Cold Chain Tracking
SDP 2021
Team 25

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Meet the Team

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The Dangers of Warm Oysters

- Foodborne illnesses and bacteria grow when oysters not stored at right temperature(< 4 degrees Celsius)
- Many oysters are shipped and served raw
- Important for supply chain to maintain correct temperature throughout transport

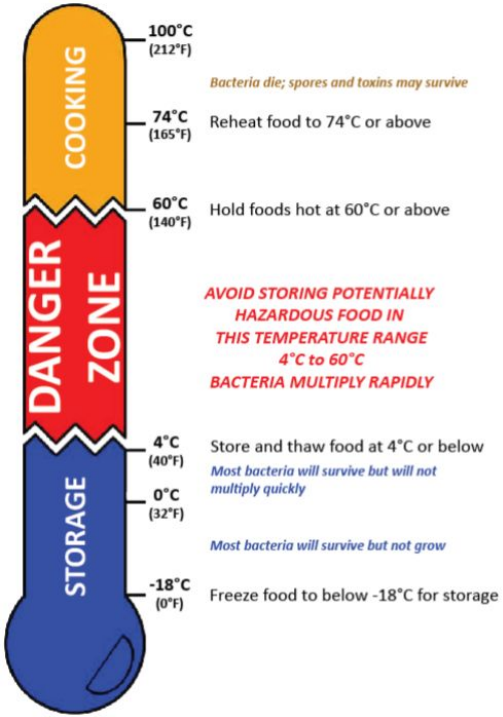

Figure 1. Temperature guidelines for oysters from the British Columbia Centre for Disease Control [1].

Supply Chain

Supply Chain

- Starting from Oyster farm - raised, sorted and packaged in 100 count bags
- Bought and shipped wholesale to seafood distributor
- Distributor have seafood orders to fulfill. Oysters are then moved from warehouse and shipped to restaurants/supermarkets alongside other products
- Simplest chain, there can be more intermediates along the way

Problem with Supply Chain

- Study observed that ⅛ of oyster shipments sampled had unsafe temperatures during transit [2]
- The average amount of time these boxes of oysters spent out of temperature compliance was 2.5 hours [2]
- Liability falls onto the oyster farm if people get sick
- A small oyster farm can ship 100,000 oysters a week
- Often processed manually by people
- Temperature recordings are based on honor system human measurement

Problem Statement and Solution

- Need to monitor temperature during transit for accountability - cold chain tracking
- Current cold chain tracking products are not waterproof, solely single use, and high end ones are too expensive for scalable use

Our Solution:

- Will provide accurate timing, location, and temperature in real time to all parties involved in supply chain via web service
- Will be low cost and reusable for oyster farmer
- Will be durable and waterproofed to be stuffed in oyster bags

System Specifications

- Must be able to provide real time tracking to user with the following parameters:
  - Temperature: within 1 degree Fahrenheit
  - Location: within 25 ft
  - Time: Record the correct time in Eastern Standard Time within 1 sec
  - Updated every 15 minutes with connection
- Battery power must be able to last 1 week
- Waterproof
- Materials before discounts cost less than $110, $85 optimal
- Physical size smaller than 6”x6”x3”
- Rechargeable/reusable

Current Solutions #1 - CargoData

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Product	Lightning NFC	Lightning Real Time	Streamer 4G
Real Time?	No	Yes	Yes
Single Use/Reusable?	Single Use	Single Use	Reusable
Communication Technology	NFC with phone app	Uses 2G to upload data to website	4G with cellular triangulation from cell phone tower
Battery Duration	10 days	10 days	5 days without external power source
Waterproof?	No	No	Yes but as a mount case that is sold separately. Product intended to be mounted to truck.
Cost	$23.50	$40	$355 with $25/month subscription

Current Solutions #2 - Bosch

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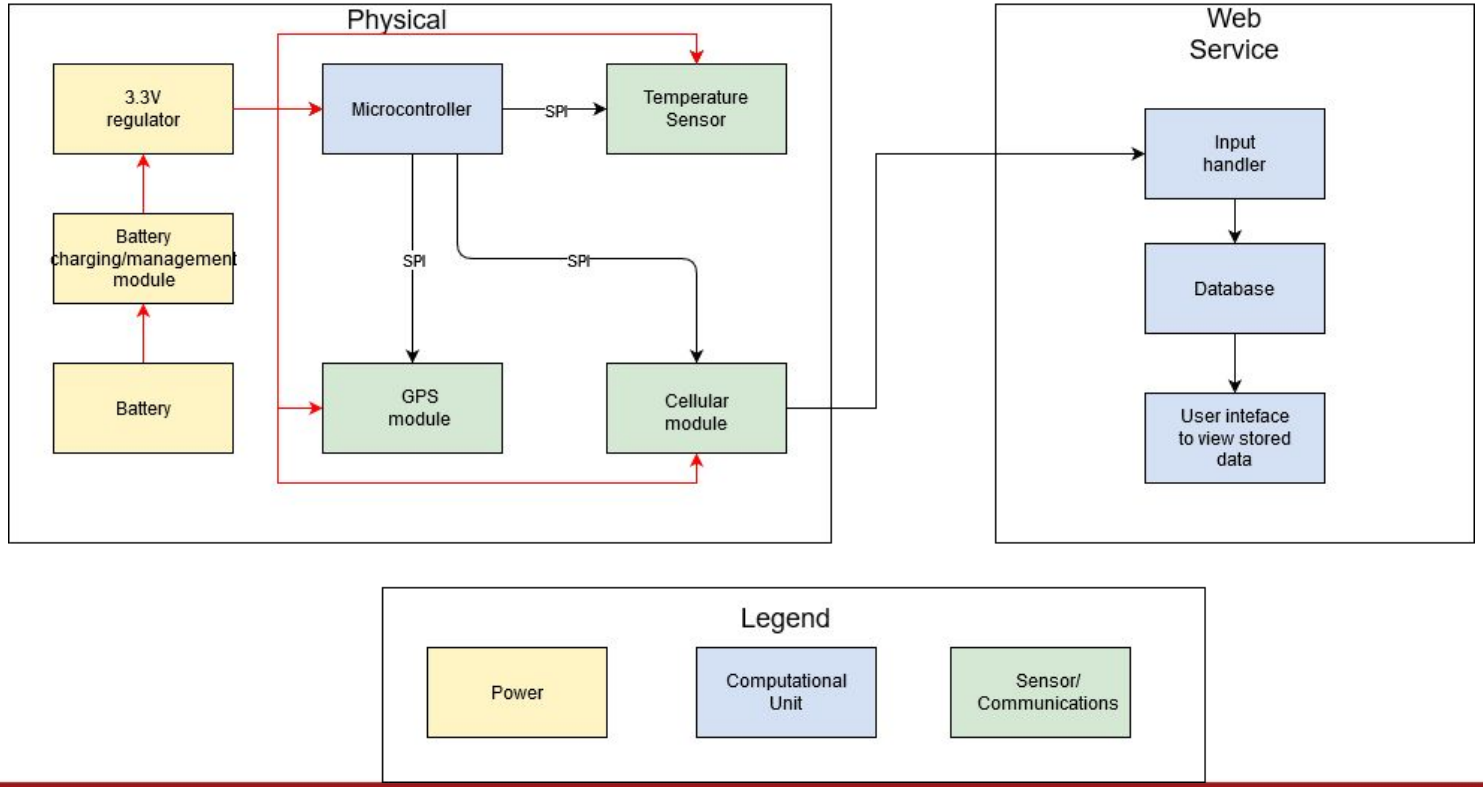
Product	TDL110	TDL140
Real Time?	No	Yes. At minimum, can only measure every 1 hour interval.
Single Use/Reusable	Reusable	Reusable
Communication Technology	Bluetooth Low Energy Version 4.0	Penta Band GSM/GPRS/EDGE/UMTS/HSDPA/HSUPA
Battery Duration	CR 123A Lithium Battery, 1400 mAh	30 days (1 report every 1 hour, +25°C)
Waterproof	Yes	Yes
Cost	$101	$656.25

Block Diagram



Microcontroller

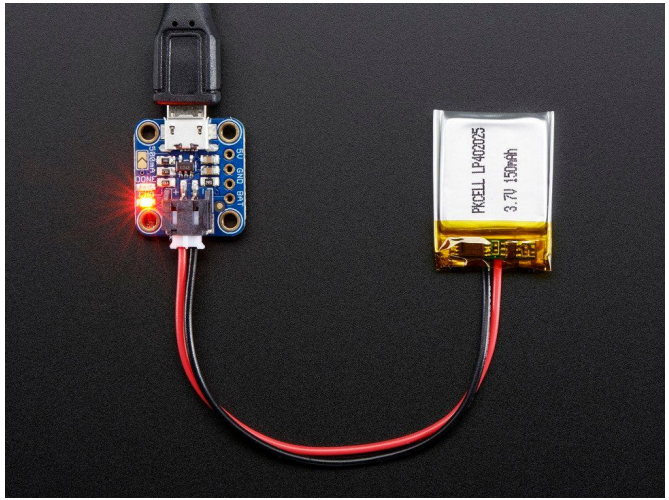
Requirements:

- Accurate real-time counter for 15-minute interval
- Maintain low power mode
- Query peripherals for necessary measurements
- Format data for communication with server

Power Management Module

Requirements:

- Allow battery to charge off of USB power
- Supply power to voltage regulator



Temperature Sensor

Requirements:

- Accurately measure temperature of the system (±1℉)
- Communicate with the microcontroller

GPS Module

Requirements:

- Accurately measure latitude and longitude within 25 feet
- Communicate with the microcontroller

Cellular Module

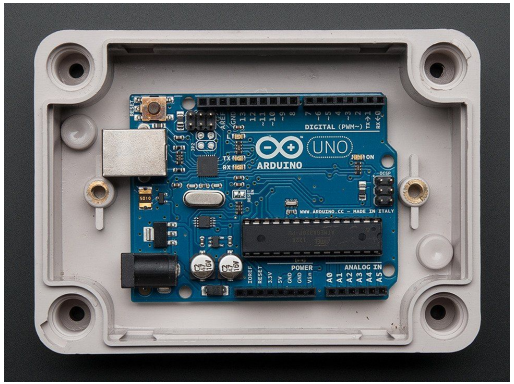
Requirements:

- Facilitate communication between microcontroller and server
- Establish persistent connection to ensure reception
- Must use a low-power, highly available protocol
- Communicate with microcontroller

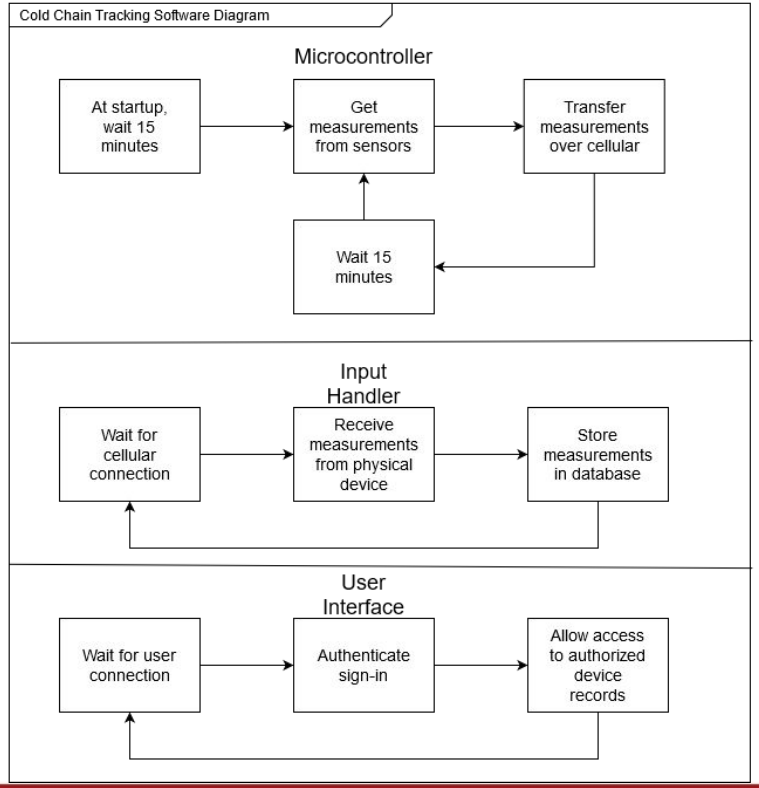
Waterproof casing

Requirements:

- Protect physical system from water and impact
- Watertight seal
- Easy to open to access physical system as needed



Software Block Diagram

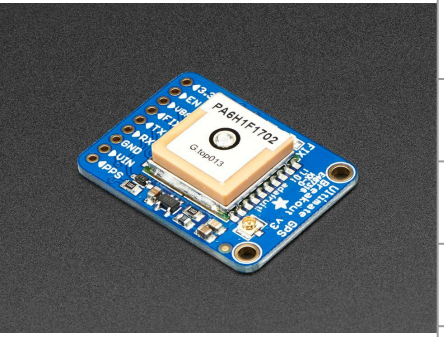


Custom Hardware

PCBA system

- Connect and integrate our physical system
  - Microcontroller
  - Temperature sensor
  - GPS module
  - Cellular module
  - Power management module
- Contained within waterproof casing with battery

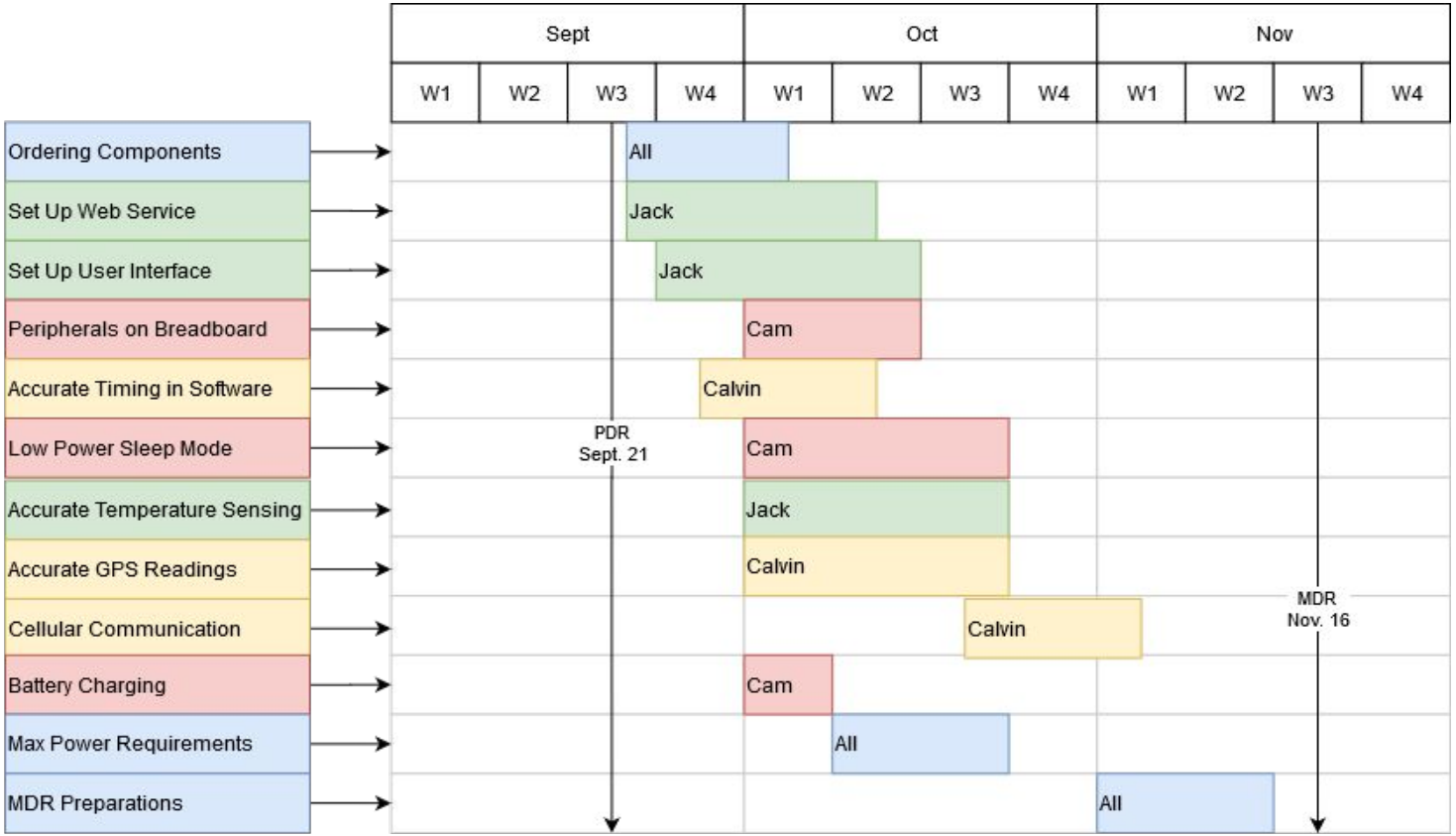
Costs



Component/Material	Experimental Pricing	Ideal Prototype
GPS Modules	$100	$10
Cellular Modules	$100	$20
Microcontroller	$10	$2
PCB	$30	$30
Temperature Sensors	$30	$5
Batteries	$15	$10
Screws/nuts	$5	$2
3D Printer Filament	$10	$5
Total:	**$300**	**$84**

Responsibilities

Calvin Lee	Jack Newton	Cam Harvey
Altium lead, Cellular communication lead	Budget management lead, Web service lead	Team coordinator, Peripheral communication lead, 3D print lead


Sept
Oct
Nov
W1
W2
W3
W4
W1
W2
W3
W4
W1
W2
W3
W4
Ordering Components
Set Up Web Service
Set Up User Interface
Peripherals on Breadboard
Accurate Timing in Software
Low Power Sleep Mode
Accurate Temperature Sensing
Accurate GPS Readings
Cellular Communication
Battery Charging
Max Power Requirements
MDR Preparations
All
Jack
Jack
Cam
Calvin
Cam
Jack
Calvin
Calvin
Cam
All
All
PDR
Sept. 21
MDR
Nov. 16

MDR Deliverables

- Enable GPS, cellular, and temperature on a solderless breadboard
- Cellular communication between Arduino and Web input handler
- Basic user interface enabled for web service
- Determine max power requirements for 7 day use
- Battery charging on solderless breadboard with usb input

Stretch goals:

- Replace Arduino with ATMEGA328P on breadboard
- Print unfitted container to test waterproofing

Works Cited

[1] British Columbia Centre for Disease Control, "Guide for Restaurant Operators Serving Raw Oysters and Bivalve Shellfish,"*http://covid-19.bccdc.ca*. [Online]. Available: http://www.bccdc.ca/resource-gallery/Documents/Educational%20Materials/EH/FPS/Fish/GuideForRestaurantsServingRawOystersAndBivalveShellfish.pdf. [Accessed: Sept., 21, 2020].

[2] D. Love et al., "Supply chains for aquacultured oysters: enhancing opportunities for businesses and shellfish growers, and examining traceability and food safety," CLF., JHSPH, Baltimore, MD, USA, Project Number: NA16NMF4270230, Final Rep., Oct. 25, 2019. Accessed: Sept., 21, 2020. [Online]. Available: https://clf.jhsph.edu/sites/default/files/2019-11/NOAA-grant-report.pdf

Questions?