UMassAmherst

Smart Coaster

SDP20
Team 16
MDR

December 4th, 2019

Meet the Team

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Advisor

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EE

Angus Mo
EE

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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.

Specifications

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

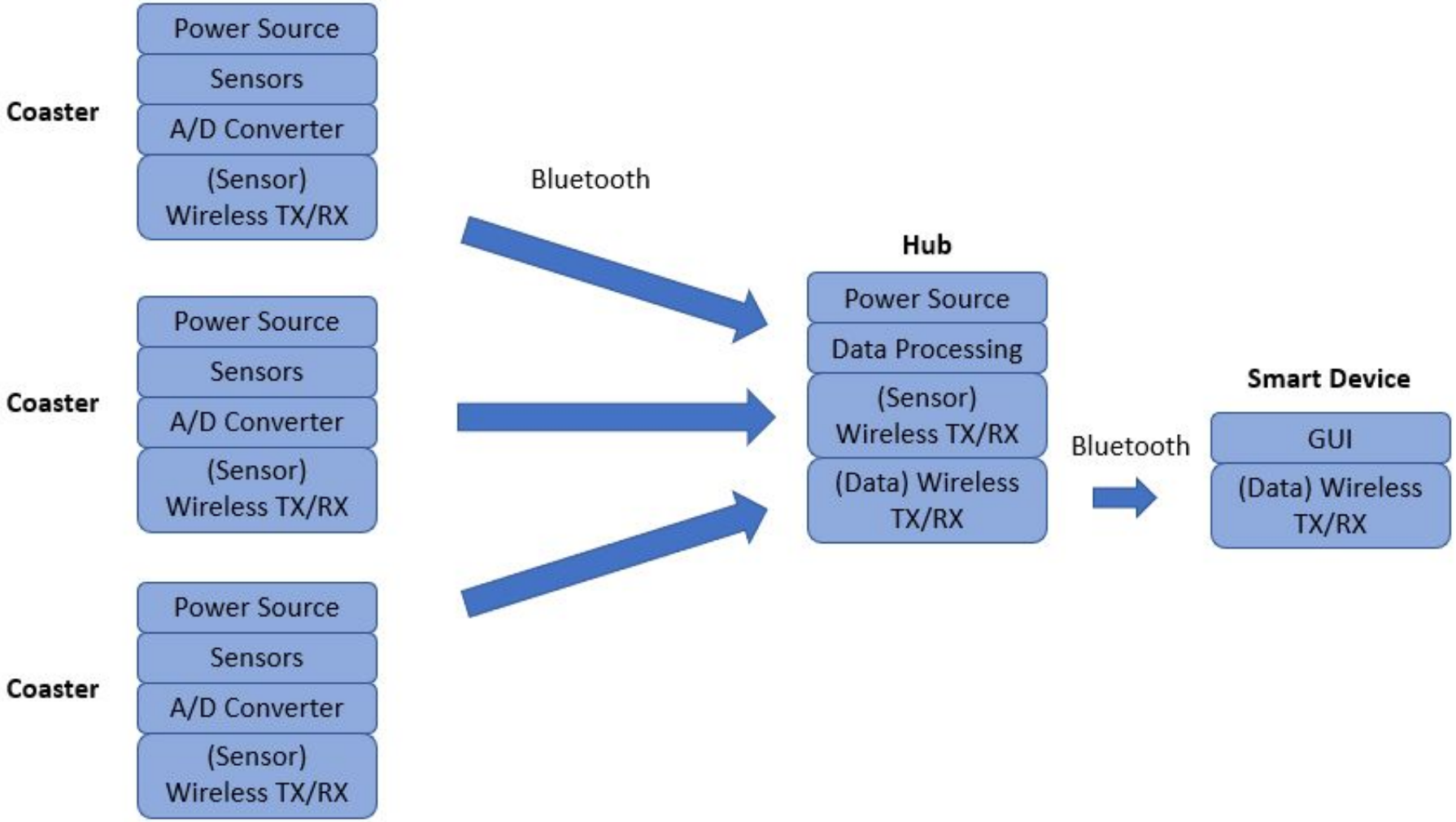
- Accurately detects a new/refilled beverage
- Accurately determines weight of glass itself
- Accounts for ice or other leftovers

- Reach Goal: Wireless charging station

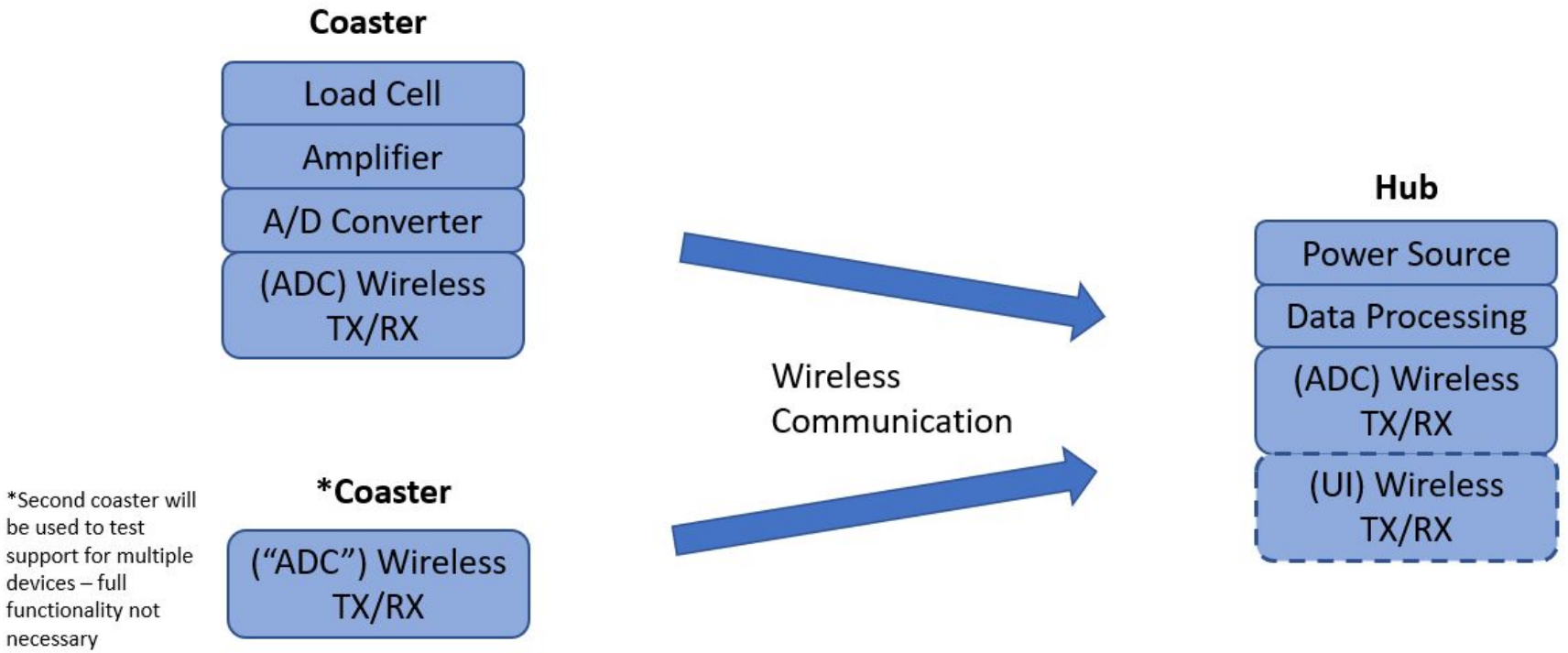
Block Diagram - Software Requirements

- 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

Block Diagram



MDR Block Diagram



Power Plan

Battery Choice:

- Each coaster will have two 3.7V 2600mAH Li-Ion rechargeable batteries in series.
- This 7.4V supply voltage will be stepped down to the 5V operating voltage chosen.
- If we were to bring down the operating voltage of our Amplifier we could potentially use a series of nickel metal hydride (NiMH) batteries.
- Subject to change based on the current needs of future part selection such as the microcontroller.

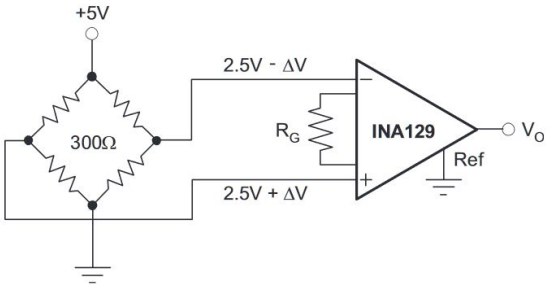
Power Plan

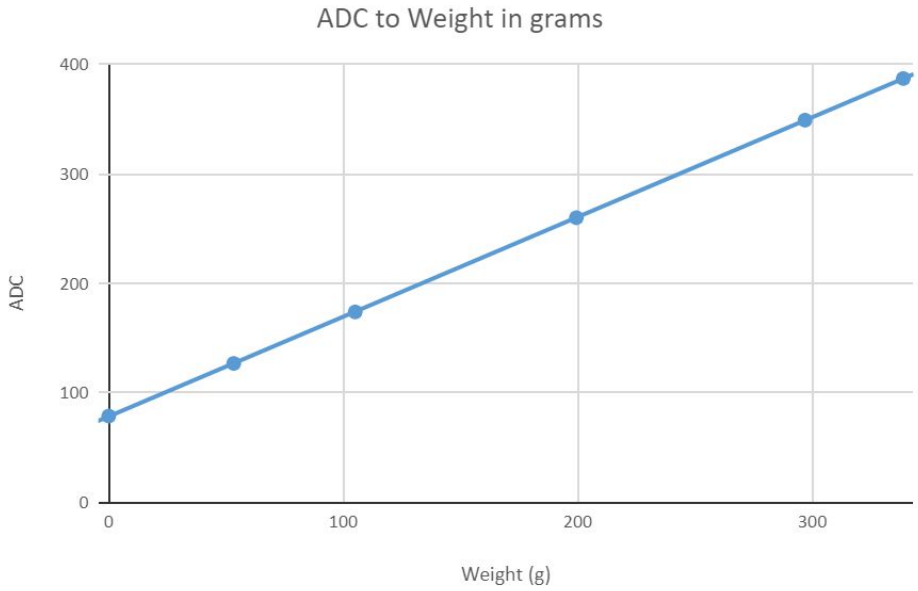
Charging:

- Recharge station on the central hub (Regulated power supply using the same wall supply the hub is connected to)
- The coasters are rechargeable through the same process as restaurant pagers
  - Metal Contacts on the screws that hold the enclosure together
  - The charge travels up through all the coasters that are stacked, charging them all simultaneously
  - Metal plates make contact with the screws internally to charge the batteries

Load Cell

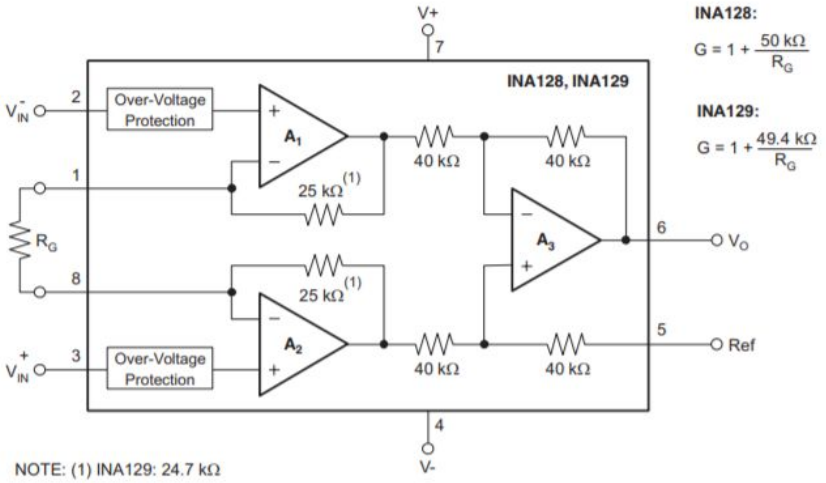
- High accuracy
- Highly linear
- Small output voltage
- Needs an amplifier so that we can use the range of our ADC





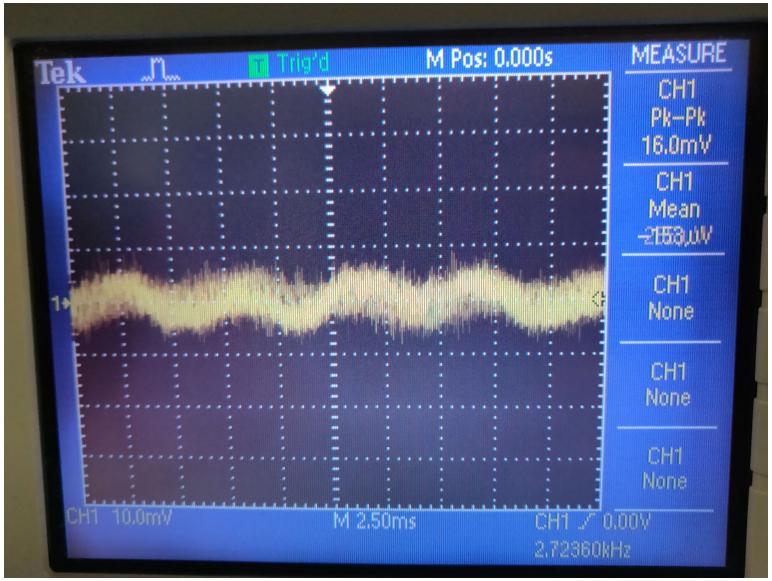
Instrumentation Amplifier

- Needed to bring the output voltage range of the load cell to the range of the ADC
- ~ .4mV-3.7mV from the load cell
- Picked a gain resistor to reach for 1000 V/V gain
- Operating at a supply voltage of 5V



ADC and Measurement Precision

- ATMEGA328 ADC maps analog input between 0-5V to a digital range 0-1023
- Each ADC value represented roughly by 5mV
- Considering noise ~ 7.5mV amplitude, expected +/- 1.5 error in ADC value
- Depending on calibration, accuracy of about X grams/ADC value



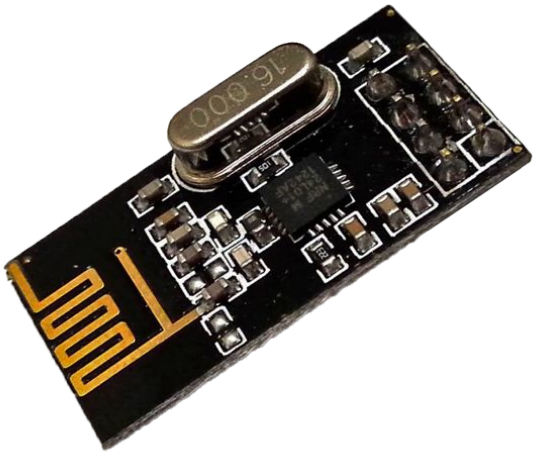
Wireless Communication

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



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


Gantt Chart
1/27/2020
2/6/2020
2/16/2020
2/26/2020
3/7/2020
3/17/2020
3/27/2020
4/6/2020
4/16/2020
4/26/2020
5/6/2020
Coaster PCB Design
Coaster Battery Supply
Recharge Station
Coaster Enclosure
Code Translation
Microprocessor Selection
HUB User Interface
HUB Enclosure
HUB PCB Design
2nd Coaster Module
Refinement
Demo Day

Responsibilities

TASK NAME	ASSIGNED TO	START DATE	DUE DATE	DURATION
Coaster PCB Design	Jonathan/Tim	2/3/2020	2/20/2020	17
Coaster Battery Supply	Jonathan	1/30/2020	2/10/2020	11
Recharge Station	Jonathan/Tim/Angus	1/27/2020	2/25/2020	29
Coaster Enclosure	Tim/Jonathan	2/23/2020	3/9/2020	15
Code Translation	Josh	2/1/2020	2/20/2020	19
Microprocessor Selection	Tim/Angus	1/23/2020	2/1/2020	9
HUB User Interface	Josh/Angus	2/18/2020	2/27/2020	9
HUB Enclosure	Tim/Jonathan	3/8/2020	3/24/2020	16
HUB PCB Design	Tim/Jonathan	2/20/2020	3/8/2020	17
2nd Coaster Module	Team	2/29/2020	3/12/2020	12
Refinement	Team	3/12/2020	4/3/2020	22
Demo Day	Team	4/24/2020	4/25/2020	1

Demo

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