Spark

Smart Parking for an Interconnected Campus

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Abstract

Parking on a college campus is understood to be a challenge for commuters. With a rising matriculation rate in the United States, the task of finding parking on an expansive campus grows even more daunting. However, the rising prominence of the Internet of Things has initiated a paradigm shift in data-analysis computing. The point of data collection is often outlier locations, removed from existing infrastructure, and parking lots are no exception. Using proximity sensors, solar power, and cellular communication, we can create such an IoT system to monitor parking lot in- and outflows. The parking data collected can be analyzed to create a smarter, more efficient parking experience.

Problem Statement

College campuses do not have the capacity to expand at the same rate as their student populations. With little ability to increase available infrastructure—most notably parking areas—we seek to create another system to facilitate the dispersion of parking gridlock entangling colleges.

Mission

Our goal is to create a system that:

- Monitors and analyzes parking trends on campus
- Costs less than 5% of a student parking pass per spot
- Requires no infrastructure modification or construction

Proposed Solution

Our design consists of three modules, shown on a dummy parking lot in Fig. 1:

Sentinel: Counts the cars entering and leaving the parking lot

Scout: Monitors the status of a single parking space. Used when there is a mixture of reserved and general availability spaces

Uplink: Connects Spark devices to our IoT Cloud Platform. Links to a data analytics engine and a smartphone application.

All devices are solar powered, using excess energy to trickle-charge backup batteries.

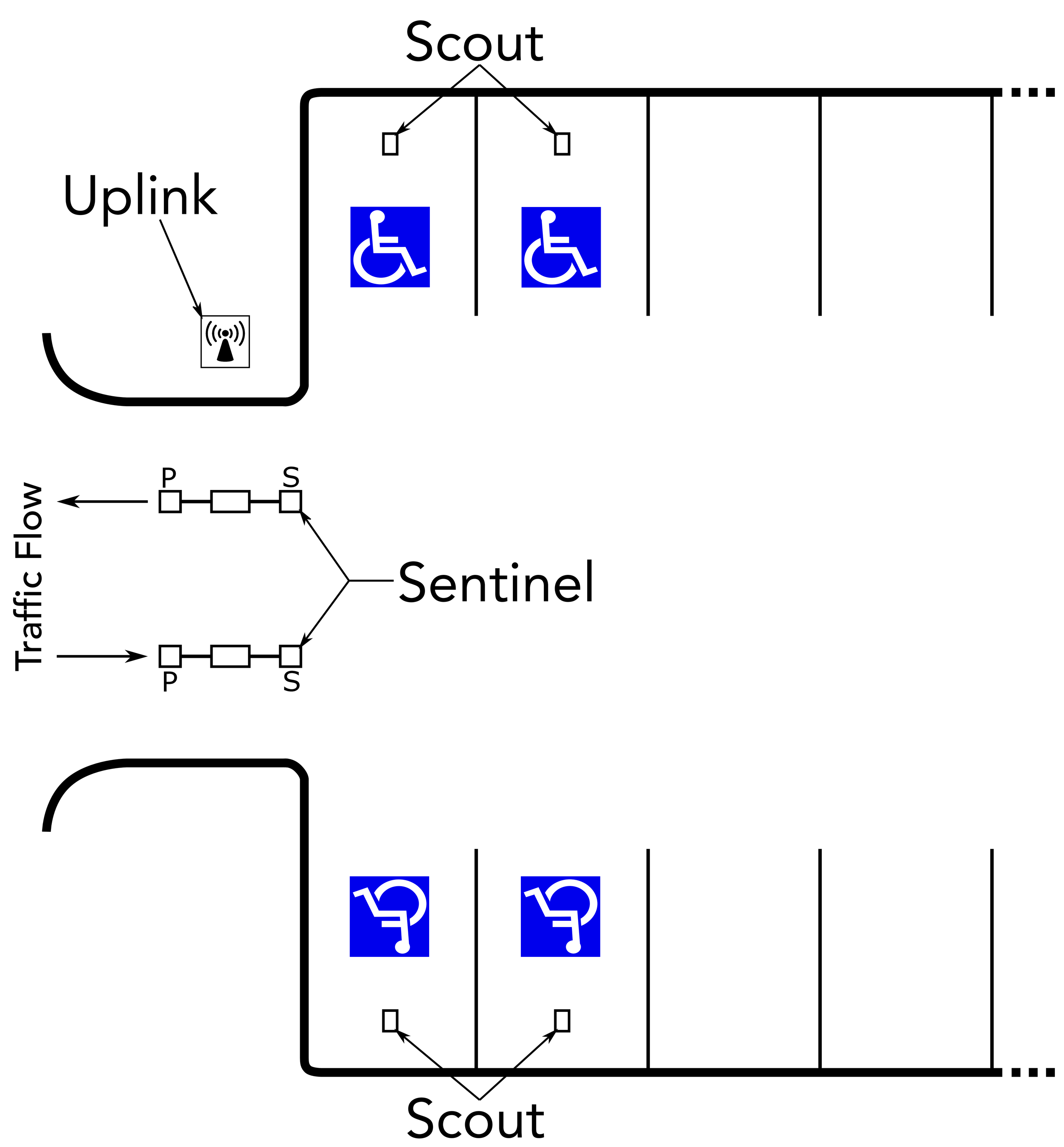

Fig. 1 Proposed Solution Schematic

Implementation

Fig. 2 Proximity Sensor (VCNL4200)

Fig. 3 WiFi Module (ESP-WROOM-02)

Fig. 4 LTE Modem (SARA-R410M)

- Proximity sensors (Fig. 2) on Scout & Sentinel modules throw interrupts when they detect an object 16 inches away.
- WiFi modules (Fig. 3) handle transmission, but any protocol could be used.
- Transmissions occur when
  1. A Scout detects a car entering or leaving the space
  2. Both Sentinel sensors are covered
     - Entry/exit is determined by order of sensor interrupts (P then S, or vice versa)
- Uplink buffers the data to prevent offsetting transmissions and uses the LTE Modem (Fig. 4) to query the IoT Platform.

Cost Analysis

For a simple parking lot, with no reserved spaces, the required cost is

Module	Quantity	Price ($)
Sentinel	2	24.66
Scout	0	16.56
Uplink	1	32.73
Power	3	17.39
TOTAL	**6**	**134.22**

For a lot of 200 spaces:

- **$0.67** per spot
- **0.89%** of a TCU student parking pass

For a more complex lot, with 15 reserved spaces, the required cost is

Module	Quantity	Price ($)
Sentinel	2	24.66
Scout	15	16.56
Uplink	1	32.73
Power	3	17.39
Scout Power	15	13.34
TOTAL	**36**	**607.38**

For a lot of 200 spaces:

- **$3.04** per spot
- **4.05%** of a TCU student parking pass

Power Consumption

- **3.55 mA** (11.7 mW) when active
- **2.3 mA** (7.59 mW) when idle

For an 800 mAh battery:

- Worst case: 225.4 hours (9.4 days)
- Ideal case: 347.8 hours (14.5 days)
- Typical case*: 300 hours (12.5 days)

*Typical case assumes 70/30 idle/active ratio

Future Work

- The mechanical housings and fastener mechanisms need to be created.
- The application server and backend need to be made production ready.
- A suitable UI needs to be designed for the application and website.
- Larger volume deployment strategies and support technology need development.

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