ParkSmart - An IoT Parking System for a Smart Campus

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Introduction

The Internet of Things (IoT) is the interconnection of everyday objects, via embedded computing devices and the internet, for the purpose of sending and receiving data.

An IoT-based smart parking system enables the availability of parking spaces to be communicated to a user via a user-friendly mobile application. By directing drivers to available parking spaces, the frustration of finding a place to park is mitigated; saving both time and money.

Objectives

- Develop a system which can accurately and reliably communicate parking availability in real time
- Provide the most feasible cost effective solution
- Keep the system energy efficient, increasing operational time on a single battery charge
- Make the system scalable to accommodate any parking lot size
- Ensure the system is robust and easy to maintain
- Communicate data through a user-friendly mobile application, built using the Android framework

System Design

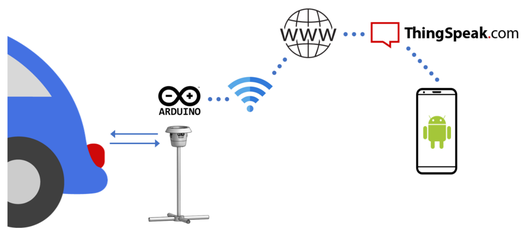

Figure 1: A high-level depiction of the implemented system

System Features

- The availability of 72 parking spaces is detected
- Empty spaces are communicated to users through a user-friendly mobile application
- Parking availability status is updated every 30 seconds
- Operates during active parking hours (7 am - 3 pm)
- Fail-safes are in place in case of node failures

Hardware Setup

- Ultrasonic distance measurement sensor
- Arduino Nano microprocessor
- 2.4 GHz radio module
- 2*AA rechargeable 2300 mAh NiMh batteries
- 5 V boost converter
- ESP8266 based Wi-Fi module

System Design (cont.)

Software Setup

- A scalable Wireless Sensor Network (WSN) utilising 2.4GHz RF communication is designed
- To maintain a low cost node design, system complexity increases with increasing number of parkings
- Sensor data is aggregated and uploaded according to the node hierarchy depicted in Figure 2

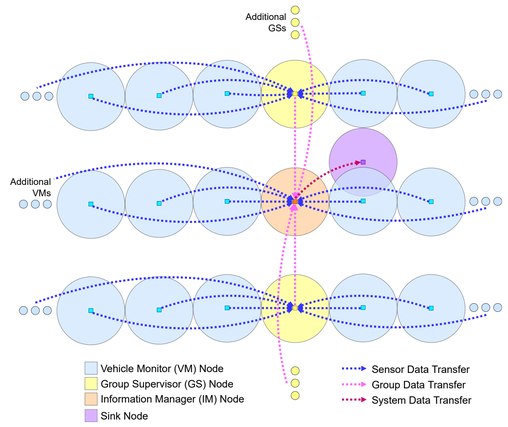

Figure 2: Visulisation of the flow of data, during retrieval, from Sensor Nodes to Sink Node

- Data upload is optimised by utilising the ThingSpeak MQTT broker
  - Very fast connection and upload time
  - Small payload size
- An intuitive mobile application is built for Android
- Parking lot data is retrieved by the application through the provided ThingSpeak API
- The application automatically updates, ensuring up-to-date parking lot data is always displayed

Smart System Operation

- A full cycle (see Figure 3) incurs an average operation time of approximately 1.6 seconds
- The mobile application highlights non-transmitting nodes, indicating system fault to network managers

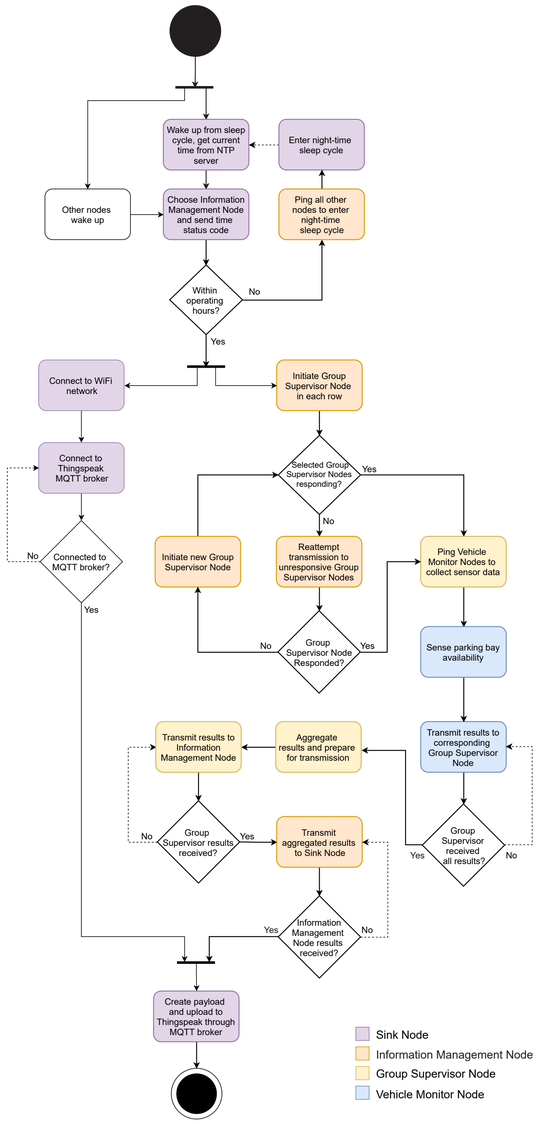

Figure 3: Detailed system interactions between role specific nodes per cycle during operational hours

Deployment

Construction Specifics

- PCB design for optimized system production
- 3D printed sensor holders allow customised sensor placement within each node
- Waterproof encasing and tamper-proof lid
- Robust stand, prevents damage caused by rain runoff

Figure 4: Screenshot of the developed mobile application

Results & Evaluation

System performance

- Estimated lifetime on a single charge cycle is 276 days, limited by the highest consumption node

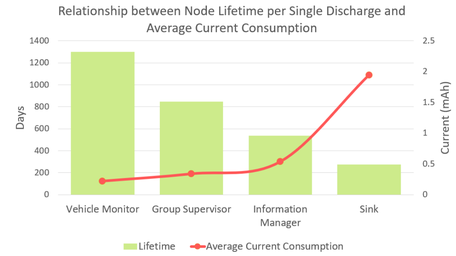

Figure 5: Energy performance of the designed system

- Data consumption of the implemented smart parking system is approximately 3.7 MB per month, and scales non-linearly with parking lot size

Number of Parkings	Payload Size (B)	Monthly Usage (MB)
1	60	0.08
72	262	3.77
192	582	8.38

Table 1: Effect of parking lot size on WSN data consumption

- Mobile application data consumption is minimal with a refresh interval of 5 seconds
- Requests for data which has not been updated incur a cost of only 4 kB per request
- At the current scale, the calculated price per node is R 273.52, with a cost-per-parking of R 68.38

Future Work

- Sensors take multiple consecutive readings and use this information to distinguish between the type of object being sensed. This will avoid false positives from pedestrians or other objects crossing the sensor path temporarily.
- Mobile application updates, including the option to manually refresh the parking lot information.

Conclusions

A scalable IoT-based smart parking system has been designed which communicates parking bay availability to drivers via a mobile application. The expected lifetime of the system is 276 days and incurs a monthly data cost of only 3.77 MB. Implementing the system for 72 parking bays results in a cost-per-parking of R 68.38. The ParkSmart system meets all of its objectives, making the project a success.