Ensuring data integrity with asynchronous programming in a cloud IoT core
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#fleet_management #IoT
#embeded #async #programming
Our Story: Forrest and Lieutenant Dan

Backstage: Two friends working in the same start-up!
Our Story: The fellowship of the core

**Backstage:** Two friends working in the same start-up!

**Mission:** Create a fully-operational IoT Core working on fleet management.

**IoT (Internet of things):** A network of Internet connected objects, able to collect and exchange data.
Requirement 1: Send data packets from device/sensor to a server.
Requirements’ menace

Requirement 1: Send data packets from device/sensor to a server.

Component 1: Devices (*OBDII for our use case*) which get signals from vehicles and sends data packets to a server. *Plenty of devices around the web.*

Component 2: An IoT server (*IoT core*) able to save incoming data and provide it to applications. *Cheap and reliable solutions - cloud servers.*
Requirement 2: Implement some services, inside IoT core, which will save all incoming data/signals to database.
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The dark side of data

Are you sure that your incoming data packets were stored properly and in the desired format?
Scope of Data Integrity

Two basic principles:

1. Correct and not unintended storage
2. Ensure data quality

Two additional principles:

1. Services Integrity
2. Devices Integrity
The dark side of data

Are you sure that your incoming data packets were stored properly and in the desired format?
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**Idea:** Upon failure, use filesystem and temporarily save all signals into files. Then, retry to save all signals to database.

```python
while True:
    for filename in os.listdir('/dir/path'):
        with open('/dir/path/' + filename) as f:
            content = f.readlines()
            content = [path.strip('
') for x in content]
            reader = csv.reader(content)
```
The greatest teacher, failure is.

*Master Yoda, The Last Jedi*
Asynchronous, concurrent days

**Ingest Module/Device Gateway**: Connected with RabbitMQ with a publisher. If something goes wrong publish signal to *queue*. 
Asynchronous ways of Python

**Asynchronous:** The occurrence of events independent of the main program flow.

- **Instance 1**
- **Instance 2**
- **Message broker**

Request:
- Synchronous response *(instant)*

Asynchronous response from worker or thread
Concurrent ways of Python

**Concurrency:** executing multiple tasks at the same time but not necessarily simultaneously *(like example 2).*

```python
# NO CONCURRENCE
# First task
[2020-07-09 14:21:56,030] Received from: ('127.0.0.1', 39580)
[2020-07-09 14:21:56,066] Event ('127.0.0.1', 39580) Pushed Successfully to PostgreSQL
# Second task
[2020-07-09 14:21:56,067] Received from: ('127.0.0.1', 39584)
[2020-07-09 14:21:56,109] Event ('127.0.0.1', 39584) Pushed Successfully to PostgreSQL

# CONCURRENCE
# First task starts
[2020-07-09 14:21:56,030] Received from: ('127.0.0.1', 39580)
# Second task starts
[2020-07-09 14:21:56,031] Received from: ('127.0.0.1', 39584)
# First task ends
[2020-07-09 14:21:56,066] Event ('127.0.0.1', 39580) Pushed Successfully to PostgreSQL
# Second task ends
[2020-07-09 14:21:56,083] Event ('127.0.0.1', 39584) Pushed Successfully to PostgreSQL
```
Multi-ways of Python

How to achieve concurrency: Multi-threading vs Asyncio.

Thread: The smallest instance that can be managed independently.
How to achieve concurrency: Multi-threading is important to support concurrency and performance into our Ingesting part.

```python
# Start a thread pool executor with specific number of workers
# in order to avoid high amount of threads
with cf.ThreadPoolExecutor(max_workers=3) as ingest_executor:
    # signals come to ingest with sockets
    with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as gw_socket:
        gw_socket.bind((host, port))
        # Wait to port until a new signal comes
        gw_socket.listen()
        while True:
            # Accept a new signal and save it to db with a new thread.
            connection, address = gw_socket.accept()
            ingest_executor.submit(save_signal_to_db_method, connection, address)
```
Small recap

- **Python Ingest**: Small module which accepts incoming data and parses it to database.

- **Threads - Thread Pool Executor**: Multi-threading is used to our python ingest in order to achieve better performance.

- **Device Gateway**: A module which receives data packets from devices and forwards them as signals to ingest.
RabbitMQ as message broker

**RabbitMQ**: It gives your applications/modules a common platform to send and receive messages, and your messages a safe place to live until received.
Publisher

**Producer:** Able to connect with RabbitMQ and publish a message to a specific queue or exchange.

```python
import pika

def publish(self, signal):
    # We skipped try-except blocks in order to have a very simple code
    # Create connection with pika. Parameters are credentials.
    connection = pika.BlockingConnection(parameters)
    # Get a connection channel.
    channel = connection.channel()
    # Declare a new queue. If it's durable it will be there after a restart.
    channel.queue_declare(queue='queue', durable=True)
    # Publish message to rabbitmq
    properties=pika.BasicProperties(delivery_mode=2)
    channel.basic_publish(exchange='', routing_key='queue', body=signal, properties=properties)
```

- Connects with RabbitMQ
- Gets connection.channel()
- If not exists, declares queue
- Publishes message
Consumer

**Consumer**: Able to receive/consume all messages inside this queue or exchange. With aioamqp can share thread with other tasks while waiting.

```python
async def consume(**kwargs):
    ""
    Consumer written with aioamqp in order to work with asyncio.
    ""
    transport, connection = await aioamqp.connect(
        host=host, port=port, login=username,
        password=password, login_method='PLAIN')
    # some possible exceptions here
    # except aioamqp.AmqpClosedConnection
    # except ConnectionRefusedError
    
    # create a channel again in order to receive messages
    channel = await connection.channel()
    # Await for a new signal from queue
    await channel.basic_consume(callback, queue_name='events')
```

**Connects with RabbitMQ**

**Gets connection.channel()**

**Awaits for a signal**

**Pushes it back to Ingest**
Organize module

**Duty:** Schedule quality/service checks, push back every failed signal. Built with asyncio.

**Asyncio:** Useful tool which support cooperative multitasking. It gives you the advantage of concurrency inside a single thread.
Organize module

Initialize event loop: Create the event loop, gather all tasks and run it.

# Create new loop
event_loop = asyncio.new_event_loop()
# Set new loop to asyncio
asyncio.set_event_loop(event_loop)
# Gather all tasks
event_loop_tasks = asyncio.gather(
    consumer(),
    periodic_task_1(timeout),
    periodic_task_2(timeout))

Try:

# Run the loop
event_loop.run_forever()
except KeyboardInterrupt:
    event_loop_tasks.cancel()
The rise of asyncio

After the implementation of previous module the flow of our IoT Core would be like this:
Clockwork organizer

Idea 1:

Periodic quality check - Data Quality

Example case - broken gps

Catch 2 - Devices Integrity.

After some errors for the same device, notify for device check.
Idea 2:

Periodic check for services’ heartbeat. Pretty simple, though not completed, way to check for services integrity.

```python
async def check_heartbeat(timeout):
    
    """
    Checks if services are up.
    """
    services_list = [('127.0.0.1',2006),('127.0.0.1',5432)]
    while True:
        for address, port in services_list:
            # simplest way to bind with socket to port
            # in order to check if service is up
            running = bind_to_service(address, port)
            if not running:
                # Notify admin that service is down.
            else:
                # Log that everything into IoT core is ok.
                # give up execution for timeout
                await asyncio.sleep(timeout)
```
Another step forward: Merge everything into python ingest. Make message broker the actual middleman between gateway and ingest.
The artilleryman’s song

Call artillery for help: You could combine this logic with celery or other task queue software.

Before do so: *Code it, break it, smash it and practice!* **First you have to understand!**
Our Story: Endgame

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Our Story: Drop us a line!

Github Repo:

2. https://github.com/thepetk/python-ingest

Discord channel:

#talk-data-integrity-with-async