What's That Smell?

Detecting Air Quality with Python, Raspberry Pi, and Redis

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(AP Photo/ Eric Risberg)

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Covered today:

- Motivation for this project
- How air quality is determined
- How to measure airborne particulate matter
- Assembling the hardware sensor device
- Parsing the raw data
- Visualizing the data
- Extensibility and utility of data

Sad Introductory Stats for 2023 Wildfires in the United States West Coast:

- **2,540,000** acres of land burned
- **48,681** individual fires
- **176** acres average per fire
- **13,887** buildings destroyed
- Western US wildfires destroyed 246% more homes and buildings over the past decade

Sad Introductory Stats for 2020s Wildfires in the United States West Coast:

- **We learned about fire tornadoes**

Wildfire Smoke - How does it affect us?

- Eye and respiratory tract irritation
- Reduced lung function
- Bronchitis
- Exacerbation of Asthma and Heart Failure
- Overall Premature death

Wildfire Smoke - How we measure it

- PM 2.5: Particulate Matter 2.5 micrometers and smaller
- Small enough to pass through to the deepest part of the lungs and into the bloodstream
- AQI (Air Quality Index): a computed value based on PM 2.5 to convey health risks

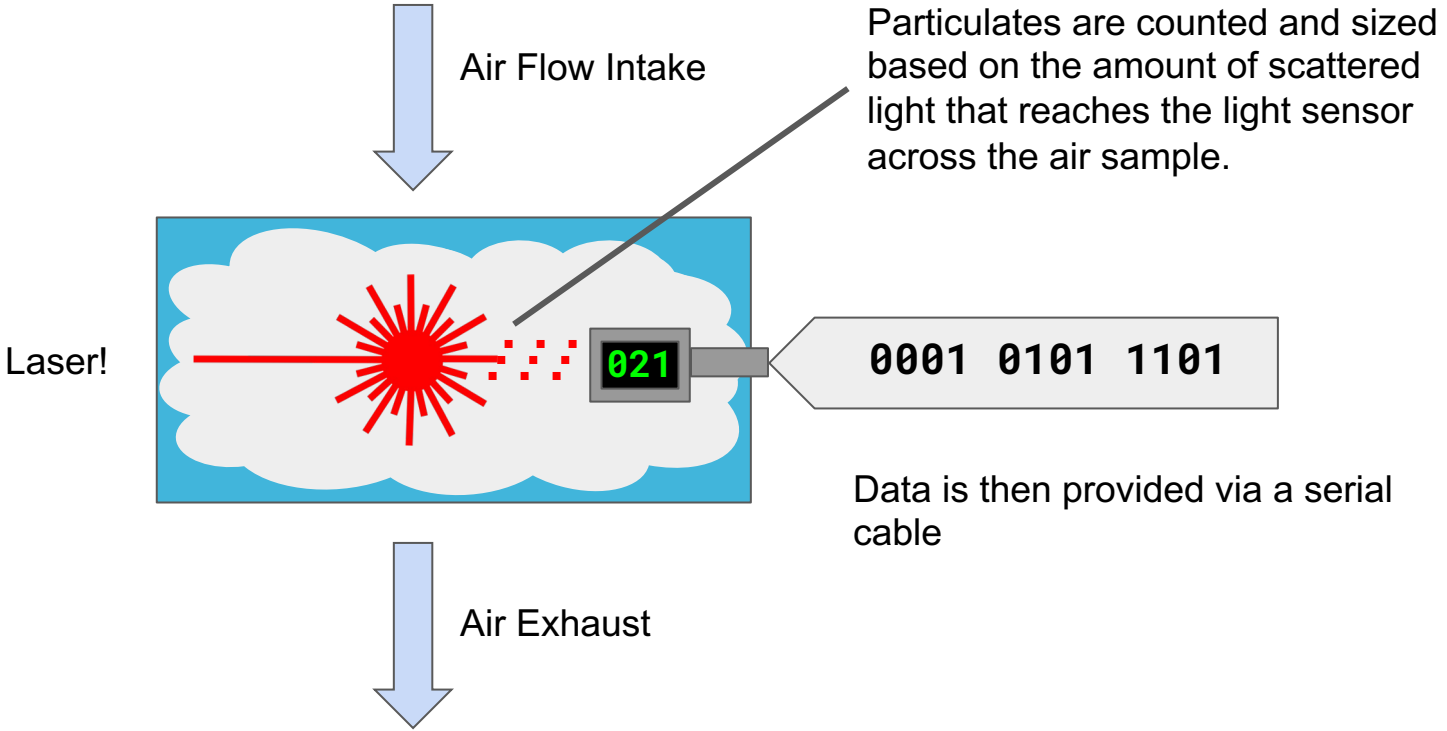
Wildfire Smoke - How we measure it

0 - 50	Good	Air quality is considered satisfactory, and air pollution poses little or no risk
51 - 100	Moderate	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
101-150	Unhealthy for Sensitive Groups	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
151-200	Unhealthy	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects
201-300	Very Unhealthy	Health warnings of emergency conditions. The entire population is more likely to be affected.
300+	Hazardous	Health alert: everyone may experience more serious health effects

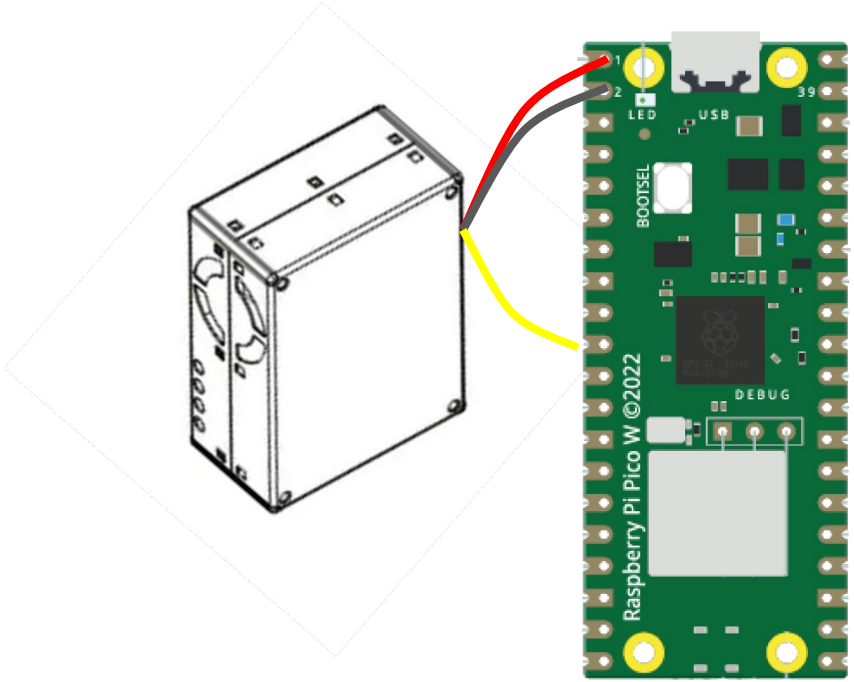
Wildfire Smoke - How do we measure it

Plantower PMS 5003 Particulate Matter Sensor

Wildfire Smoke - Plantower PMS5003 breakdown



The Raspberry Pi Pico



- Capable of running Micropython or Circuitpython
- Wireless capabilities
- Dual-core ARM processor,
- 264 kB of SRAM
- 2MB of on-board flash memory
- Runs on 5v, 1a USB power
- 21x51mm (4/5 x 2 inches)
- Only $6.00 (USD)

Redis

Store key and value pairs

- **Strings/Numbers**
- Lists/Sets/Sorted Sets
- Hashes
- **Streams**
- **TimeSeries**
- **JSON**
- Query

Pi Pico W Code - Tasks

- Send a liveliness pulse every five minutes
- Sample the air every five seconds
  - Convert PM2.5 to AQI
- Send PM2.5, AQI, and temperature to a Redis Stream

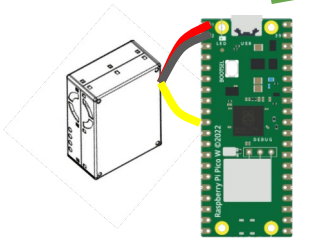
Pi Pico W Code - Send a liveliness pulse

```
import secrets
import picoredis as client

SENSOR_LOCATION = 'unit:2’
TTL_TIMER = 60 * 5

# Connect to RedisCloud database
redis = client.Redis(
host = secrets.REDIS_HOST,
port = secrets.REDIS_PORT)
redis.auth(secrets.REDIS_PASS)

# Initial announcement that we exist
redis.SET(f'ttl:{SENSOR_LOCATION}', 'active', 'EX', TTL_TIMER)
```

Pi Pico W Code – Sample the air

```
import PMS5003
import utility

sensor = PMS5003.PMS5003(
  uart=UART_connection,
  pin_enable=machine.Pin(3),
  pin_reset=machine.Pin(2),
  mode="active")

raw_reading = sensor.read()
pm25 = raw_reading['pm25’]
aqi = utility.convert(raw_reading)
temperature_reading = utility.read_onboard_temp()
```

Pi Pico W Code – But what's a Stream?



"office"

```
target:'office'
PM2.5: 4
AQI: 16
temp: 67.75
```

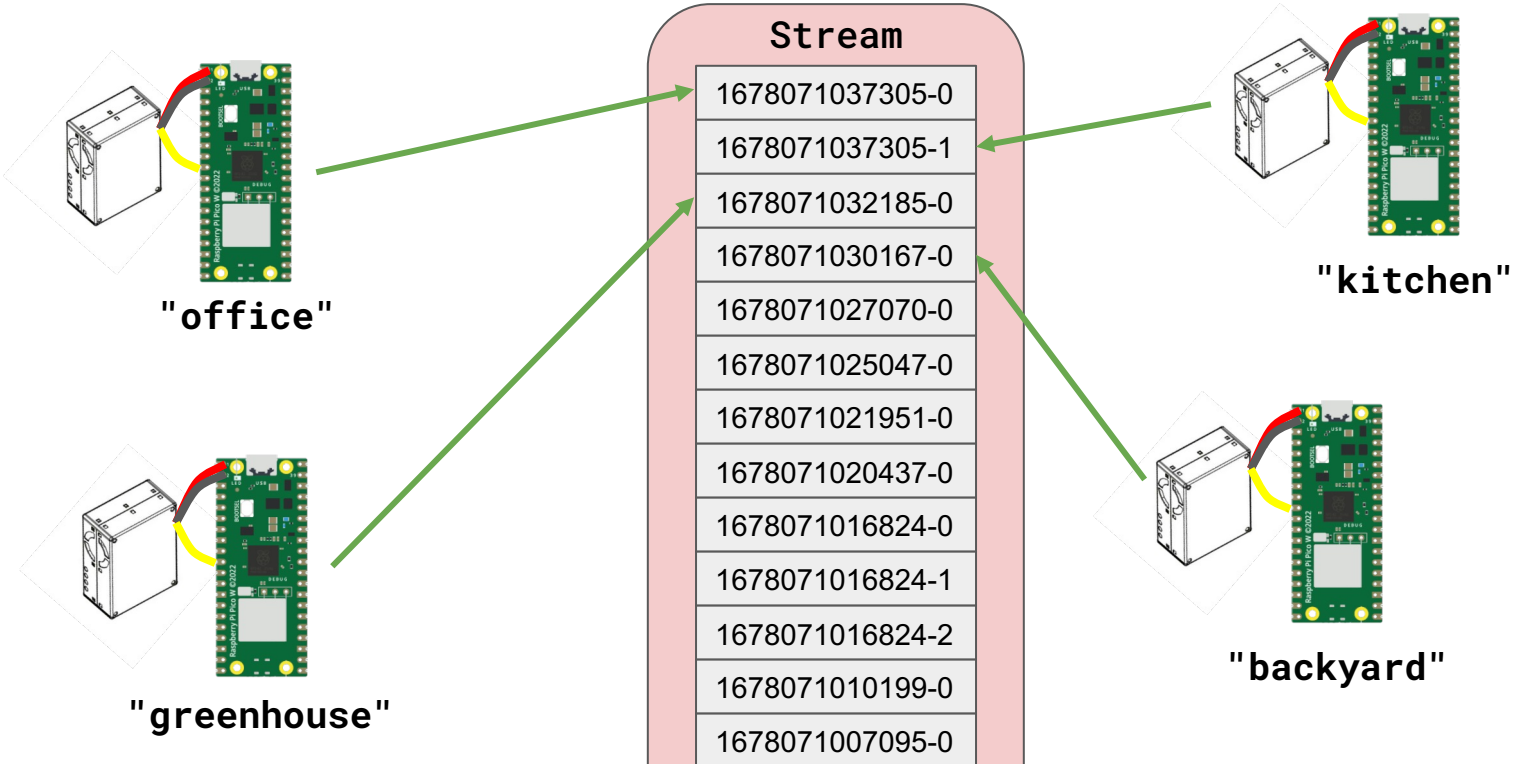
Stream

- 1678071037305-0
- 1678071035287-0
- 1678071032185-0
- 1678071030167-0
- 1678071027070-0
- 1678071025047-0
- 1678071020437-0
- 1678071016824-0
- 1678071016824-1
- 1678071016824-2
- 1678071010199-0
- 1678071007095-0
- 1678071005081-0

Newest

Oldest

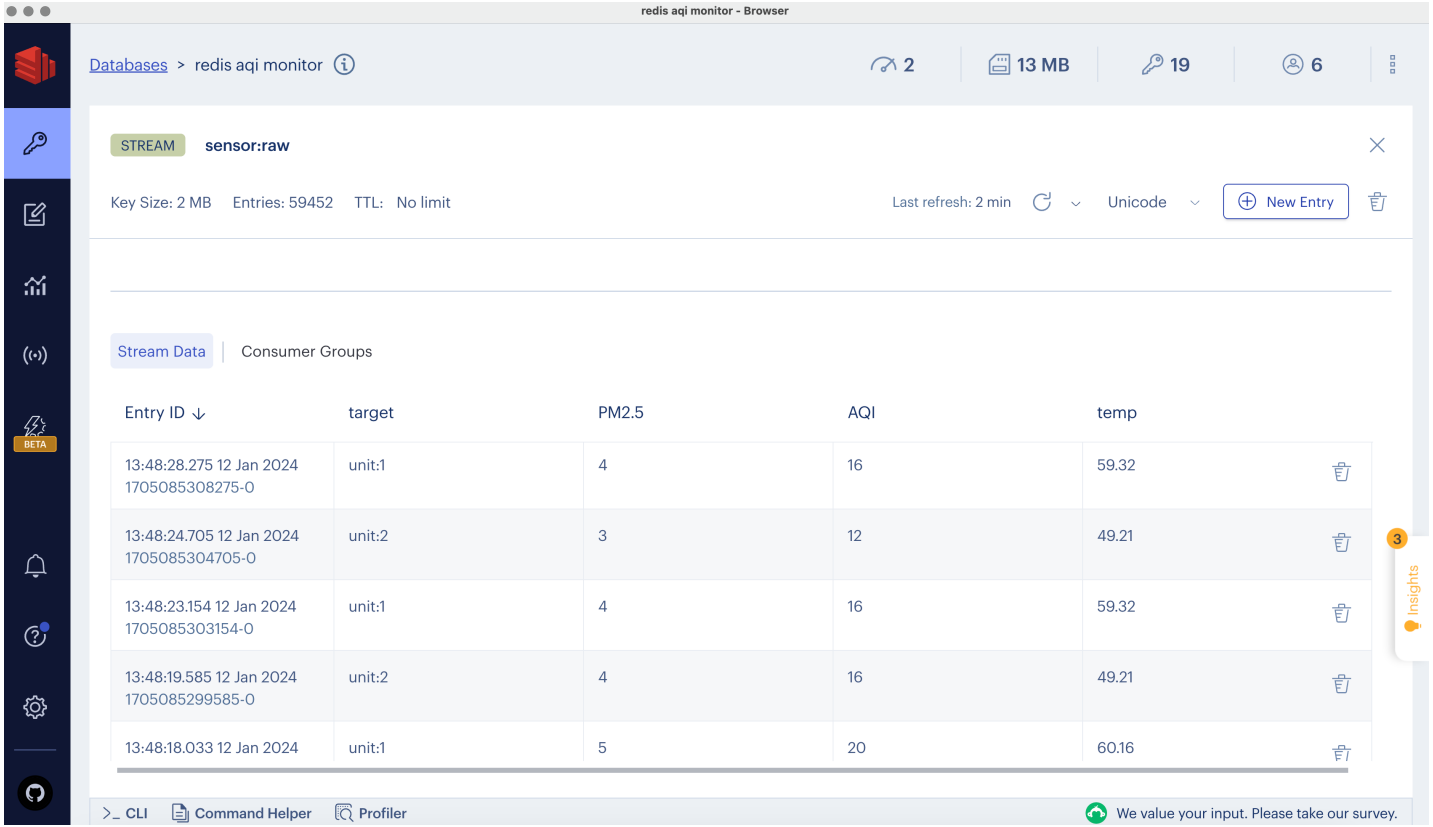
Pi Pico W Code – Scaling out our sensors



Pi Pico W Code – Send data to Redis Stream

```
SENSOR_LOCATION = 'unit:2'
STREAM_KEY = 'sensor:raw'

# send readings to Redis via a stream add command
redis.XADD(STREAM_KEY,
  '*',
  'target', SENSOR_LOCATION,
  'PM2.5', raw_reading,
  'AQI', aqi,
  'temp', temperature_reading)
```

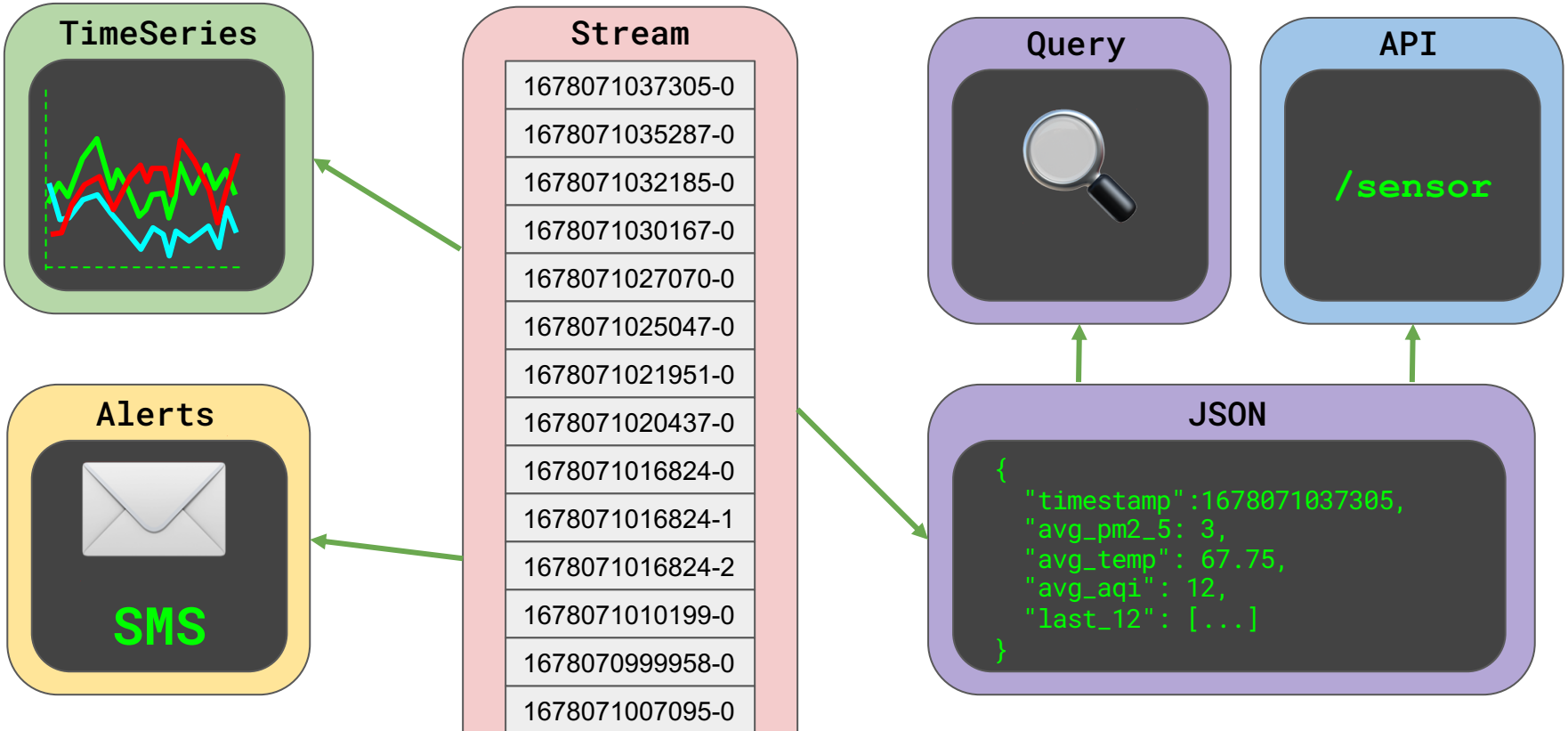
Pi Pico W Code – Send data to Redis Stream



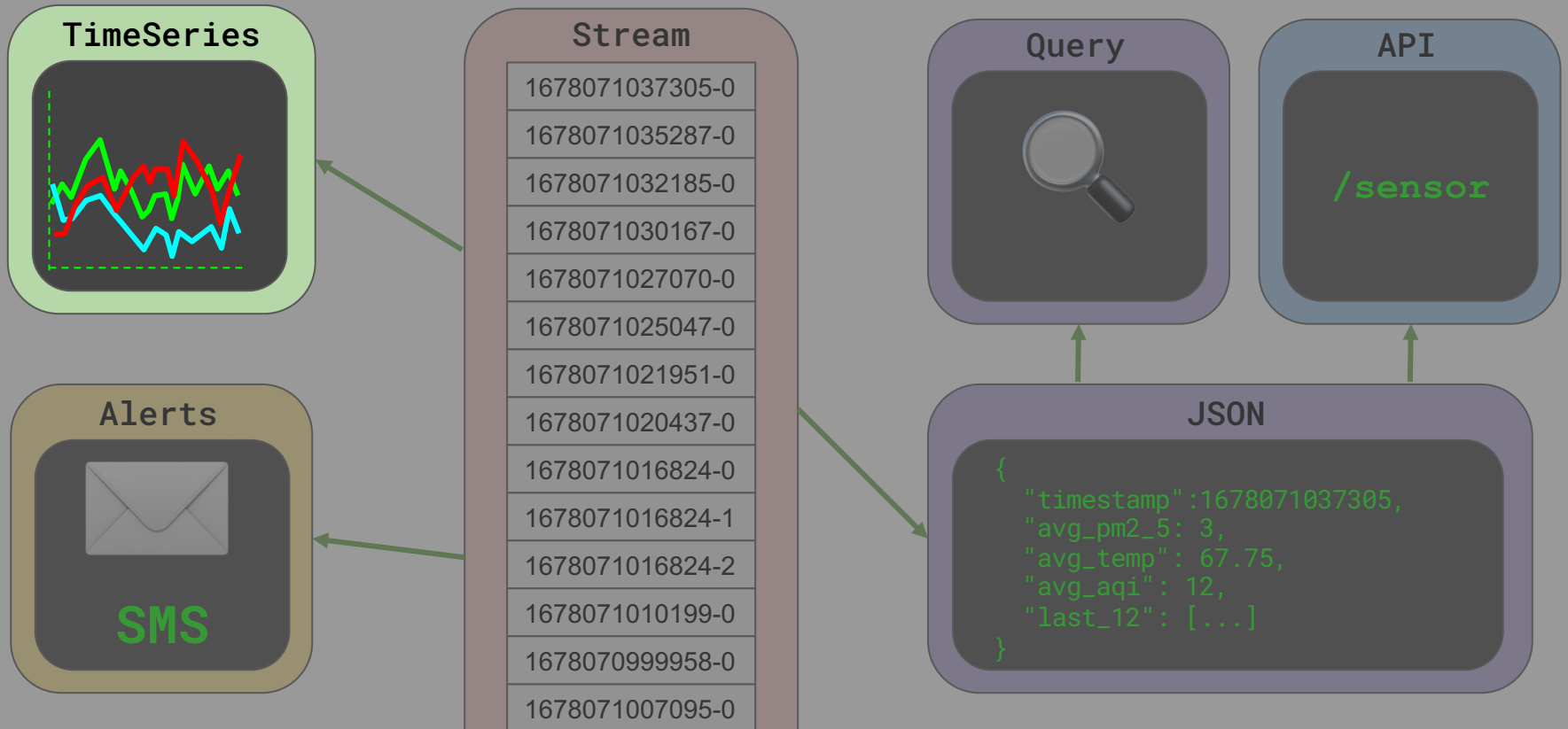
Python Microservices - Tasks

- Insert PM2.5, AQI, and temperature into individual timeseries per sensor unit
- Trigger SMS when air quality threshold is met
- Provide an API to Grafana for visualization

Producers and Consumers - Making the data work



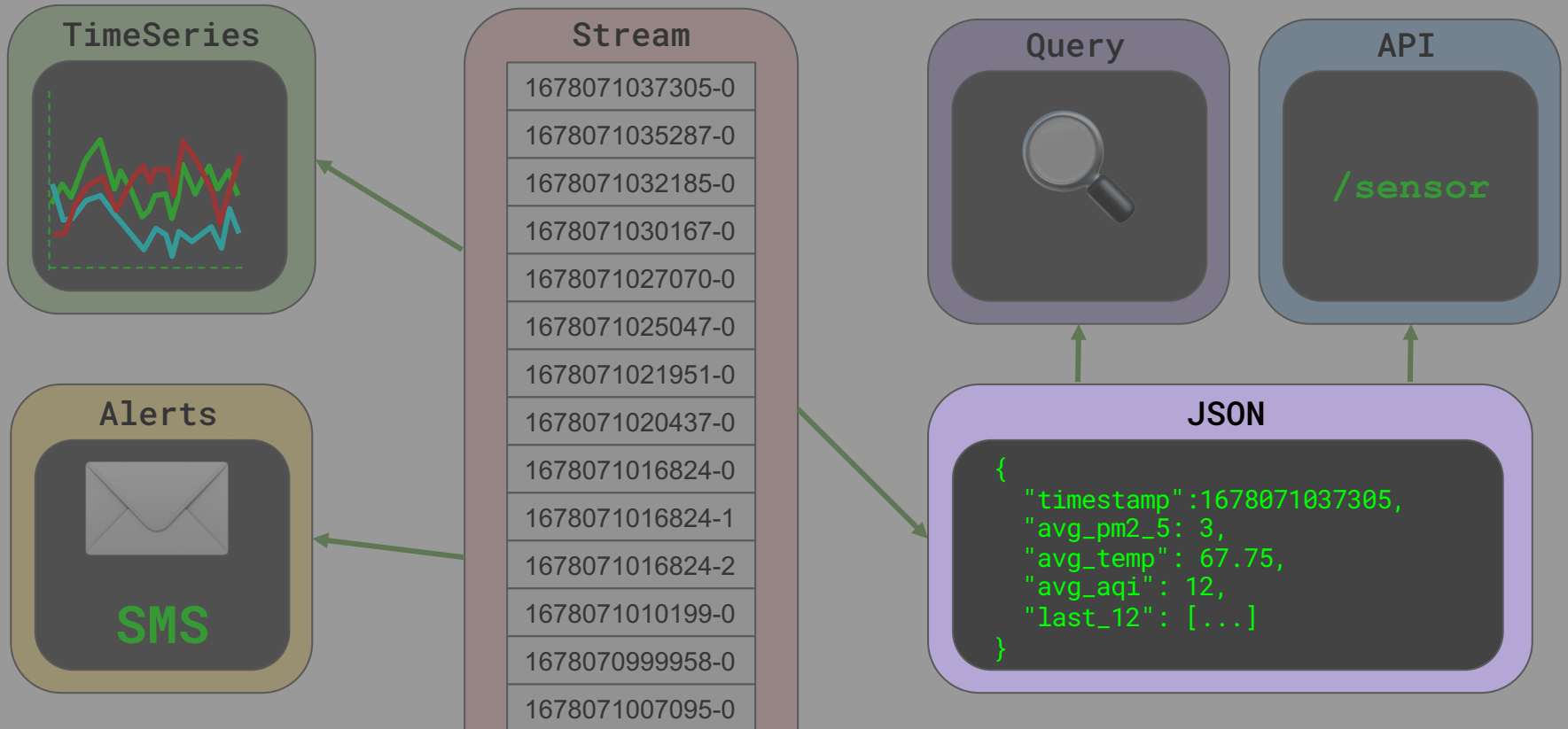
Python Microservices – Insert data into Timeseries



Python Microservices – Insert data into Timeseries

```
STREAM_KEY = 'sensor:raw'
stream_entry_id = '$'

while(True):
  # wait to get most recent stream entry
  result = redis.XREAD(streams={STREAM_KEY: stream_entry_id} ,
    count=1,
    block=50000)

  ts_key_prefix = f'ts:{result["target"]}'

  # create three separate timeseries entries from each stream entry
  redis.TS().ADD(f'{ts_key_prefix}:aqi',
    result['timestamp'],
    result['AQI'])

  stream_entry_id = result[‘entry_id']
```

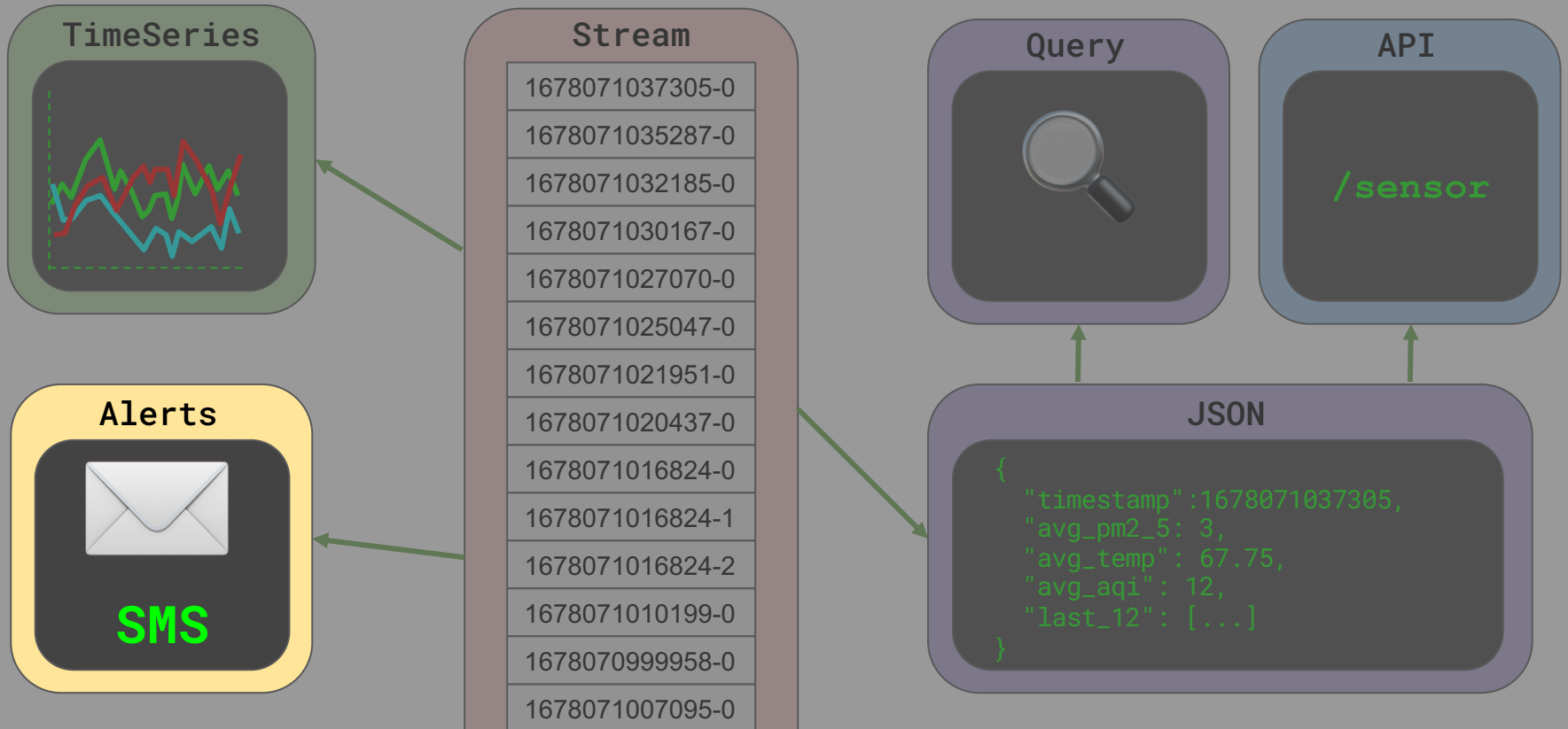
Python Microservices – Convert Data to JSON



Python Microservices – Convert Data to JSON

```
STREAM_KEY = 'sensor:raw'
stream_entry_id = '$'

while(True):
  result = r.xread(streams={STREAM_KEY: stream_entry_id},
    count=1,
    block=50000)

  redis.JSON().SET(json_key, '.',
    { 'timestamp': result['timestamp']
      'current_pm2_5': result['pm2_5'],
      'current_temp': result['temp'],
      'current_aqi': result['aqi'],
    })

  stream_entry_id = result['entry_id']
```

Python Microservices – SMS Alerts!



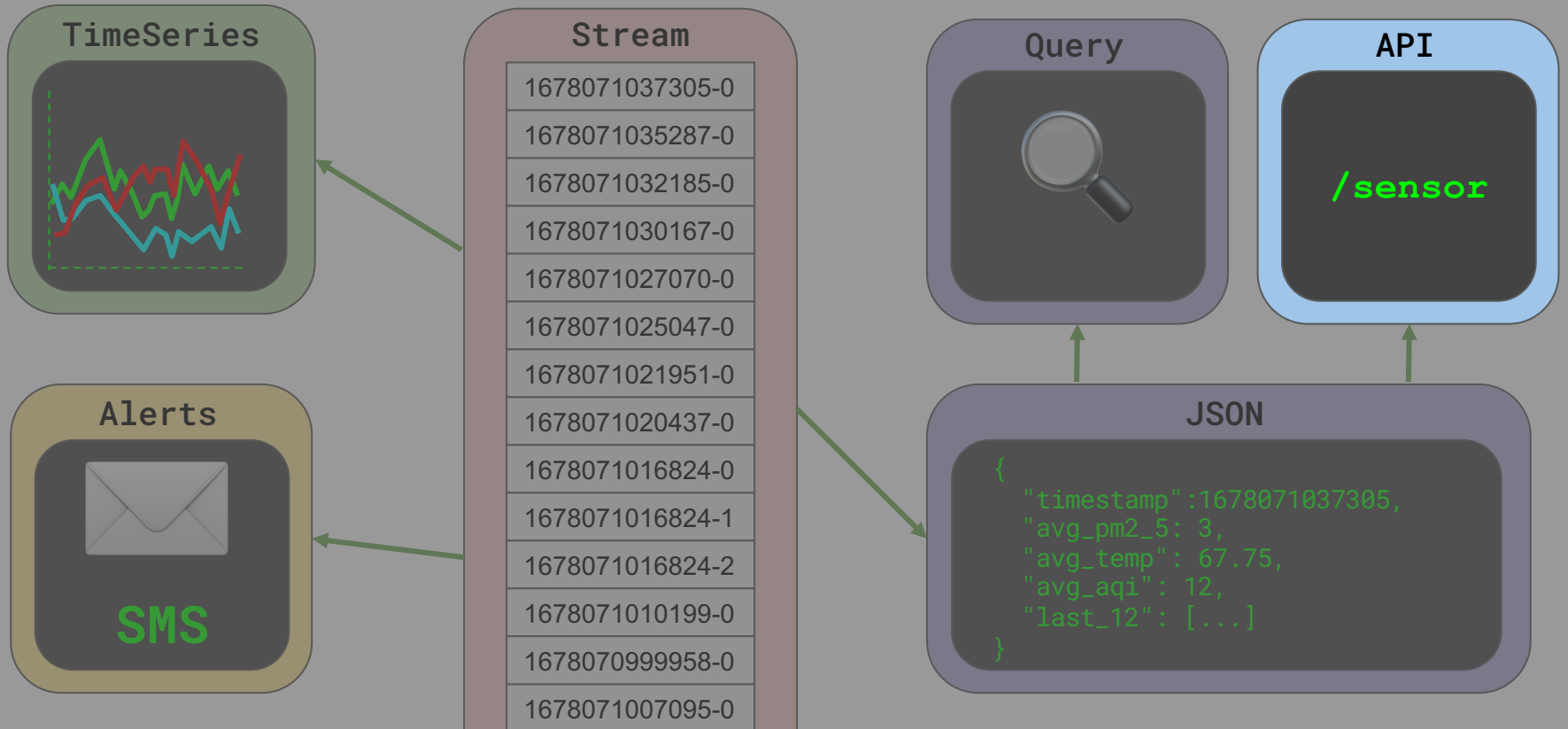
Python Microservices – SMS Alerts!

```
AQI_THRESHOLD = 100*12

last_12 = [-1] * 12
redis.JSON().SET(json_key, '$',{ 'last_12': last_12 })

# "slide" out the oldest aqi reading, add the newest
last_12.append(aqi)
last_12.pop(0)

if sum(last_12) >= AQI_THRESHOLD:
  aqi_average = floor(sum(last_12)/12)
  was_notified = redis.GET('user_notified')

  if not was_notified:
    alert(aqi_average, target)
    r.set('user_notified', 1, 3600)
```

Python Microservices – SMS Alerts!

```
from twilio.rest import Client

client = Client(account_sid, auth_token)

def alert(value, location):
  message = client.messages.create(
    from_='my-phone-number',
    body=f'Hello, the current AQI is {value} at the {location} location.',
    to=phone_number)
  return message
```

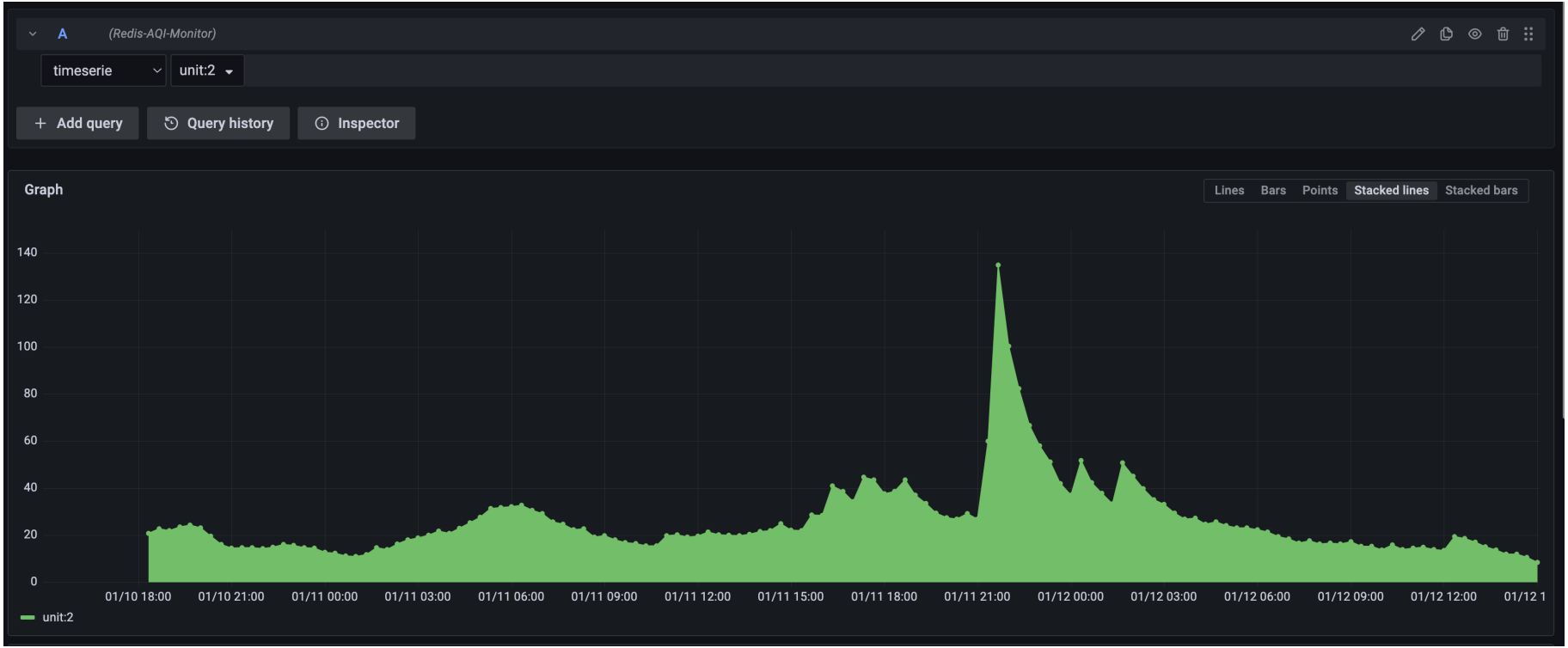
Python Microservices – Provide API to Grafana



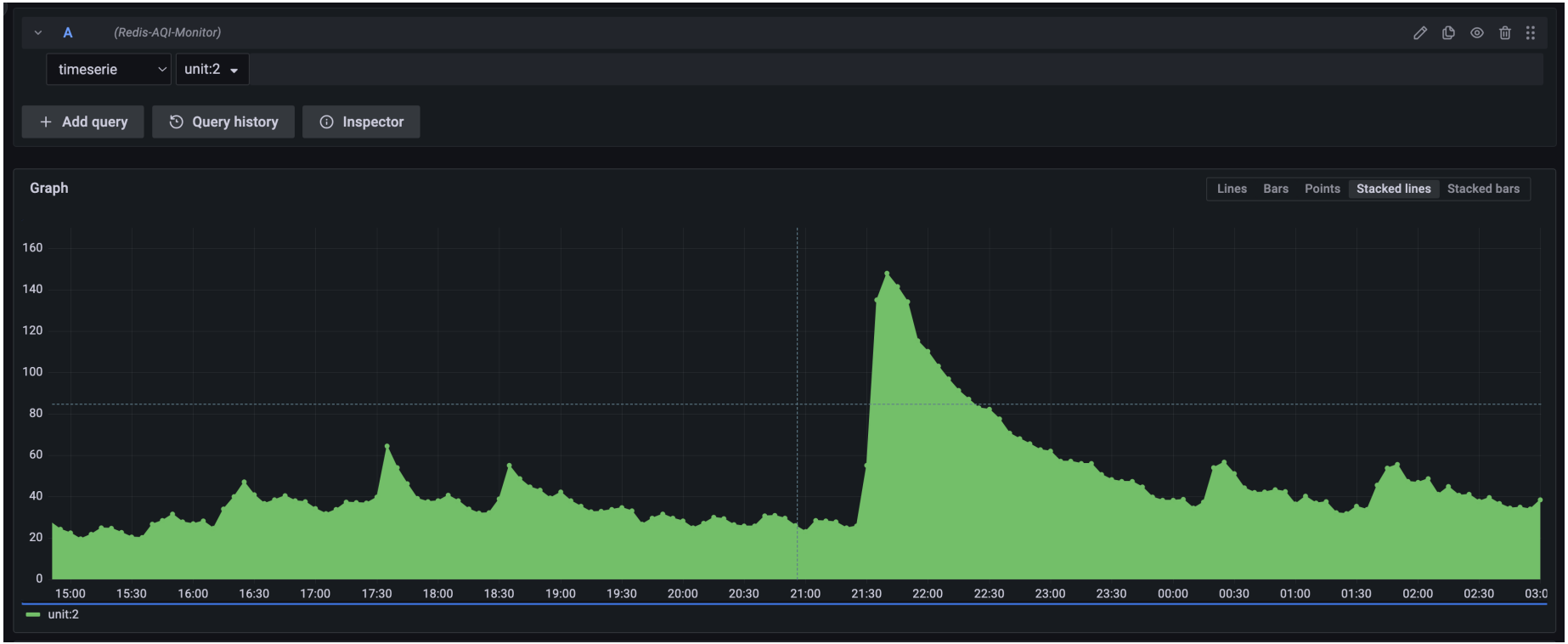
Python Microservices – Provide API to Grafana

```
@app.post("/search")
  active_sensors = redis.KEYS('ttl:*’) # gathers all active keys

@app.post("/query") # sends from, to, and interval size

  results = redis.TS().RANGE(ts_key,
  from_time,
  to_time,
  aggregation_type = 'avg’,
  bucket_size_msec = int(interval))
```

Python Microservices – Provide API to Grafana

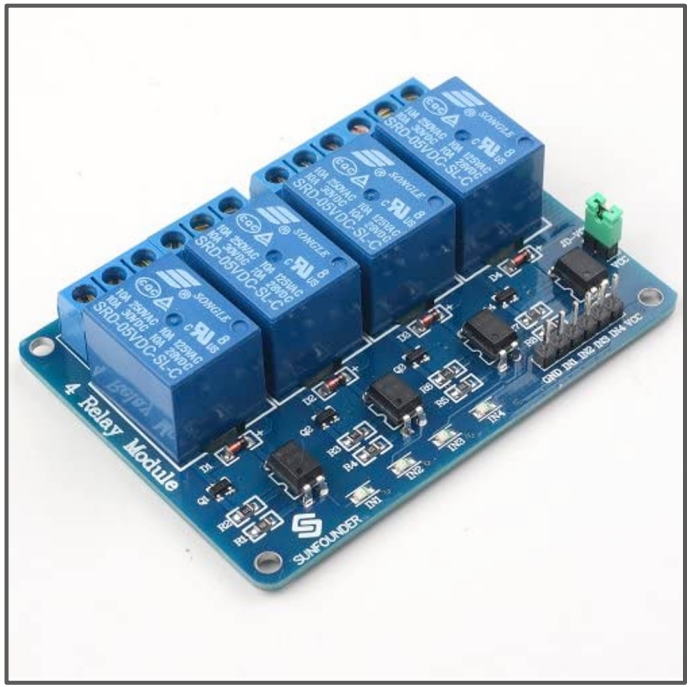


Python Microservices – Provide API to Grafana



What else can you do with this data?

- Trigger an electric relay to activate a fan, air purifier, window opener, or HVAC system.
- Share outdoor locations with crowdsourced AQI maps, such as PurpleAir.
- Send notifications to Alexa to alert rooms of high AQI values
- Email notifications
- Create a heat map of a building of changing AQI values
- Create a predictive model of air dispersal/ventilation



Shoutout to PurpleAir!

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https://map.purpleair.com/

Learn more about this project

Github repository:

- Pico W code
- Consumer services code
- API code
- Instructions on assembling your own unit
- .STL files for printing a box at home
- Data sources of statistics

https://github.com/redis-developer/redis-aqi-monitor.git

Learn more about Redis

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