UMassAmherst

Smart Coaster

SDP20
Team 16
PDR

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Meet the Team

Professor Joshua Yang
Advisor

Jonathan Capozzi
EE

Timothy Shum
EE

Angus Mo
EE

Joshua Howell
CSE

Problem Statement

At restaurants, fast and responsive service leads to higher customer satisfaction. Waiters/waitresses often juggle serving several tables at the same time. A customer might finish their drink and have to wait a while for service.

Solution - Smart Coaster

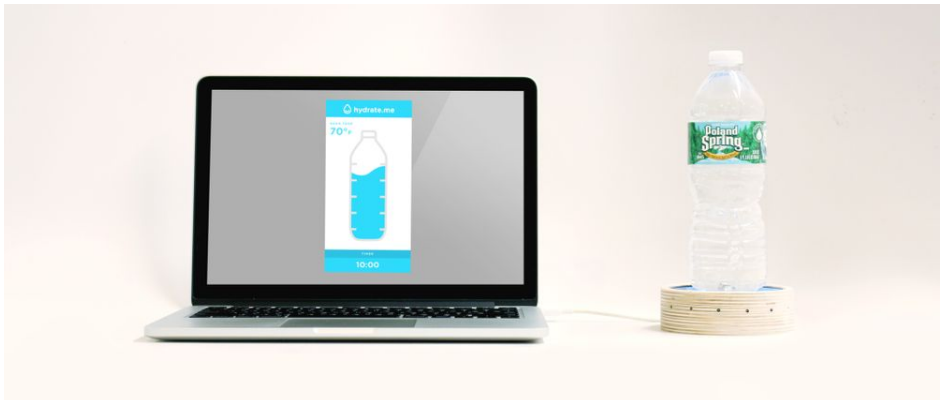
- Monitor multiple tables' drinks with ease
  - Coasters connect to a single device to easily see what table needs a drink/refill
- Faster customer service response
  - Coasters send a notification to the smart device when a cup is emptied
- Intuitive system
  - Low maintenance coaster with long lasting battery life

Similar Products

- Brio Smart Coaster
  - *New Potato Technologies*
  - Interactive app recommends pubs and restaurants
  - Includes coaster position tracking
  - "Drink Guard" notifies if a drink has been tampered with

Similar Products

- HYDRATE.ME
  - *NYU Design Team*
  - Coaster reminds user periodically to drink water
  - Notifies the user when to refill water bottle
  - Widget provides visual representation of water bottle



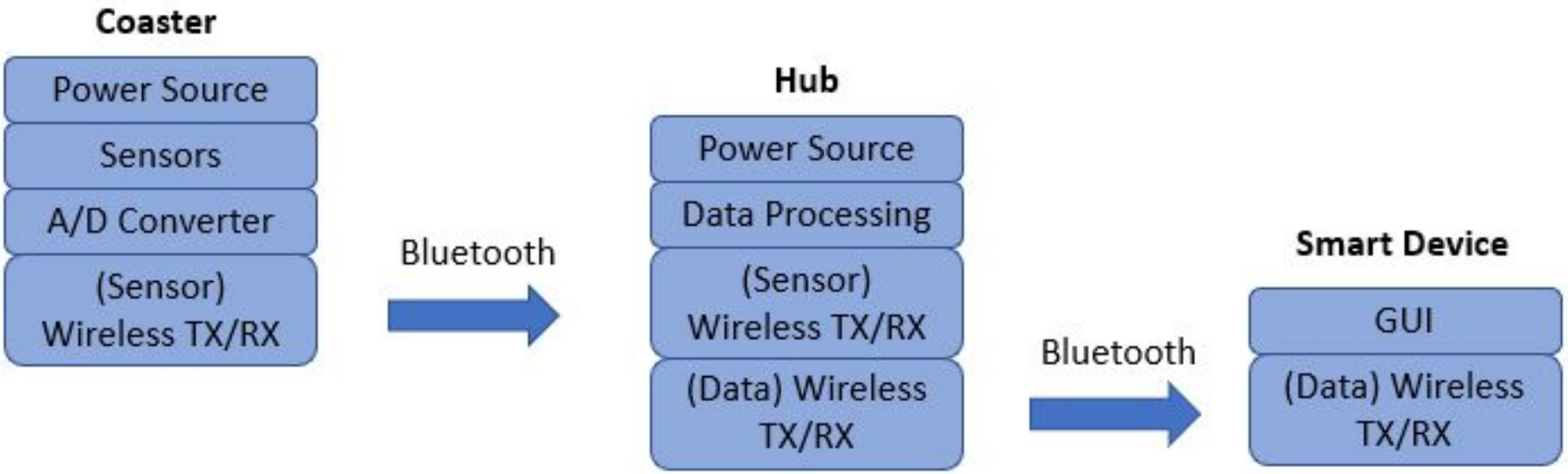
Specifications

- >95% “empty glass” detection rate
- <1% “empty glass” false positives
- >12hr battery life
- <5hr recharge time
- <2cm coaster thickness
- Supports multiple coasters

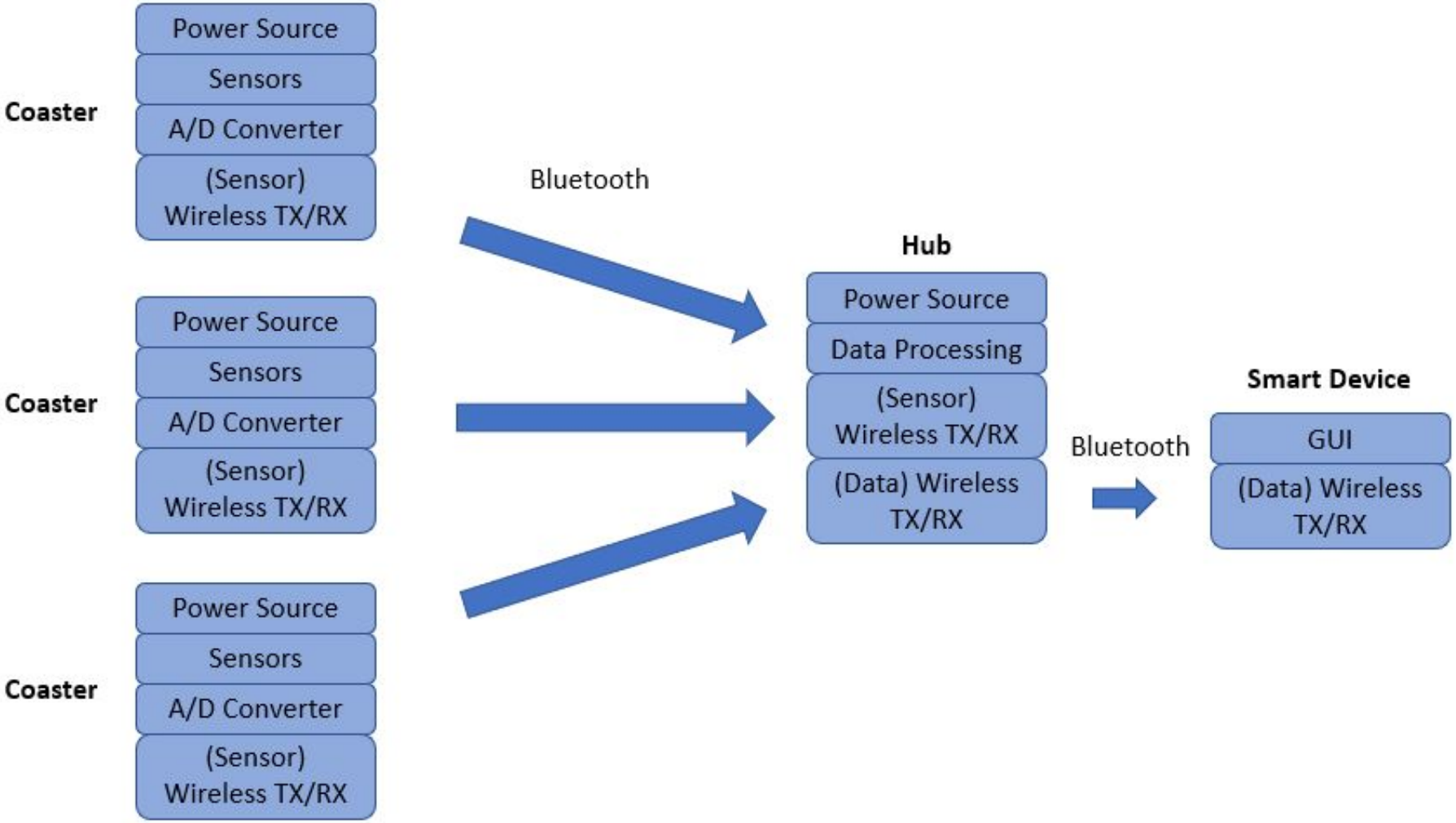
- Accurately detects a new/refilled beverage
- Accurately determines weight of glass itself
- Accounts for ice or other leftovers

- Reach Goal: Wireless charging station

Block Diagram



Block Diagram



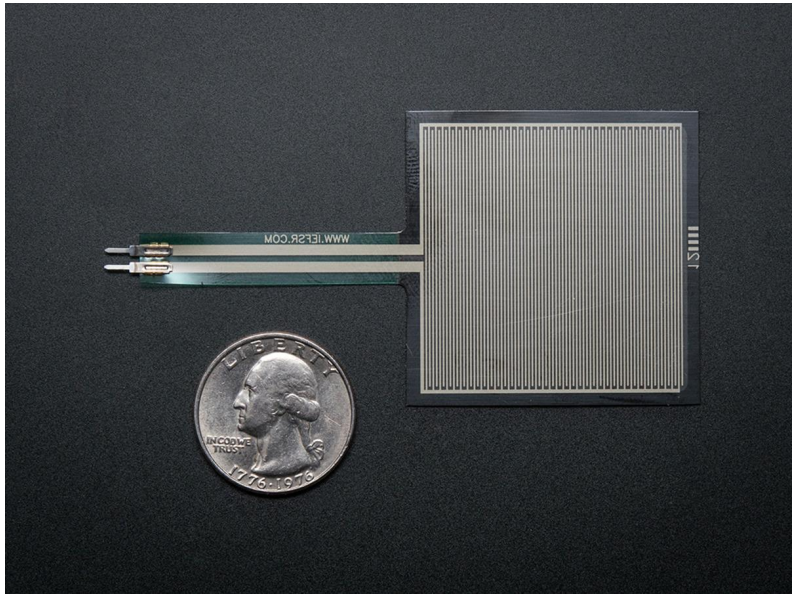
Block Diagram - Sensing Components

- Possible Implementations:
  - Load Cell
    - High precision
    - Bulky - adds thickness
    - High cost
  - Force Sensitive Capacitors
    - Thin/small form factor
    - Low precision
    - High cost
  - Velostat - Variable Resistor
    - Thin/small form factor
    - Low precision
    - Low cost

Block Diagram - Sensing Components

Force Sensitive Resistors:

- Compact and discrete form factor
- Capable of measuring weight within desired weight range (50 - 300 grams)



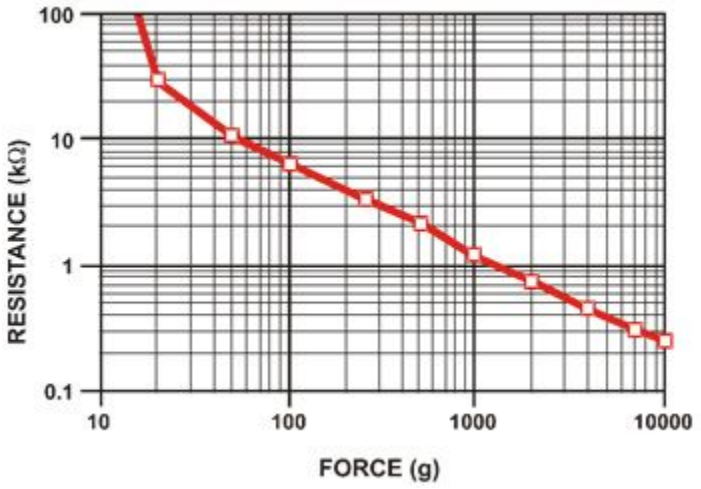


Figure 1. Plot of resistance vs force for a force sensing resistor.
Source: https://learn.adafruit.com/assets/429

Block Diagram - Sensing Components

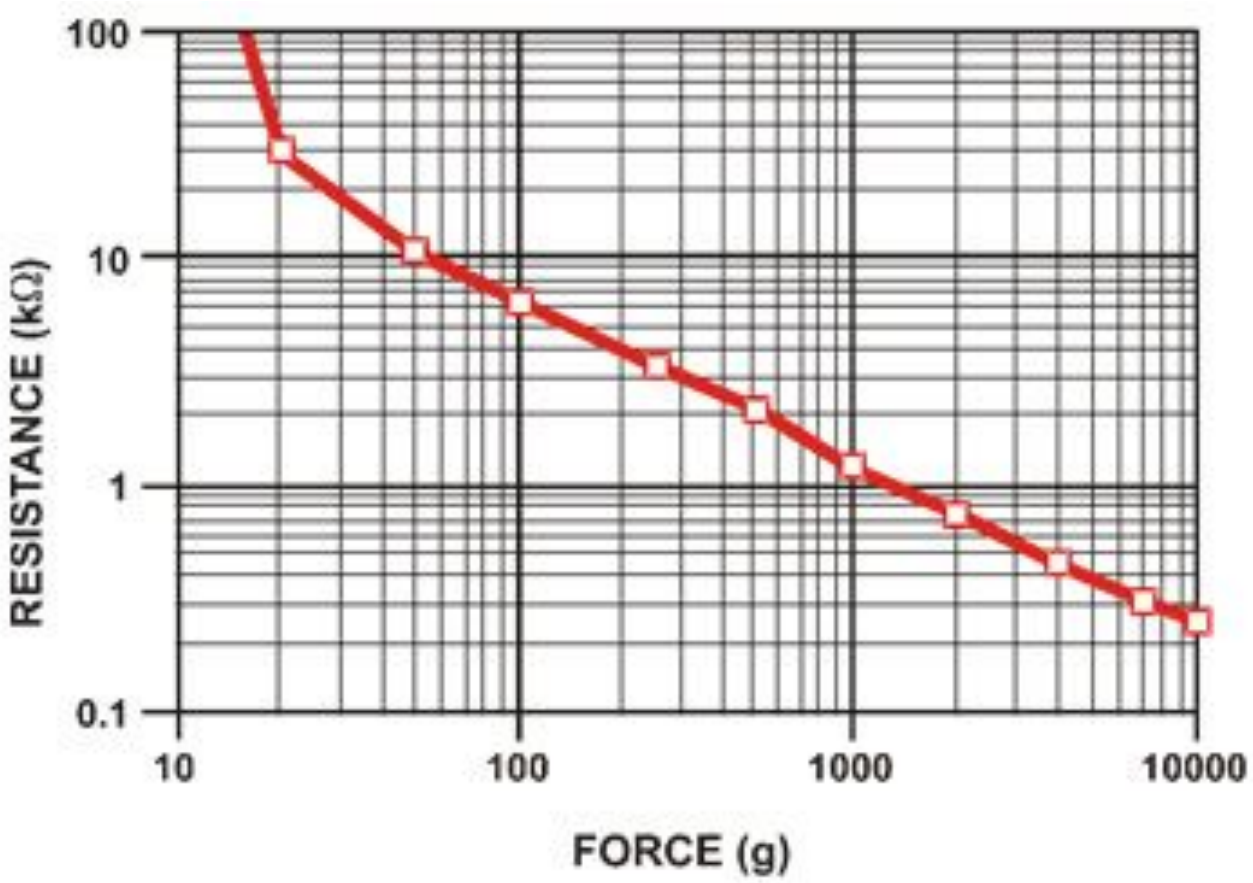


Figure 1. Plot of resistance vs force for a force sensing resistor. Source: https://learn.adafruit.com/assets/429

Analog Digital Converter

- Needs to translate analog voltage into a force/weight measurement (ADC)
- Has enough resolution to detect small changes in weight
- Low power consumption

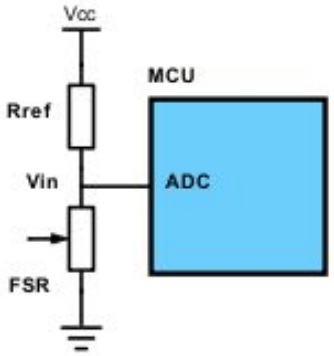


Figure 2. Wiring diagram of the force resistive sensor into the Microcontroller ADC

$$ADC\ Value = \frac{V_{IN} \cdot 2^{(Bit\ Resolution)}}{V_{CC}}$$

Figure 3. Expression for evaluating the ADC output value based on the input voltage

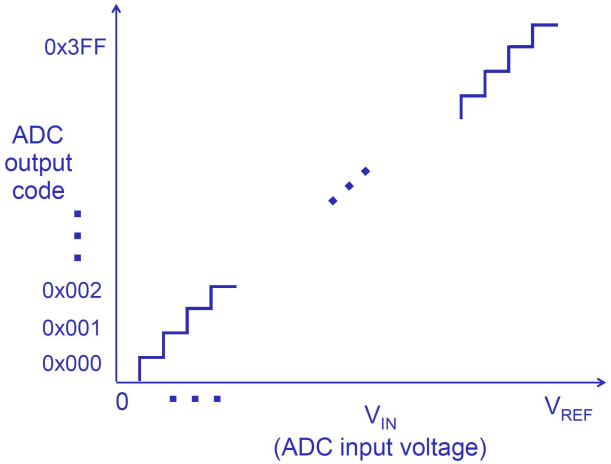


Figure 4. Translation of ADC input voltage into output codes

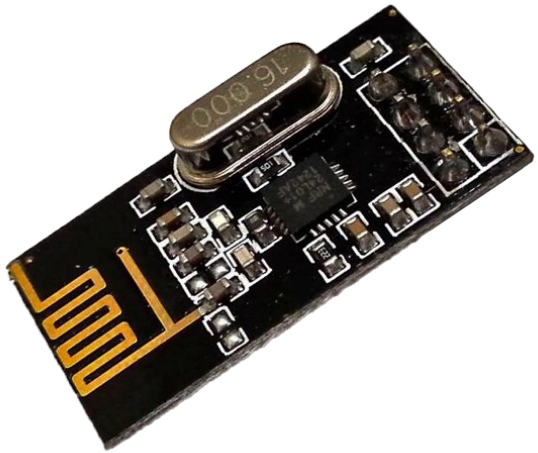
Wireless Communication

Requirements:

- Send status notification wirelessly to a central hub
- Does not have to be real-time, i.e. report status every few seconds
- Low power communication
- Working range up to 100m in open space

Nordic Semiconductor's **nRF24L01+** is a common 2.4GHz radio transceiver IC for low power/bandwidth scenarios.

- 1.9V-3.6V
  - Transmission: ~12mA
  - Standby: 26μA
  - Power down: 0.9μA



Block Diagram - Software Requirements

- Determine expected empty and full weights
  - Each range is bounded by the empty weight and max full weight
  - Relate weight ranges to container types
  - Standard glass, coffee mug, wine glass, etc.
- Detect empty drinks with ice/other leftovers
  - Log the time when the weight last changed by more than some threshold
  - Track how long a drink has gone untouched
- Notify staff
  - Alert waiters/waitresses when drink is low/empty
  - Hub notifies app to send alerts

MDR Deliverables

Arduino-driven coaster and hub prototype

- Sensor Accuracy:
  - Weight error <10 grams
  - Differentiate between drink levels
- Coaster Functionality:
  - Full, half-full, empty
- System Communication:
  - Hub receives and logs weight sent from coasters

Prototype Cost Analysis

Coaster:

- Enclosure: $15
- Processing unit: $25
  - Microcontroller
  - PCB
  - Passive Components
- Wireless comms: $7
- Battery: $5
- Force sensors: $25

Coaster Total: $77

Hub:

- Enclosure: $15
- Processing unit: $25
  - Microcontroller
  - PCB
  - Passive Components
- Wireless comms: $7

HUB Total: $47

Major Tasks

Josh

- Wireless implementation
- App/UI Development

Angus

- Embedded Software
- Data analysis/processing

Tim

- Hardware/Sensor implementation
- Enclosure Design

Jon

- PCB
- Power budgeting

Questions?

References

- FSR Wiring
  - https://www.electronicdesign.com/analog/signal-conditioning-force-sensing-resistors
- Connecting FSR to AVR
  - https://learn.adafruit.com/force-sensitive-resistor-fsr/using-an-fsr
- MCU Wifi
  - https://circuitdigest.com/microcontroller-projects/esp8266-nodemcu-with-atmega16-avr-microcontroller-to-send-an-email
- nRF24L01+ RF Transceiver IC
  - https://lastminuteengineers.com/nrf24l01-arduino-wireless-communication/
- Force Sensing Resistor (FSR)
  - https://www.adafruit.com/product/1075