Launcher Service-based EOSIO Testing Framework

What is It

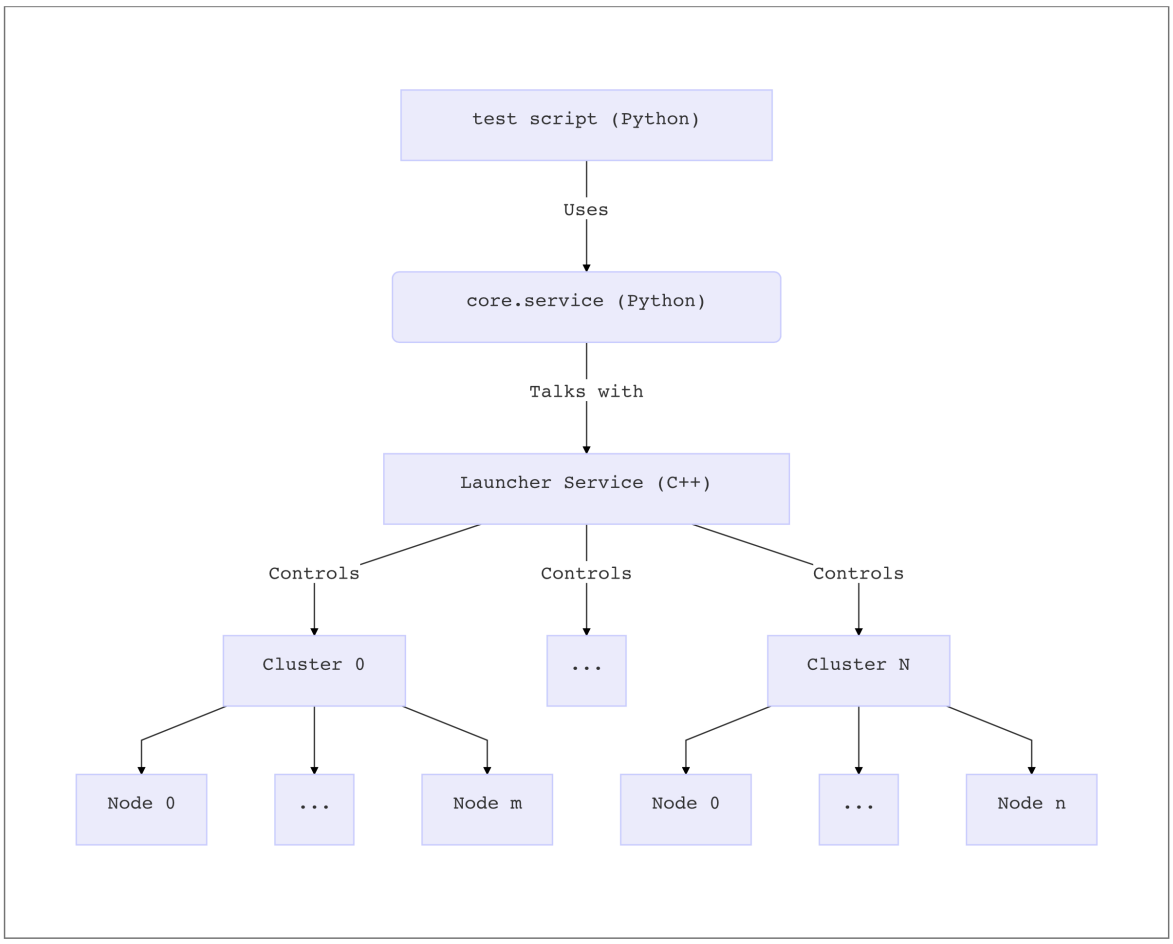
The Launcher Service-based EOSIO Testing Framework aims to provide a more manageable, deterministic and independent nodeos test environment to replace the original python testing framework.

Features

- **Fully-Customizable** -- With launcher service, it is now possible to specify
  - number of nodes/producers, network topology, and many other parameters for a cluster of nodes, either within the test script or via command-line arguments
  - specific options for an individual node in the cluster
  - different bootstrapping options, e.g. using bios contract or system contract to set up accounts
  - queries to a particular node's endpoint, including a node's port number, process ID, log

data, etc
    - queries to the whole cluster state with a single API, useful for checking if all the nodes are in sync, the head block number, etc
    - different signals (`SIGTERM`, `SIGKILL`, etc.) to a specific node in cluster
    - commands to shutdown/restart one or all nodes in a cluster, with auto clean-up
    - commands to activate any protocol feature
- **Parallel** -- Allow multiple test cases to run simultaneously without affecting each other.
    - Each test case runs on a separate cluster of nodes, with a unique cluster ID that can be specified by `cluster_id` in the test script or by `-i/--cluster-id` from the command-line.
    - Port assignment is managed by the launcher service.
    - Support up to 30 clusters.
- **Self-Contained**
    - Independent from `cleos`
        - able to send arbitrary actions to arbitrary nodes from the launcher service
    - Independent from `keosd`
        - key management and key-signing done automatically within the launcher service
        - able to import keys, generate keys by random seed, and select the right keys to sign any transaction
    - Transaction verification
        - able to verify any transaction given transaction ID, without resorting to `history_plugin`

Architecture



Getting Started

High-Level

At the very high level, a typical Python test script consists of only two steps:

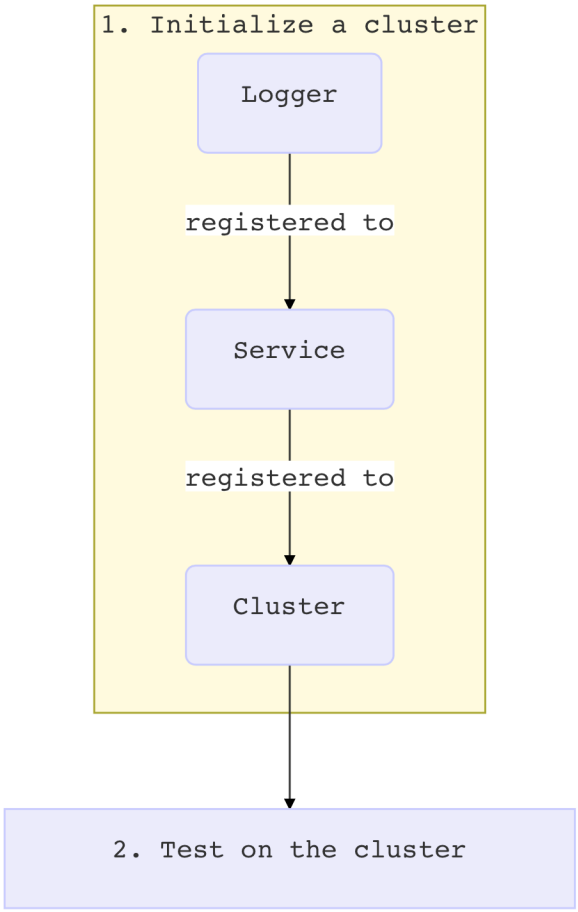
1. sInitialize a cluster
2. Test on the cluster

In order to initialize cluster, three sub-steps are needed:

(1) create a `Logger` object

(2) create a `Service` object, and register the `Logger` to it

(3) create a `Cluster` object, and register the `Service` to it



The `Logger`, `Service` and `Cluster` objects respectively control the logging behavior, the launcher service, and a particular cluster of nodes.

A Real Example

The following code is an excerpt from a real testing script. The three sub-steps for the cluster initialization are bundled in a `init_cluster()` function. This exemplifies a typical way to start a test script.

```
# fork_test.py
import time
from core.logger import ScreenWriter, FileWriter, Logger
from core.service import Service, Cluster, LauncherServiceError,
BlockchainError, SyncError

def init_cluster():
    test = "fork"
    logger = Logger(ScreenWriter(threshold="info"),
                    FileWriter(filename=f"{test}-info.log",
                               threshold="info",
                               monochrome=True),
                    FileWriter(filename=f"{test}-debug.log",
                               threshold="debug",
                               monochrome=True),
                    FileWriter(filename=f"{test}-trace.log",
```

```
                                threshold="trace",
                                monochrome=True))
    service = Service(logger=logger)
    cluster = Cluster(service=service,
                      node_count=3,
                      pnode_count=3,
                      producer_count=7,
                      topology="bridge",
                      center_node_id=1,
                      dont_setprod=True)
    return cluster


def main():
    with init_cluster() as clus:
        clus.info(">>> [DB Guard Test] --- BEGIN ---")
        # testing (e.g. set contract, push actions) via clus
        clus.info(">>> [DB Guard Test] --- END -----")

if __name__ == "__main__":
    main()
```

The imports bring into scope the related classes. Note that `Logger` resides in `core.logger` while `Service` and `Cluster` reside in `core.service`. `LauncherServiceError`, `BlockchainError`, `SyncError` represent `RuntimeError` types but are specifically related to the launcher service, blockchain logic, and in particular, the in-sync status of nodes.

A `Logger` object has the full control over the logging behavior through the test. It is created by specifying where to log, and what to log. In this case, the `Logger` has four logging destinations: printing to the screen, plus writing to three log files, at different log levels.

A `Service` object should know the `Logger` and the settings regarding the launcher service. In this case, except for registering the `Logger`, everything is set to default. Normally it is safe to do so. The `Service` object will automatically detect the file and port if there is an existing launcher service running in the background.

A `Cluster` object should know the `Service` and the settings regarding the cluster of nodes. In this case, the settings include:

1. `node_count=3` : there will be 3 nodes in the cluster
2. `pnode_count=3` : the 3 nodes all have producers
3. `producer_count=7` : there will be 7 producers in the cluster
4. `topology="bridge"` : the network topology will be `bridge`
5. `center_node_id=1` : node 1 will be the center node for `bridge` topology
6. `dont_setprod` : do not set producers (using `setprods`) during bootstrapping

The first three settings together suggest that the node mapping will be 3 producer accounts in node #0, and 2 producer accounts each in nodes #1 and #2.

Node #1 is going be to the connecting node for the `bridge` network topology.

In the process of bootstrapping, the producer accounts will be created using `newaccount`, but they will *not* be set as producers using `setprods`. This is because there will be customized producer-setting process in the body of testing.

The Context Manager

It is recommended to operate on a `Cluster` object using a context manager, i.e. the `with` statement in the example. With the `with` statement,

```
with init_cluster() as clus:
```

it is guaranteed that when the program crashes, say because of an unexpected `RuntimeError`, all the buffered information will be flushed.

Configuration

The `Logger`, `Service` and `Cluster` objects are all configured at their creation.

Hierarchy

While there are many arguments, the values in general come from three sources, with the latter capable of override the former:

1. default values
2. in-script arguments, and
3. command-line arguments.

For example, the default value for the number of nodes in a cluster is 4

```
DEFAULT_NODE_COUNT = 4
```

which can be overridden in the script when creating a cluster

```
cluster = Cluster(service=service, node_count=5)
```

which can be again overridden from the command line. When running the test script, the number of nodes can be changed to 6, by specifying

```
./script.py --node-count=6
```

or simply

```
./script.py -n 6
```

The purpose of the design is to allow flexibility in the testing. It allows users to temporarily change the testing behavior without modifying the script. For example, if the user pass `--debug` at the command line, the logger will print out all the logging information at or above `debug` level on the screen, regardless of the original threshold for the log level.

Ask for Help

For command-line configuration, pass `-h` or `--help` will list all the settings. Below is a list made from the list.

```
Launcher Service-based EOSIO Testing Framework

-h, --help                    Show this message and exit
----- Service options ------------------------------------------------------
-a IP, --addr IP              IP address of launcher service
-o PORT, --port PORT          Listening port of launcher service
-w PATH, --wdir PATH          Working directory
-f PATH, --file PATH          Path to local launcher service file
-g PATH, --gene PATH          Path to genesis file
-s, --start                   Always start a new launcher service
-k, --kill                    Kill existing launcher services (if any)
----- Cluster options ------------------------------------------------------
-c PATH, --cdir PATH          Smart contracts directory
-i ID, --cluster-id ID        Cluster ID to launch with
-n NUM, --node-count NUM      Number of nodes
-p NUM, --pnode-count NUM     Number of nodes with producers
-q NUM, --producer-count NUM  Number of producers
-u NUM, --unstarted-count NUM Number of unstarted nodes
-t SHAPE, --topology SHAPE    Cluster topology to launch with
-x ID, --center-node-id ID    Center node ID (for bridge or star topology)
-y NUM, --tokens-supply NUM   Total supply of tokens (in regular launch)
-r, -dbios, --dont-bios       Do not BIOS launch (regular launch instead)
-dnewa, --dont-newacco        Do not create accounts in launch
-dsetp, --dont-setprod        Do not set producers in BIOS launch
-dvote, --dont-vote           Do not vote for producers in regular launch
--http-retry NUM              HTTP connection: max num of retries
--http-sleep TIME             HTTP connection: sleep time between retries
-va, --verify-async           Verify transaction: verify asynchronously
--verify-retry NUM            Verify transaction: max num of retries
--verify-sleep TIME           Verify transaction: sleep time between retries
--sync-retry NUM              Check sync: max num of retries
--sync-sleep TIME             Check sync: sleep time between retries
----- Logger options -------------------------------------------------------
-l LEVEL, --log-level LEVEL   Stdout logging level (numeric)
--all                         Set stdout logging level to ALL (0)
--trace                       Set stdout logging level to TRACE (10)
--debug                       Set stdout logging level to DEBUG (20)
--info                        Set stdout logging level to INFO (30)
--warn                        Set stdout logging level to WARN (40)
```

```
  --error                       Set stdout logging level to ERROR (50)
  --fatal                       Set stdout logging level to FATAL (60)
  --flag                        Set stdout logging level to FLAG (90)
  --off                         Set stdout logging level to OFF (100)
  -dcolo, --monochrome          Do not print in colors for stdout logging
  -dbuff, --dont-buffer         Do not buffer for stdout logging
  -drena, --dont-rename         Do not rename log file(s) by cluster ID
  -hct, --hide-clock-time       Hide clock time in stdout logging
  -het, --hide-elapsed-time     Hide elapsed time in stdout logging
  -hfi, --hide-filename         Hide filename in stdout logging
  -hli, --hide-lineno           Hide line number in stdout logging
  -hfu, --hide-function         Hide function name in stdout logging
  -hth, --hide-thread           Hide thread name in stdout logging
  -hll, --hide-log-level        Hide log level in stdout logging
  -hall, --hide-all             Hide all the above in stdout logging
```

`Logger`

A `Logger` is a composite of one or multiple writers, which typically include one `ScreenWriter` and several `FileWriter`. One writer corresponds to one logging destination. A `ScreenWriter` writes to the screen (`stdout`) while a `FileWriter` writes to a particular file whose name is given in `filename`.

A Quick Example

Suppose a `Logger` object

```
logger = Logger(ScreenWriter(threshold="info"),
                FileWriter(threshold="debug", filename="debug.log"),
                FileWriter(threshold="trace", filename="trace.log"))
```

has been set properly for a `Cluster` object whose name is `clus`.

Then a line in the Python test script

```
clus.log("Some debug information.", level="debug")
```

or equivalently

```
clus.debug("Some debug information.")
```

will write down a line such as

```
Some debug information.
```

in the files `debug.log` and `trace.log`, because the log level of this line, which is `DEBUG`, is at or above the thresholds of the log files.

However, this line will not show up on the screen, because `DEBUG` is lower than `INFO`, the threshold of the `ScreenWriter`.

Writer Settings

In general, for a writer, the settings include

1. `threshold` : Information at or above the `threshold` will be written to the logging destination.
2. `monochrome` : If `True`, remove all the style and color codes (e.g. `\033[1;31m` for bold red) when writing the text to the logging destination. Default value is `False`.
3. `buffered` : If `True`, it will be *possible* to buffer the logging information and flush it in a coordinated manner. This is helpful when there are multiple threads running simultaneously.
4. `show_clock_time` : Show the clock time in the line. Default value is `True`.
5. `show_elapsed_time` : Show the elapsed time in the line. Default value is `True`.
6. `show_filename` : Show the name of the file that invokes the logging. Default value is `True`.
7. `show_lineno` : Show the line number of the function that invokes the logging. Default value is `True`.
8. `show_function` : Show the name of the function that invokes the logging. Default value is `True`.
9. `show_thread` : Show the name of the thread that invokes the logging. Default value is `True`.
10. `show_log_level` : Show the log level of the line. Default value is `True`.

More about Buffering

Buffering only matters when there are multiple threads, for example, when creating multiple accounts in parallel, or when verifying a transaction asynchronously.

For a writer, if `buffered=True`, it will be possible to keep information organized and make the log result human-readable. If `buffered=False`, logging will take place as soon as a line is ready. Multiple threads may log in an interleaving manner, unaware of others' existence. In general, setting `buffered=False` will *not* reduce the entire logging time, but will keep the lines in a strict chronological order, though the information itself may not be human-readable.

Note that, `buffered=True` only provides a possibility to buffer. Buffering does not happen automatically. A line of information will only be buffered when it is explicitly told to do so.

For example, given two threads, both scheduled to execute

```
# clus is a Cluster object
clus.log("{}: first half.".format(thread_name), level="debug", buffer=True)
clus.log("{}: second half.".format(thread_name), level="debug", buffer=True)
clus.flush()
```

or equivalently

```
# clus is a Cluster object
clus.log("{}: first half.".format(thread_name), level="debug", buffer=True)
clus.log("{}: second half.".format(thread_name), level="debug")
```

setting `buffered=True` will guarantee that the log file will be looking like

```
thread-1: first half
thread-1: second half
thread-2: first half
thread-2: second half
```

or

```
thread-2: first half
thread-2: second half
thread-1: first half
thread-1: second half
```

but will never be of the following form

```
thread-2: first half
thread-1: first half
thread-1: second half
thread-2: second half
```

Log Levels

level	value
`OFF`	100
`FLAG`	90
`FATAL`	60
`ERROR`	50
`WARN`	40
`INFO`	30
`DEBUG`	20
`TRACE`	10
`ALL`	0

The `LogLevel` class accepts either a numeric value or a case-insensitive string for the level. While there are text names given for the level values, all the integers in `[0, 100]` are valid log levels.

```
clus.log("Some warning information.", level="warn")
```

is equivalent to

```
clus.log("Some warning information.", level=40)
```

or

```
clus.warn("Some warning information.")
```

As another example,

```
clus.log("Some info more prominent than INFO but not yet a WARN", level=35)
```

This line will be written to any logging destination with a threshold at or lower than 35. It will be printed out on the screen if the `ScreenWriter` has an `INFO`-level threshold. It will be written to a log file if there is a file writer `FileWriter(threshold=35)`. But it will not appear on the log file that captures only `WARN`-or-higher-level information.

`Service`

A `Service` object represents the connection with the launcher service running in the background. Once a `Service` object is created, it will try to connect the launcher service automatically.

After configuration, the `Service` will change the working directory, register (and possibly *modify*) the Logger, and then connect to launcher service. *Currently, it is only possible to connect to a local launcher service.*

If there is already an existing launcher service running in the background, the `Service` object will by default connect to it (without starting a ew one). It is possible to override this default behavior by requesting to always start a new launcher service and/or to kill all the existing launcher service(s).

A detailed explanation of the parameters to initialize a `Service` object can be found in its docstring.

```
 Parameters
 ----------
logger : Logger
    Logger object which controls logging behavior.
addr : str
    IP address of launcher service.
    Currently, only local launcher service is supported. That is, only
```

```
    default value "127.0.0.1" is supported.
port : int
    Listening port of launcher service.
    If there are multiple launcher service running in the background,
    they must have different listening ports.
    Default is 1234.
wdir : str
    Working directory.
    Default is the build folder.
file : str
    Path to local launcher service file.
    Can be either absolute or relative to the working directory.
gene : str
    Path to the genesis file.
    Can be either absolute or relative to the working directory.
start : bool
    Always start a new launcher service.
    Note that if to start a new instance alongside the existing ones,
    make sure the listening ports are different. Otherwise, the
    new launcher service will issue an error.
    Default is False (will not start a new one if there is an existing
    launcher service running in the background).
kill : bool
    Kill existing launcher services (if any).
    Kill all the existing launcher services running in the background
    (and freshly start a new one).
    Default is False (will not kill existing launcher services; instead
    will connect to an existing launcher service).
```

`Cluster`

A `Cluster` object represents a cluster of nodes running on launcher service. It is the major proxy for tests to communicate with launcher service. A `Cluster` object must have a `Service` object registered to it at initialization.

After configuration, the node cluster will be launched in one of two modes:

1. BIOS mode, using `eosio.bios` to set producers;
2. regular mode, using `eosio.token` to create and issue tokens, and using `eosio.system` to vote.

By default, a cluster is launched in the BIOS mode.

A detailed explanation of the parameters to initialize a `Cluster` object can be found in its docstring.

```
Parameters
----------
service : Service
    Launcher service object on which the node cluster will run
```

```
cidr : str
    Smart contracts directory.
    Can be either absolute or relative to service's working directory.
cluster_id : int
    Cluster ID to launch with.
    Tests with different cluster IDs can be run in parallel.
    Valid range is [0, 30). Default is 0.
node_count : int
    Number of nodes in the cluster.
    Default is 4.
pnode_count : int
    Number of nodes with at least one producer.
    Default is 4.
producer_count : int
    Number of producers in the cluster.
    Default is 4.
unstarted_count : int
    Number of unstarted nodes.
    Default is 0.
topology : str
    Cluster topology to launch with.
    Valid choices are "mesh", "bridge", "line", "ring", "star", "tree".
    Default is "mesh".
center_node_id : int
    Center node ID (for bridge or star topology).
    If topology is bridge, center node ID cannot be 0 or last one.
    No default value.
tokens_supply : float
    Total supply of tokens in regular launch mode.
    Default is 1000000000 (1e9).
extra_configs : list
    Extra configs to pass to launcher service.
    e.g. ["plugin=SOME_EXTRA_PLUGIN"]
    No default value.
extra_args : str
    Extra arguments to pass to launcher service.
    e.g. "--delete-all-blocks"
    No default value.
dont_bios : bool
    Do not launch in BIOS mode. Launch in regular mode instead.
    Default is False (will launch in BIOS mode).
dont_newacco : bool
    Do not create accounts in launch.
    Default is False (will create producer accounts).
dont_setprod : bool
    Do not set producers in BIOS launch mode.
    Default is False (will set producers).
dont_vote: bool
    Do not vote in regular launch mode.
```

```
    Default is False (will vote for producers).
http_retry : int
    Max number of retries in HTTP connection.
    Default is 100.
http_sleep : float
    Sleep time (in seconds) between HTTP connection retries.
    Default is 0.25.
verify_async : bool
    Verify transactions asynchronously.
    Start a separate thread for transaction verfication. Do not wait
    for a transaction to be verified before making next transaction.
    Default is False (will wait for verification result).
verify_retry : int
    Max number of retries in transaction verfication.
    Default is 100.
verify_sleep : float
    Sleep time (in seconds) between verfication retries.
    Default is 0.25.
sync_retry : int
    Max number of retries in checking if nodes are in sync.
    Default is 100.
sync_sleep : float
    Sleep time (in seconds) between check-sync retries.
    Default is 0.25.
```

Testing

The `Cluster` class provides a list of methods, such as `set_contract()` and `push_actions()`, which serve as building blocks for a test script to build up the testing scenario.

Mechanism

Behind the scenes, a `Cluster` object communicates with the launcher service via HTTP connection in a request-and-response model.

Almost all the methods finally passes through or are dependent on the `call()` method in the `Cluster` class. The standard steps to make a call include

```
  Steps to take to make a call
  ----------------------------
  1. print header
  2. establish HTTP connection
  3. log URL and request of connection
  4. retry connection if response not ok
  5. log response
  6. verify transaction
  7. return the result as a Connection object
```

The exact actions to take are fully customizable. Refer to `**call_kwargs` for the full control.

Main API

After the node cluster is successfully launched, all the test actions can be performed on the cluster, with main API listed below.

```
Main API
--------
- Start up and shut down
    - launch_cluster()
    - stop_cluster()
    - start_node()
    - stop_node()
    - stop_all_nodes()
- Queries
    - get_cluster_running_state()
    - get_cluster_info()
    - get_info()
    - get_block()
    - get_account()
    - get_protocal_features()
    - get_log()
- Transactions
    - schedule_protocol_feature_activations()
    - set_contract()
    - push_action()
- Check and Verify
    - verify()
    - check_sync()
    - check_production_round()
- Miscallaneous
    - send_raw()
    - pause_node_production()
    - resume_node_production()
    - get_greylist()
    - add_greylist_accounts()
    - remove_greylist_accounts()
    - get_net_plugin_connections()
```

The full specification of the methods can be found in their docstrings.

`**call_kwargs`

One special parameter across almost all the methods is `**call_kwargs`, which represents all the controlling keyword arguments in the `call` method, which include

```
 retry
```

```
sleep
dont_raise
verify_async
verify_key
verify_sleep
verify_retry
verify_assert
verify_dont_raise
header
level
header_level
url_level
request_text_level
retry_info_level
retry_text_level
response_code_level
response_text_level
transaction_id_level
no_transaction_id_level
error_level
error_text_level
verify_level
verify_retry_level
verify_error_level
buffer
dont_flush
```

These parameters adds to the flexibility of a test script. Consider

```
def get_cluster_info(self, **call_kwargs):
    return self.call("get_cluster_info", **call_kwargs)
```

Assume `clus` is a `Cluster` object that is properly set up, then a line in the script

```
cx = clus.get_cluster_info(retry=200, response_text_level="debug")
```

will, in getting the cluster information, change the max number of HTTP connection retries to 200 (default is 100) and set the log level for response text at `DEBUG` (default is `TRACE`). Now in a `DEBUG`-level log file, it is possible to view the text of the HTTP response.

Debugging

The `core` package provides a hassle-free debugger for quick debugging in an interactive Python environment when a cluster has already been launched. The function names are identical with the corresponding query methods in the `Cluster` object, though there is no need to specify logging controls.

For example, given a node cluster already launched with cluster ID 0, the user may, for one-time debugging, in the Python interactive environment, enter

```
>>> from core.debugger import *
```

and

```
>>> get_cluster_info(cluster_id=0)
```

or just

```
>>> get_cluster_info(0)
```

Then the Python interactive environment may return something like

```
http://127.0.0.1:1234/v1/launcher/get_cluster_info
{
    "cluster_id": 0
}
<Response [200]>
<No Transaction ID>
{
    "result": [
        [
            0,
            {
                "server_version": "3bfd1a4c",
                "chain_id":
"cf057bbfb72640471fd910bcb67639c22df9f92470936cddc1ade0e2f2e7dc4f",
                "head_block_num": 44,
                "last_irreversible_block_num": 9,
                "last_irreversible_block_id":
"00000009d9157aac80c23e056cfa2ee06f06ee50910f35a70be188a0eeda01e5",
                "head_block_id":
"0000002c69ad9d70944ca969b63230ea69b38d5e3887c88455fcad769800ef70",
                "head_block_time": "2019-11-25T10:06:03.000",
                "head_block_producer": "defproducera",
                "virtual_block_cpu_limit": 208772,
                "virtual_block_net_limit": 1094649,
                "block_cpu_limit": 199900,
                "block_net_limit": 1048576,
                "server_version_string": "v2.0.0-develop",
                "fork_db_head_block_num": 44,
                "fork_db_head_block_id":
"0000002c69ad9d70944ca969b63230ea69b38d5e3887c88455fcad769800ef70",
                "server_full_version_string": "v2.0.0-develop-
3bfd1a4cd4c912f9ff524d5753b90354d32cead3-dirty"
```

```
            }
        ],
        ...
    ]
}
```

which may be useful for debugging.