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# **decisionengine**

***Release 1.1.1***

**Fermi Research Alliance, LLC.**

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The Decision Engine is a critical component of the HEP Cloud Facility. It provides the functionality of resource scheduling for disparate resource providers, including those which may have a cost or a restricted allocation of cycles



## RELEASE NOTES

### 1.1 Release 1.3.0

In this release:

- Introduced Jsonnet based configuration system
- Improved logging
- Improved coverage of datasource

#### 1.1.1 Full list of commits since version 1.2

239e82c : postgresql: improve SQL query (#133)

668eb1f : Update to make the code compatible with both python and JSON based config files (#129)

afd8837 : Configuration-manager fixes (#128)

571e2be : Remove pip installed system python packages

407d9ed : Update Dockerfile

1fefc69 : Implement unit tests for datablock.py (#122)

43c8d7a : Adjust global configuration to include program-option values. (#126)

2840813 : Switch to Jsonnet configuration system (#125)

5c4ae0e : logging changes: added config file and command line interface (#124)

6697f22 : Further config-manager testing and factorizations. (#123)

fa89fd0 : Insulate multiprocessing test from parent environment. (#120)

139a537 : Allow empty base directory for log file. (#119)

f14d40c : Factorize configuration-loading steps. (#118)

e00afee : Enhance testing and error reporting of ConfigManager (#117)

c3d1be3 : Python 3 upgrades. (#116)

e7399af : Header fix (#114)

0456abf : Adding editor config file, see <https://editorconfig.org/> (#115)

82112d1 : Dockerfile: fetch osg 3.5 repo rpm (#113)

97c21b1 : osg version 3.5 (#112)

33f28a8 : Introduce jsonnet dependency (#110)  
3f8b55e : improve server error handling (#108)  
f15588e : added 1.2.0 release notes  
b433325 : Remove unnecessary 'main' functionality. (#107)

## 1.2 Release 1.2.0

In this release:

- Switched to python3
- Improved coverage
- Database data retention : added reaper to remove data older than configurable number of days
- Improved logging

### 1.2.1 decisionengine

3dfe167 : Jenkins pipeline improvements (#106)  
22a7073 : pull request for review request 137 (#105)  
cafff2 : Make it possible to run code directly (for tests), and (#100)  
802e98b : replace psycog2 with psycog2-binary (#101)  
573ce8f : Jenkins pipeline improvements (#99)  
9d08835 : Run coveralls even under failed state (#97)  
bc1df4b : Add tests for PostgreSQL datasource (#71)  
c1ac391 : Fix missing py-modules.html (#96)  
8dbfdee : Setup gh-pages doc workflow (#94)  
cd4a01a : Doc (#93)  
673080d : set version to 1.2.0 (for now). Supply conf file that corresponds to (#91)  
f912225 : Db (#92)  
dc8b68a : Add reaper to the RPC (#83) (#90)  
29ade91 : adding .Jenkinsfile with Jenkins pipeline configuration (#86)  
c1dfe5c : Don't exclude E1004 from pylint, do exclude line breaks (#89)  
440f949 : Fix varname (#88)  
313d135 : Compress (#87)  
6b8dc4b : Revert "Add reaper to the RPC (#83)"  
dbea8e5 : Update utils.sh so pytest will complete.  
e848316 : Update to postgresql11  
7f4b805 : Add reaper to the RPC (#83)  
0ba2c51 : remove astpp module and dependencies it pulls in (#81)



6b8eab9 : don't track test coverage of tests (#80)  
0da18ec : made reaper.py executable  
aca24a3 : make reaper.py executable, make symbolic link to it from /usr/bin (#72)  
0202acf : Implementation of data reaper (#70)  
16b6be1 : Simple changes for Python 3 deployment (#69)  
fd2418c : Fix warnings caught by PEP-8 Speaks.  
d16359b : Python 3 (and other) simplifications.  
3c7b6b7 : Only run Github Actions for python3.6 (#68)  
453cbba : Update README.md  
b27ed53 : remove unnecessary (and atually harmful) python shebang (#66)

## 1.2.2 decisionengine\_modules

30d928b : clone version 1.2.0 of decisionengine  
ae7c5a6 : Jenkins pipeline improvements (#236)  
310befd : T198 (#235)  
a65886d : Fix import as reported in : <https://github.com/HEPcloud/decisionengin...> (#232)  
93711cc : Run coveralls even if tests fail (#229)  
03d763a : Jenkins pipeline improvements (#230)  
f48d30f : Fix/223 (#228)  
c8aa262 : github ticket 199 (#222)  
0323bda : Address : [https://github.com/HEPcloud/decisionengine\\_modules/issues/224](https://github.com/HEPcloud/decisionengine_modules/issues/224) (#226)  
62e4df6 : Add support to run CI on Jenkins (#221)  
5ab1541 : bump master version to 1.2.0 (for now) (#219)  
bc19c65 : decisionengine\_modules/NERSC: Added retry loop for NERSC API Calls (#220)  
41a50de : Sync up pep8speaks and run\_pylint.sh with decisionengine settings (#218)  
db4634f : silence pylint error (#217)  
1b95141 : Fix whitespace around operator error  
746ea38 : ignore W503  
8a8b5f4 : remove unused variable  
a6668bf : fix PEP8 warnings  
13773ee : address pep8 warnings  
6bea4ca : silence pylint error  
f589895 : Pass sort=True parameter to fix future warning (#215)  
a1d0507 : fixing pep8 warning  
a10bd17 : debugging one import error  
ec501ad : make coveralls.io links work

deab1a7 : T201 (#204)

69f2645 : Add coveragerc

6d8a5f5 : decisionengine\_modules/NERSC: Make Nersc API call backward-compatible with old config (#196)

a7e0af9 : Only run Github Actions for python3.6 (#24)

## 1.3 Release 1.1.0

In this release:

- Fixed. [https://github.com/HEPCloud/decisionengine\\_modules/issues/108](https://github.com/HEPCloud/decisionengine_modules/issues/108) “Supply Postgres script to delete fields in main database before a certain date”
- significant code cleanup and pep8 compliance
- unit test work
- CI (GitHub actions and Travis) is introduced

commits

f894b1d : Skip unittest (#77)

632e64b : Add ipython

f681a79 : Make python 2.7 tests run on 1.1 branch

d6a32c0 : implementation of data reaper (#75)

2ad8614 : Use sparse checkout for first checkout to get .github/actions (#65)

812f032 : Cat output of pytest log Exit pylint entrypoint with the line count of pep8 and pylint logs Deal with (detach from ...) Only tar up (S)RPMS dirs for rpm build.

6b05ec7 : Fix errors reported by run\_pylint (#62)

d9f5b66 : Setup pep8speaks

c3b8ac2 : Run github actions as non-root uid. Install packages in virtualenv and remove system rpms.

ae01f9e : Support Python 3 for Boost Python

579761c : Support Python 3 for Boost Python

044b979 : Remove unnecessary using declarations.

00f6d00 : Add extra header dependency due to Boost Python ommission.

24e0795 : Apply clang-format

17c17f9 : Remove JSON dependency.

faa0b22 : Massive cleanup.

07b555f : Updates to Github Actions to allow building with python3.6

fef6c11 : Fix errors when running pylint.sh multiple times

da6f077 : Autopep8 -i fixes

39fe5b3 : TaskManager: fix calling log\_exception with correct number of arguments and minor format changes to reduce PEP8 warnings

17396da : logicengine: get rid of compuler warnings

01dc3d1 : Only track what we need  
b609d73 : Configure coveralls (and some minor cleanup)  
bd9ed5e : Many C++ cleanups  
2a61876 : Add Badges  
c864f27 : Do not call pytest fixtures directly.  
307db5f : white space fix  
882b58f : fix unit tests  
1da687c : Replace Boost facilities with C++ STL ones.  
5a6e6b1 : Run tests on push  
8404245 : Add missing Boost regex library dependency.  
ceb5fe7 : Apply clang-format to files that were missed earlier.  
3de9940 : Apply clang-format to C++ code.  
8a8f560 : Cache venv directory instead  
ad017ce : Build private boost for testing  
928c64a : Test pip cache  
358939a : Adjust CMakeLists.txt files to use correct Python versions  
9f0ddb3 : Add pylint github action.  
5e6ce4a : Remove more unused C++ files.  
63717fe : Setup travis to use new cmake var  
74fab2a : Use cmake argument -DPYVER=3.6 to build python3 library <https://fermicloud140.fnal.gov/reviews/r/31/>  
843f30c : Minor cleanups per travis-lint  
a538cac : Remove unused C++ files.  
4c9d125 : Update repo where action is taken from  
87fb2d9 : Update rpms installed in docker image. Update entrypoint.sh to use cmake3.  
199ee87 : Find python3 libraries using cmake3 from epel rpm Also need to install python3-devel  
4c79d2c : Remove unnused GNUmakefiles.  
94342ee : Add unit test as a Github Action  
1a0e102 : more advanced travis.yml  
0be413f : Add helper file for pip  
7794327 : Make recursive import happy  
7005c78 : Add simple target  
de8b0fa : python3 compliance: replace string.join() where appropriate, handle UserDict  
2662e6c : note required packages  
3b87119 : Add missing header includes.  
3e79b84 : Remove defunct code and its tests

b1dbe1a : Ensure attribs are defined at **init**  
c4ad78a : Correct logger arguments do avoid duplicate string parse  
a8dcc67 : Remove unused imports (per pylint)  
d3502b5 : Remove obsolete CVS directories.  
d744111 : add six module to the list of required modules  
0a9b1e8 : Fix class declaration  
b83157e : Handle metaclasses  
549f33b : Add config for Travis CI  
ee71044 : Drop trailing white space  
3f82af6 : Python3 forward compatible syntax  
28bf291 : Add safe (for python 2.7) python3 compatible syntax  
1d1d76f : prepare for python3

## DEVELOPER DOCUMENTATION

First command `cd` is just to make sure that you end up in a directory that will contain two subdirectory `decisionengine` and `decisionengine_modules`. Of course this can be done in any directory, not necessarily home directory.

### 2.1 Decisionengine framework

#### 2.1.1 Prerequisites:

```
yum install -y https://dl.fedoraproject.org/pub/epel/epel-release-latest-7.noarch.rpm
yum install -y https://download.postgresql.org/pub/repos/yum/repos/pms/EL-7-x86_64/
↳ pgdg-redhat-repo-latest.noarch.rpm
yum install -y python3 python3-pip cmake3 boost-devel python36-devel boost-python36-
↳ devel postgresql11 postgresql11-server
pip3 install pandas DBUtils psycpg2-binary tabulate mock pytest
```

#### 2.1.2 Build & test

```
cd
git clone https://github.com/HEPcloud/decisionengine

export PYTHONPATH=`pwd`

mkdir decisionengine/framework/logicengine/cxx/build
cd decisionengine/framework/logicengine/cxx/build
cmake3 .. -DPYVER=3.6
make -j <number> # say number of CPUs on your box
cd ../../
ln -s cxx/build/ErrorHandler/RE.so
ln -s cxx/build/ErrorHandler/libLogicEngine.so
export LD_LIBRARY_PATH=`pwd`
cd ../../
#pytest -v --tb=native
python3 -m pytest

===== test session starts
↳ =====
platform linux -- Python 3.6.8, pytest-5.3.5, py-1.8.1, pluggy-0.13.1
rootdir: /root/junjk/decisionengine
collected 26 items
```

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```

framework/dataspace/tests/test_Reaper.py .....
↳ [ 26%]
framework/logicengine/tests/test_cascaded_rules.py ..
↳ [ 34%]
framework/logicengine/tests/test_construction.py .....
↳ [ 53%]
framework/logicengine/tests/test_facts.py .....
↳ [ 73%]
framework/logicengine/tests/test_pandas_fact.py ..
↳ [ 80%]
framework/logicengine/tests/test_rule_with_negated_fact.py ..
↳ [ 88%]
framework/logicengine/tests/test_simple_configuration.py ..
↳ [ 96%]
framework/util/tests/test_tsort.py .
↳ [100%]

```

```

===== 26 passed in 23.86s_
↳=====

```

## 2.2 Decisionengine\_modules

### 2.2.1 Prerequisites:

In Addition to above installed packages

```

yum install condor
pip3 install htcondor boto boto3 google_auth google-api-python-client gcs-oauth2-boto-
↳plugin

```

### 2.2.2 Test

```

cd

git clone https://github.com/HEPCloud/decisionengine_modules
python3 -m pytest decisionengine_modules

```

Current status:

```

[root@fermicloud371 tmp]# python3 -m pytest decisionengine_modules
===== test session starts_
↳=====
platform linux -- Python 3.6.8, pytest-5.3.5, py-1.8.1, pluggy-0.13.1
rootdir: /root/junjk
collected 85 items

decisionengine_modules/AWS/tests/test_AWSInstancePerformance.py ..
↳ [ 2%]
decisionengine_modules/AWS/tests/test_AWSJobLimits.py ..
↳ [ 4%]
decisionengine_modules/AWS/tests/test_AWSOccupancyWithSourceProxy.py ..
↳ [ 7%]

```

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```

decisionengine_modules/AWS/tests/test_AWSSpotPriceWithSourceProxy.py ..
↳ [ 9%]
decisionengine_modules/AWS/tests/test_AWS_figure_of_merit_publisher.py ..
↳ [ 11%]
decisionengine_modules/AWS/tests/test_AWS_price_performance_publisher.py ..
↳ [ 14%]
decisionengine_modules/AWS/tests/test_FigureOfMerit.py ...
↳ [ 17%]
decisionengine_modules/tests/test_AwsBurnRate.py ..
↳ [ 20%]
decisionengine_modules/tests/test_GCEBillingInfo.py ..
↳ [ 22%]
decisionengine_modules/tests/test_GCEFigureOfMerit_publisher.py ..
↳ [ 24%]
decisionengine_modules/tests/test_GCEInstancePerformanceInfo.py ..
↳ [ 27%]
decisionengine_modules/tests/test_GCEPricePerformance_publisher.py ..
↳ [ 29%]
decisionengine_modules/tests/test_GCEResourceLimits.py ..
↳ [ 31%]
decisionengine_modules/tests/test_GceBurnRate.py ..
↳ [ 34%]
decisionengine_modules/tests/test_GceFigureOfMerit.py ..
↳ [ 36%]
decisionengine_modules/tests/test_GceOccupancy.py ..
↳ [ 38%]
decisionengine_modules/tests/test_NerscAllocationInfo.py ..
↳ [ 41%]
decisionengine_modules/tests/test_NerscFigureOfMerit.py ..
↳ [ 43%]
decisionengine_modules/tests/test_NerscFigureOfMerit_publisher.py ..
↳ [ 45%]
decisionengine_modules/tests/test_NerscInstancePerformance.py ..
↳ [ 48%]
decisionengine_modules/tests/test_NerscJobInfo.py ..
↳ [ 50%]
decisionengine_modules/tests/test_factory_client.py ....
↳ [ 55%]
decisionengine_modules/tests/test_factory_entries.py ....
↳ [ 60%]
decisionengine_modules/tests/test_factory_global.py ....
↳ [ 64%]
decisionengine_modules/tests/test_fomorderplugin.py ....
↳ [ 69%]
decisionengine_modules/tests/test_grid_figure_of_merit.py .
↳ [ 70%]
decisionengine_modules/tests/test_htcondor_query.py ....
↳ [ 75%]
decisionengine_modules/tests/test_job_clustering.py .....
↳ [ 81%]
decisionengine_modules/tests/test_job_clustering_publisher.py ..
↳ [ 83%]
decisionengine_modules/tests/test_job_q.py ...
↳ [ 87%]
decisionengine_modules/tests/test_slots.py ..
↳ [ 89%]
decisionengine_modules/tests/glideinwms/publishers/test_decisionenginemonitor.py ...
↳ [ 92%]

```

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```
decisionengine_modules/tests/glideinwms/publishers/test_fe_group_classads.py ...
↳ [ 96%]
decisionengine_modules/tests/glideinwms/publishers/test_glideclientglobal.py ...
↳ [100%]

===== warnings summary
↳=====
/usr/local/lib/python3.6/site-packages/boto/plugin.py:40
  /usr/local/lib/python3.6/site-packages/boto/plugin.py:40: DeprecationWarning: the
↳imp module is deprecated in favour of importlib; see the module's documentation for
↳alternative uses
    import imp

-- Docs: https://docs.pytest.org/en/latest/warnings.html
===== 85 passed, 1 warning in 9.73s
↳=====
```



## SOURCE CODE

### 3.1 Welcome to decisionengine's documentation!

#### 3.1.1 decisionengine package

##### Subpackages

##### decisionengine.framework package

##### Subpackages

##### decisionengine.framework.configmanager package

##### Subpackages

##### decisionengine.framework.configmanager.tests package

##### Submodules

##### decisionengine.framework.configmanager.tests.test\_configmanager module

```
decisionengine.framework.configmanager.tests.test_configmanager.load(monkeypatch)
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_channel_empty_config(load)
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_channel_empty_dict(load)
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_channel_names(load)
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_channel_no_config_file(load)
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_channel_no_modules(load)
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_empty_config(load)
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_empty_dict(load)
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_empty_dict_with_leading(load)
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_minimal_jsonnet_right
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_minimal_jsonnet_wrong
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_minimal_python(load,  
                                                                                      cap-  
                                                                                      sys)
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_minimal_python_default
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_program_options_default
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_program_options_update
```

```
decisionengine.framework.configmanager.tests.test_configmanager.test_wrong_type(load)
```

## Module contents

### Submodules

#### decisionengine.framework.configmanager.ConfigManager module

**class** decisionengine.framework.configmanager.ConfigManager.**ConfigManager** (*program\_options=None*)  
Bases: object

**\_load\_channels** ()

**static create** (*module\_name, class\_name, parameters*)  
Factory method: create instance of dynamically loaded module

**get\_channels** ()

**get\_global\_config** ()

**get\_produces** (*channel\_config*)

**is\_updated** ()

**load** (*config\_file\_name=None*)

**reload** (*config\_file\_name=None*)

decisionengine.framework.configmanager.ConfigManager.**\_check\_keys** (*channel\_conf\_dict*)  
check that channel config has mandatory keys :type data: dict

decisionengine.framework.configmanager.ConfigManager.**\_config\_from\_file** (*config\_file*)

decisionengine.framework.configmanager.ConfigManager.**\_convert\_to\_json** (*config\_file*)  
Attempt to convert JSON non-compliant configuration into a compliant one.

This is a temporary facility to aid the migration of Python-based configurations to Jsonnet-based ones. Python dictionaries that are similar in structure to JSON documents are generally trivially convertible.

decisionengine.framework.configmanager.ConfigManager.**\_make\_logger** (*global\_config*)

decisionengine.framework.configmanager.ConfigManager.**\_validate\_channel** (*channel*)  
Validate channels :type channel: dict

## Module contents

### decisionengine.framework.dataspace package

#### Subpackages

### decisionengine.framework.dataspace.datasources package

#### Subpackages

### decisionengine.framework.dataspace.datasources.tests package

#### Submodules

### decisionengine.framework.dataspace.datasources.tests.test\_postgresql module

```
decisionengine.framework.dataspace.datasources.tests.test_postgresql.data()
decisionengine.framework.dataspace.datasources.tests.test_postgresql.dataprod( )
decisionengine.framework.dataspace.datasources.tests.test_postgresql.datasource(postgresql,
                                         data)
decisionengine.framework.dataspace.datasources.tests.test_postgresql.header(data)
decisionengine.framework.dataspace.datasources.tests.test_postgresql.metadata(data)
decisionengine.framework.dataspace.datasources.tests.test_postgresql.taskmanager( )
decisionengine.framework.dataspace.datasources.tests.test_postgresql.test_create_tables(data)
decisionengine.framework.dataspace.datasources.tests.test_postgresql.test_generate_insert_c
decisionengine.framework.dataspace.datasources.tests.test_postgresql.test_get_last_generat

decisionengine.framework.dataspace.datasources.tests.test_postgresql.test_get_taskmanager(data)

decisionengine.framework.dataspace.datasources.tests.test_postgresql.test_insert(datasource,
                                         dat-
                                         aprod-
                                         uct,
                                         header,
                                         meta-
                                         data)
decisionengine.framework.dataspace.datasources.tests.test_postgresql.test_store_taskmanager
```

## Module contents

### Submodules

#### decisionengine.framework.dataspace.datasources.postgresql module

```
class decisionengine.framework.dataspace.datasources.postgresql.Postgresql (config_dict)
    Bases: decisionengine.framework.dataspace.datasource.DataSource
    Implementation of postgresql data source

    __query (query_string, values=None, cursor_factory=None)
    _abc_cache = <_weakrefset.WeakSet object>
    _abc_negative_cache = <_weakrefset.WeakSet object>
    _abc_negative_cache_version = 185
    _abc_registry = <_weakrefset.WeakSet object>
    _delete (sql_query, values=None)
    _insert (table_name_or_sql_query, record=None)
    _insert_returning_result (table_name_or_sql_query, record=None)
    _remove (sql_query, values=None)
    _select (query_string, values=None, cursor_factory=None)
    _select_dictresult (sql_query, values=None)
    _select_getresult (sql_query, values=None)
    _select_tuple (sql_query, values)
    _update (query_string, values=None)
    _update_returning_result (query_string, values=None)

    close ()
        Close all connections to the database

    connect ()
        Create a pool of database connections

    create_tables ()
        Create database tables

    delete_data_older_than (days)
        Delete data older than days interval :type days: int :arg days: remove data older than days interval

    duplicate_datablock (taskmanager_id, generation_id, new_generation_id)
        For the given taskmanager_id, make a copy of the datablock with given generation_id, set the generation_id
        for the datablock copy

    Parameters
        • taskmanager_id (string) – taskmanager_id for generation to be retrieved
        • generation_id (int) – generation_id of the data
        • new_generation_id (int) – generation_id of the new datablock created

    get_connection ()
```

**get\_datablock** (*taskmanager\_id*, *generation\_id*)

Return the entire datablock from the dataproduct table for the given taskmanager\_id, generation\_id

**Parameters**

- **taskmanager\_id** (*string*) – taskmanager\_id for generation to be retrieved
- **generation\_id** (*int*) – generation\_id of the data

**get\_dataproduct** (*taskmanager\_id*, *generation\_id*, *key*)

Return the data from the dataproduct table for the given taskmanager\_id, generation\_id, key

**Parameters**

- **taskmanager\_id** (*string*) – taskmanager\_id for generation to be retrieved
- **generation\_id** (*int*) – generation\_id of the data
- **key** (*string*) – key for the value

**get\_header** (*taskmanager\_id*, *generation\_id*, *key*)

Return the header from the header table for the given taskmanager\_id, generation\_id, key

**Parameters**

- **taskmanager\_id** (*string*) – taskmanager\_id for generation to be retrieved
- **generation\_id** (*int*) – generation\_id of the data
- **key** (*string*) – key for the value

**get\_last\_generation\_id** (*taskmanager\_name*, *taskmanager\_id=None*)

Return last generation id for current task manager or taskmanager w/ task\_manager\_id.

**Parameters**

- **name** (*string*) – task manager name
- **taskmanager\_id** (*string*) – task manager id

**get\_metadata** (*taskmanager\_id*, *generation\_id*, *key*)

Return the metadata from the metadata table for the given taskmanager\_id, generation\_id, key

**Parameters**

- **taskmanager\_id** (*string*) – taskmanager\_id for generation to be retrieved
- **generation\_id** (*int*) – generation\_id of the data
- **key** (*string*) – key for the value

**get\_schema** (*table=None*)

Given the table name return it's schema

**Parameters** **table** (*string*) – Name of the table

**get\_taskmanager** (*taskmanager\_name*, *taskmanager\_id=None*)

Retrieve TaskManager :type taskmanager\_name: *string* :arg taskmanager\_name: name of taskmanager to retrieve :type taskmanager\_id: *string* :arg taskmanager\_id: id of taskmanager to retrieve

**insert** (*taskmanager\_id*, *generation\_id*, *key*, *value*, *header*, *metadata*)

Insert data into respective tables for the given taskmanager\_id, generation\_id, key

**Parameters**

- **taskmanager\_id** (*string*) – taskmanager\_id for generation to be retrieved
- **generation\_id** (*int*) – generation\_id of the data

- **key** (string) – key for the value
- **value** (object) – Value can be an object or dict
- **header** (Header) – Header for the value
- **header** – Metadata for the value

**store\_taskmanager** (name, taskmanager\_id)

Store TaskManager :type taskmanager\_name: string :arg taskmanager\_name: name of taskmanager to

retrieve :type taskmanager\_id: string :arg taskmanager\_id: id of taskmanager to retrieve

**tables** = {'dataprodukt': ['taskmanager\_id TEXT', 'generation\_id INT', 'key TEXT', 'va

**update** (taskmanager\_id, generation\_id, key, value, header, metadata)

Update the data in respective tables for the given taskmanager\_id, generation\_id, key

#### Parameters

- **taskmanager\_id** (string) – taskmanager\_id for generation to be retrieved
- **generation\_id** (int) – generation\_id of the data
- **key** (string) – key for the value
- **value** (object) – Value can be an object or dict
- **header** (Header) – Header for the value
- **header** – Metadata for the value

decisionengine.framework.dataspace.datasources.postgresql.**generate\_insert\_query** (table\_name,  
keys)

Generate insert query given table name and list of fields

#### Parameters

- **table\_name** (str) – Name of the table to insert into
- **keys** – List of column names

**Keys** list

**Return type** str - insert query

## Module contents

### Submodules

#### decisionengine.framework.dataspace.datablock module

**class** decisionengine.framework.dataspace.datablock.**DataBlock** (dataspace,  
name, taskman-  
ager\_id=None,  
genera-  
tion\_id=None, se-  
quence\_id=None)

Bases: object

**\_insert** (key, value, header, metadata)

Insert a new product into database with header and metadata

**\_\_setitem** (*key, value, header, metadata=None*)  
 put a product in the database with header and metadata

**\_\_update** (*key, value, header, metadata*)  
 Update an existing product in the database with header and metadata

**duplicate** ()  
 Duplicate the datablock and return this new DataBlock. The intent is that at the point the duplication occurs there is only information from the sources in the DataBlock. This also increments the generation\_id of this DataBlock.

TODO: Also update the header and the metadata information TODO: Make this threadsafe

**Return type** *DataBlock*

**get** (*key, default=None*)  
 Return the value associated with the key in the database

**Return type** *dict*

**get\_header** (*key*)  
 Return the Header associated with the key in the database

**Return type** *Header*

**get\_metadata** (*key*)  
 Return the metadata associated with the key in the database

**Return type** *Metadata*

**get\_taskmanager** (*taskmanager\_name, taskmanager\_id=None*)  
 Retrieve TaskManager :type taskmanager\_name: *string* :arg taskmanager\_name: name of taskmanager to retrieve :type taskmanager\_id: *string* :arg taskmanager\_id: id of taskmanager to retrieve :rtype: :obj: *dict*

The dictionary returned looks like : {'datestamp': datetime.datetime(2017, 12, 20, 17, 37, 17, 503210, tzinfo=psycpg2.tz.FixedOffsetTimezone(offset=-360, name=None)),  
 'sequence\_id': 135L, 'name': 'AWS\_Calculations', 'taskmanager\_id': '77B16EB5-C79E-45B0-B1B1-37E846692E1D'}

**is\_expired** (*key=None*)  
 Check if the dataproduct for a given key or any key is expired

**keys** ()

**mark\_expired** (*expiration\_time*)  
 Set the expiration\_time for the current generation of the dataproduct and mark it as expired if expiration\_time <= current time

**put** (*key, value, header, metadata=None*)  
 Put data into the DataBlock

**store\_taskmanager** (*taskmanager\_name, taskmanager\_id*)  
 Persist TaskManager, returns sequence number :type taskmanager\_name: *string* :type taskmanager\_id: :obj: *string* :rtype: *int*

```
class decisionengine.framework.dataspace.datablock.Header(taskmanager_id, create_time=None, expiration_time=None, scheduled_create_time=None, creator='module', schema_id=None)

Bases: collections.UserDict

__abc_cache = <_weakrefset.WeakSet object>
__abc_negative_cache = <_weakrefset.WeakSet object>
__abc_negative_cache_version = 185
__abc_registry = <_weakrefset.WeakSet object>
default_data_lifetime = 1800

is_valid()
    Check if the Header has minimum required information

required_keys = {'create_time', 'creator', 'expiration_time', 'scheduled_create_time',

exception decisionengine.framework.dataspace.datablock.InvalidMetadataError
Bases: Exception

Errors due to invalid Metadata

class decisionengine.framework.dataspace.datablock.Metadata(taskmanager_id, state='NEW', generation_id=None, generation_time=None, missed_update_count=0)

Bases: collections.UserDict

__abc_cache = <_weakrefset.WeakSet object>
__abc_negative_cache = <_weakrefset.WeakSet object>
__abc_negative_cache_version = 185
__abc_registry = <_weakrefset.WeakSet object>
required_keys = {'generation_id', 'generation_time', 'missed_update_count', 'state', '

set_state(state)
    Set the state for the Metadata

valid_states = {'END_CYCLE', 'METADATA_UPDATE', 'NEW', 'START_BACKUP'}

decisionengine.framework.dataspace.datablock.compress(obj)
    Compress python object :param obj: python object :return: compressed object

decisionengine.framework.dataspace.datablock.decompress(zbytes)
    Decompress zipped byte stream, convert to string. :param zbytes: byte stream :return: uncompressed string

decisionengine.framework.dataspace.datablock.zdumps(obj)
    Pickle and compress :param obj: a python object :return: compressed string

decisionengine.framework.dataspace.datablock.zloads(zbytes)
    Decompress and unpickle If input is not compressed attempts to just unpickle it

    Parameters zbytes – compressed bytes
```



**Returns** returns python object

### decisionengine.framework.dataspace.datasource module

```
class decisionengine.framework.dataspace.datasource.DataSource(config)
    Bases: object

    _abc_cache = <_weakrefset.WeakSet object>
    _abc_negative_cache = <_weakrefset.WeakSet object>
    _abc_negative_cache_version = 185
    _abc_registry = <_weakrefset.WeakSet object>

    abstract close()
        Close all connections to the database

    abstract connect()
        Create a pool of database connections

    abstract create_tables()
        Create database tables

    dataproduct_table = 'dataproduct'
        Name of the dataproduct table

    abstract delete_data_older_than(days)
        Delete data older that interval :type days: long :arg days: remove data older than interval

    abstract duplicate_datablock(taskmanager_id, generation_id, new_generation_id)
        For the given taskmanager_id, make a copy of the datablock with given generation_id, set the generation_id
        for the datablock copy

        Parameters
            • taskmanager_id(string) – taskmanager_id for generation to be retrieved
            • generation_id(int) – generation_id of the data
            • new_generation_id(int) – generation_id of the new datablock created

    abstract get_datablock(taskmanager_id, generation_id)
        Return the entire datablock from the dataproduct table for the given taskmanager_id, generation_id

        Parameters
            • taskmanager_id(string) – taskmanager_id for generation to be retrieved
            • generation_id(int) – generation_id of the data

    abstract get_dataproduct(taskmanager_id, generation_id, key)
        Return the data from the dataproduct table for the given taskmanager_id, generation_id, key

        Parameters
            • taskmanager_id(string) – taskmanager_id for generation to be retrieved
            • generation_id(int) – generation_id of the data
            • key(string) – key for the value

    abstract get_header(taskmanager_id, generation_id, key)
        Return the header from the header table for the given taskmanager_id, generation_id, key
```

**Parameters**

- **taskmanager\_id** (string) – taskmanager\_id for generation to be retrieved
- **generation\_id** (int) – generation\_id of the data
- **key** (string) – key for the value

**abstract get\_last\_generation\_id** (name, taskmanager\_id=None)

Return last generation id for current task manager or taskmanager w/ task\_manager\_id.

**Parameters**

- **name** (string) – task manager name
- **taskmanager\_id** (string) – task manager id

**abstract get\_metadata** (taskmanager\_id, generation\_id, key)

Return the metadata from the metadata table for the given taskmanager\_id, generation\_id, key

**Parameters**

- **taskmanager\_id** (string) – taskmanager\_id for generation to be retrieved
- **generation\_id** (int) – generation\_id of the data
- **key** (string) – key for the value

**abstract get\_schema** (table=None)

Given the table name return it's schema

**Parameters table** (string) – Name of the table

**abstract get\_taskmanager** (taskmanager\_name, taskmanager\_id)

Retrieve TaskManager :type taskmanager\_name: string :arg taskmanager\_name: name of taskmanager to retrieve :type taskmanager\_id: string :arg taskmanager\_id: id of taskmanager to retrieve

**header\_table = 'header'**

Name of the header table

**abstract insert** (taskmanager\_id, generation\_id, key, value, header, metadata)

Insert data into respective tables for the given taskmanager\_id, generation\_id, key

**Parameters**

- **taskmanager\_id** (string) – taskmanager\_id for generation to be retrieved
- **generation\_id** (int) – generation\_id of the data
- **key** (string) – key for the value
- **value** (object) – Value can be an object or dict
- **header** (Header) – Header for the value
- **header** – Metadata for the value

**metadata\_table = 'metadata'**

Name of the metadata table

**abstract store\_taskmanager** (taskmanager\_name, taskmanager\_id)

Store TaskManager :type taskmanager\_name: string :arg taskmanager\_name: name of taskmanager to retrieve :type taskmanager\_id: string :arg taskmanager\_id: id of taskmanager to retrieve

**taskmanager\_table = 'taskmanager'**

Name of the taskmanager table

**abstract update** (*taskmanager\_id, generation\_id, key, value, header, metadata*)

Update the data in respective tables for the given taskmanager\_id, generation\_id, key

**Parameters**

- **taskmanager\_id** (*string*) – taskmanager\_id for generation to be retrieved
- **generation\_id** (*int*) – generation\_id of the data
- **key** (*string*) – key for the value
- **value** (*object*) – Value can be an object or dict
- **header** (*Header*) – Header for the value
- **header** – Metadata for the value

### decisionengine.framework.dataspace.dataspace module

**class** decisionengine.framework.dataspace.dataspace.**DataSourceLoader** (*\*args, \*\*kwargs*)

Bases: object

**\_ds** = None

**static create\_datasource** (*module\_name, class\_name, config*)

**class** decisionengine.framework.dataspace.dataspace.**DataSpace** (*config*)

Bases: object

DataSpace class is collection of datablocks and provides interface to the database used to store the actual data

**\_tables\_created** = False

Description of tables and their columns

**close** ()

**delete** (*taskmanager\_id, all\_generations=False*)

**duplicate\_datablock** (*taskmanager\_id, generation\_id, new\_generation\_id*)

**get\_dataproduct** (*taskmanager\_id, generation\_id, key*)

**get\_header** (*taskmanager\_id, generation\_id, key*)

**get\_last\_generation\_id** (*taskmanager\_name, taskmanager\_id=None*)

**get\_metadata** (*taskmanager\_id, generation\_id, key*)

**get\_taskmanager** (*taskmanager\_name, taskmanager\_id=None*)

**insert** (*taskmanager\_id, generation\_id, key, value, header, metadata*)

**mark\_demented** (*taskmanager\_id, keys, generation\_id=None*)

**mark\_expired** (*taskmanager\_id, generation\_id, key, expiry\_time*)

**store\_taskmanager** (*name, id*)

**update** (*taskmanager\_id, generation\_id, key, value, header, metadata*)

**exception** decisionengine.framework.dataspace.dataspace.**DataSpaceConfigurationError**

Bases: Exception

Errors related to database access

**exception** decisionengine.framework.dataspace.dataspace.**DataSpaceConnectionError**  
Bases: Exception

Errors related to database access

**exception** decisionengine.framework.dataspace.dataspace.**DataSpaceError**  
Bases: Exception

Errors related to database access

**exception** decisionengine.framework.dataspace.dataspace.**DataSpaceExistsError**  
Bases: Exception

Errors related to database access

**class** decisionengine.framework.dataspace.dataspace.**Reaper** (*config*)  
Bases: object

Reaper provides functionality of periodic deletion of data older than retention\_interval in days

**\_reaper\_loop** (*delay*)

**\_set\_state** (*value*)

**get\_retention\_interval** ()

**get\_state** ()

**reap** ()

**set\_retention\_interval** (*interval*)

**start** (*delay=0*)

Start thread with an optional delay to start the thread in X seconds

**stop** ()

**class** decisionengine.framework.dataspace.dataspace.**Singleton**  
Bases: type

Singleton pattern using Metaclass <http://stackoverflow.com/questions/6760685/creating-a-singleton-in-python>

**\_instances** = {}

**class** decisionengine.framework.dataspace.dataspace.**State** (*value*)  
Bases: enum.Enum

An enumeration.

**ERROR** = 7

**IDLE** = 1

**RUNNING** = 3

**SLEEPING** = 4

**STARTING** = 2

**STOPPED** = 6

**STOPPING** = 5

## Module contents

### decisionengine.framework.engine package

#### Submodules

#### decisionengine.framework.engine.DecisionEngine module

Main loop for Decision Engine. The following environment variable points to decision engine configuration file: `DECISION_ENGINE_CONFIG_FILE` if this environment variable is not defined the `DE-Config.py` file from the `../tests/etc/` directory will be used.

```
class decisionengine.framework.engine.DecisionEngine(DecisionEngine (cfg,
                                                                    server_address)
    Bases: socketserver.ThreadingMixIn, xmlrpc.server.SimpleXMLRPCServer
    _disable_channels_with_terminated_processes ()
    _dispatch (method, params)
        Dispatches the XML-RPC method.

        XML-RPC calls are forwarded to a registered function that matches the called XML-RPC method name.
        If no such function exists then the call is forwarded to the registered instance, if available.

        If the registered instance has a _dispatch method then that method will be called with the name of the
        XML-RPC method and its parameters as a tuple e.g. instance._dispatch('add',(2,3))

        If the registered instance does not have a _dispatch method then the instance will be searched to find a
        matching method and, if found, will be called.

        Methods beginning with an '_' are considered private and will not be called.

    get_logger ()
    handle_sighup (signum, frame)
    reaper_start (delay)
    reaper_status ()
    reaper_stop ()
    reload_config ()
    rpc_get_channel_log_level (channel)
    rpc_get_log_level ()
    rpc_print_product (product, columns=None, query=None)
    rpc_print_products ()
    rpc_reaper_start (delay=0)
        Start the reaper process after 'delay' seconds. Default 0 seconds delay. :type delay: int
    rpc_reaper_status ()
    rpc_reaper_stop ()
    rpc_reload_config ()
    rpc_set_channel_log_level (channel, log_level)
        Assumes log_level is a string corresponding to the supported logging-module levels.
```

```
rpc_show_config(channel)

rpc_show_de_config()
rpc_start_channel(channel)
rpc_start_channels()
rpc_status()
rpc_stop()
rpc_stop_channel(channel)
rpc_stop_channels()
service_actions()
    Called by the serve_forever() loop.
    May be overridden by a subclass / Mixin to implement any code that needs to be run during the loop.
start_channel(channel)
start_channels()
stop_channel(channel)
stop_channels()

class decisionengine.framework.engine.DecisionEngine.RequestHandler(request,
                                                                    client_address,
                                                                    server)

    Bases: xmlrpc.server.SimpleXMLRPCRequestHandler
    rpc_paths = ('/RPC2',)

class decisionengine.framework.engine.DecisionEngine.Worker(task_manager, logger_config)

    Bases: multiprocessing.context.Process
    run()
        Method to be run in sub-process; can be overridden in sub-class

decisionengine.framework.engine.DecisionEngine.main(args=None)
    If you pass a list of args, they will be used instead of sys.argv

decisionengine.framework.engine.DecisionEngine.parse_program_options(args)
```

### decisionengine.framework.engine.de\_client module

```
decisionengine.framework.engine.de_client.build_xmlrpc_connection(host, port)
decisionengine.framework.engine.de_client.create_parser()
decisionengine.framework.engine.de_client.execute_command_from_args(argsparsed,
                                                                    xmlrpc-
                                                                    socket)

    argsparsed should be from create_parser in this file

decisionengine.framework.engine.de_client.main(args_to_parse=None)
    If you pass a list of args, they will be used instead of sys.argv
```

## Module contents

### decisionengine.framework.modules package

#### Submodules

#### decisionengine.framework.modules.LogicEngine module

```
class decisionengine.framework.modules.LogicEngine.LogicEngine(set_of_parameters)
    Bases: decisionengine.framework.modules.Module.Module
    evaluate(data_block)
```

#### decisionengine.framework.modules.Module module

```
class decisionengine.framework.modules.Module.Module(set_of_parameters)
    Bases: object
    get_data_block()
    get_parameters()
    set_data_block(data_block)
```

#### decisionengine.framework.modules.Publisher module

```
class decisionengine.framework.modules.Publisher.Publisher(set_of_parameters)
    Bases: decisionengine.framework.modules.Module.Module
    consumes(name_list)
    publish(data_block=None)
```

#### decisionengine.framework.modules.Source module

```
class decisionengine.framework.modules.Source.Source(set_of_parameters)
    Bases: decisionengine.framework.modules.Module.Module
    acquire()
    produces(name_schema_id_list)
```

#### decisionengine.framework.modules.SourceProxy module

Fill in data from another channel data block

```
class decisionengine.framework.modules.SourceProxy.SourceProxy(*args,
                                                                **kwargs)
    Bases: decisionengine.framework.modules.Source.Source
```

Source Proxy Channel configuration using source proxy must have in parameters 'channel\_name', defining foreign channel name and 'Dataproducts', defining foreign (and optionally local) data keys. See consumes() doc. Example of source proxy configuration:

```
    "AWSJobLimits": { "module": "modules.source_proxy", "name": "SourceProxy", "parameters":
    {"channel_name": "channel_aws_config_data",
      "Dataproducts": [("aws_instance_limits", "Job_Limits)], "retries": 3,
      "retry_timeout": 20,
    },
    "schedule": 360,
  },
  _get_data (data_block, key)
  acquire ()
    Overrides Source class method
  consumes ()
    Assumes that self.datakeys has the following structure: is a list of tuples or singletons: [
      (data_product_name, data_product_name_translation), .... ] or [ data_product_name, ....
    ]
  must_have = ('channel_name', 'Dataproducts')
  produces ()
    Assumes that self.datakeys has the following structure or
decisionengine.framework.modules.SourceProxy.main ()
  Call this a test unit or use as CLI of this module
decisionengine.framework.modules.SourceProxy.module_config_info ()
  print this module configuration information
decisionengine.framework.modules.SourceProxy.module_config_template ()
  print a template for this module configuration data
```

### decisionengine.framework.modules.Transform module

```
class decisionengine.framework.modules.Transform.Transform (set_of_parameters)
  Bases: decisionengine.framework.modules.Module.Module
  consumes (name_list)
  produces (name_schema_id_list)
  transform ()
```

### decisionengine.framework.modules.de\_logger module

Logger to use in all modules

```
decisionengine.framework.modules.de_logger.get_logger ()
  get default logger - "decision_engine" :rtype: logging.Logger - rotating file logger
decisionengine.framework.modules.de_logger.set_logging (log_file_name='/tmp/decision_engine_logs/decision_
  max_file_size=200000000,
  max_backup_count=6,
  log_level='DEBUG')
```

#### Parameters



- **log\_file\_name** (str) – log file name
- **max\_file\_size** (int) – maximal size of log file. If reached save and start new log.
- **max\_backup\_count** (int) – start rotaion after this number is reached

**Return type** logging.Logger - rotating file logger

`decisionengine.framework.modules.de_logger.set_stream_logging(logger_name="")`  
This is for debugging. Set stream logging for logger.

**Parameters** **logger\_name** (str) – logger name

**Return type** logging.Logger

## Module contents

### decisionengine.framework.taskmanager package

#### Submodules

#### decisionengine.framework.taskmanager.TaskManager module

Task Manager

**class** `decisionengine.framework.taskmanager.TaskManager.Channel` (*channel\_dict*)  
Bases: object

Decision Channel. Instantiates workers according to channel configuration

**class** `decisionengine.framework.taskmanager.TaskManager.State` (*value*)  
Bases: `enum.Enum`

An enumeration.

**BOOT** = 0

**OFFLINE** = 2

**SHUTDOWN** = 4

**SHUTTINGDOWN** = 3

**STEADY** = 1

**class** `decisionengine.framework.taskmanager.TaskManager.TaskManager` (*name,*  
*task\_manager\_id,*  
*genera-*  
*tion\_id,*  
*chan-*  
*nel\_dict,*  
*global\_config*)

Bases: object

Task Manager

**\_take\_offline** (*current\_data\_block*)  
offline and stop task manager

**data\_block\_put** (*data, header, data\_block*)  
Put data into data block

**Parameters**

- **data** (dict) – key, value pairs
- **header** (Header) – data header
- **data\_block** (DataBlock) – data block

**decision\_cycle()**

Decision cycle to be run periodically (by trigger)

**do\_backup()**

Duplicate current data block and return its copy

**Return type** DataBlock**get\_loglevel()****get\_state()****get\_state\_name()****run()**

Task Manager main loop

**run\_logic\_engine** (*data\_block=None*)

Run Logic Engine.

**Parameters** **data\_block** (DataBlock) – data block**run\_publishers** (*actions, facts, data\_block=None*)

Run Publishers in main process.

**Parameters** **data\_block** (DataBlock) – data block**run\_source** (*src*)

Get the data from source and put it into the data block

**Parameters** **src** (*Worker*) – source Worker**run\_transform** (*transform, data\_block*)

Run a transform

**Parameters**

- **transform** (*Worker*) – source Worker
- **data\_block** (DataBlock) – data block

**run\_transforms** (*data\_block=None*)

Run transforms. So far in main process.

**Parameters** **data\_block** (DataBlock) – data block**set\_loglevel** (*log\_level*)

Assumes log\_level is a string corresponding to the supported logging-module levels.

**set\_state** (*state*)**start\_sources** (*data\_block=None*)

Start sources, each in a separate thread

**Parameters** **data\_block** (DataBlock) – data block**wait\_for\_all** (*events\_done*)

Wait for all sources or transforms to finish

**Parameters** **events\_done** (list) – list of events to wait for

**wait\_for\_any** (*events\_done*)  
Wait for any sources to finish

**Parameters** **events\_done** (*list*) – list of events to wait for

**class** `decisionengine.framework.taskmanager.TaskManager.Worker` (*conf\_dict*)  
Bases: `object`

Provides interface to loadable modules an events to synchronise execution

`decisionengine.framework.taskmanager.TaskManager._make_workers_for` (*configs*)

## Module contents

### decisionengine.framework.tests package

#### Submodules

#### decisionengine.framework.tests.PublisherNOP module

**class** `decisionengine.framework.tests.PublisherNOP.PublisherNOP` (*config*)  
Bases: `decisionengine.framework.modules.Publisher.Publisher`  
  
**consumes** (*name\_list=None*)  
**publish** (*data\_block=None*)

#### decisionengine.framework.tests.SourceNOP module

**class** `decisionengine.framework.tests.SourceNOP.SourceNOP` (*config*)  
Bases: `decisionengine.framework.modules.Source.Source`  
  
**acquire** ()  
**produces** ()

#### decisionengine.framework.tests.TransformNOP module

**class** `decisionengine.framework.tests.TransformNOP.TransformNOP` (*config*)  
Bases: `decisionengine.framework.modules.Transform.Transform`  
  
**consumes** (*name\_list=None*)  
**produces** (*name\_schema\_id\_list=None*)  
**transform** (*data\_block*)

## decisionengine.framework.tests.test\_channel module

```
class decisionengine.framework.tests.test_channel.TestChannel (methodName='runTest')
    Bases: unittest.case.TestCase

    de_client_request (*args)

    pytestmark = [Mark (name='usefixtures', args=('fixtures',), kwargs={})]

    setUp ()
        Hook method for setting up the test fixture before exercising it.

    tearDown ()
        Hook method for deconstructing the test fixture after testing it.

    test_client_can_get_de_server_status ()

class decisionengine.framework.tests.test_channel.Worker (db_parameters, port)
    Bases: multiprocessing.context.Process

    run ()
        Method to be run in sub-process; can be overridden in sub-class

decisionengine.framework.tests.test_channel.datasource (request, postgresql)
decisionengine.framework.tests.test_channel.fixtures (request, datasource)
```

## Module contents

### decisionengine.framework.util package

#### Submodules

#### decisionengine.framework.util.sockets module

```
decisionengine.framework.util.sockets.get_random_port ()
```

#### decisionengine.framework.util.tsort module

See:

[https://en.wikipedia.org/wiki/Topological\\_sorting](https://en.wikipedia.org/wiki/Topological_sorting)

Kahn's topological sorting algorithm

L Empty list that will contain the sorted elements S Set of all nodes with no incoming edge while S is non-empty do

    remove a node n from S add n to tail of L for each node m with an edge e from n to m do

        remove edge e from the graph if m has no other incoming edges then

            insert m into S

**if graph has edges then** return error (graph has at least one cycle)

**else** return L (a topologically sorted order)

```
decisionengine.framework.util.tsort.tsort (graph)
```

Function implementing Kahn's topological sorting algorithm returns two lists : sorted list and cyclic lost (if graph is acyclic second list is always None)

**Return type** `list`

**Module contents**

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## INDICES AND TABLES

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