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

- Available parking spaces are 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
- 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

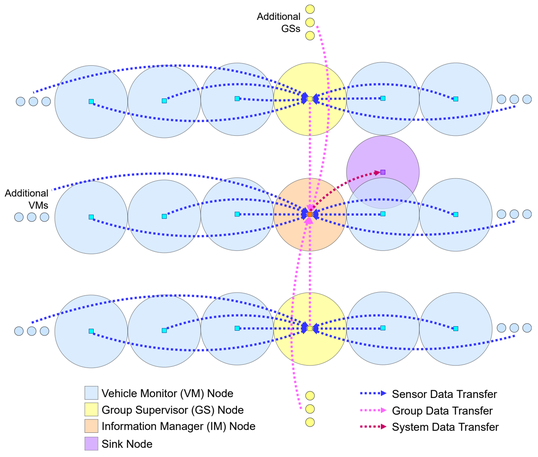

Figure 2: Visulisation of the flow of data, during retrieval, from Sensor Nodes to Sink Node

Smart System Operation

- A full cycle incurs an average operation time of approximately 1.6 s (refer to Figure 3)
- Mobile application highlights non-transmitting nodes

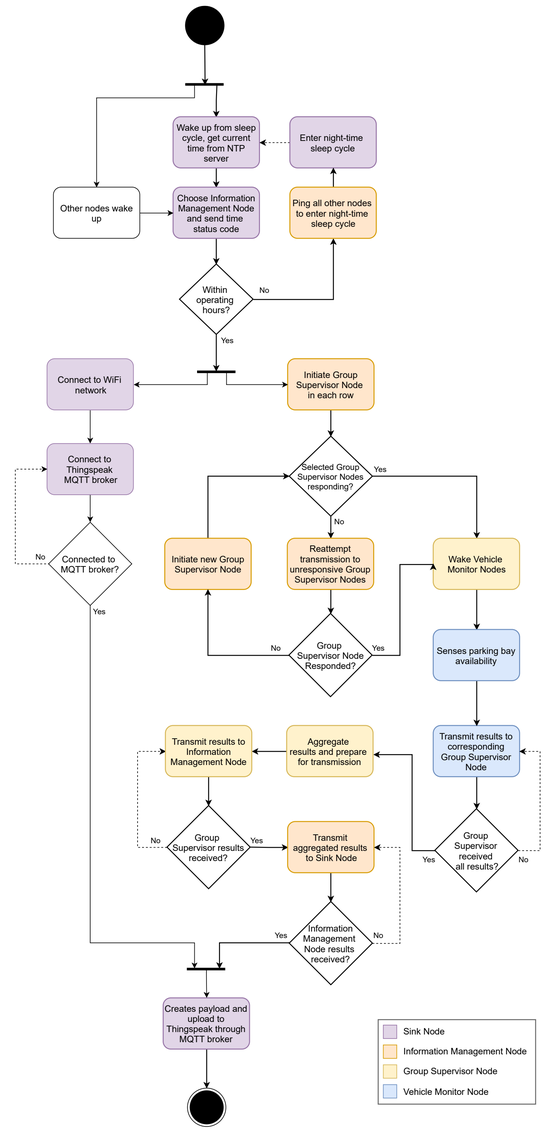

Figure 3: Detailed system interactions between role specific nodes

Deployment

Construction Specifics

- PCB design for optimized production
- 3D printed sensor holders allow customised angles per node
- Waterproof encasing and tamper-proof lid
- Robust stand with runoff resistance

Figure 4: Screenshot of the developed mobile application

Results & Evaluation

System performance

- Estimated system lifetime on a single charge cycle is 276 days
- This lifetime is limited by the highest consumption node (refer to Figure 5)
- Mobile app data consumption is minimal with a refresh time of 5 s
- unupdated requests incur a cost of only 4 kB per request
- Data upload cost of implemented system is approximately 3.7 MB per month

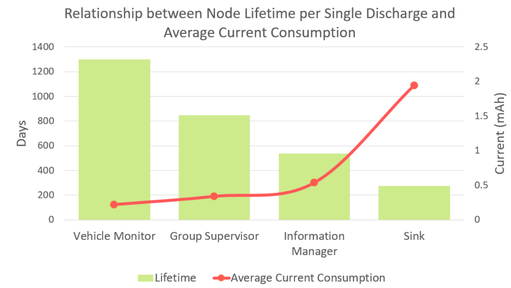

Figure 5: Graph depicting energy performance of the system

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

Table 1: Data consumption of system scaling

Future Work

- An alternative row administrator node row is established if any of the current row administrators go down, allowing negative effects to be dramatically decreased.
- Allow sensors to take multiple consecutive readings, 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.
- Small application updates, including the option to manually refresh the parking lot page

Conclusions

A prototype IoT-based smart parking system has been designed which comminucates parking availability to