pickle — Object Serialization

Purpose: Object serialization

The `pickle` module implements an algorithm for turning an arbitrary Python object into a series of bytes. This process is also called *serializing* the object. The byte stream representing the object can then be transmitted or stored, and later reconstructed to create a new object with the same characteristics.

Warning

The documentation for `pickle` makes clear that it offers no security guarantees. In fact, unpickling data can execute arbitrary code. Be careful using `pickle` for inter-process communication or data storage, and do not trust data that cannot be verified as secure. See the `hmac` module for an example of a secure way to verify the source of a pickled data source.

Encoding and Decoding Data in Strings

This first example Uses `dumps()` to encode a data structure as a string, then prints the string to the console. It uses a data structure made up of entirely built-in types. Instances of any class can be pickled, as will be illustrated in a later example.

```
# pickle_string.py

import pickle
import pprint

data = [{'a': 'A', 'b': 2, 'c': 3.0}]
print('DATA:', end=' ')
pprint.pprint(data)

data_string = pickle.dumps(data)
print('PICKLE: {!r}'.format(data_string))
```

By default, the pickle will be written in a binary format most compatible when sharing between Python 3 programs.

```
$ python3 pickle_string.py

DATA: [{'a': 'A', 'b': 2, 'c': 3.0}]
PICKLE: b'\x80\x03]q\x00}q\x01(X\x01\x00\x00\x00cq\x02G@\x08\x00
\x00\x00\x00\x00\x00X\x01\x00\x00\x00bq\x03K\x02X\x01\x00\x00\x0
0aq\x04X\x01\x00\x00\x00Aq\x05ua.'
```

After the data is serialized, it can be written to a file, socket, pipe, etc. Later, the file can be read and the data unpickled to construct a new object with the same values.

```
# pickle_unpickle.py

import pickle
import pprint

data1 = [{'a': 'A', 'b': 2, 'c': 3.0}]
print('BEFORE: ', end=' ')
pprint.pprint(data1)

data1_string = pickle.dumps(data1)

data2 = pickle.loads(data1_string)
print('AFTER : ', end=' ')
pprint.pprint(data2)

print('SAME? :', (data1 is data2))
print('EQUAL?:', (data1 == data2))
```

The newly constructed object is equal to, but not the same object as, the original.

```
$ python3 pickle_unpickle.py

BEFORE:  [{'a': 'A', 'b': 2, 'c': 3.0}]
AFTER :  [{'a': 'A', 'b': 2, 'c': 3.0}]
SAME? : False
EQUAL?: True
```

Working with Streams

In addition to `dumps()` and `loads()`, `pickle` provides convenience functions for working with file-like streams. It is possible to write multiple objects to a stream, and then read them from the stream without knowing in advance how many objects are written, or how big they are.

```
# pickle_stream.py

import io
import pickle
import pprint


class SimpleObject:

    def __init__(self, name):
        self.name = name
        self.name_backwards = name[::-1]
        return


data = []
data.append(SimpleObject('pickle'))
data.append(SimpleObject('preserve'))
data.append(SimpleObject('last'))

# Simulate a file.
out_s = io.BytesIO()

# Write to the stream
for o in data:
    print('WRITING : {} ({})'.format(o.name, o.name_backwards))
    pickle.dump(o, out_s)
    out_s.flush()

# Set up a read-able stream
in_s = io.BytesIO(out_s.getvalue())

# Read the data
while True:
    try:
        o = pickle.load(in_s)
    except EOFError:
        break
    else:
        print('READ    : {} ({})'.format(
            o.name, o.name_backwards))
```

The example simulates streams using two `BytesIO` buffers. The first receives the pickled objects, and its value is fed to a second from which `load()` reads. A simple database format could use pickles to store objects, too. The `shelve` module is one such implementation.

```
$ python3 pickle_stream.py

WRITING : pickle (elkcip)
WRITING : preserve (evreserp)
WRITING : last (tsal)
READ    : pickle (elkcip)
READ    : preserve (evreserp)
```

```
READ    : last (tsal)
```

Besides storing data, pickles are handy for inter-process communication. For example, `os.fork()` and `os.pipe()` can be used to establish worker processes that read job instructions from one pipe and write the results to another pipe. The core code for managing the worker pool and sending jobs in and receiving responses can be reused, since the job and response objects do not have to be based on a particular class. When using pipes or sockets, do not forget to flush after dumping each object, to push the data through the connection to the other end. See the `multiprocessing` module for a reusable worker pool manager.

Problems Reconstructing Objects

When working with custom classes, the class being pickled must appear in the namespace of the process reading the pickle. Only the data for the instance is pickled, not the class definition. The class name is used to find the constructor to create the new object when unpickling. The following example writes instances of a class to a file.

```
# pickle_dump_to_file_1.py

import pickle
import sys


class SimpleObject:

    def __init__(self, name):
        self.name = name
        l = list(name)
        l.reverse()
        self.name_backwards = ''.join(l)


if __name__ == '__main__':
    data = []
    data.append(SimpleObject('pickle'))
    data.append(SimpleObject('preserve'))
    data.append(SimpleObject('last'))

    filename = sys.argv[1]

    with open(filename, 'wb') as out_s:
        for o in data:
            print('WRITING: {} ({})'.format(
                o.name, o.name_backwards))
            pickle.dump(o, out_s)
```

When run, the script creates a file based on the name given as argument on the command line.

```
$ python3 pickle_dump_to_file_1.py test.dat

WRITING: pickle (elkcip)
WRITING: preserve (evreserp)
WRITING: last (tsal)
```

A simplistic attempt to load the resulting pickled objects fails.

```
# pickle_load_from_file_1.py

import pickle
import pprint
import sys

filename = sys.argv[1]

with open(filename, 'rb') as in_s:
    while True:
        try:
            o = pickle.load(in_s)
        except EOFError:
            break
        else:
```

```
            print('READ: {} ({})'.format(
                o.name, o.name_backwards))
```

This version fails because there is no `SimpleObject` class available.

```
$ python3 pickle_load_from_file_1.py test.dat

Traceback (most recent call last):
  File "pickle_load_from_file_1.py", line 15, in <module>
    o = pickle.load(in_s)
AttributeError: Can't get attribute 'SimpleObject' on <module '_
_main__' from 'pickle_load_from_file_1.py'>
```

The corrected version, which imports `SimpleObject` from the original script, succeeds. Adding this import statement to the end of the import list allows the script to find the class and construct the object.

```
from pickle_dump_to_file_1 import SimpleObject
```

Running the modified script now produces the desired results.

```
$ python3 pickle_load_from_file_2.py test.dat

READ: pickle (elkcip)
READ: preserve (evreserp)
READ: last (tsal)
```

Unpicklable Objects

Not all objects can be pickled. Sockets, file handles, database connections, and other objects with runtime state that depends on the operating system or another process may not be able to be saved in a meaningful way. Objects that have non-picklable attributes can define `__getstate__()` and `__setstate__()` to return a subset of the state of the instance to be pickled.

The `__getstate__()` method must return an object containing the internal state of the object. One convenient way to represent that state is with a dictionary, but the value can be any picklable object. The state is stored, and passed to `__setstate__()` when the object is loaded from the pickle.

```
# pickle_state.py

import pickle


class State:

    def __init__(self, name):
        self.name = name

    def __repr__(self):
        return 'State({!r})'.format(self.__dict__)


class MyClass:

    def __init__(self, name):
        print('MyClass.__init__({})'.format(name))
        self._set_name(name)

    def _set_name(self, name):
        self.name = name
        self.computed = name[::-1]

    def __repr__(self):
        return 'MyClass({!r}) (computed={!r})'.format(
            self.name, self.computed)

    def __getstate__(self):
        state = State(self.name)
        print('__getstate__ -> {!r}'.format(state))
        return state
```

```
    def __setstate__(self, state):
        print('__setstate__({!r})'.format(state))
        self._set_name(state.name)


inst = MyClass('name here')
print('Before:', inst)

dumped = pickle.dumps(inst)

reloaded = pickle.loads(dumped)
print('After:', reloaded)
```

This example uses a separate `State` object to hold the internal state of `MyClass`. When an instance of `MyClass` is loaded from a pickle, `__setstate__()` is passed a `State` instance which it uses to initialize the object.

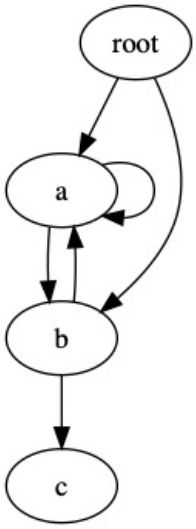
```
$ python3 pickle_state.py

MyClass.__init__(name here)
Before: MyClass('name here') (computed='ereh eman')
__getstate__ -> State({'name': 'name here'})
__setstate__(State({'name': 'name here'}))
After: MyClass('name here') (computed='ereh eman')
```

Warning

If the return value is false, then `__setstate__()` is not called when the object is unpickled.

Circular References

The pickle protocol automatically handles circular references between objects, so complex data structures do not need any special handling. Consider the directed graph in the figure. It includes several cycles, yet the correct structure can be pickled and then reloaded.



Pickling a Data Structure With Cycles

```
# pickle_cycle.py

import pickle


class Node:
    """A simple digraph
    """
    def __init__(self, name):
        self.name = name
        self.connections = []
```

```
    def add_edge(self, node):
        "Create an edge between this node and the other."
        self.connections.append(node)

    def __iter__(self):
        return iter(self.connections)


def preorder_traversal(root, seen=None, parent=None):
    """Generator function to yield the edges in a graph.
    """
    if seen is None:
        seen = set()
    yield (parent, root)
    if root in seen:
        return
    seen.add(root)
    for node in root:
        recurse = preorder_traversal(node, seen, root)
        for parent, subnode in recurse:
            yield (parent, subnode)


def show_edges(root):
    "Print all the edges in the graph."
    for parent, child in preorder_traversal(root):
        if not parent:
            continue
        print('{:>5} -> {:>2} ({})'.format(
            parent.name, child.name, id(child)))


# Set up the nodes.
root = Node('root')
a = Node('a')
b = Node('b')
c = Node('c')

# Add edges between them.
root.add_edge(a)
root.add_edge(b)
a.add_edge(b)
b.add_edge(a)
b.add_edge(c)
a.add_edge(a)

print('ORIGINAL GRAPH:')
show_edges(root)

# Pickle and unpickle the graph to create
# a new set of nodes.
dumped = pickle.dumps(root)
reloaded = pickle.loads(dumped)

print('\nRELOADED GRAPH:')
show_edges(reloaded)
```

The reloaded nodes are not the same object, but the relationship between the nodes is maintained and only one copy of the object with multiple references is reloaded. Both of these statements can be verified by examining the `id()` values for the nodes before and after being passed through pickle.

```
$ python3 pickle_cycle.py

ORIGINAL GRAPH:
 root ->  a (4315798272)
    a ->  b (4315798384)
    b ->  a (4315798272)
    b ->  c (4315799112)
    a ->  a (4315798272)
 root ->  b (4315798384)

RELOADED GRAPH:
```

```
RELOADED GRAPH:
 root ->  a (4315904096)
    a ->  b (4315904152)
    b ->  a (4315904096)
    b ->  c (4315904208)
    a ->  a (4315904096)
 root ->  b (4315904152)
```

See also

- Standard library documentation for pickle
- **PEP 3154** – Pickle protocol version 4
- `shelve` – The `shelve` module uses `pickle` to store data in a DBM database.
- Pickle: An interesting stack language. – by Alexandre Vassalotti

Data Persistence and Exchange

shelve — Persistent Storage of Objects

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This page was last updated 2016-12-29.

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The output from all the example programs from PyMOTW-3 has been generated with Python 3.7.1, unless otherwise noted. Some of the features described here may not be available in earlier versions of Python.

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