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# Porting Extension Modules to Python 3

*Release 2.7.13*

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December 17, 2016

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### Abstract

Although changing the C-API was not one of Python 3's objectives, the many Python-level changes made leaving Python 2's API intact impossible. In fact, some changes such as `int()` and `long()` unification are more obvious on the C level. This document endeavors to document incompatibilities and how they can be worked around.

## 1 Conditional compilation

The easiest way to compile only some code for Python 3 is to check if `PY_MAJOR_VERSION` is greater than or equal to 3.

```
#if PY_MAJOR_VERSION >= 3
#define IS_PY3K
#endif
```

API functions that are not present can be aliased to their equivalents within conditional blocks.

## 2 Changes to Object APIs

Python 3 merged together some types with similar functions while cleanly separating others.

### 2.1 str/unicode Unification

Python 3's `str()` type is equivalent to Python 2's `unicode()`; the C functions are called `PyUnicode_*` for both. The old 8-bit string type has become `bytes()`, with C functions called `PyBytes_*`. Python 2.6 and later provide a compatibility header, `bytesobject.h`, mapping `PyBytes` names to `PyString` ones. For best compatibility with Python 3, `PyUnicode` should be used for textual data and `PyBytes` for binary data. It's also important to remember that `PyBytes` and `PyUnicode` in Python 3 are not interchangeable like `PyString` and `PyUnicode` are in Python 2. The following example shows best practices with regards to `PyUnicode`, `PyString`, and `PyBytes`.

```
#include "stdlib.h"
#include "Python.h"
#include "bytesobject.h"

/* text example */
static PyObject *
say_hello(PyObject *self, PyObject *args) {
    PyObject *name, *result;

    if (!PyArg_ParseTuple(args, "U:say_hello", &name))
        return NULL;

    result = PyUnicode_FromFormat("Hello, %S!", name);
    return result;
}

/* just a forward */
static char * do_encode(PyObject *);

/* bytes example */
static PyObject *
encode_object(PyObject *self, PyObject *args) {
    char *encoded;
    PyObject *result, *myobj;

    if (!PyArg_ParseTuple(args, "O:encode_object", &myobj))
        return NULL;

    encoded = do_encode(myobj);
    if (encoded == NULL)
        return NULL;
    result = PyBytes_FromString(encoded);
    free(encoded);
    return result;
}
```

## 2.2 long/int Unification

Python 3 has only one integer type, `int()`. But it actually corresponds to Python 2's `long()` type—the `int()` type used in Python 2 was removed. In the C-API, `PyInt_*` functions are replaced by their `PyLong_*` equivalents.

## 3 Module initialization and state

Python 3 has a revamped extension module initialization system. (See [PEP 3121](#).) Instead of storing module state in globals, they should be stored in an interpreter specific structure. Creating modules that act correctly in both Python 2 and Python 3 is tricky. The following simple example demonstrates how.

```
#include "Python.h"

struct module_state {
    PyObject *error;
};

#if PY_MAJOR_VERSION >= 3
#define GETSTATE(m) ((struct module_state*)PyModule_GetState(m))
#else
#define GETSTATE(m) (&_state)
static struct module_state _state;
#endif

static PyObject *
error_out(PyObject *m) {
    struct module_state *st = GETSTATE(m);
    PyErr_SetString(st->error, "something bad happened");
    return NULL;
}

static PyMethodDef myextension_methods[] = {
    {"error_out", (PyCFunction)error_out, METH_NOARGS, NULL},
    {NULL, NULL}
};

#if PY_MAJOR_VERSION >= 3

static int myextension_traverse(PyObject *m, visitproc visit, void *arg) {
    Py_VISIT(GETSTATE(m)->error);
    return 0;
}

static int myextension_clear(PyObject *m) {
    Py_CLEAR(GETSTATE(m)->error);
    return 0;
}

static struct PyModuleDef moduledef = {
    PyModuleDef_HEAD_INIT,
    "myextension",
    NULL,
    sizeof(struct module_state),
    myextension_methods,
    NULL,
```

```

        myextension_traverse,
        myextension_clear,
        NULL
};

#define INITERROR return NULL

PyMODINIT_FUNC
PyInit_myextension(void)

#else
#define INITERROR return

void
initmyextension(void)
#endif
{
    #if PY_MAJOR_VERSION >= 3
        PyObject *module = PyModule_Create(&moduledef);
    #else
        PyObject *module = Py_InitModule("myextension", myextension_methods);
    #endif

    if (module == NULL)
        INITERROR;
    struct module_state *st = GETSTATE(module);

    st->error = PyErr_NewException("myextension.Error", NULL, NULL);
    if (st->error == NULL) {
        Py_DECREF(module);
        INITERROR;
    }

    #if PY_MAJOR_VERSION >= 3
        return module;
    #endif
}

```

## 4 CObject replaced with Capsule

The `Capsule` object was introduced in Python 3.1 and 2.7 to replace `CObject`. `CObjects` were useful, but the `CObject` API was problematic: it didn't permit distinguishing between valid `CObjects`, which allowed mismatched `CObjects` to crash the interpreter, and some of its APIs relied on undefined behavior in C. (For further reading on the rationale behind Capsules, please see [issue 5630](#).)

If you're currently using `CObjects`, and you want to migrate to 3.1 or newer, you'll need to switch to Capsules. `CObject` was deprecated in 3.1 and 2.7 and completely removed in Python 3.2. If you only support 2.7, or 3.1 and above, you can simply switch to `Capsule`. If you need to support Python 3.0, or versions of Python earlier than 2.7, you'll have to support both `CObjects` and Capsules. (Note that Python 3.0 is no longer supported, and it is not recommended for production use.)

The following example header file `capsulethunk.h` may solve the problem for you. Simply write your code against the `Capsule` API and include this header file after `Python.h`. Your code will automatically use Capsules in versions of Python with Capsules, and switch to `CObjects` when Capsules are unavailable.

`capsulethunk.h` simulates Capsules using `CObjects`. However, `CObject` provides no place to store the capsule's "name". As a result the simulated `Capsule` objects created by `capsulethunk.h` behave slightly differently from real Capsules. Specifically:

- The name parameter passed in to `PyCapsule_New()` is ignored.
- The name parameter passed in to `PyCapsule_IsValid()` and `PyCapsule_GetPointer()` is ignored, and no error checking of the name is performed.
- `PyCapsule_GetName()` always returns `NULL`.
- `PyCapsule_SetName()` always raises an exception and returns failure. (Since there's no way to store a name in a `CObject`, noisy failure of `PyCapsule_SetName()` was deemed preferable to silent failure here. If this is inconvenient, feel free to modify your local copy as you see fit.)

You can find `capsulethunk.h` in the Python source distribution as `Doc/includes/capsulethunk.h`. We also include it here for your convenience:

```
#ifndef __CAPSULETHUNK_H
#define __CAPSULETHUNK_H

#if ( (PY_VERSION_HEX < 0x02070000) \
    || ((PY_VERSION_HEX >= 0x03000000) \
    && (PY_VERSION_HEX < 0x03010000)) )

#define __PyCapsule_GetField(capsule, field, default_value) \
    ( PyCapsule_CheckExact(capsule) \
      ? ((PyObject *)capsule)->field \
      : (default_value) \
    ) \

#define __PyCapsule_SetField(capsule, field, value) \
    ( PyCapsule_CheckExact(capsule) \
      ? ((PyObject *)capsule)->field = value, 1 \
      : 0 \
    ) \

#define PyCapsule_Type PyObject_Type

#define PyCapsule_CheckExact(capsule) (PyObject_Check(capsule))
#define PyCapsule_IsValid(capsule, name) (PyObject_Check(capsule))

#define PyCapsule_New(pointer, name, destructor) \
    (PyObject_FromVoidPtr(pointer, destructor))

#define PyCapsule_GetPointer(capsule, name) \
    (PyObject_AsVoidPtr(capsule))

/* Don't call PyObject_SetPointer here, it fails if there's a destructor */
#define PyCapsule_SetPointer(capsule, pointer) \
    __PyCapsule_SetField(capsule, cobject, pointer)

#define PyCapsule_GetDestructor(capsule) \
    __PyCapsule_GetField(capsule, destructor)

#define PyCapsule_SetDestructor(capsule, dtor) \
    __PyCapsule_SetField(capsule, destructor, dtor)

/*
 * Sorry, there's simply no place
```

```

    * to store a Capsule "name" in a CObject.
    */
#define PyCapsule_GetName(capsule) NULL

static int
PyCapsule_SetName(PyObject *capsule, const char *unused)
{
    unused = unused;
    PyErr_SetString(PyExc_NotImplementedError,
        "can't use PyCapsule_SetName with CObjects");
    return 1;
}

#define PyCapsule_GetContext(capsule) \
    __PyCapsule_GetField(capsule, descr)

#define PyCapsule_SetContext(capsule, context) \
    __PyCapsule_SetField(capsule, descr, context)

static void *
PyCapsule_Import(const char *name, int no_block)
{
    PyObject *object = NULL;
    void *return_value = NULL;
    char *trace;
    size_t name_length = (strlen(name) + 1) * sizeof(char);
    char *name_dup = (char *)PyMem_MALLOC(name_length);

    if (!name_dup) {
        return NULL;
    }

    memcpy(name_dup, name, name_length);

    trace = name_dup;
    while (trace) {
        char *dot = strchr(trace, '.');
        if (dot) {
            *dot++ = '\0';
        }

        if (object == NULL) {
            if (no_block) {
                object = PyImport_ImportModuleNoBlock(trace);
            } else {
                object = PyImport_ImportModule(trace);
                if (!object) {
                    PyErr_Format(PyExc_ImportError,
                        "PyCapsule_Import could not "
                        "import module \"%s\"", trace);
                }
            }
        } else {
            PyObject *object2 = PyObject_GetAttrString(object, trace);
            Py_DECREF(object);
        }
    }
}

```

```

        object = object2;
    }
    if (!object) {
        goto EXIT;
    }

    trace = dot;
}

if (PyCObject_Check(object)) {
    PyCObject *cobject = (PyCObject *)object;
    return_value = cobject->cobject;
} else {
    PyErr_Format(PyExc_AttributeError,
        "PyCapsule_Import \"%s\" is not valid",
        name);
}

EXIT:
Py_XDECREF(object);
if (name_dup) {
    PyMem_FREE(name_dup);
}
return return_value;
}

#endif /* #if PY_VERSION_HEX < 0x02070000 */

#endif /* __CAPSULETHUNK_H */

```

## 5 Other options

If you are writing a new extension module, you might consider [Cython](#). It translates a Python-like language to C. The extension modules it creates are compatible with Python 3 and Python 2.

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