Miniature Implementation of an IoT-based Smart City

Final Year Project in Computer Engineering (ICT3908)

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- Introduction and Background
- Design and Implementation
- Testing and Results
- Conclusion
- Future Work

Overview

Smart Cities

- Leverage digital technologies to enhance resource efficiency, improve residents' quality of life, and drive sustainable economic growth within local areas.
- Integrate intelligent solutions across various domains.

Technologies Enabling Smart Cities

Distributed Ledger Technologies

Secure Transactions and Identities

Internet of Things

Real-world Interface.

AI/ML

Pattern Recognition and
Autonomous System Management

Approach

- Focus on Data Collection
- Small but Scalable
- Different Tasks

Physical Nodes

- Arduino MKR NB 1500
- SAMD21 Cortex®-M0+ 32bit low power ARM MCU
- u-blox SARA-R4 module for Narrowband Connectivity

Car Park Sensor

- Proof of concept based on a single parking spot
- Event-based
- Detects whether there is a vehicle present on the sensor
- Makes use of the HC-SR04 Ultrasonic Sensor

Air Quality Monitoring System

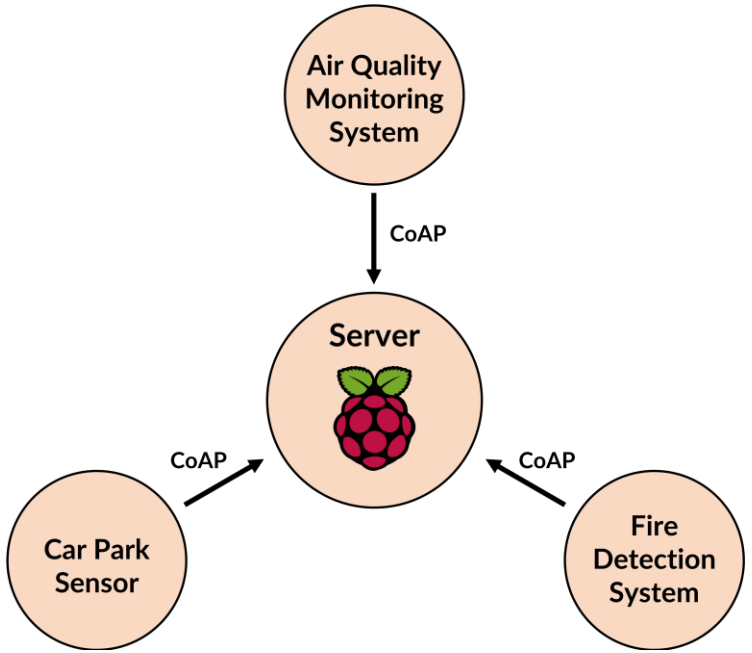
- Measures temperature, humidity and CO, CO_2 PPM levels
- Makes use of DHT11 for measuring temperature, humidity
- Makes use of MQ-135 for measuring CO, CO2 PPM levels

Fire Detection System

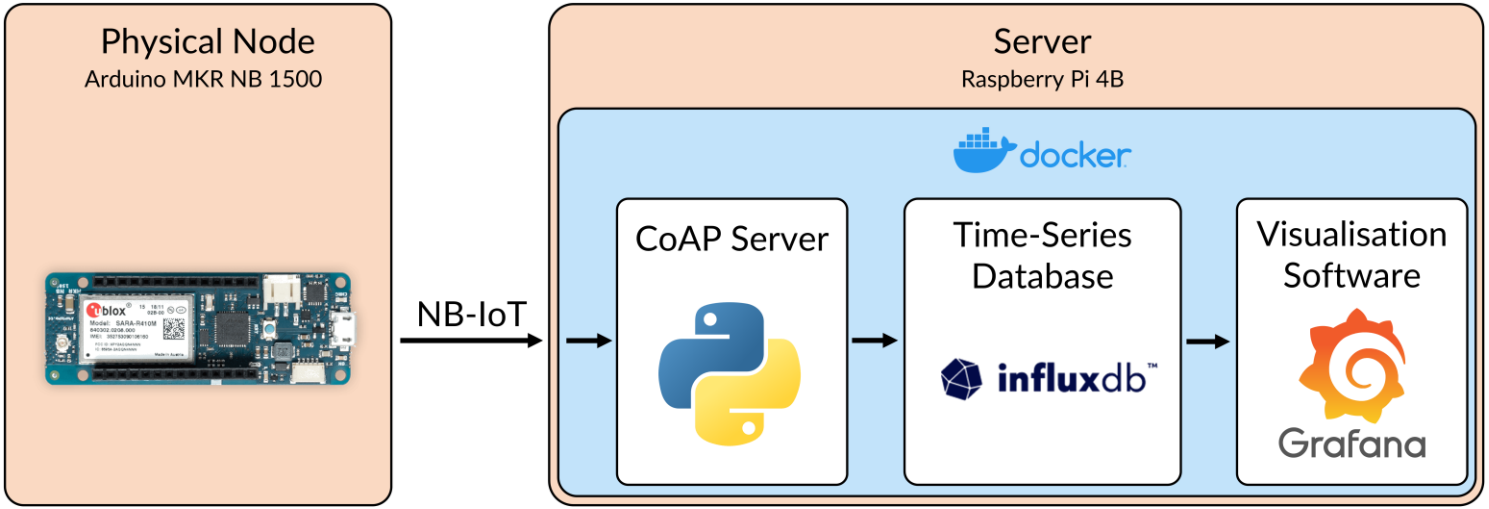
- Measures temperature, humidity and CO, smoke PPM levels, presence of infrared
- Makes use of DHT11 for measuring temperature, humidity
- Makes use of MQ-4 for measuring CO, smoke PPM levels
- Makes use of an IR module for detecting infrared

System Architecture

- Centralised Server
- Star Topology
- Data Sent to the Server by making use of CoAP and NB-IoT



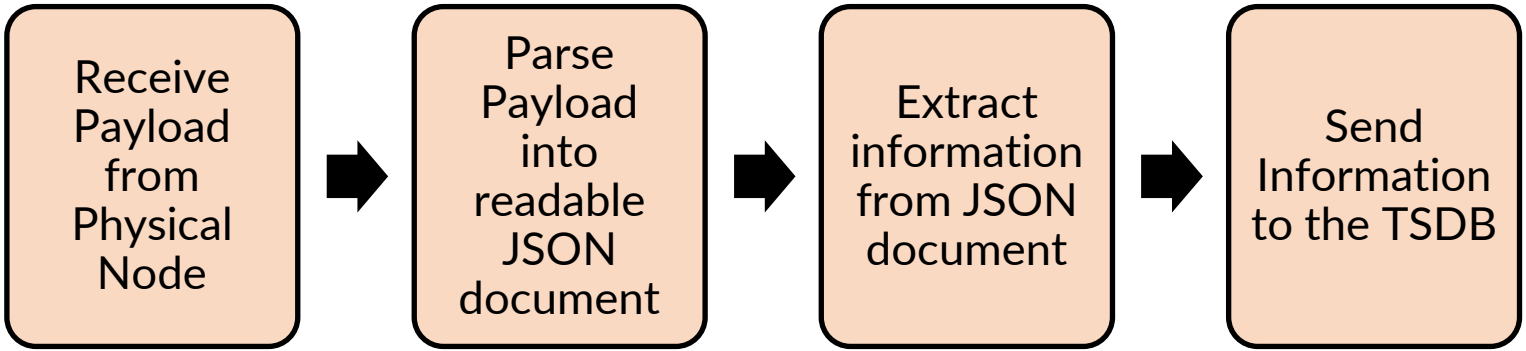
Data Collection Pipeline



CoAP Server

- Consists of 4 Resources
- Supports Observational Capabilities
- Interfaced with the database

CoAP Server


Receive Payload from Physical Node
Parse Payload into readable JSON document
Extract information from JSON document
Send Information to the TSDB

Time Series Database

- *InfluxDB* Instance
- Provides *Flux* querying
- Configured Pre-build

Visualisation Software

- *Grafana* Instance
- Configured post-build

Visualisation Software

Parking Sensor

Free Parking Space

FDS: IR Detection System

No IR Detected

FDS: Gas Concentrations

1.40 ppm
co_level_ppm

0.500 ppm
smoke_level_ppm

FDS: Gas Concentrations Plot

FDS: Humidity

90.9 %H

FDS: Humidity Plot

FDS: Temperature

24.3 °C

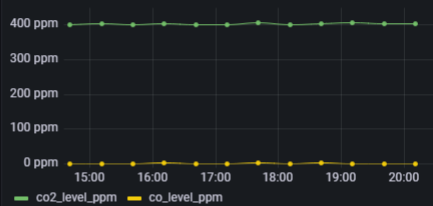
FDS: Temperature Plot

AQMS: Gas Concentrations

404 ppm
co2_level_ppm

0.900 ppm
co_level_ppm

AQMS: Gas Concentrations Plot



AQMS: Humidity

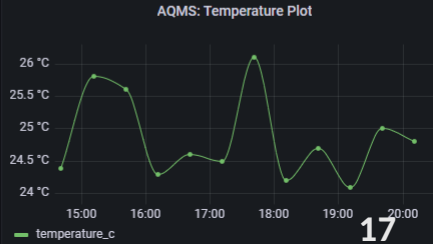
88.7 %H

AQMS: Humidity Plot

AQMS: Temperature

24.8 °C

AQMS: Temperature Plot



Prototyping

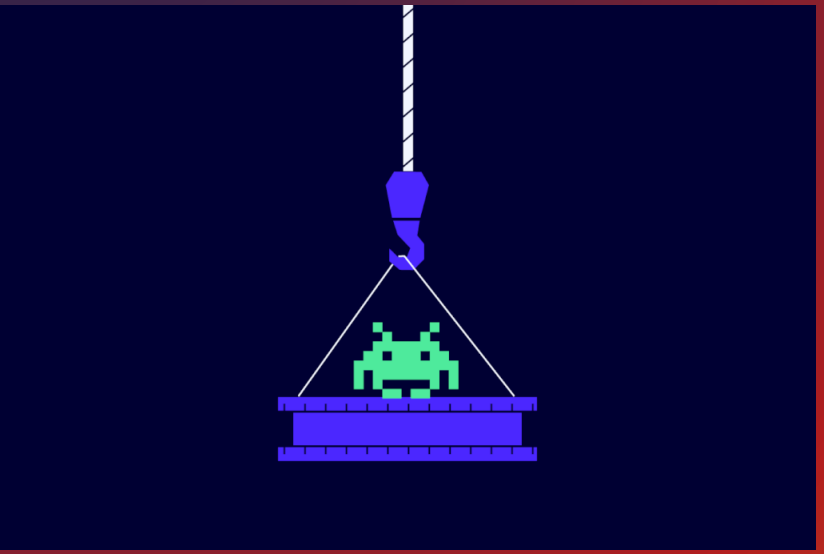
- Integration Testing
- Load Testing
- Battery Consumption

Testing & Results

Integration Testing

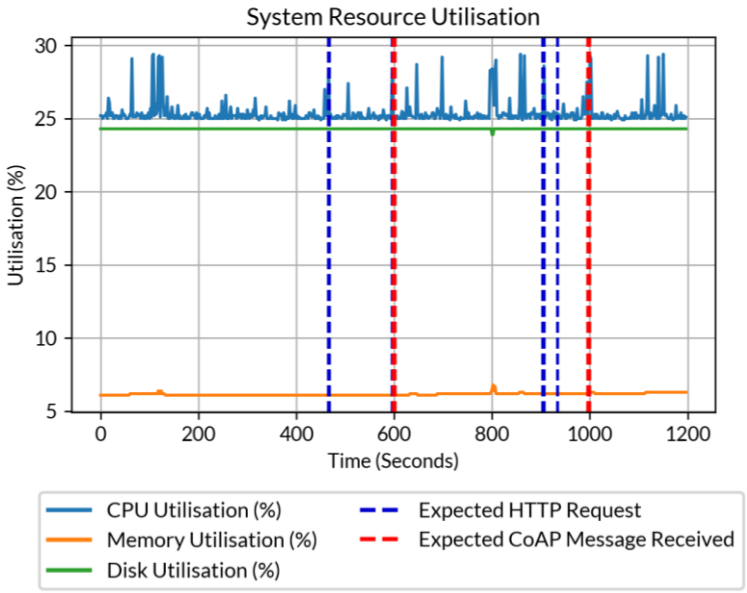
- Ensures proper integration and communication of all components.
- Involved sending data from test physical node to the server and verifying its receipt and processing.
- Data transmission and receipt were confirmed

Load Testing



- Automated Testing Process
- Measuring CPU, Memory and Disk usage over 20 minutes

Load Testing

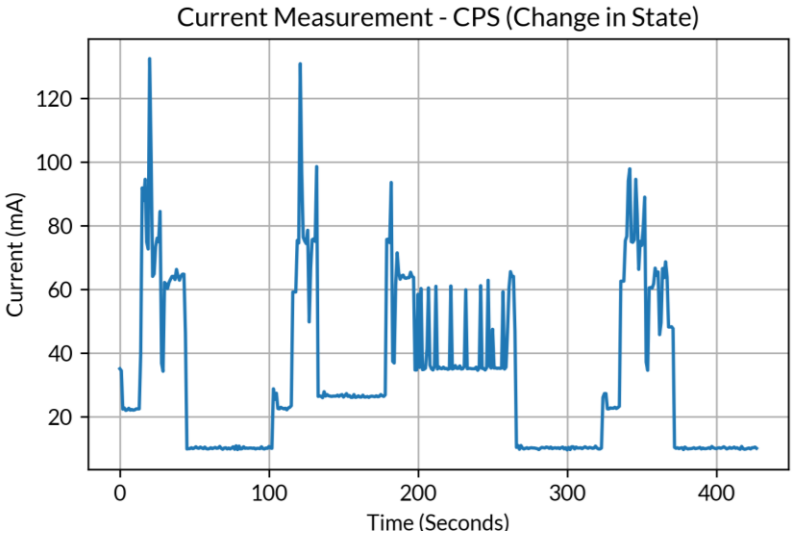


	CPU (%)	Memory (%)	Disk (%)
Mean	25.35	6.16	24.30
Std. Deviation	0.81	0.08	0.02
Minimum	24.90	6.10	23.90
Maximum	29.40	6.80	24.30

Battery Consumption

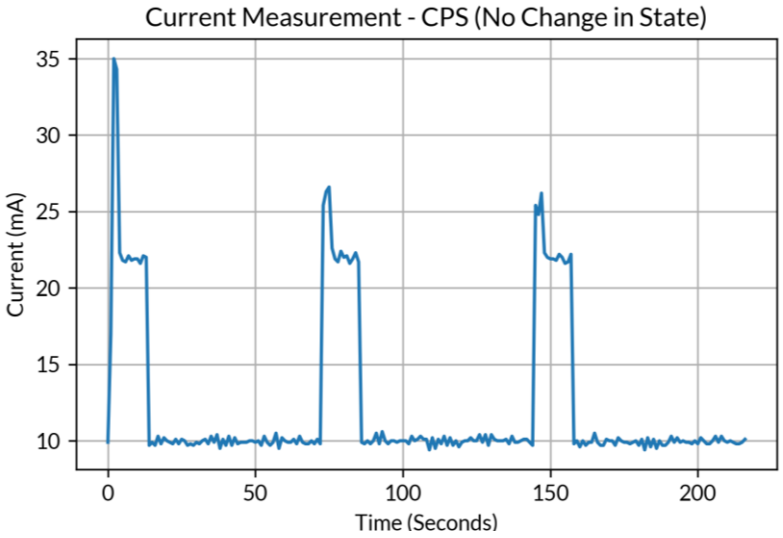
- Measuring current for three transmission-sleep cycles
- Measurements made using the INA219 DC Current Sensor Breakout Board
- Measurements were logged for further analysis
- Battery life metric based on a 10,000 mAh battery

Battery Consumption – CPS



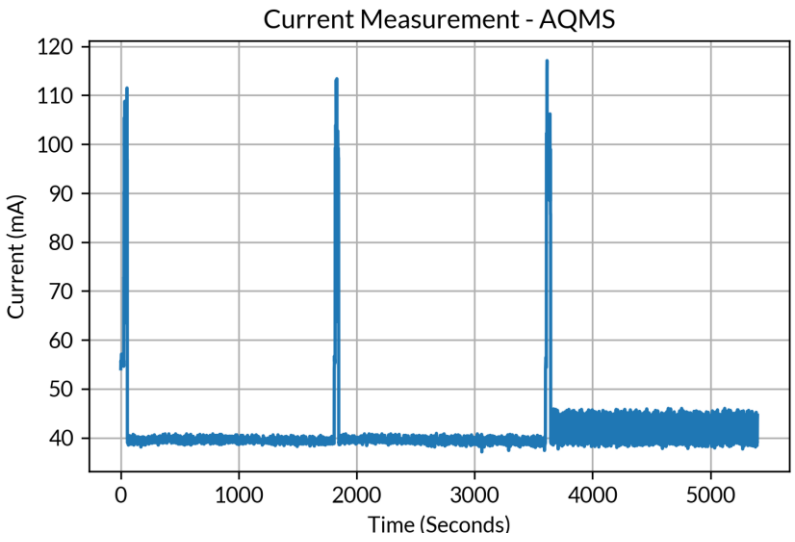
- Average Current Load: 32 mA
- Battery Life: N/A

Battery Consumption – CPS



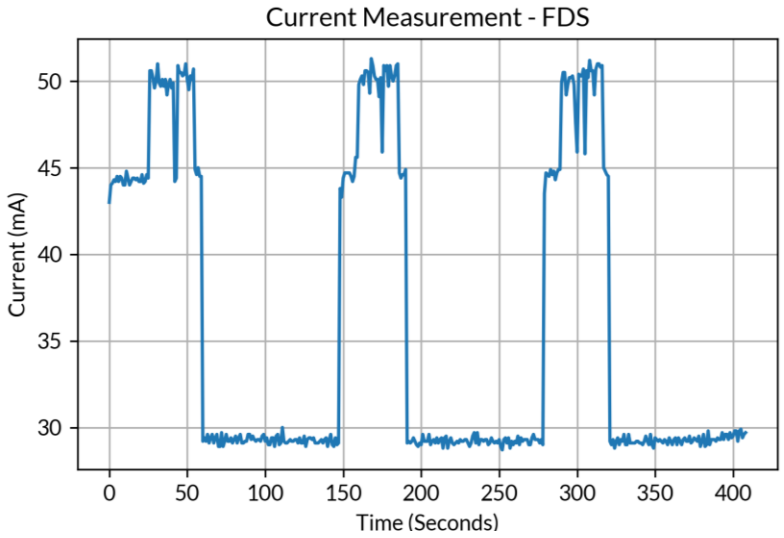
- Average Current Load: 12 mA
- Battery Life: N/A

Battery Consumption – AQMS



- Average Current Load: 41 mA
- Battery Life: 242 hours (10 days)

Battery Consumption – FDS



- Average Current Load: 36 mA
- Battery Life: 280 hours (12 days)

Conclusion

- Seamless integration within data collection pipeline
- Server resource utilisation was low and stable with reasonable CPU usage range
- Battery consumption differs for each physical node due to different operating conditions
- CPS, AQMS have lowest, highest battery consumption respectively

Future Work

- More robust server infrastructure
- Moving beyond the development board
- Expanding the number of physical nodes and their capabilities
- Possible integration of other technologies

Thank You For Your Attention

Do you have any questions?