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Quantum chemistry program executor and IO standardizer (QCSchema) for quantum chemistry.
A simple example of QC Engine’s capabilities is as follows:

```python
>>> import qcengine as qcng
>>> import qcelemental as qcel

>>> mol = qcel.models.Molecule.from_data(""
O 0.0 0.000 -0.129
H 0.0 -1.494 1.027
H 0.0 1.494 1.027
"")

>>> input = qcel.models.ResultInput(
molecule=mol,
driver="energy",
model={"method": "SCF", "basis": "sto-3g"},
keywords={"scf_type": "df"}
)

>>> ret = qcng.compute(input, "psi4")

The results contain a complete record of the computation:

```python
>>> ret.return_result
-74.45994963230625

>>> ret.properties.scf_dipole_moment
[0.0, 0.0, 0.6635967188869244]

>>> ret.provenance.cpu
Intel(R) Core(TM) i7-7820HQ CPU @ 2.90GHz
```
Currently available compute backends for single results are as follow:

- **Quantum Chemistry:**
  - Terachem
  - Molpro
  - Psi4
- **AI Evaluation:**
  - TorchANI
- **Molecular Mechanics:**
  - RDKit

In addition, several procedures are available:

- **Geometry Optimization:**
  - geomeTRIC

Information about detected compute backends and procedures may be printed using the `CLI`:

```bash
qcengine info --programs
cqengine info --procedures
```
In addition, QCengine can automatically determine the following quantities:

- The number of physical cores on the system and to use.
- The amount of physical memory on the system and the amount to use.
- The provenance of a computation (hardware, software versions, and compute resources).
- Location of scratch disk space.
- Location of quantum chemistry programs binaries or Python modules.

Each of these options can be specified by the user as well.

```python
>>> qcng.get_config()
<JobConfig ncores=2 memory=2.506 scratch_directory=None>
```

```python
>>> qcng.get_config(local_options={"scratch_directory": "/tmp"})
<JobConfig ncores=2 memory=2.506 scratch_directory="/tmp">
```

```python
>>> os.environ["SCRATCH"] = "/my_scratch"
>>> qcng.get_config(local_options={"scratch_directory": "$SCRATCH"})
<JobConfig ncores=2 memory=2.506 scratch_directory="/my_scratch">
```

Configuration information may be printed using the CLI:

```
qcengine info --config
```
Getting Started

- Install QC Engine

### 4.1 Install QC Engine

You can install qcengine with conda or with pip.

#### 4.1.1 Conda

You can install qcengine using conda:

```bash
$ conda install qcengine -c conda-forge
```

This installs QCEngine and its dependencies. The qcengine package is maintained on the conda-forge channel.

#### 4.1.2 Pip

You can also install QCEngine using pip:

```bash
$ pip install qcengine
```

#### 4.1.3 Test the Installation

**Note:** QCEngine is a wrapper for other quantum chemistry codes. The tests for QCEngine will only test the wrapper for a given code if its detected in the $PATH or current Python Environment, otherwise the tests for that package are skipped. Keep this in mind if you see many skip or s codes output from PyTest.

You can test to make sure that Engine is installed correctly by first installing pytest.

From conda:

```bash
$ conda install pytest -c conda-forge
```

From pip:
4.1.4 Developing from Source

If you are a developer and want to make contributions to the Engine, you can access the source code from github.

User Interface

- Single Compute
- Environment Detection
- Command Line Interface

4.2 Single Compute

QCEngine’s primary purpose is to consume the MolSSI QCSchema and produce QCSchema results for a variety of quantum chemistry, semiempirical, and molecular mechanics programs. Single QCSchema representation comprises of a single energy, gradient, hessian, or properties evaluation.

4.2.1 Input Description

An input description has the following fields:

- molecule - A QCSchema compliant dictionary or Molecule model.
- driver - The energy, gradient, hessian, or properties option.
- model - A description of the evaluation model. For quantum chemistry this is typically method and basis. However, non-quantum chemistry models are often a simple method as in method = 'UFF' for forcefield evaluation.
- keywords - a dictionary of keywords to pass to the underlying program. These are program-specific keywords.

An example input is as follows:

```python
>>> import qcengine as qcng
>>> import qcelemental as qcel

>>> mol = qcel.models.Molecule.from_data('"
O 0.0 0.000 -0.129
H 0.0 -1.494 1.027
H 0.0 1.494 1.027
"

>>> inp = qcel.models.ResultInput(
    molecule=mol,
    driver="energy",
    model=({"method": "SCF", "basis": "sto-3g"},
    keywords={"scf_type": "df"})
)```
4.2.2 Computation

A single computation can be evaluated with the `compute` function as follows:

```python
>>> ret = qcng.compute(inp, "psi4")
```

By default the job is given resources relating to the compute environment it is in; however, these variables can be overridden:

```python
>>> ret = qcng.compute(inp, "psi4", local_options={"memory": 2, "ncores": 3})
```

4.2.3 Results

The results contain a complete record of the computation:

```python
>>> ret.return_result
-74.45994963230625
>>> ret.properties.scf_dipole_moment
[0.0, 0.0, 0.6635967188869244]
>>> ret.provenance.cpu
Intel(R) Core(TM) i7-7820HQ CPU @ 2.90GHz
```

A short description of the fields is as follow:

- `return_result` - the direct return of the `driver` input. That is energy and gradient for a driver `energy` and `gradient` call, respectively.
- `properties` - Values associated with the `return_result` such as the `scf_one_electron_energy`.
- `stdout` - The `stdout` or log of a programs run.
- `provenance` - A description of the calling program, version, wall time, etc.

A complete description of the input is also available in the output:

```python
>>> ret.driver
energy
```

4.2.4 Fields

A list of all fields is available through the `fields` property on the input and output:

```python
>>> ret.fields
['molecule', 'driver', 'model', 'id', 'schema_name', 'schema_version', 'keywords', 'extras', 'provenance', 'return_result', 'success', 'properties', 'stdout', 'stderr', 'error']
```

4.3 Environment Detection

QCEngine can inspect the current compute environment to determine the resources available to it.
4.3.1 Node Description

QCEngine can detect node descriptions to obtain general information about the current node.

```python
>>> qcng.config.get_node_descriptor()
<NodeDescriptor hostname_pattern='*' name='default' scratch_directory=None
    memory=5.568 memory_safety_factor=10 ncores=4 jobs_per_node=2>
```

4.3.2 Config

The configuration file operated based on the current node descriptor and can be overridden:

```python
>>> qcng.get_config()
<JobConfig ncores=2 memory=2.506 scratch_directory=None>

>>> qcng.get_config(local_options={"scratch_directory": "/tmp"})
<JobConfig ncores=2 memory=2.506 scratch_directory="/tmp">

>>> os.environ["SCRATCH"] = "/my_scratch"

>>> qcng.get_config(local_options={"scratch_directory": "$SCRATCH"})
<JobConfig ncores=2 memory=2.506 scratch_directory='/my_scratch'>
```

4.3.3 Global Environment

The global environment can also be inspected directly.

```python
>>> qcng.config.get_global()
{
    'hostname': 'qcarchive.molssi.org',
    'memory': 5.568,
    'username': 'user',
    'ncores': 4,
    'cpuinfo': {
        'python_version': '3.6.7.final.0 (64 bit)',
        'brand': 'Intel(R) Core(TM) i7-7820HQ CPU @ 2.90GHz',
        'hz_advertised': '2.9000 GHz',
        ...
    },
    'cpu_brand': 'Intel(R) Core(TM) i7-7820HQ CPU @ 2.90GHz'
}
```

4.4 Command Line Interface

QCEngine provides a command line interface with three commands:

- `qcengine info` displays information about the environment detected by QCEngine.
- `qcengine run` runs a program.
- `qcengine run-procedure` runs a procedure.
4.4.1 Info Command

Command Invocation

qcengine info <options>

Command Description

This command prints information about the QCEngine environment.

Arguments

category  The information categories to show. Choices include:

• version: Print version of QCEngine and QCElemental.
• programs: Print detected and supported programs.
• procedures: Print detected and supported procedures.
• config: Print host, compute, and job configuration
• all: Print all available information.

By default, all available information is printed.

4.4.2 Run Command

Command Invocation

qcengine run <program> <data>

Command Description

This command runs a program on a given task and outputs the result as a JSON blob.

Arguments

program  The program to run.

data  Data describing the task. One of:

• A JSON blob.
• A file name.
• `-`, indicating data will be read from STDIN.
4.4.3 Run-Procedure Command

Command Invocation

```
qcengine run-procedure <program> <data>
```

Command Description

This command runs a procedure on a given task and outputs the result as a JSON blob.

Arguments

- **procedure**: The procedure to run.
- **data**: Data describing the task. One of:
  - A JSON blob.
  - A file name.
  - '-', indicating data will be read from STDIN.

Developer Documentation

- **QCEngine API**
- **Changelog**

4.5 QCEngine API

4.5.1 qcengine Package

Base file for the dqm_compute module.

Functions

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<thead>
<tr>
<th>Function</th>
<th>Description</th>
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<tbody>
<tr>
<td><code>compute(input_data, program[, raise_error, ...])</code></td>
<td>Executes a single quantum chemistry program given a QC Schema input.</td>
</tr>
<tr>
<td><code>compute_procedure(input_data, procedure[, ...])</code></td>
<td>Runs a procedure (a collection of the quantum chemistry executions)</td>
</tr>
<tr>
<td><code>get_config(*[, hostname, local_options])</code></td>
<td>Returns the configuration key for qcengine.</td>
</tr>
<tr>
<td><code>get_molecule(name)</code></td>
<td>Returns a QC JSON representation of a test molecule.</td>
</tr>
<tr>
<td><code>get_procedure(name)</code></td>
<td>Returns a procedures executor class</td>
</tr>
<tr>
<td><code>get_program(name[, check])</code></td>
<td>Returns a program’s executor class</td>
</tr>
<tr>
<td><code>list_all_procedures()</code></td>
<td>List all procedures registered by QCEngine.</td>
</tr>
<tr>
<td><code>list_all_programs()</code></td>
<td>List all programs registered by QCEngine.</td>
</tr>
<tr>
<td><code>list_available_procedures()</code></td>
<td>List all procedures that can be executed (found) by QCEngine.</td>
</tr>
<tr>
<td><code>list_available_programs()</code></td>
<td>List all programs that can be executed (found) by QCEngine.</td>
</tr>
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</table>

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<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>register_program(entry_point)</td>
<td>Register a new ProgramHarness with QCEngine.</td>
</tr>
<tr>
<td>unregister_program(name)</td>
<td>Unregisters a given program.</td>
</tr>
</tbody>
</table>

### compute

```python
cqengine.compute(input_data: Union[Dict[str, Any], ResultInput], program: str, raise_error: bool = False, local_options: Optional[Dict[str, Any]] = None, return_dict: bool = False) → Result
```

Executes a single quantum chemistry program given a QC Schema input.


**Parameters**

- **input_data** (*Union[Dict[str, Any], 'ResultInput']*) – A QCSchema input specification in dictionary or model from QCElemental.models
- **program** (*str*) – The program to execute the input with.
- **raise_error** (*bool, optional*) – Determines if compute should raise an error or not.
- **retries** (*int, optional*) – The number of random tries to retry for.
- **local_options** (*Optional[Dict[str, Any]], optional*) – A dictionary of local configuration options
- **return_dict** (*bool, optional*) – Returns a dict instead of qcelemental.models.ResultInput

**Returns** A computed Result object.

**Return type** Result

### compute_procedure

```python
cqengine.compute_procedure(input_data: Union[Dict[str, Any], BaseModel], procedure: str, raise_error: bool = False, local_options: Optional[Dict[str, str]] = None, return_dict: bool = False) → BaseModel
```

Runs a procedure (a collection of the quantum chemistry executions)

**Parameters**

- **input_data** (*dict or qcelemental.models.OptimizationInput*) – A JSON input specific to the procedure executed in dictionary or model from QCElemental.models
- **procedure** (*"geometric"*) – The name of the procedure to run
- **raise_error** (*bool, option*) – Determines if compute should raise an error or not.
- **local_options** (*dict, optional*) – A dictionary of local configuration options
- **return_dict** (*bool, optional, default True*) – Returns a dict instead of qcelemental.models.ResultInput

**Returns** A QC Schema representation of the requested output, type depends on return_dict key.

**Return type** dict, Optimization, FailedOperation
get_config

qcengine.get_config(*, hostname: Optional[str] = None, local_options: Dict[str, Any] = None) → qcengine.config.JobConfig

Returns the configuration key for qcengine.

get_molecule

qcengine.get_molecule(name)

Returns a QC JSON representation of a test molecule.

get_procedure

qcengine.get_procedure(name: str) → ProcedureHarness

Returns a procedures executor class

get_program

qcengine.get_program(name: str, check: bool = True) → ProgramHarness

Returns a program’s executor class

Parameters check – True Do raise error if program not found. False is handy for the specialized case of calling non-execution methods (like parsing for testing) on the returned Harness.

list_all_procedures

qcengine.list_all_procedures() → Set[str]

List all procedures registered by QCEngine.

list_all_programs

qcengine.list_all_programs() → Set[str]

List all programs registered by QCEngine.

list_available_procedures

qcengine.list_available_procedures() → Set[str]

List all procedures that can be executed (found) by QCEngine.

list_available_programs

qcengine.list_available_programs() → Set[str]

List all programs that can be executed (found) by QCEngine.
**register_program**

qcengine.

register_program(entry_point: ProgramHarness) → None

Register a new ProgramHarness with QC Engine.

**unregister_program**

qcengine.

unregister_program(name: str) → None

Unregisters a given program.

### 4.5.2 qcengine.compute Module

Integrates the computes together

**Functions**

```python
compute(input_data, program[, raise_error, ...])

Executes a single quantum chemistry program given a QC Schema input.
```

```python
compute_procedure(input_data, procedure[, ...])

Runs a procedure (a collection of the quantum chemistry executions)
```

**compute**

qcengine.compute.

compute(input_data: Union[Dict[str, Any], ResultInput], program: str, raise_error: bool = False, local_options: Optional[Dict[str, Any]] = None, return_dict: bool = False) → Result

Executes a single quantum chemistry program given a QC Schema input.


**Parameters**

- **input_data** (Union[Dict[str, Any], ‘ResultInput’]) – A QCSchema input specification in dictionary or model from QCElemental.models
- **program** (str) – The program to execute the input with.
- **raise_error** (bool, optional) – Determines if compute should raise an error or not.
- **retries** (int, optional) – The number of random tries to retry for.
- **local_options** (Optional[Dict[str, Any]], optional) – A dictionary of local configuration options
- **return_dict** (bool, optional) – Returns a dict instead of qcelemental.models.ResultInput

**Returns** A computed Result object.

**Return type** Result
compute_procedure

cqengine.compute.compute_procedure(input_data: Union[Dict[str, Any], BaseModel], procedure: str, raise_error: bool = False, local_options: Optional[Dict[str, str]] = None, return_dict: bool = False) → BaseModel

Runs a procedure (a collection of the quantum chemistry executions)

Parameters

- **input_data** (dict or qcelemental.models.OptimizationInput) – A JSON input specific to the procedure executed in dictionary or model from QCElemental.models
- **procedure** (f“geometric”) – The name of the procedure to run
- **raise_error** (bool, optional) – Determines if compute should raise an error or not.
- **local_options** (dict, optional) – A dictionary of local configuration options
- **return_dict** (bool, optional, default True) – Returns a dict instead of qcelemental.models.ResultInput

Returns A QC Schema representation of the requested output, type depends on return_dict key.

Return type dict, Optimization, FailedOperation

4.5.3 cqengine.config Module

Creates globals for the cqengine module

Functions

<table>
<thead>
<tr>
<th>get_config(*[, hostname, local_options])</th>
<th>Returns the configuration key for cqengine.</th>
</tr>
</thead>
<tbody>
<tr>
<td>get_provenance_augments()</td>
<td>A representation of the current global configuration.</td>
</tr>
<tr>
<td>global_repr()</td>
<td></td>
</tr>
</tbody>
</table>

get_config

cqengine.config.get_config(*, hostname: Optional[str] = None, local_options: Dict[str, Any] = None) → cqengine.config.JobConfig

Returns the configuration key for cqengine.

get_provenance_augments

cqengine.config.get_provenance_augments() → Dict[str, str]

global_repr

cqengine.config.global_repr() → str

A representation of the current global configuration.
Classes

**NodeDescriptor**(data)  Description of an individual node

**NodeDescriptor**

class qcengine.config.NodeDescriptor(**data: Dict[str, Any])**

Bases: pydantic.main.BaseModel

Description of an individual node

Class Inheritance Diagram

BaseModel → NodeDescriptor

4.5.4 qcengine.util Module

Several import utilities

Functions

```python
compute_wrapper([capture_output, raise_error]) → Dict[str, Any]
```

Wraps compute for timing, output capturing, and raise protection

```python
get_module_function(module, func_name[, ...]) → Callable[..., Any]
```

Obtains a function from a given string

```python
model_wrapper(input_data, model) → Dict[str, Any]
```

Wrap input data in the given model, or return a controlled error

```python
handle_output_metadata(output_data, metadata) → Dict[str, Any]
```

Fuses general metadata and output together.

**compute_wrapper**

qcengine.util.compute_wrapper(capture_output: bool = True, raise_error: bool = False) → Dict[str, Any]

Wraps compute for timing, output capturing, and raise protection

**get_module_function**

qcengine.util.get_module_function(module: str, func_name: str, subpackage=None) → Callable[..., Any]

Obtains a function from a given string
Parameters

- **module (str)** – The module to pull the function from
- **func_name (str)** – The name of the function to acquire, can be in a subpackage
- **subpackage (None, optional)** – Explicitly import a subpackage if required

**Returns** ret – The requested functions

**Return type** function

**Example**

```python
# Import numpy.linalg.eigh f = get_module_function("numpy", "linalg.eigh") f(np.ones((2, 2)))
```

**model_wrapper**

```python
cqengine.util.model_wrapper(input_data: Dict[str, Any], model: BaseModel) → BaseModel
Wrap input data in the given model, or return a controlled error
```

**handle_output_metadata**

```python
cqengine.util.handle_output_metadata(output_data: Union[Dict[str, Any], BaseModel], metadata: Dict[str, Any], raise_error: bool = False, return_dict: bool = True) → Union[Dict[str, Any], BaseModel]
Fuses general metadata and output together.

**Returns** result – Output type depends on return_dict or a dict if an error was generated in model construction

**Return type** dict or pydantic.models.Result
```

### 4.5.5 qcengine.programs Package

**Functions**

- **get_program (name[, check])** Returns a program’s executor class
- **list_all_programs()** List all programs registered by QCEngine.
- **list_available_programs()** List all programs that can be executed (found) by QCEngine.
- **register_program(entry_point)** Register a new ProgramHarness with QCEngine.
- **unregister_program(name)** Unregisters a given program.

**get_program**

```python
cqengine.programs.get_program(name: str, check: bool = True) → ProgramHarness
Returns a program’s executor class
```

**Parameters**

- **check**: True Do raise error if program not found. **False** is handy for the specialized case of calling non-execution methods (like parsing for testing) on the returned **Harness**.
list_all_programs

cqengine.programs.list_all_programs() \rightarrow Set[str]
List all programs registered by QCEngine.

list_available_programs

cqengine.programs.list_available_programs() \rightarrow Set[str]
List all programs that can be executed (found) by QCEngine.

register_program

cqengine.programs.register_program(entry_point: ProgramHarness) \rightarrow None
Register a new ProgramHarness with QCEngine.

unregister_program

cqengine.programs.unregister_program(name: str) \rightarrow None
Unregisters a given program.

Classes

ProgramHarness(**kwargs)

ProgramHarness

class cqengine.programs.ProgramHarness(**kwargs)
    Bases: pydantic.main.BaseModel, abc.ABC

Class Inheritance Diagram
4.6 Changelog

4.6.1 v0.11.0 / 2019-10-01

New Features

- (GH#162) Adds a test to take advantage of Elemental’s Protocols. Although this PR does not technically change anything in Engine, bumping the minor version here allows upstream programs to note when this feature was available because the minimum version dependency on Elemental has been bumped as well.

Enhancements

- (GH#143) Updates to Entos and Molpro to allow Entos to execute functions from the Molpro Harness. Also helps the two drivers to conform to GH#86.
- (GH#145, GH#148) Initial CLI tests have been added to help further ensure Engine is running proper.
- (GH#149) The GAMESS Harness has been improved by adding testing.
- (GH#150, GH#153) TorchANI has been improved by adding a Hessian driver to it and additional information is returned in the extra field when energy is the driver. This also bumped the minimum version of TorchANI Engine supports from 0.5 to 0.9.
- (GH#154) Molpro’s harness has been improved to support callinfo_X properties, unrestricted HF and DFT calculations, and the initial support for parsing local correlation calculations.
- (GH#158) Entos’ output parsing has been improved to read the json dictionary produced by the program directly. Also updates the input file generation.
- (GH#161) Updates MOPAC to have more sensible quantum-chemistry like keywords by default.

Bug Fixes

- (GH#156) Fixed a compatibility bug in specific version of Intel-OpenMP by skipping version 2019.5-281.
- (GH#161) Improved error handling in MOPAC if the execution was incorrect.

4.6.2 v0.10.0 / 2019-08-25

New Features

- (GH#132) Expands CLI for info, run, and run-procedure options.
- (GH#137) A new CI pipeline through Azure has been developed which uses custom, private Docker images to house non-public code which will enable us to test Engine through integrated CI on these codes securely.
- (GH#140) GAMESS, CFOUR, NWChem preliminary implementations.

Enhancements

- (GH#138) Documentation on Azure triggers.
- (GH#139) Overhauls install documentation and clearly defines dev install vs production installs.
4.6.3 v0.9.0 / 2019-08-14

New Features

- (GH#120) Engine now takes advantage of Elemental’s new Msgpack serialization option for Models. Serialization defaults to msgpack when available (conda install msgpack-python [-c conda-forge]), falling back to JSON otherwise. This results in substantial speedups for both serialization and deserialization actions and should be a transparent replacement for users within Engine and Elemental themselves.

Enhancements

- (GH#112) The MolproHarness has been updated to handle DFT and CCSD(T) energies and gradients.
- (GH#116) An environment context manager has been added to catch NumPy style parallelization with Python functions.
- (GH#117) MOPAC and DFTD3 can now accept an extras field which can pass around additional data, conforming to the rest of the Harnesses.
- (GH#119) Small visual improvements to the docs have been made.
- (GH#120) Lists inside models are now generally converted to numpy arrays for internal storage to maximize the benefit of the new Msgpack feature from Elemental.
- (GH#133) The GAMESS Harness now collects the CCSD as part of its output.

Bug Fixes

- (GH#127) Removed unused imports from the NWChem Harvester module.
- (GH#129) Missing type hints from the MolproHarness have been added.
- (GH#131) A code formatting redundancy in the GAMESS input file parser has been removed.

4.6.4 v0.8.2 / 2019-07-25

Bug Fixes

- (GH#114) Make compute and compute_procedure not have required kwargs while debugging a Fractal serialization issue. This is intended to be a temporary change and likely reverted in a later release.

4.6.5 v0.8.1 / 2019-07-22

Enhancements

- (GH#110) Psi4’s auto-retry exception handlers now catch more classes of random errors

Bug Fixes

- (GH#109) Geometric auto-retry settings now correctly propagate through the base code.
4.6.6 v0.8.0 / 2019-07-19

New Features

- (GH#95, GH#96, GH#97, and GH#98) The NWChem interface from QCDB has been added. Thanks to @violacebelles and @jygrace for this addition!
- (GH#100) The MOPAC interface has now been added to QC Engine thanks help to from @godotalgorithm.

Enhancements

- (GH#94) The gradient and molecule parsed from a GAMESS calculation output file are now returned in `parse_output`
- (GH#101) Enabled extra files in TeraChem scratch folder to be requested by users, collected after program execution, and recorded in the `Result` object as extras.
- (GH#103) Random errors can now be retried a finite, controllable number of times (current default is zero retries). Geometry optimizations automatically set retries to 2. This only impacts errors which are categorized as `RandomError` by QC Engine and all other errors are raised as normal.

Bug Fixes

- (GH#99) QC Engine now manages an explicit folder for each `Psi4` job to write into and passes the scratch directory via `-s` command line. This resolves a key mismatch which could cause an error.
- (GH#102) DFTD3 errors are now correctly returned as a `FailedOperation` instead of a raw `dict`.

4.6.7 v0.7.1 / 2019-06-18

Bug Fixes

- (GH#92) Added an `__init__.py` file to the `programs/tests` directory so they are correctly bundled with the package.

4.6.8 v0.7.0 / 2019-06-17

Breaking Changes

- (GH#85) The resource file `programs.dftd3.dashparam.py` has relocated and renamed to `programs.empirical_dispersion_resources.py`.
- (GH#89) Function `util.execute` forgot str argument `scratch_location` and learned `scratch_directory` in the same role of existing directory within which temporary directories are created and cleaned up. Non-user-facing function `util.scratch_directory` renamed to `util.temporary_directory`.

New Features

- (GH#60) WIP: QC Engine interface to GAMESS can run the program (after light editing of rungms) and parse selected output (HF, CC, FCI) into QC Schema.
• (GH#73) WIP: QCEngine interface to CFOUR can run the program and parse a variety of output into QC-Schema.

• (GH#59, GH#71, GH#75, GH#76, GH#78, GH#88) Molpro improvements: Molpro can be run by QCEngine; and the input generator and output parser now supports CCSD energy and gradient calculations. Large thanks to @srl for many of the improvements.

• (GH#69) Custom Exceptions have been added to QCEngine’s returns which will make parsing and diagnosing them easier and more programmatic for codes which invoke QCEngine. Thanks to @dgasmith for implementation.

• (GH#82) QCEngine interface to entos can create input files (dft energy and gradients), run the program, and parse the output.

• (GH#85) MP2D interface switched to upstream repo (https://github.com/Chandemonium/MP2D v1.1) and now produces correct analytic gradients.

Enhancements

• (GH#62, GH#67, GH#83) A large block of TeraChem improvements thanks to @ffangliu contributions. Changed the input parser to call qcelemental_to_string method with bohr unit, improved output of parser to turn stdout into Result, and modified how version is parsed.

• (GH#63) QCEngine functions util.which, util.which_version, util.parse_version, and util.safe_version removed after migrating to QCElemental.

• (GH#65) Torchani can now handle the ANI1-x and ANI1-ccx models. Credit to @dgasmith for implementation.

• (GH#74) Removes caching and reduces pytorch overhead from Travis CI. Credit to @dgasmith for implementation.

• (GH#77) Rename ProgramExecutor to ProgramHarness and BaseProcedure to ProcedureHarness.

• (GH#77) Function util.execute(..., outfiles=[]) learned to collect output files matching a globbed filename.

• (GH#81) Function util.execute learned list argument as_binary to handle input or output files as binary rather than string.

• (GH#81) Function util.execute learned bool argument scratch_exist_ok to run in a preexisting directory. This is handy for stringing together execute calls.

• (GH#84) Function util.execute learned str argument scratch_suffix to identify temp dictionaries for debugging.

• (GH#90) DFTD3 now supports preliminary parameters for zero and Becke-Johnson damping to use with SAPT0-D.

Bug Fixes

• (GH#80) Fix “psi4:qvars” handling for older Psi4 versions.

4.6.9 v0.6.4 / 2019-03-21
Bug Fixes

- (GH#54) Psi4’s Engine implementation now checks its key words in a case insensitive way to give the same value whether you called Psi4 or Engine to do the compute.
- (GH#55) Fixed an error handling routine in Engine to match Psi4.
- (GH#56) Complex inputs are now handled better through Psi4’s wrapper which caused Engine to hang while trying to write to `stdout`.

4.6.10 v0.6.3 / 2019-03-15

New Features

- (GH#28) TeraChem is now a registered executor in Engine! Thanks to @ffangliu for implementing.
- (GH#46) MP2D is now a registered executor in Engine! Thanks to @loriab for implementing.

Enhancements

- (GH#46) dftd3’s workings received an overhaul. The `mol` keyword has been replaced with `dtype=2`, full Psi4 support is now provided, and an MP2D interface has been added.

Bug Fixes

- (GH#50 and GH#51) Executing Psi4 on a single node with multiprocessing is more stable because Psi4 temps are moved to scratch directories. This behavior is now better documented with an example as well.
- (GH#52) Psi4 calls are now executed through the `subprocess` module to prevent possible multiprocessing issues and memory leak after thousands of runs. A trade off is this adds about 0.5 seconds to task start-up, but its safe. A future Psi4 release will correct this issue and the change can be reverted.

4.6.11 v0.6.2 / 2019-03-07

Enhancements

- (GH#38 and GH#39) Documentation now pulls from the custom QC Archive Sphinx Theme, but can fall back to the standard RTD theme. This allows all docs across QCA to appear consistent with each other.
- (GH#43) Added a base model for all `Procedure` objects to derive from. This allows procedures’ interactions with compute programs to be more unified. This PR also ensured GeomeTRIC provides Provenance information.

Bug Fixes

- (GH#40) This PR improved numerous back-end and testing quality of life aspects. Fixed `setup.py` to call `pytest` instead of `unittest` when running tests on install. Some conda packages for Travis-CI are cached to reduce the download time of the larger computation codes. Psi4 is now pinned to the 1.3 version to fix build-level pin of libint. Conda-build recipe removed to avoid possible confusion for everyone who isn’t a Conda-Forge recipe maintainer. Tests now rely exclusively on the `conda env` setups.
4.6.12 v0.6.1 / 2019-02-20

Bug Fixes

• (GH#37) Fixed an issue where RDKit methods were not case agnostic.

4.6.13 v0.6.0 / 2019-02-28

Breaking Changes

• (GH#36) **breaking change** Model objects are returned by default rather than a dictionary.

New Features

• (GH#18) Add the dftd3 program to available computers.
• (GH#29) Adds preliminary support for the Molpro compute engine.
• (GH#31) Moves all computation to ProgramExecutor to allow for a more flexible input generation, execution, output parsing interface.
• (GH#32) Adds a general execute process which safely runs subprocess jobs.

Enhancements

• (GH#33) Moves the dftd3 executor to the new ProgramExecutor interface.
• (GH#34) Updates models to the more strict QCElemental v0.3.0 model classes.
• (GH#35) Updates CI to avoid pulling CUDA libraries for torchani.
• (GH#36) First pass at documentation.

4.6.14 v0.5.2 / 2019-02-13

Enhancements

• (GH#24) Improves load times dramatically by delaying imports and cpuutils.
• (GH#25) Code base linting.
• (GH#30) Ensures Psi4 output is already returned and Pydantic v0.20+ changes.

4.6.15 v0.5.1 / 2019-01-29

Enhancements

• (GH#22) Compute results are now returned as a dict of Python Primals which have been serialized-deserialized through Pydantic instead of returning un-processed Python objects or json-compatible string.
New Features

- (GH#8) Adds the TorchANI program for ANI-1 like energies and potentials.
- (GH#16) Adds QCElemental models based off QCSchema to QCEngine for both validation and object-based manipulation of input and output data.

Enhancements

- (GH#14) Migrates option to Pydantic objects for validation and creation.
- (GH#14) Introduces NodeDescriptor (for individual node description) and JobConfig (individual job configuration) objects.
- (GH#17) NodeDescriptor overhauled to work better with Parsl/Balsam/Dask/etc.
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