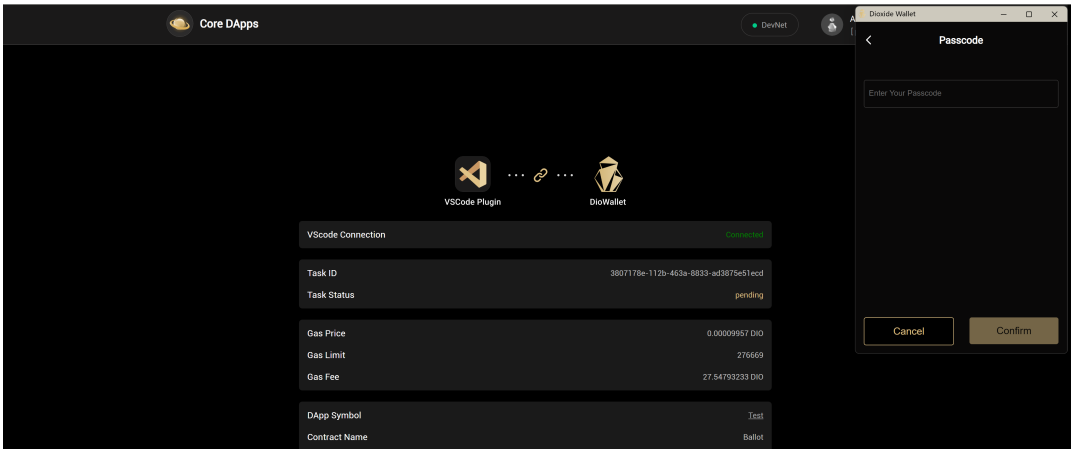
Then enter the contract deployment parameters



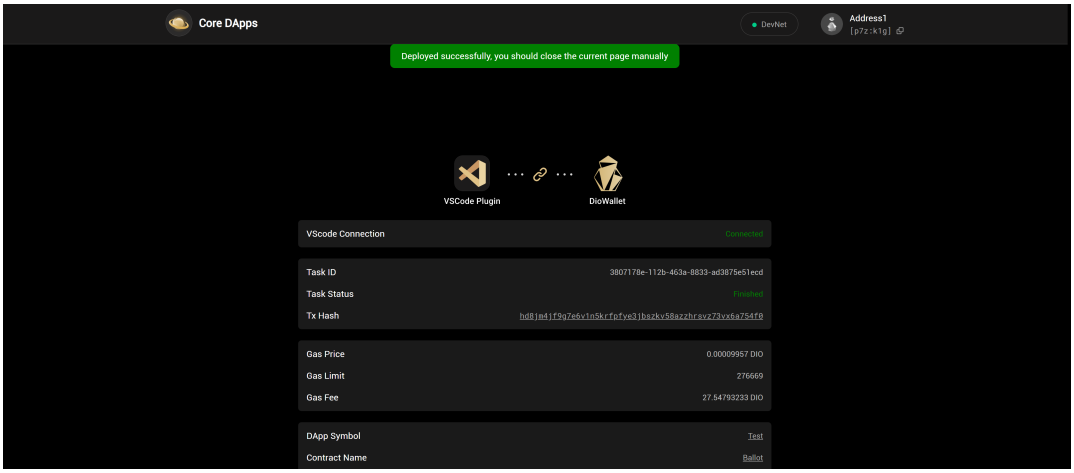
Press `Enter` to confirm



Press `Open`



Enter your passcode to confirm transaction.



Now, congratulations on the successful deployment of the contract!

Chain info visualization

PREDA-Toolchain provides a visual interface for displaying information on the chain, after executing the test script, users can specify the information to be displayed through the `viz.` command.

PREDA test script syntax

Allocate address

Description:

Generate specific number of addresses, The actual number of addresses applied for conforms to the following formula:

$$\begin{cases} actual\_number = shard * n \\ shard * (n-1) < specific\_number <= shard * n \end{cases}$$

- **shard:** the number of shards

- **n:** positive integer

Command:

```
allocate.address [address_number]
```

Parameter:

- **address_number:** the number of addresses to be generated

Example:

```
allocate.address 10
```

Output:

```
12 addresses added and evenly distributed in shards
```

Specify address

Description:

Use the Allocated address in the test script

Command:

```
@address_order
@all
@random
```

Parameter:

- **address_order:** address order n, random, all, represents the number n+1th address, random address, and all addresses respectively.

Example:

```
// address_0 initiate a vote
Ballot.init @0 { names: ["Spring", "Yarn", "Combat"] }
// all address vote
Ballot.vote @all { proposal_index: $random(0,2)$, case_num: 1 }
// a random address vote
Ballot.vote @random { proposal_index: $random(0,2)$, case_num: 1 }
```

Random

Description:

The PREDA-Toolchain provides some functions related to random numbers, for example, specify random address or specify a random input parameter.

First at all, we should specify a seed for random.

Command:

```
random.reseed [seed]
```

Parameters:

- **seed:** the default seed is timestamp, but you can set as any value manually

Example:

```
// set the random seed
random.reseed 88
// specify a random address when call a contract function
Ballot.init @random { names: ["Spring", "Yarn", "Combat"] }
// specify a random input parameter between 0 and 2
Ballot.vote @0 { proposal_index: $random(0,2)$, case_num: 1 }
```

Set gas limit

Description:

Set the gas limit which is the maximum amount of gas that transactions in a block can consume.

Command:

```
chain.gaslimit [limit]
```

Parameters:

- **limit:** the limit for all transaction's gaslimit in a block

Example:

```
chain.gaslimit 128
```

Deploy smart contracts

Description:

Deploy smart contracts, multiple contracts can be deployed.

Command:

```
chain.deploy @address_order [contract_file] [*contract_file]
```

Parameters:

- **contract_file:** the name of the contract file, which supports multiple names to be set at the same time, with space-separated.
- **address_order:** the order of the address that initiated the contract deployment.

Example:

```
chain.deploy @0 SimpleStorage.prd
```

Output:

```
Compiling 1 contract code(s) ...
contract `SimpleStorage`: 2 function(s) with states in address scope(s)
  0) SimpleStorage.increment: txn
  1) SimpleStorage.decrement: txn
Linking and deploying ...
[PRD]: Successfully deployed 1 contract(s)
```

Set contract states

Description:

Set the state for the blockchain, which is used to initialize the contract state. Users need to set all states in the contract.

Command:

- Set global state

```
state.set contract_name.global { state_name:state_value }
```

- Set shard state

```
state.set contract_name.shard @shard_order { state_name:state_value }
```

- Set address state

```
state.set contract_name.address @address_order { state_name:state_value }
```

Parameters:

- **contract_name:** the name of the contract
- **shard_order:** the serial number for shard
- **address_order:** the serial number for address
- **state_name:** the name of the state to be set
- **state_value:** the value of the state to be set

Example:

Set global state

```
state.set Ballot.global { controller:"$@0$", current_case:0, proposals:[], last_result:{topVoted:"",case:0},
shardGatherRatio:0}
```

Set shard state

```
state.set Ballot.shard #all { votedWeights:[] }
```

Set address state

```
state.set Ballot.address @all { weight:$random(1, 20)$, voted_case:0 }
```

Update contract state

Description:

Update the state for the blockchain, which is used to initialize the contract state. Users can individually update the specified state in the contract.

Command:

- Update global state

```
state.update contract_name.global { state_name:state_value }
```

- Update shard state

```
state.update contract_name.shard @shard_order { state_name:state_value }
```

- Update address state

```
state.update contract_name.address @address_order { state_name:state_value }
```

Parameters:

- **contract_name:** the name of the contract
- **shard_order:** the serial number for shard
- **address_order:** the serial number for address
- **state_name:** the name of the state to be set
- **state_value:** the value of the state to be set

Example:

Update global state

```
state.update Ballot.global { controller:"$@0$", current_case:0, proposals:[], last_result:
{topVoted:"",case:0}, shardGatherRatio:0}
```

Update shard state

```
state.update Ballot.shard #all { votedWeights:[] }
```

Update address state

```
state.update Ballot.address @all { weight:$random(1, 20)$, voted_case:0 }
```

Call a contract function

Description:

Call a contract function and generate the transaction into mempool .

Command:

```
// call a global function
contract_name.contract_function[*call_number] contract_params
// call a shard function
contract_name.contract_function[*call_number] #shard_order contract_params
// call a address function
contract_name.contract_function[*call_number] @address_order contract_params
```

Parameters:

- **contract_name:** the name of the contract
- **contract_function:** the name of the contract function
- **call_number:** the number of call times, which is an optional parameter
- **shard_order:** the serial number for shard, users can also use `#all` to specify shard
- **address_order:** the serial number for address, users can also use `@random` and `@all` to specify address
- **contract_params:** the contract input parameters

Example:

```
// call a global function
KittyBreeding.mint*3 { genes: "$bigint.random(32)$", gender: true, owner: "$@all$" }
// call a shard function
KittyBreeding.registerNewBorns #all {}
// call a address function
KittyBreeding.breed*$~count$ @random { m: $random(1, ~count-1)$, s: $random(~count+1, ~count*2-1)$, gender :
false }
```

Set the permission to issue FCA (First-Class Asset)

Description:

Set the permission to issue FCA, only contracts with FCA issuance authority can mint token in the contract.

Command:

```
state.token mint token_name by contract_name
```

Parameters:

- **token_name:** the name of the first-class asset
- **contract_name:** the name of the contract which will mint first-class asset

Example:

```
state.token mint BTC by FCA
```

Call a contract function with FCA (First-Class Asset)

Description:

Carry the specified FCA with contract function call.

Command:

```
contract_name.contract_function @address_order {contract_params} <= (token_amount token_name..)
```

Parameters:

- **contract_name:** the name of the contract
- **contract_function:** the name of the contract function
- **address_order:** the serial number for address, users can also use `@random` and `@all` to specify address
- **token_amount:** the number of tokens carried
- **token_name:** the name of the first-class asset

Example:

```
FCA.transfer @0 {to:"$@1$"} <= (100BTC)
```

Run the blockchain

Description:

Run the blockchain to execute transactions in the mempool, then add them to block **until each shard is archived**.

Command:

```
chain.run
```

Example:

```
chain.run
```

Get chain info

Description:

Output the number of transactions and addresses of current shard in the blockchain.

Command:

```
chain.info
```

Example:

```
chain.info
```

Output:

```
Global: h:0 txn:0/0/0 addr:0
Shd#0:  h:0 txn:17/0/0 addr:25
Shd#1:  h:0 txn:31/0/0 addr:25
Shd#2:  h:0 txn:23/0/0 addr:25
Shd#3:  h:0 txn:29/0/0 addr:25
Total Txn:100/0
```

log

Description:

Print log or print highlight log

Command:

```
log text
log.highlight text
```

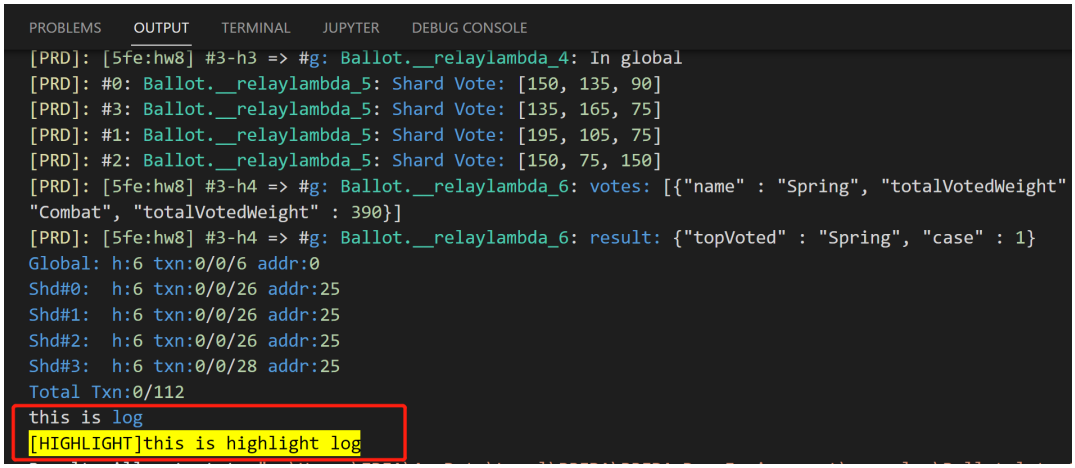
Parameters:

- **text:** content of the log

Example:

```
log this is log
log.highlight this is highlight log
```

Output:



stopwatch

Description:

Test contract performance with stopwatch.

Command:

```
stopwatch.restart
stopwatch.report
```

Example:

```
stopwatch.restart
chain.run
stopwatch.report
```

Output:

```
Stopwatch: 5 msec
Order: 2, TPS:20000, uTPS:20000
```

Visualization

viz.block

Description:

Display block information in the visual interface

Command:

```
// Display the block information of the specified shard
viz.block #shard_order
// Display the block information of the specified shard and block height
viz.block #shard_order:height
// Display the block information of all shard
viz.block #all
// Display the block information of global shard
viz.block #g
```

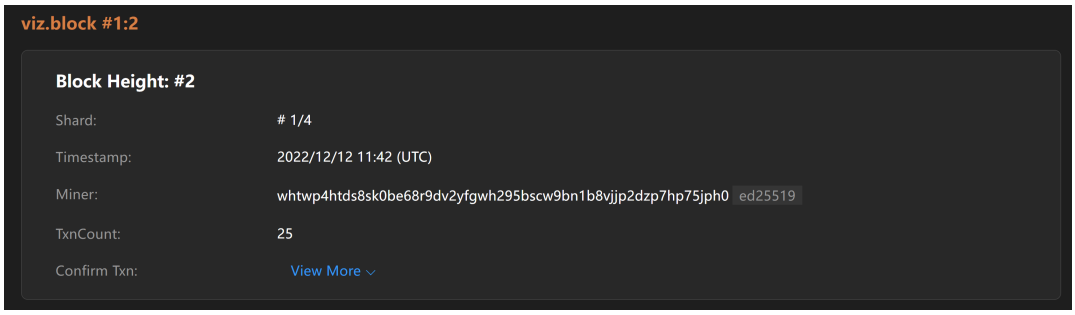
Parameters:

- **shard_order:** the order of shards
- **height:** the block height

Example:

```
viz.block #1:2
```

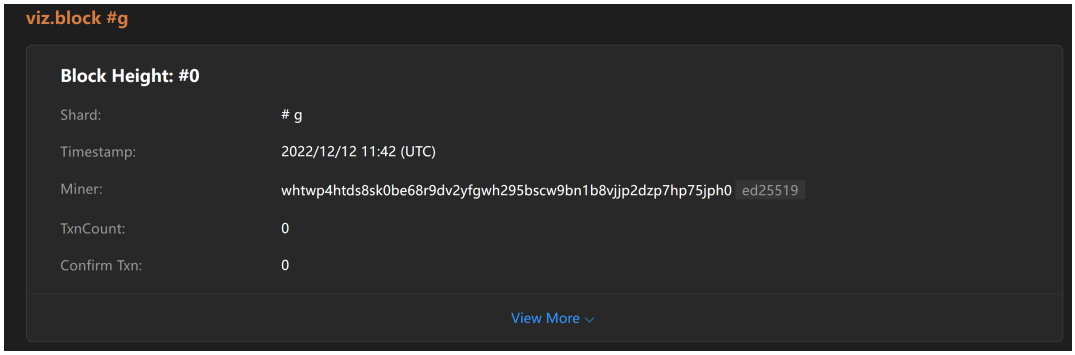
Output:



Example:

```
log.block #g
```

Output:



viz.shard

Description:

Display shard states in the visual interface

Command:

```
// Display the shard states of the specified shard
viz.shard #shard_order
// Display the global states
viz.shard #g
// Display all shard states
viz.shard #all
// Display the shard states of the specified shard and contract
viz.shard #shard contract_name
```

Parameters:

- **shard_order:** the order of shards
- **contract_name:** the name of contract

Example:

```
viz.shard #all
```

Output:

Example:

```
viz.shard #g
```

Output:

Example:

```
viz.shard #1 Ballot
```

Output:

viz.addr

Description:

Display address states in the visual interface

Command:

```
// Display the address states of the specified address
viz.addr @address_order
// Display all address states
viz.shard @all
// Display a random address states
viz.shard @random
// Display the address states of the specified address and contract
viz.shard @address_order contract_name
```

Parameters:

- **address_order:** the order of addresses
- **contract_name:** the name of contract

Example:

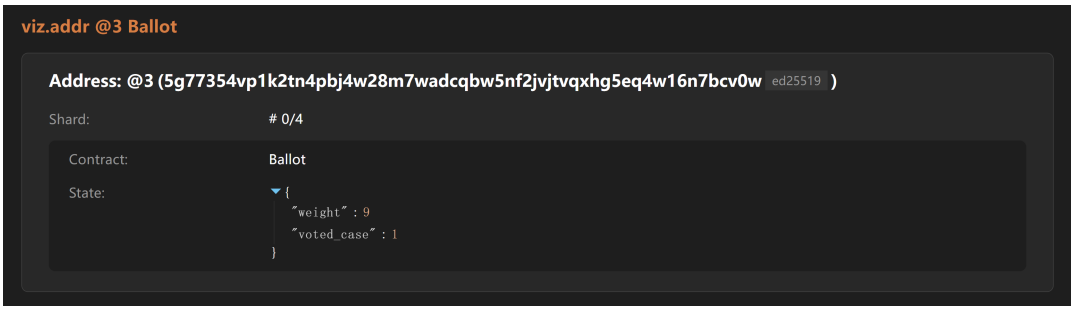
```
viz.addr @random
```

Output:

Example:

```
viz.addr @3 Ballot
```

Output:



Example:

```
viz.addr @all
```

Output:

viz.txn

Description:

Display transaction information in the visual interface

Command:

```
viz.txn txn_name
```

Parameters:

- **txn_name:** identifies a contract method call, which cannot be repeated

Example:

```
txn1 = Ballot.init @0 { names: ["Spring", "Yarn", "Combat"] }
chain.run
viz.txn txn1
```

Output:

viz.txn txn1

Timestamp: 2022/12/12 12:43 (UTC)

InvokeContextType:	Normal
Target:	@0 (qjmdcvjjc0df1y5kt37f89vpb2q6bzzjb5jpff5x3q111sgmfpbr6652mr ed25519)
BuildNum:	1
Function:	init.Ballot
Block Height:	0
Shard:	# 0/4
Return Value:	Success

Example:

```
txn2[] = Ballot.vote @all { proposal_index: $random(0,2)$, case_num: 1 }
chain.run
viz.txn txn2[0]
```

Output:

viz.txn txn2[0]

Timestamp: 2022/12/12 12:44 (UTC)

InvokeContextType:	Normal
Target:	@0 (kpfy499nznz3rspa6ck6ptf4wm3ppgv94hwhyf55t2drdnbjx4x86srg2c ed25519)
BuildNum:	1
Function:	vote.Ballot
Block Height:	2
Shard:	# 3/4
Return Value:	Success

viz.trace

Description:

Display the transaction call chain in the visual interface

Command:

```
viz.trace txn_name
```

Parameters:

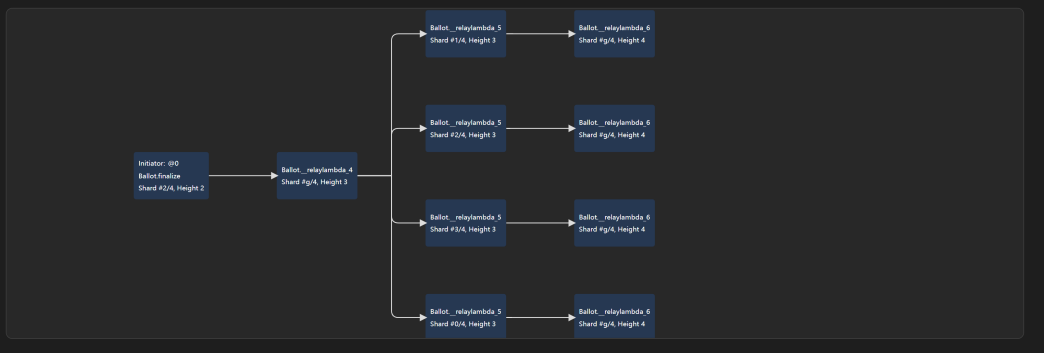
- **txn_name:** identifies a contract method call, which cannot be repeated

Example:

```
txn3 = Ballot.finalize @0 {}
chain.run
viz.trace txn3
```

Output:

viz.trace txn3



viz.section

Description:

Display section information in the visual interface

Command:

```
viz.section section_name
```

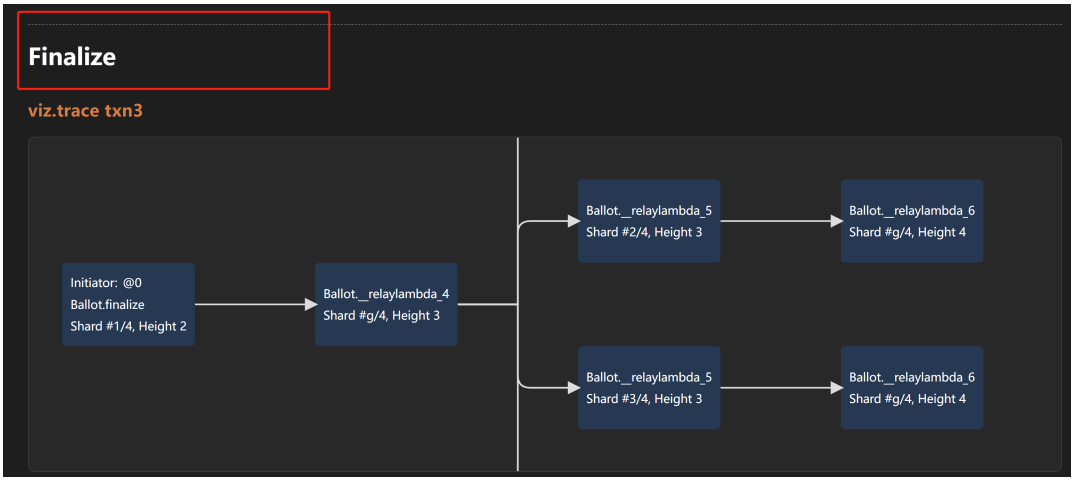
Parameters:

- **section_name:** the name of section

Example:

```
viz.section Finalize
```

Output:



viz.profiling

Description:

Display performance information in the visual interface, this information relies on the statistics of the stopwatch.

Command:

```
viz.profiling
```

Example:

```
viz.profiling
```

Output: