gRPC Python, C Extensions, and AsyncIO

Discord channel: #talk-grpc-and-asyncio
About us

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  - Maintainer of gRPC Python

- **Pau Freixes**
  - Former Senior Software Engineer at Skyscanner
  - Currently at Onna.com (we are hiring!)
  - Python enthusiast, but definitely what likes most is solve problems.
  - Open source contributor: Aiohttp, emcache, etc
What is gRPC?

- RPC framework upon HTTP/2
- Fast, light-weight and feature rich:
  - Bi-directional streaming RPC
  - Client-side/Look-aside load balancing
  - Interceptors
  - ProtoBuf
  - ...
- ~400k downloads / day (grpcio)
Core and Python

- Python is a wrapper over Core
- 14 supported languages
- Benefits:
  - Better performance
  - Lower maintenance burden
- Frictions:
  - Segfaults
  - Memory leaks
  - Compilation
What’s Python C Extension?

- Module written in C/C++
- Python.h
- Complex to write:
  - Version compatibility
  - Lot’s of boilerplate
- Why?
  - Integration
  - Performance

```c
#include <Python.h>

static PyObject* hello_world(PyObject* self, PyObject* args) {
    printf("Hello World\n");
    return Py_None;
}

static PyMethodDef methods[] = {
    { "hello_world", hello_world, METH_NOARGS, "Prints hello world." },
    { NULL, NULL, 0, NULL }
};

static struct PyModuleDef hello_world_module = {
    PyModuleDef_HEAD_INIT,
    "hello_world_module",
    "Test Module",
    -1,
    methods
};

PyMODINIT_FUNC PyInit_hello_world_module(void) {
    return PyModule_Create(&hello_world_module);
}
```
What’s Python C Extension?

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- Why?
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Diagram:
- Python App
- Glue Code
- C/C++ Library

Better C++ Framework
Glue Code Generator
## Popular Gluing Approaches

<table>
<thead>
<tr>
<th>Approach</th>
<th>Pros</th>
<th>Cons</th>
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<tbody>
<tr>
<td>Pyclif</td>
<td>Straightforward template syntax</td>
<td>Needs to learn the templating language; more glue logic in C++</td>
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<tr>
<td>Pybind11</td>
<td>Portable, lightweight, header-only.</td>
<td>Requires to code in C++ (might be a plus for C++ fans)</td>
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<tr>
<td>Cython</td>
<td>Ease to develop (adopted by NumPy and SciPy).</td>
<td>Language itself is a &quot;superset&quot; of Python</td>
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</tbody>
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Other options: Ctypes, CFFI, SWIG, Boost.python
Cython in a Nutshell

import math

def am_i_prime(x: int) -> bool:
    for i in range(2, math.floor(math.sqrt(x))):
        if x % i == 0:
            return False
    return True

from libc.math cimport sqrt, floor

cdef am_i_prime(int x):
    cdef double root = sqrt(<double>x)
    for i in range(2, <int>floor(root)):
        if x % i == 0:
            return False
    return True

Python & gdb

lidi@dev:grpc$ gdb python3.7
(gdb) source /users/lidi/src/Python-3.7.0/python-gdb.py
(gdb) run _channel_ready_future_test.py
...
^C
Thread 1 "python" received signal SIGINT, Interrupt.
(gdb) py-bt
Traceback (most recent call first):
  File "/usr/local/lib/python3.7/threading.py", line 300, in wait
gotit = waiter.acquire(True, timeout)
...
  File "src/python/grpcio_tests/tests/unit/_channel_ready_future_test.py", line 97, in <module>
    unittest.main(verbosity=2)
(gdb) py-list
  299    if timeout > 0:
>300      gotit = waiter.acquire(True, timeout)
  301    else:
(gdb) print __pyx_v_self
$1 = <grpc._cython.cygrpc.CompletionQueue at remote 0x7ffff360fd50>
(gdb) bt
#22 0x0000555555568416a in PyEval_EvalFrameEx (throwflag=0,
f=Frame 0x5555555fa588, for file /usr/local/lib/python3.7/unittest/case.py, line 615...

[Read More] https://wiki.python.org/moin/DebuggingWithGdb
Non-AsyncI/O Threading Model

[Read More] https://wiki.python.org/moin/GlobalInterpreterLock
gRPC and Asyncio
Not blocking the loop, what a headache

```
response = await stub.call(request)

(event = grpc_completion_queue_next(completion_queue, 1s))
```
Not blocking the loop, what a headache

- gRPC C++ interface provided a way of installing custom IO managers
  - read, write, etc ...

- But the interface for polling gRPC events was still blocking
  - For Asyncio this was a no go.

- Other frameworks had a similar problem but managed to solve the issue
  - Gevent, by just providing its custom IO manager
  - Node.js, implicit cooperation by using same libuv loop instance behind the scenes
Not blocking the loop, what a headache

- ... and gRPC C++ introduced a new completion queue based on callbacks
  - Was originally developed for having fully asynchronous C++ implementations
- Instead of making blocking calls a callback would tell you when a gRPC event would be available.
  - This allowed us to return the control to the loop for Asyncio.
- Eureka!!!
Solution 1, our own IO manager implementation

Our first implementation looked promising, based on

- implementing our own **custom IO manager**
- using the **callback completion queue**
Making sync stack compatible with async
Sync and Async compatibility

- Synchronous stack was still there, and *it will be there for a long time*
- Sync and Async coexistence was a must
  - An async server might use a library which behind the scenes might use the synchronous version of gRPC
- How the hell this could be addressed?
Sync and Async compatibility

- Rewriting the whole sync stack on top of the async one
  - Could end up blocking the loop in anyway
  - Forced to us to rewrite a large amount of code
- Modifying the gRPC C++ implementation for allowing to have multiple IO managers running at the same time.
  - Implied many changes in the core of the gRPC which could affect other languages
- Run all gRPC IO events in a separated Asyncio thread
  - Allowed to us block the current loop (main thread)
  - The amount of changes needed was affordable
  - Doubts about how performance might be affected
Sync and Async compatibility

It worked but had a very negative impact in the performance
Solution 2, poller thread
Solution 2, poller thread implementation

- Discard the usage of the callback completion queue
- Discard the usage of an ad-hoc IO manager
- gRPC Asyncio Python application would start a separated thread for polling gRPC events
- This thread won’t use any Python object, during the polling
  - Avoid GIL contention
- Events would be added into a C++ queue
- Asyncio loop will be woken up by writing into a socket
  - Again not using any Python objects at all
Solution 2, poller thread implementation

The solution had really good benefits

- Remove the burden of having to maintain a new IO manager
- Any little detail implemented by the C++ gRPC IO manager will be there
  - Unix sockets
  - etc.
- Performance degradation affordable, still a nice boost compared to the synchronous stack.
- Eureka!
Solution 2, poller thread implementation

QPS unary sync/async/async-thread-poller

- **sync**
- **async**
- **async poller thread**

![Graph showing QPS comparison between sync, async, and async poller thread for client and server.](image-url)
Thanks!!! QA