Ensuring data integrity with asynchronous programming in a cloud IoT core

Europython 2020

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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

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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.***

Requirements’ menace

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

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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.***

From theory to Python

Requirement 2: Implement some services, inside IoT core, which will save all incoming data/signals to database.

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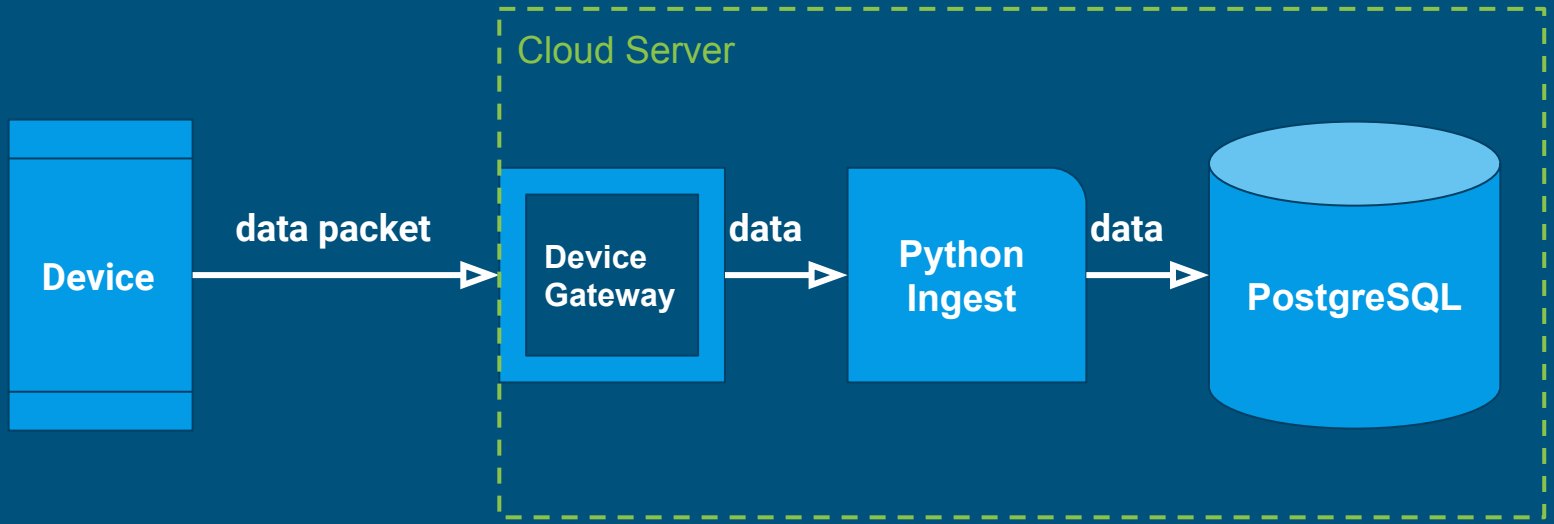

The dark side of data

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

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Idea: Upon failure, use filesystem and temporarily save all signals into files. Then, retry to save all signals to database.

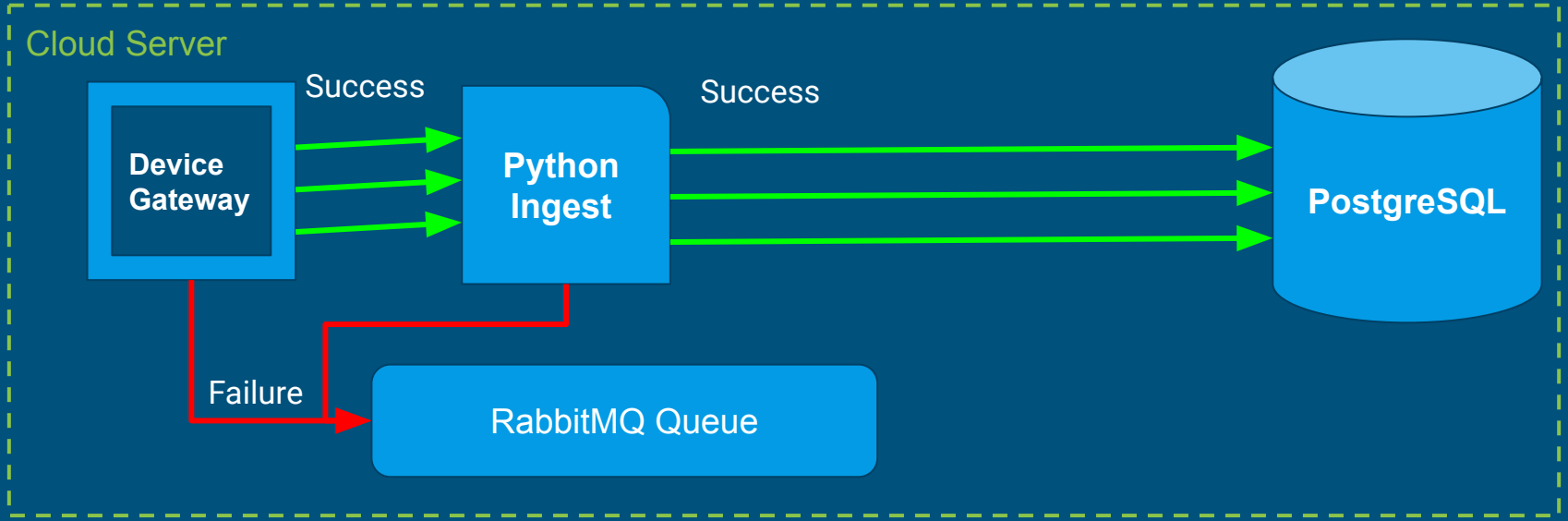
```
while True:
    for filename in os.listdir('/dir/path'):
        with open('/dir/path/' + filename) as f:
            content = f.readlines()
            content = [path.strip('\n') for x in content]
            reader = csv.reader(content)
```

The greatest teacher, failure is.

Master Yoda, The Last Jedi

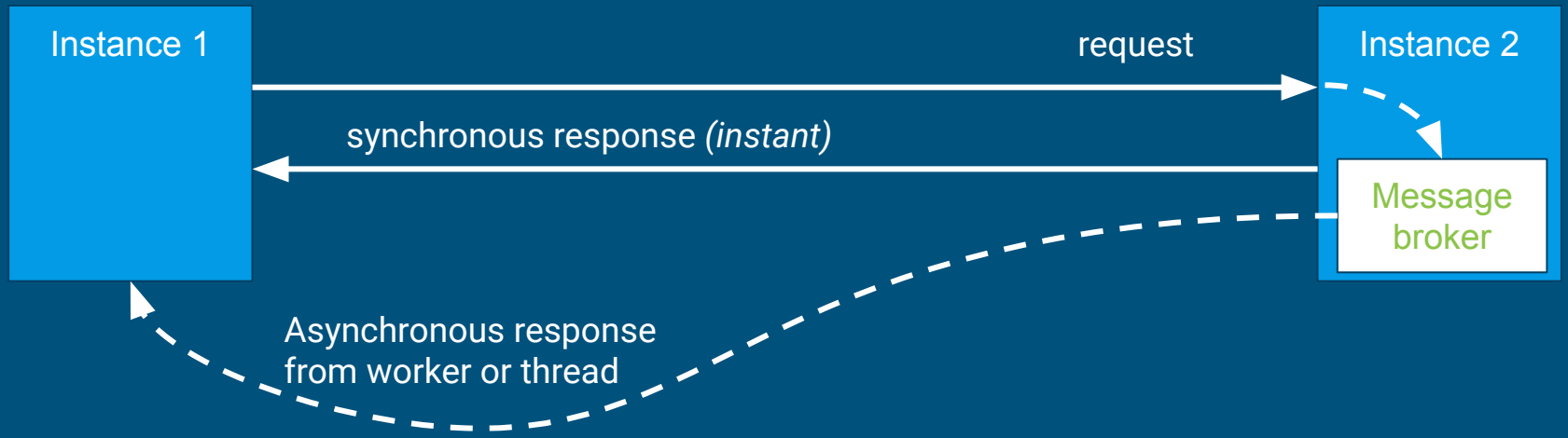
Asynchronous, concurrent days

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.



Concurrent ways of Python

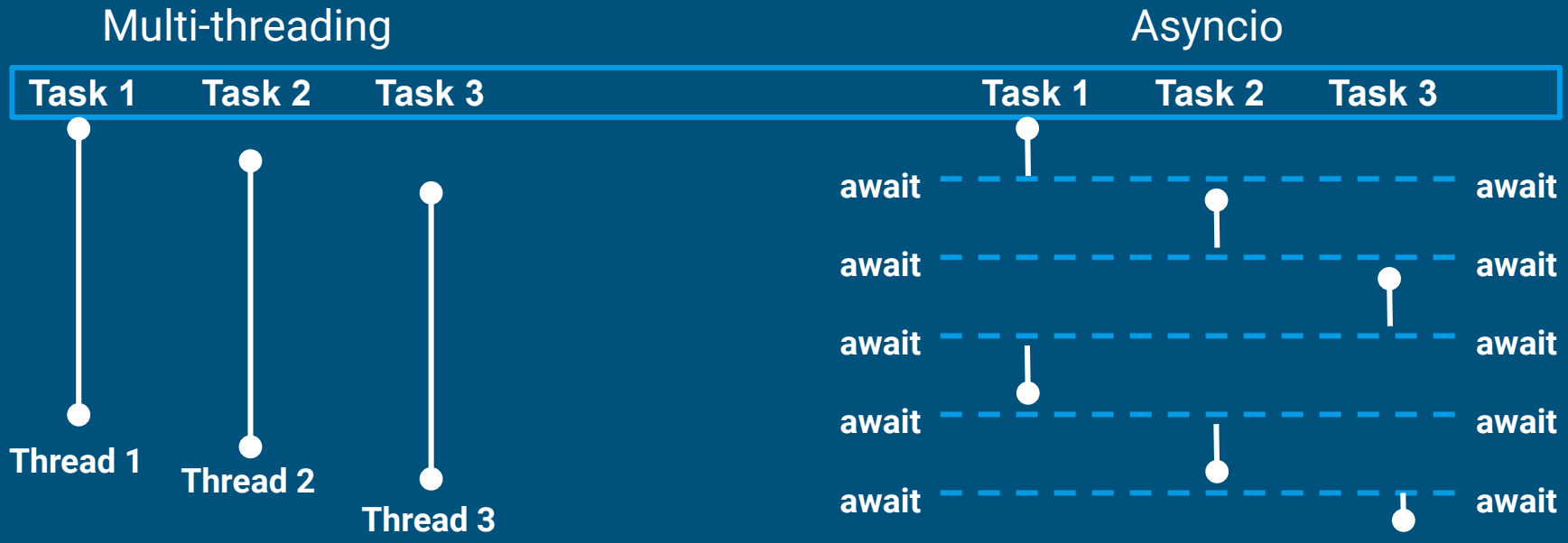
Concurrency: executing multiple tasks at the same time but not necessarily simultaneously *(like example 2)*.

```
# NO CONCURRENCY
# 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

# CONCURRENCY
# 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
```

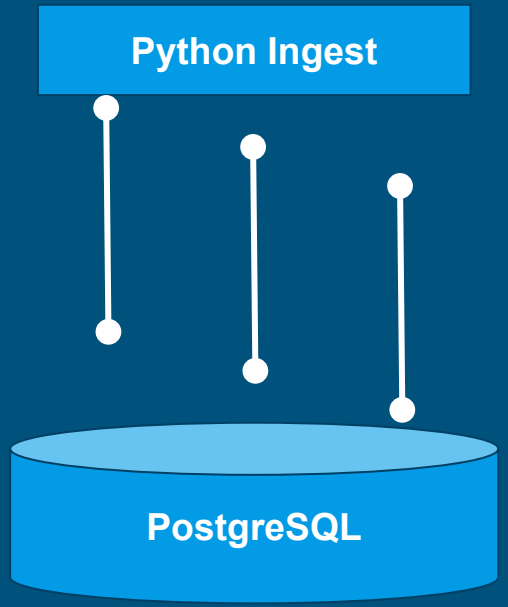
Multi-ways of Python

How to achieve concurrency: Multi-threading vs Asyncio.
Thread: The smallest instance that can be managed independently.



Multi Threading on Ingest

How to achieve concurrency: Multi-threading is important to support concurrency and performance into our Ingesting part.



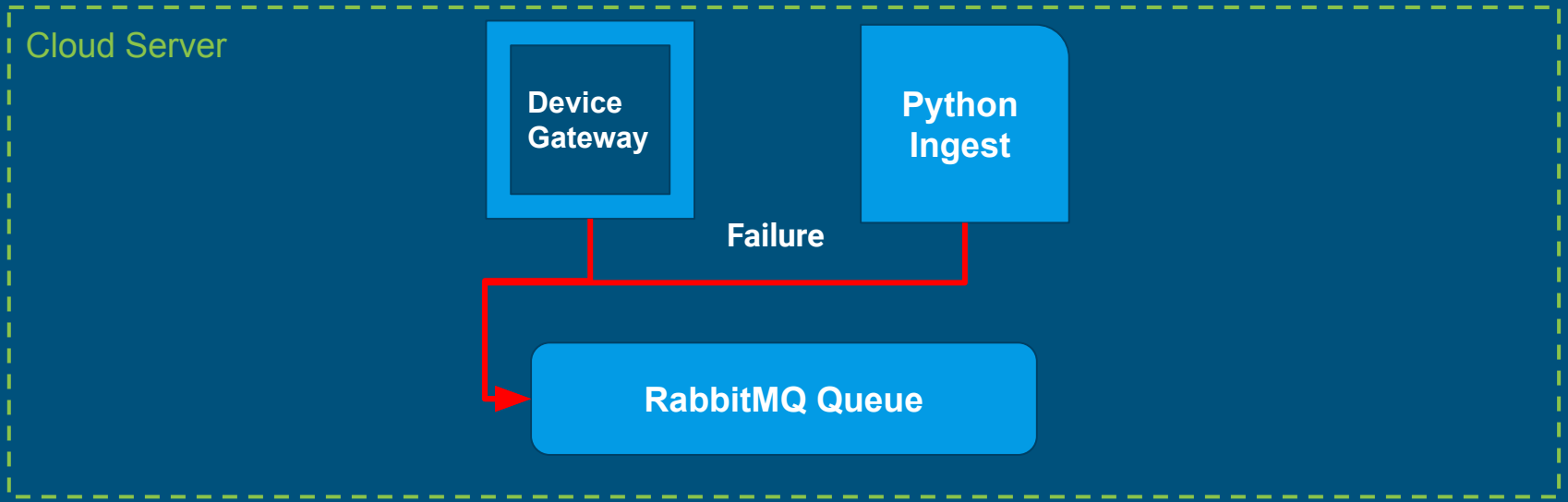

```
# Start a thread pool executor with specific number of workers
# in order to avoid high amount of threads
with cf.ThreadPoolExecutor(max_workers=3) as ingest_executor:
    # signals come to ingest with sockets
    with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as gw_socket:
        gw_socket.bind((host, port))
        # Wait to port until a 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.

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

```
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)
```

Consumer

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

- Connects with RabbitMQ
- Gets connection.channel()
- Awaits for a signal
- Pushes it back to Ingest

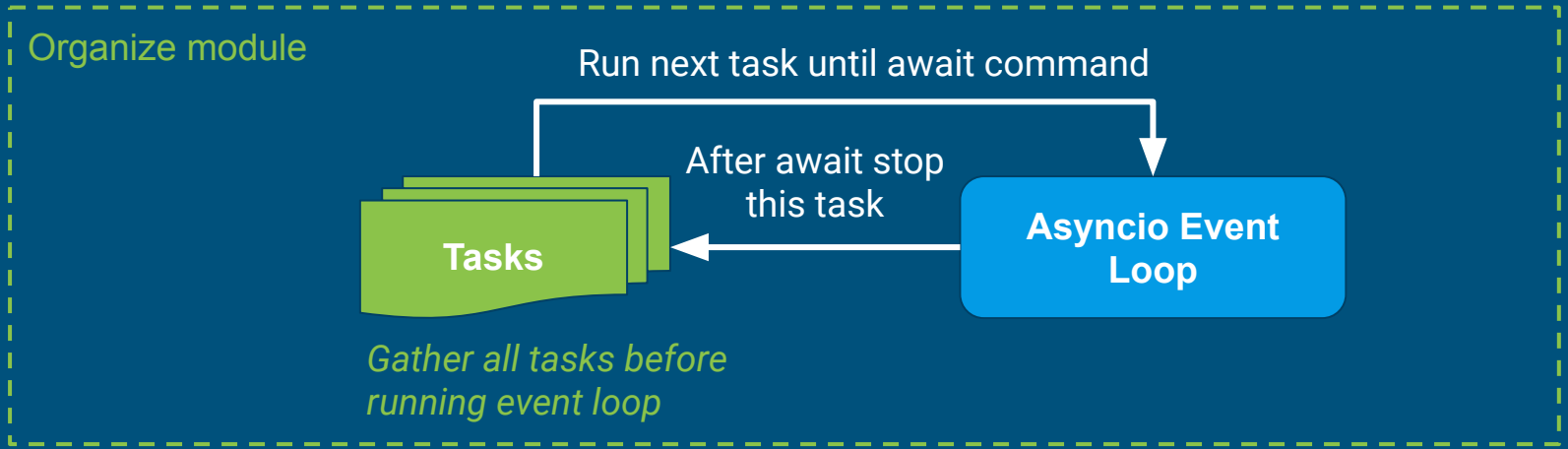
```
async def consume(**kwargs):
    """
    Consumer written with aioamqp in order to work with asyncio.
    """
    transport, connection = await aioamqp.connect(
            host=host, port=port, login=username,
            password=password, login_method='PLAIN')
    # some possible exceptions here
    # 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')
```

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 event loop

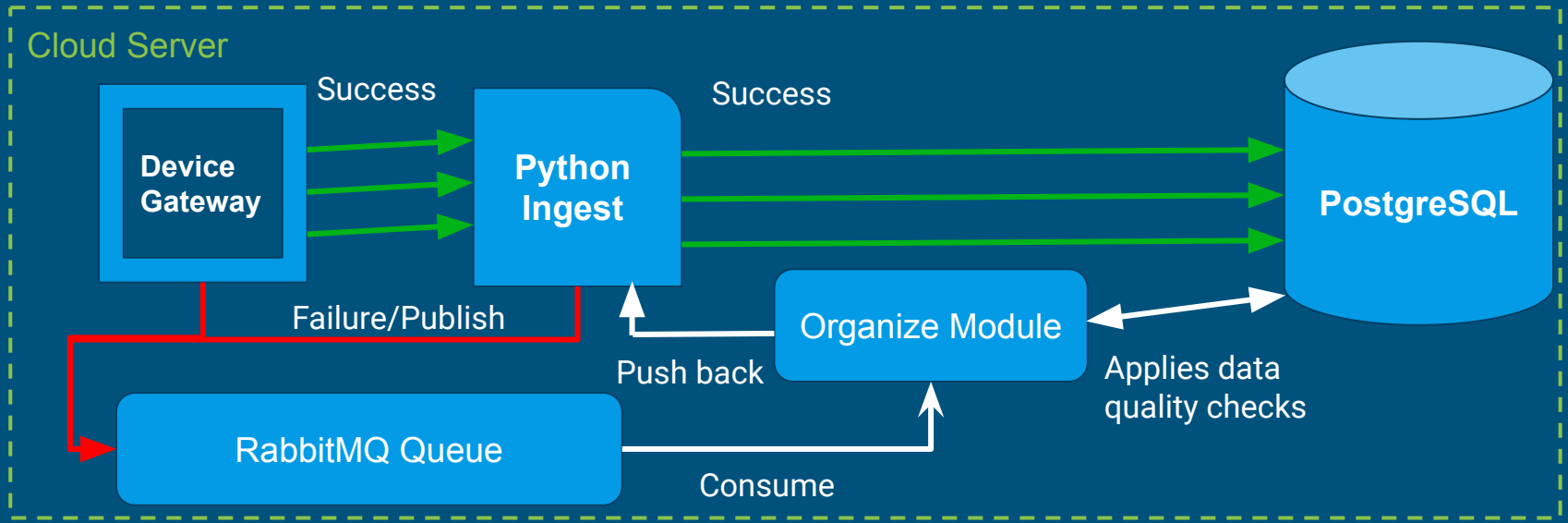
Gather your tasks

Run your event loop

```
# 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.

```
# Fetch a random set of signals from database
# and check if lan,lot values are in correct range
async def periodic_quality_check(timeout):
    while True:
        for signal in list_of_random_signals:
            if wrong_coordinates(signal.longitude, signal.latitude):
            # TODO - Notify user for broken gps.
        # Gives up execution, waits to run after timeout.
        await asyncio.sleep(timeout)


def wrong_coordinates(longitude, latitude):
    """
    Check if longitude and latitude are between correct range
    """
    if (longitude > 90 or longitude < -90 or
       longitude > 180 or longitude < -180):
        return True
    else:
        return False
```

Clockwork organizer

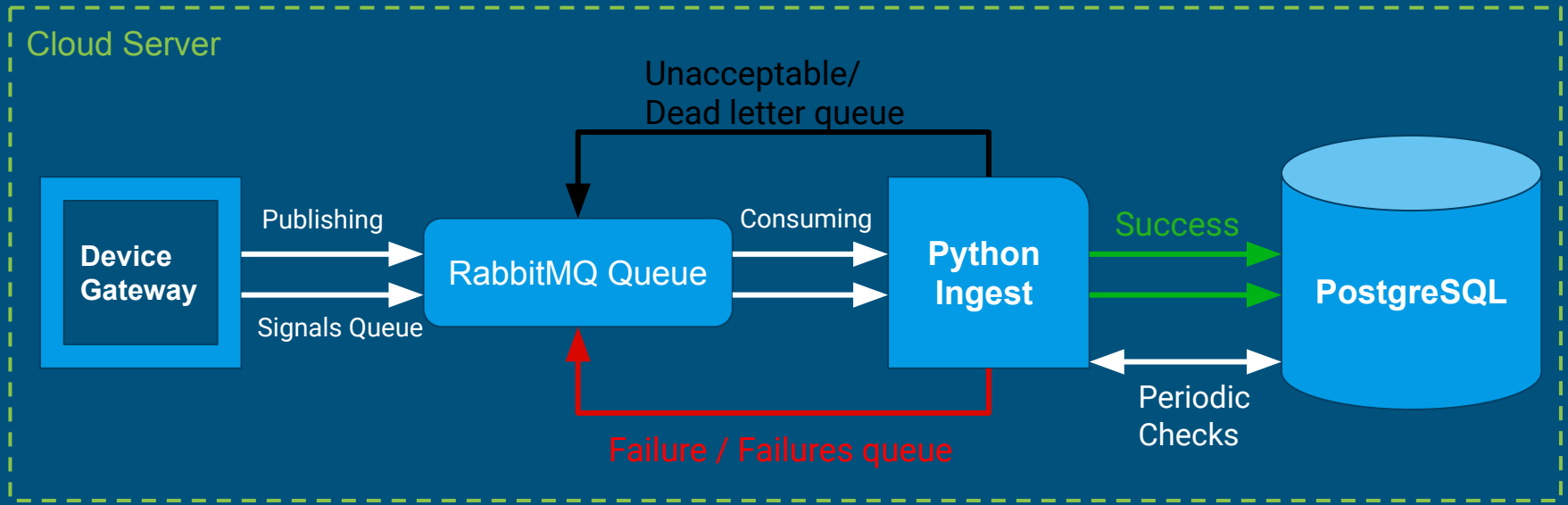
Idea 2:

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

```
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)
```

Reinventing the wheel

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

We would like to thank:

- **Andreas, George and Harry** *(the rest of our **veturilo.io** tech team)*, for their unlimited support.
- **Panos, George and Thanasis** *(from **stackmasters.eu**)*, for their important help and ideas.
- **Bill** (*from **starttech.eu**)*, for his efforts to organize this presentation.
- **The rest of *starttech.eu* wonderful community** for their daily support to our work.

Our Story: Drop us a line!

Github Repo:

1. https://github.com/gzisopoulos/python-iot-data-integrity
2. https://github.com/thepetk/python-ingest

Discord channel:

#talk-data-integrity-with-async