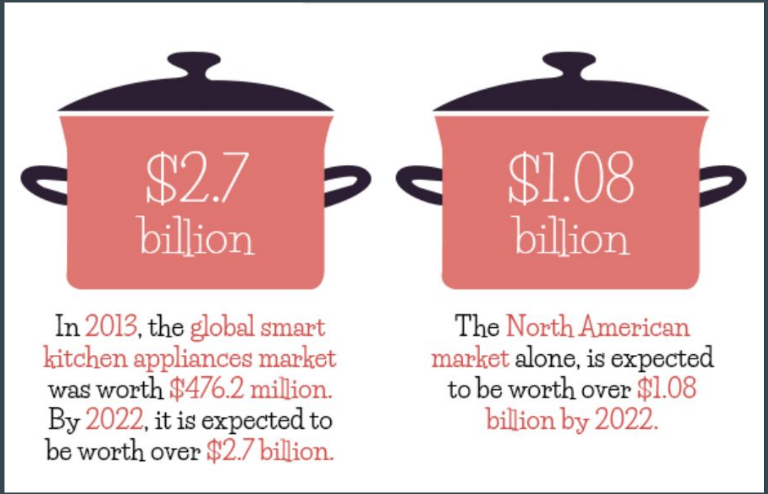
RecipeTop: Group 7
Final Presentation

Gera Versfeld, EE
Edwin Santiago, EE
Miguel Ramirez, CpE
Jason Portillo, CpE

Motivation

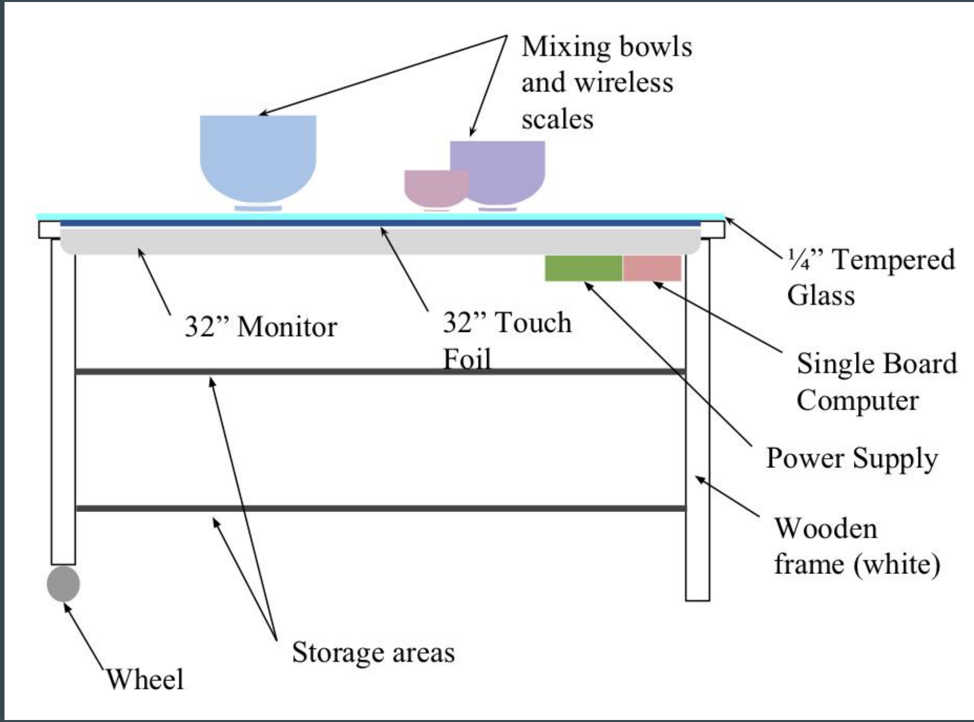
- Create something that helps people learn to cook
- Make cooking a more organized and enjoyable experience
- Make the kitchen a more fully integrated part of a modern smart home



-Irma Wallace. "The Smart Kitchen of the Future is Here [Infographic]." *Infographic Journal, 22 Feb. 2017,* https://infographicjournal.com/the-smart-kitchen-of-the-future-is-here/

What is RecipeTop?

An interactive countertop and recipe preparation assistant



Objectives

Core

A multi-touch countertop that will provide users with a unique and helpful experience when cooking.

- Multi-touch enabled display
- Intuitive user interface
- Recipe search, storage, and suggestions

Advanced

Seamlessly interface your kitchen to make cooking simpler.

- Wirelessly connected scale
- Recipe guidance with clear steps and useful features like timers
- Compact design with storage space built in

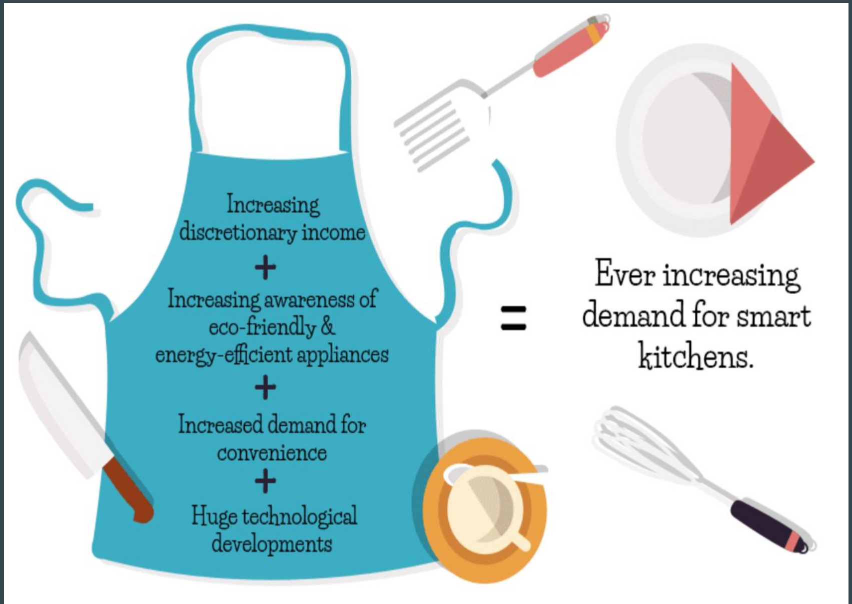
Stretch

We hope to integrate computer vision and ML to for more interactivity and better recipe suggestions.

- Companion mobile application
- Recipe search and suggestion based on ingredients on counter
- Integration with smart home products like Alexa or Google Assistant

Marketing Goals

Letter	Marketing Goal
a	Low cost
b	User Friendly
c	Durable, Kitchen Safe
d	Food safe
e	Help you learn to cook
f	Easy to clean



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Engineering Specifications

#	Specification	Target	Marketing Goal
1	Diagonal Display Size	≥30 in	a,b,e
2	Touchscreen Multi-touch Capability	≥ 2 touch points	b,e
3	Operating temperature	60°F ≤ T ≤ 140°F	c,d
4	Scale Accuracy	≤ 5g	b
5	Touch response time	≤ 100ms	b
6	Counter Height	≥ 30 in	b,c,f
7	Countertop Diagonal	≥ 35in	a,b,c,f
8	Total Prototype Cost	≤ $2000	a

Design Constraints

Economic and Time Constraints

- Overall budget for senior design: $2000
- Two semesters to complete project

Environmental, Social, and Political Constraints

- Sustainably manufactured components
- Proper disposal of electronic waste

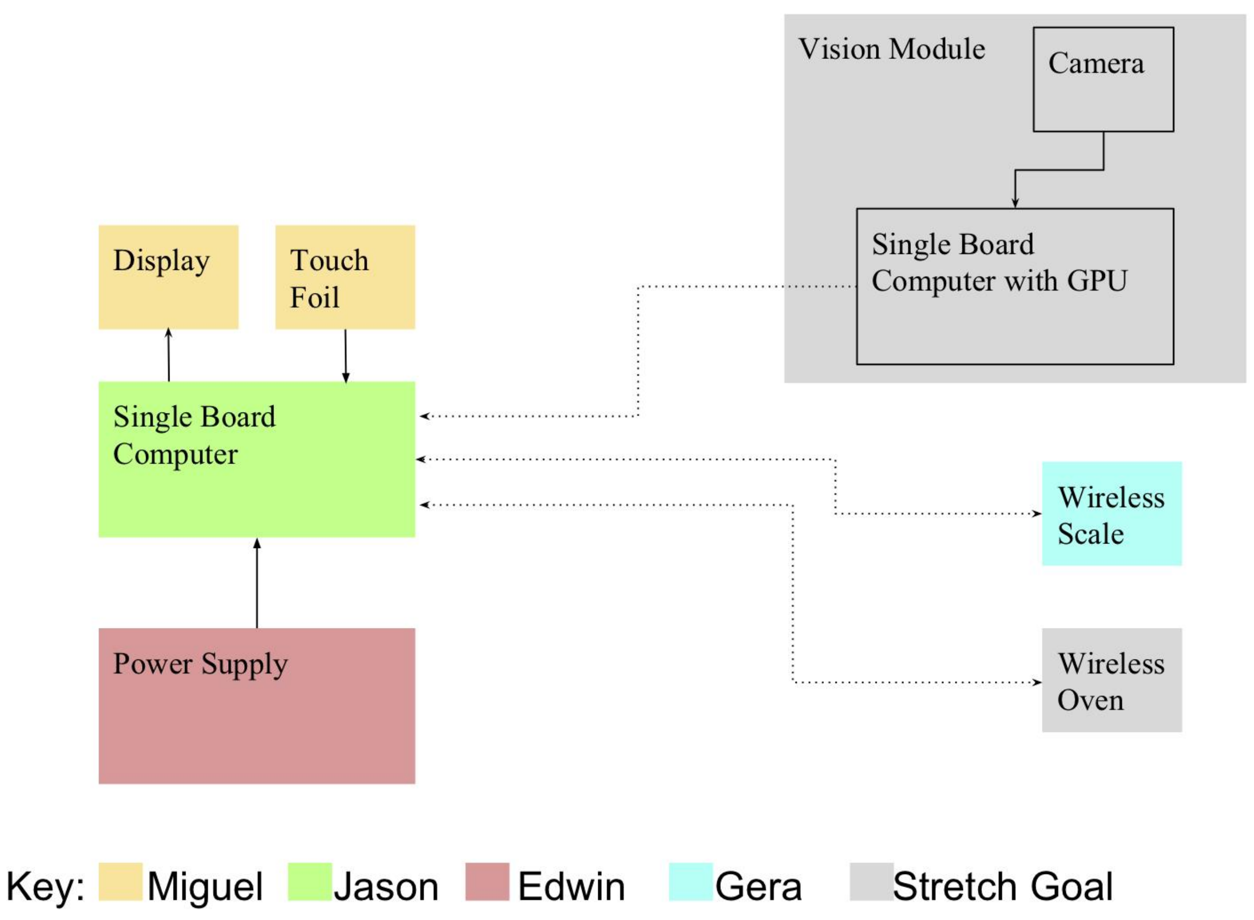
Ethical, Health, and Safety Constraints

- Smooth, non-porous surface important for safe food handling
- non-toxic, durable
- appropriate working height
- prevent risk of fire or shock, properly insulate and waterproof electronic components
- electronics need heat management systems

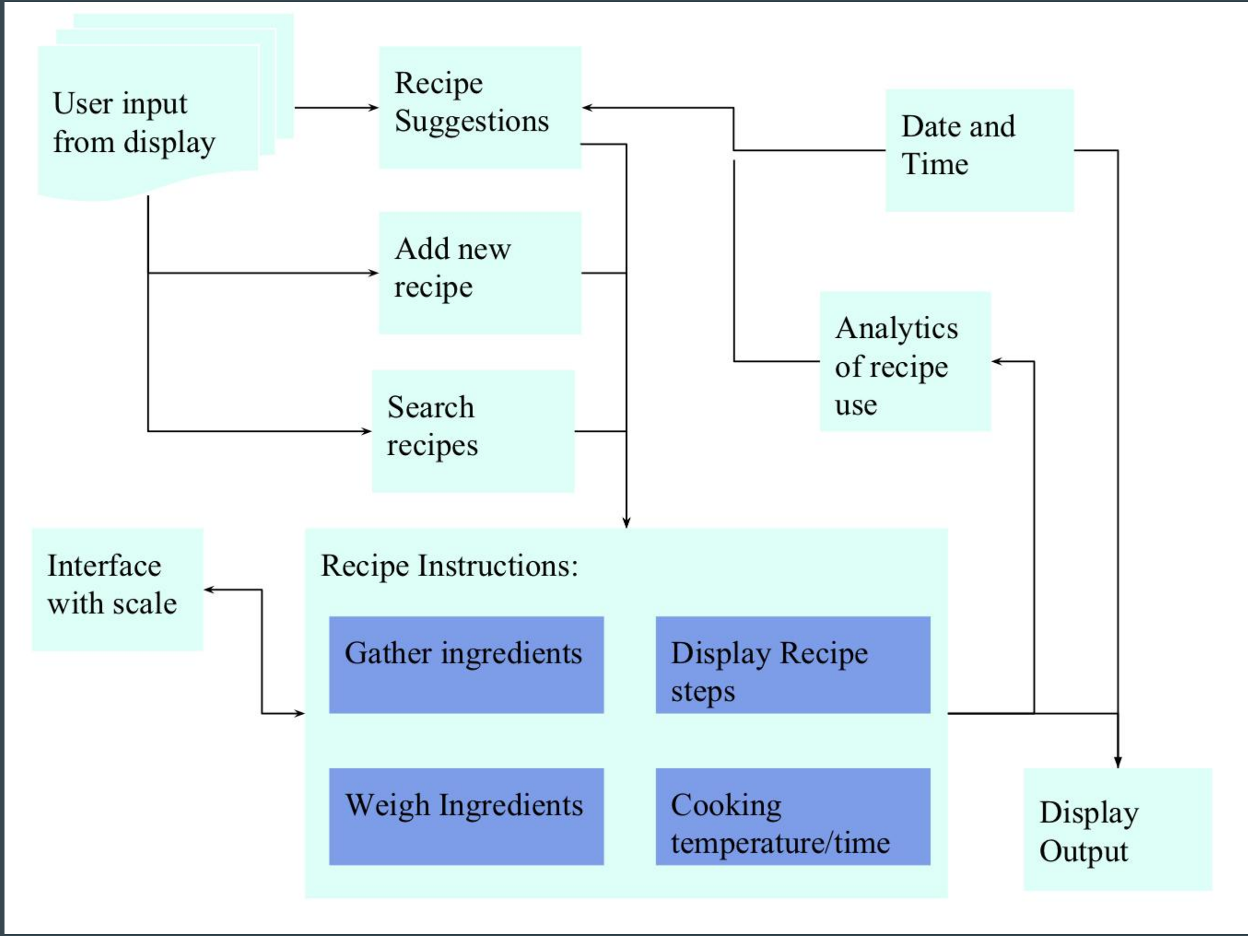
Relevant Standards

- NEMA 250 [5]
    - Provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt).
- HTML/CSS W3C
    - Code efficiency
    - Device compatibility
    - User accessibility
    - Will not follow internet search optimization guidelines since application will function locally
- NASA TECHNICAL STANDARD: SOLDERED ELECTRICAL CONNECTIONS [6]
    - Fillet - smooth concave buildup of material between two surfaces
    - Soldering environment ventilation system shall comply with OSHA requirements, 29CFR
- Javascript Standards [7]
    - Uniform and consistent coding style
    - Naming convention/commenting and semicolon use

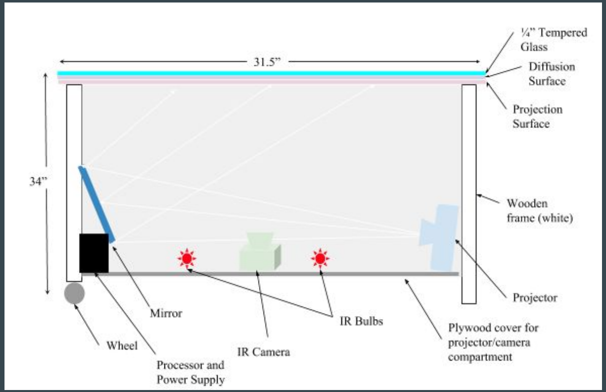
Overall System Block Diagrams: Hardware

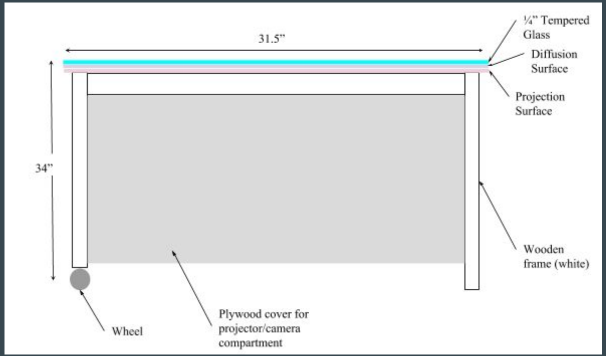


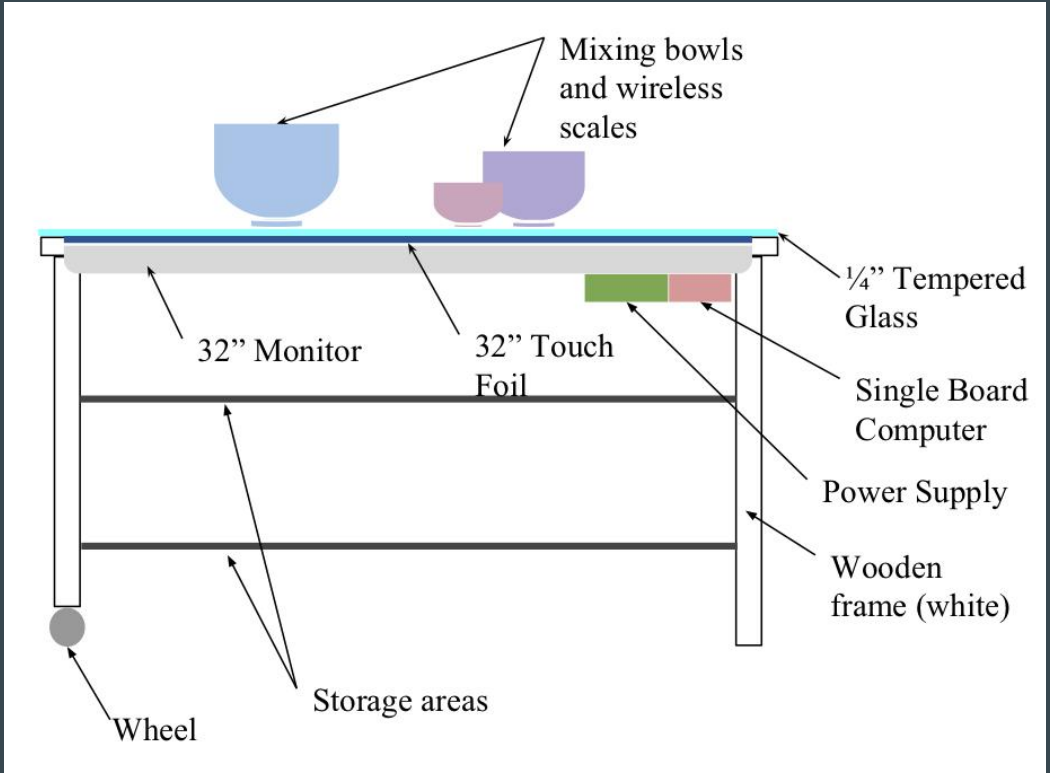
Overall System Block Diagrams: Software



Overall Approach and Proposed Implementation







Significant component and part selections

Single Board Computer

Microcontroller

Wifi Module

Touchfoil

Load Cells

Single Board Computer

Raspberry Pi 3 Model B+

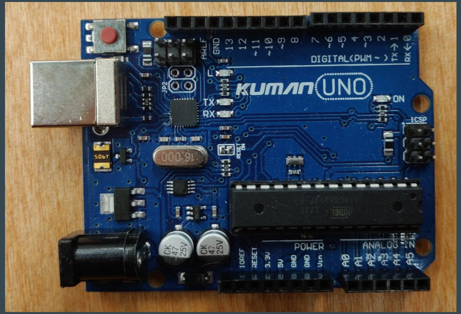
- Affordable
- Well documented
- Past projects have demonstrated what could be done with the Raspberry Pi
- Drawback: very limited processing power and RAM

	Beagle Board	Raspberry Pi 3 b+	Jetson TX2
CPU	ARM37x 1 GHz	Quad core 1.4Ghz	L2+ Quad ARM
GPU	Power VR SGx530	Broadcom Videocore IV	Nvidia Pascal, 256 CUDA cores
USB ports	4 USB 2.0	4 USB 2.0	USB 3.0 + USB 2.0
Power	2.5A @5V	2.5A @ 5V	2.5 @ 5V
Memory	512 MB	1GB	8GB
Storage	Micro SD	Micro SD	32 GB eMMC
Software	Linux	Raspbian	Jetpack (linux)
Price	$150	$35	$468.00

Microcontroller

ATMEGA328P (Arduino Uno)

- Easy to use
- Cheap
- Small footprint
- Well documented with lots of open source libraries and examples
- Compatible with our chosen A/D Converter and wifi module

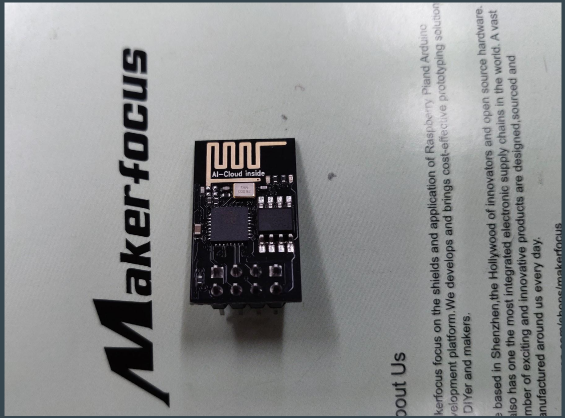


	CC3200	ATMega 328P
Cost	$0 (Provided by TI Lab)	$1.96
Clock speed	1MHz-80MHz	16Mhz
GPIO pins	27	23
Operating voltage	2.1V - 3.6V	5V
Communication	Wifi	With external module
Temperature sensor	Yes	With external module
Documentation	Detailed	Available
Libraries	Requires TI IDE	Open source
Power Consumption	Low	Medium
Size	Small	Small

Wifi Module

ESP8266 ESP-01

- Used for breadboard testing
- Small size, small price.
- Cheap external module with a relatively small footprint
- Easy to integrate with ATMEGA chip



Cost	$1-$3
Clock speed	80Mhz
Operating voltage	3.3V
Wifi	IEE 802.11 b/g/n Wi-fi
Documentation	Available
Libraries	Open source
Power Consumption	0.5uA-170mA
Size	14.3 X 24.8mm

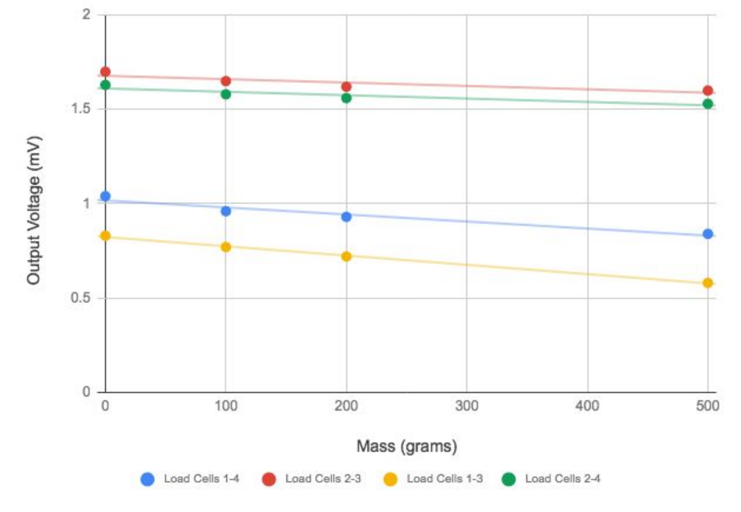
Touch Screen: Xiamen Touch Foil

- Important factors:
  - Cost
  - Response time
  - Number of touch points
  - Driver software
- Capacitive touch foils varied very widely in cost.
- Most US vendors cost upwards of $2000
- alibaba.com was used to purchase directly from the manufacturer at a lower price

Vendor/Product name	Xiamen Touch [16]	Green Touch [15]	Gerteise [44]	Pro Display [45]
Touch Points	10	10	10	N/A
Response time	10ms	<10ms	<2.5ms	18-50ms
Driver Software	Linux, Mac	Linux, Mac	Windows, Linux	Windows, Linux
Light transmittance	>93%	>90%	N/A	>93%
Aspect Ratio	16:9	16:9	16:9	16:9
Diagonal Size	32-47”	5”-60”	27-55”	17”-100”
Time for shipping	7 days	N/A	1- 2 months	N/A
Cost	$115	$105	$174.50	$1,241

Load Cells

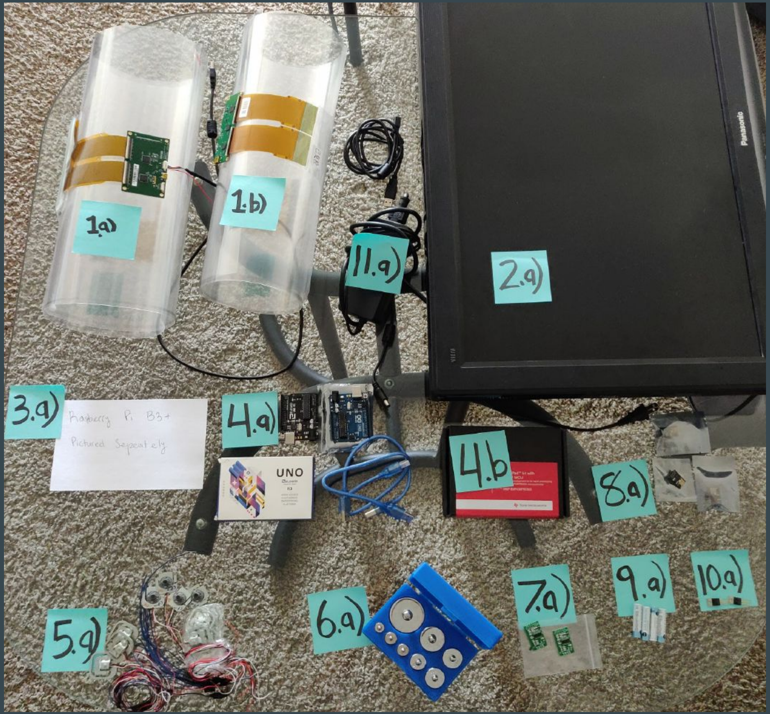
We choose to use load cells scavenged from previously owned kitchen scales due to budgetary constraints. All device specifications needed to be measured.



Load Cell Pair Output Voltage vs Applied Mass

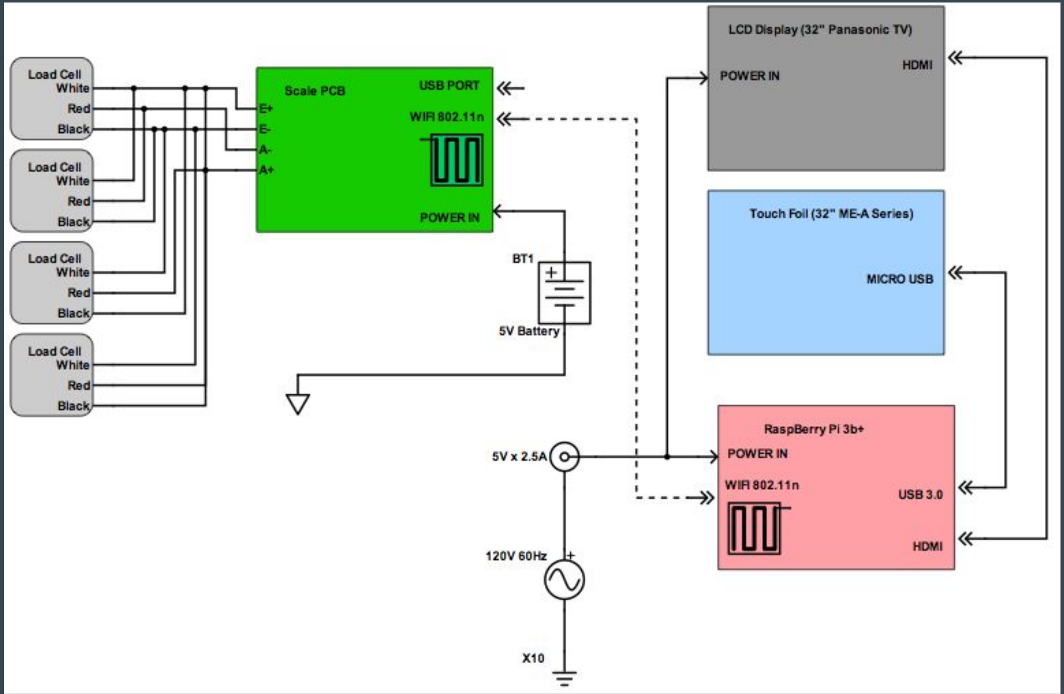
Vendor/ Manufacturer	Omega [48]	Manyyear [49]	Kitchen Scale (already owned)
Load Range	0-25lb	0-5kg	0-5kg
Output Voltage	1mV/V	unknown	unknown
Excitation Voltage	5 V (DC)	5 V (DC)	unknown
Bridge Resistance	≥350Ω	1000Ω	~500Ω
Thermal Sensitivity	Low	2%	unknown
Type	Compression	Compression	Compression
Documentation	Available	Available	Not available
Bridge type	Full	Full	Half
Accuracy	0.5%	0.05%	unknown
Size	¾”	37x47 mm	¾”
Cost	$350.00	$150	$0

Part Selection Summary



Hardware Design

- Two subsystems: display/ touch-foil/ single board computer and the wireless scale.
- The first subsystem: LCD display, touch-foil, and single-board computer.
- This subsystem will be powered from AC mains via a wall wart.
- Touch foil will be powered by and transmit data via a USB connection to the raspberry pi.
- Wireless Scale: custom designed and printed PCB connected to four load cells and powered by a 6V battery.
- Scale PCB: A/D converter, MCU, and wifi module as well as voltage regulation



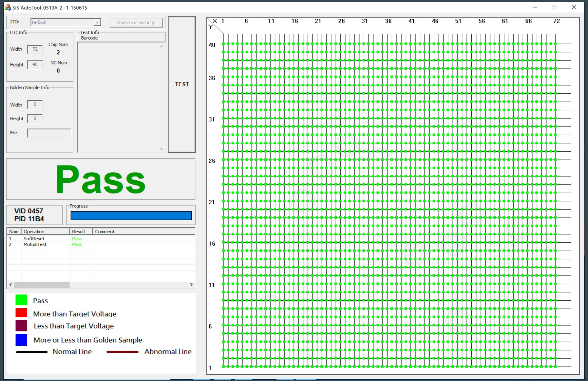
Subsystem 1: Single Board Computer and Touchscreen

Successes:

- Multi-touch capability
- Compact design with storage space

Challenges:

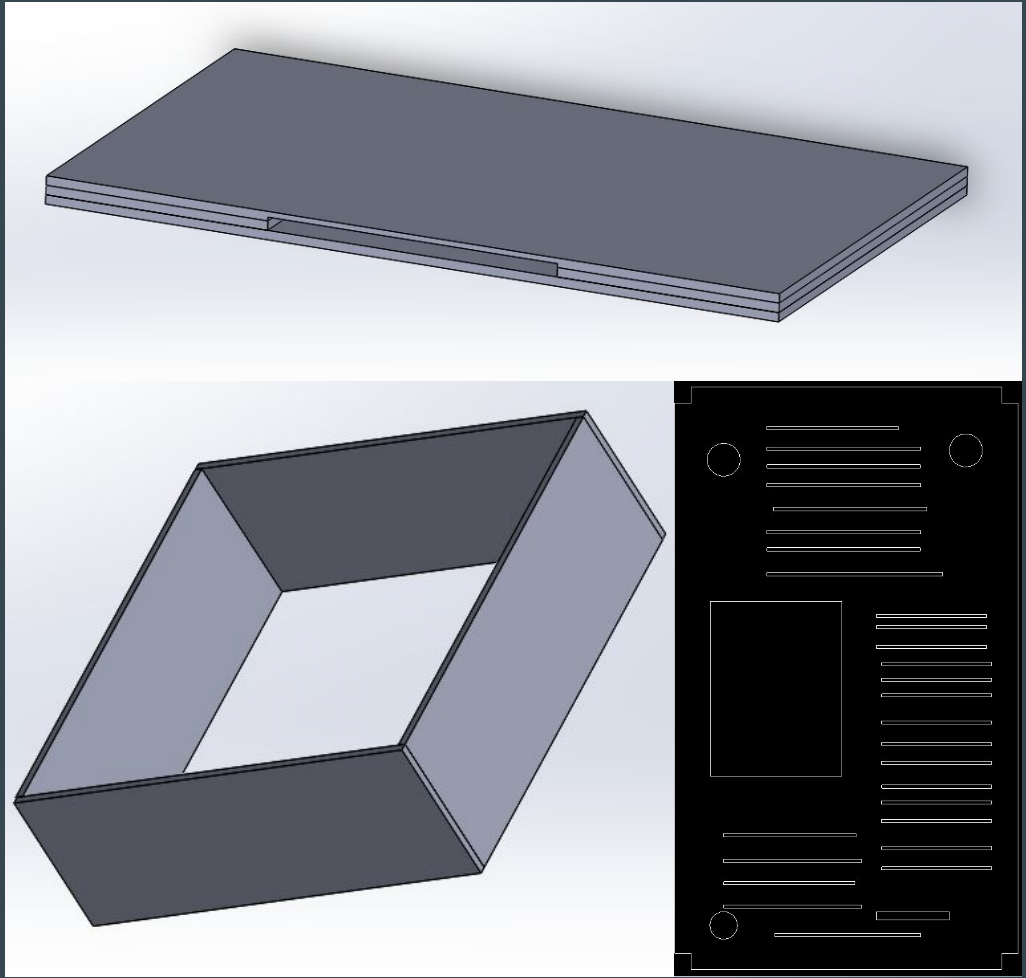
- Challenges with touch foil
  - Noise from TV
  - Difficult to paste without air bubbles
  - Ribbon needed to be carefully secured
- TV size and heat dissipation
- Limited processing power



Technology	Capacitive Touch foil [15],[16]	IR Touch Technology (RDI, FTIR)
Response time	Fast	Medium
Multitouch	Touch points add to cost	Depends on software
Light transmittance	High	100%
Sensitivity to objects	Low	High
Sensitivity to noise	Moderate (magnetic, electrical)	Moderate (natural light)
Installation size	Small	Large
Suitability for kitchen application	High	Unsuitable (exposed LEDs and electronics)
Software	Provided by manufacturer	Open source (OpenCV,CCV2)
Cost	Large range ($100-$2000)	Moderate (~$100)

Subsystem 1: Solidworks

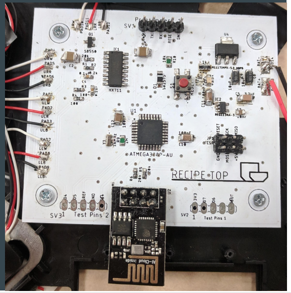
- TV wood frame
- Cutting Board
  - Secures foil circuit within slit
  - Added feature
- Bottom Cover
  - Allows for ventilation and access to Raspberry Pi

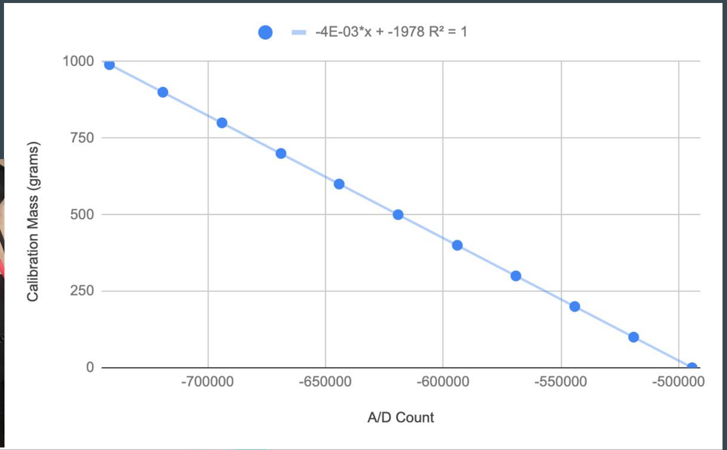


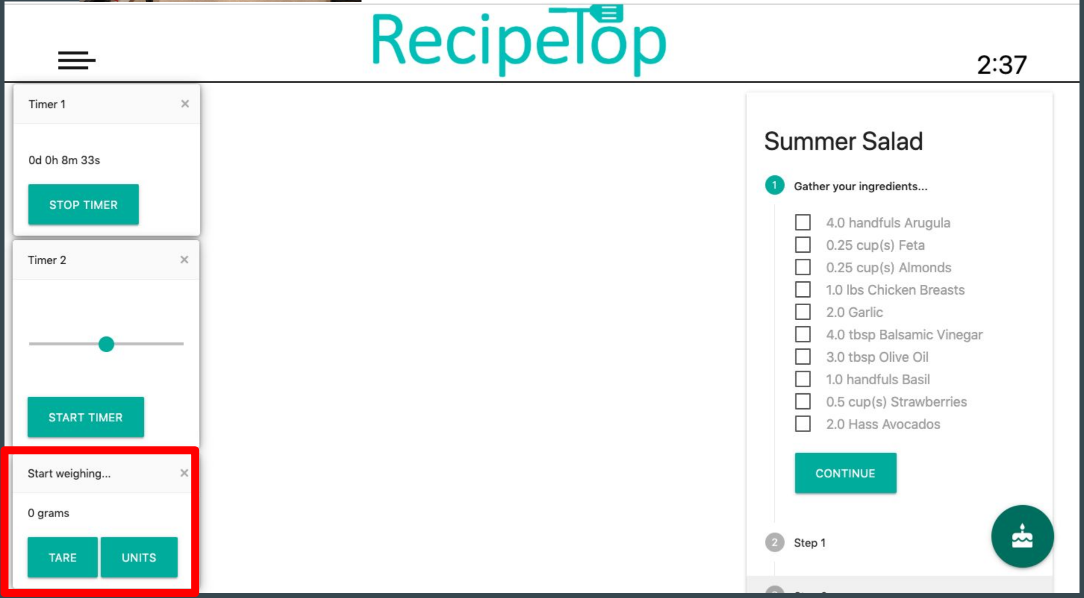
Subsystem 2: Wireless Scale

Successes:
- Accuracy of scale
- Integration with Subsystem 1

Challenges:
- Case that evenly distributed weight over all four load cells
- Calibration
- Communication between ATMEGA and wifi module

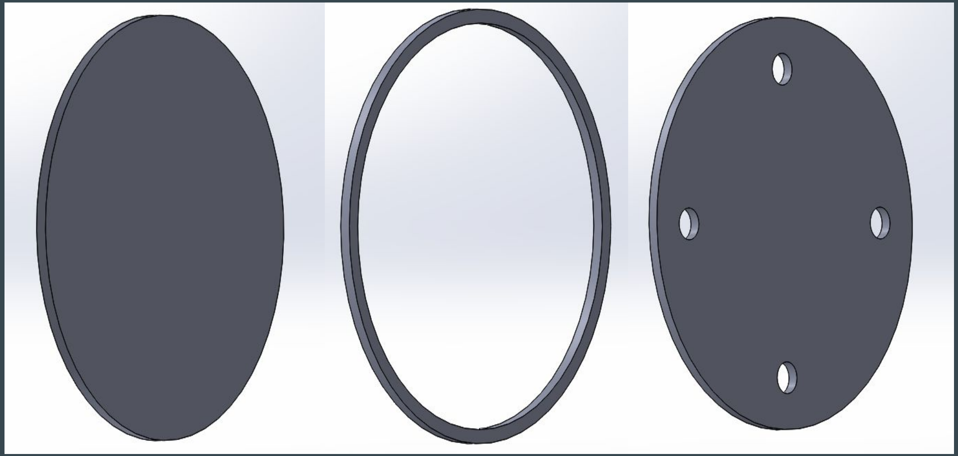






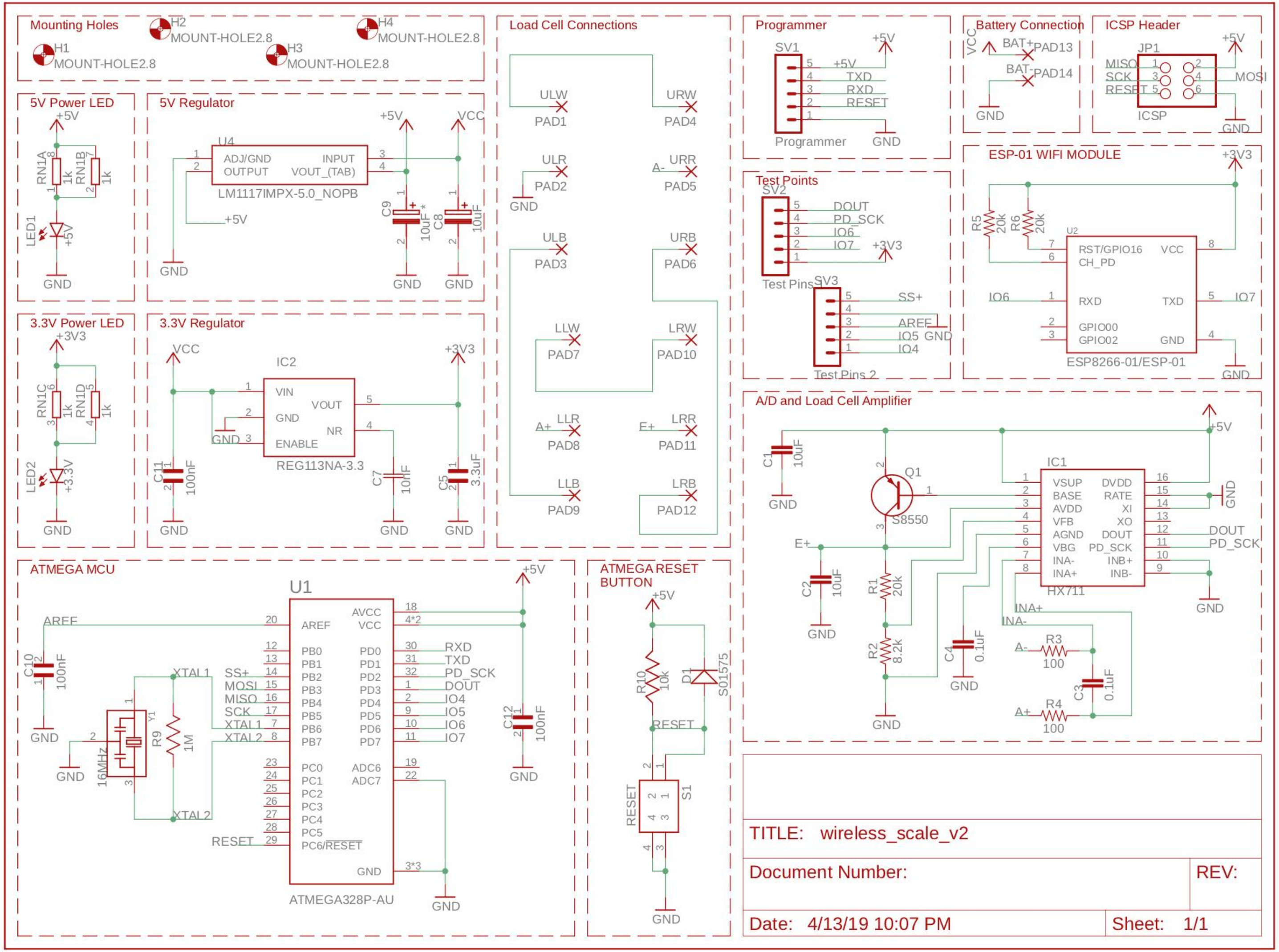
Subsystem 2: Wireless Scale Solidworks

- All designs consist of a outer diameter of 7-¾”
- Wood Panels used were ¼”
- Scale Enclosure
  - Top Section (a)
  - Middle Section (b)
  - Bottom Section (c)



(a) (b) (c)

Schematic



Mounting Holes
Load Cell Connections
Programmer
Battery Connection
ICSP Header
5V Power LED
5V Regulator
LM1117IMPX-5.0_NOPB
Test Points
ESP-01 WIFI MODULE
ESP8266-01/ESP-01
3.3V Power LED
3.3V Regulator
REG113NA-3.3
A/D and Load Cell Amplifier
HX711
ATMEGA MCU
ATMEGA328P-AU
ATMEGA RESET BUTTON
TITLE: wireless_scale_v2
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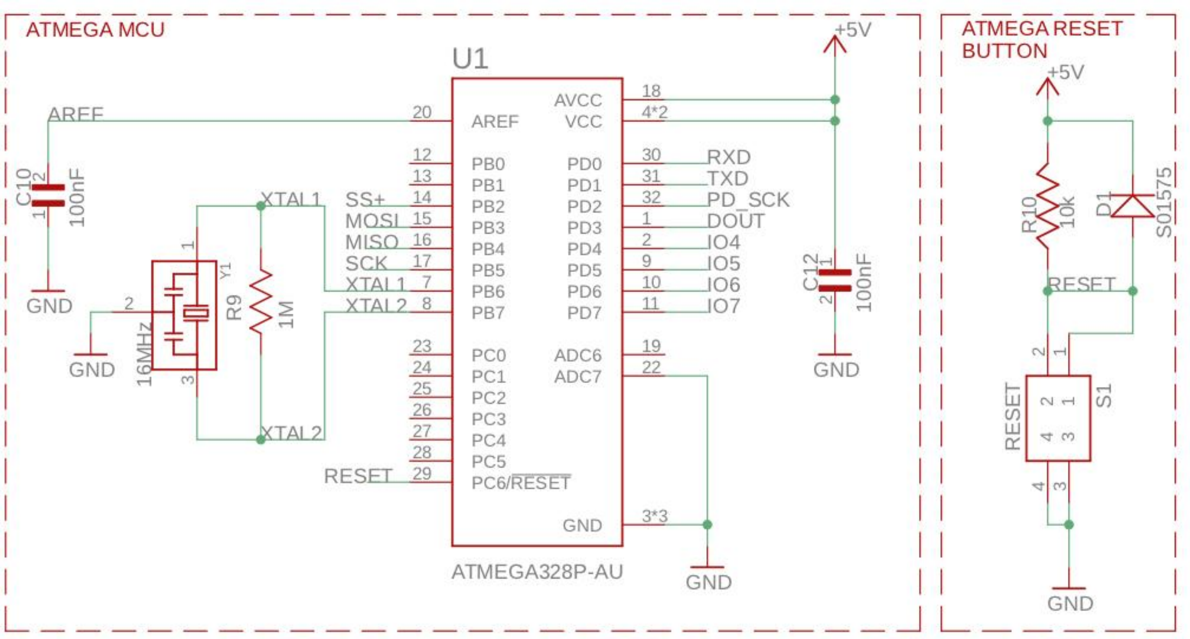
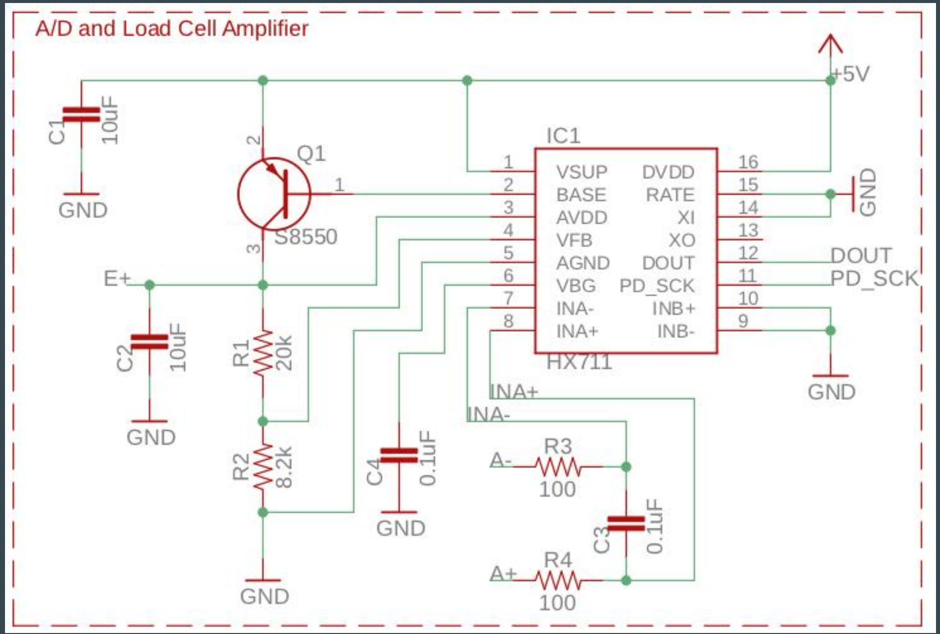
Microprocessor

- ICSP to program microprocessor
- 16 MHz clock
- Reset Button is active low
- Decoupling capacitors on power pins



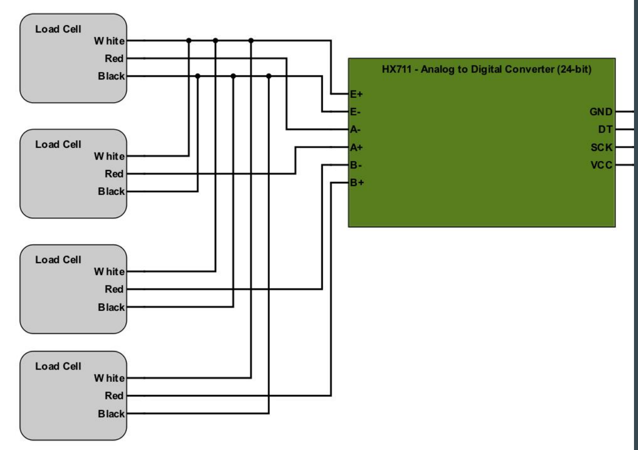
AD Converter

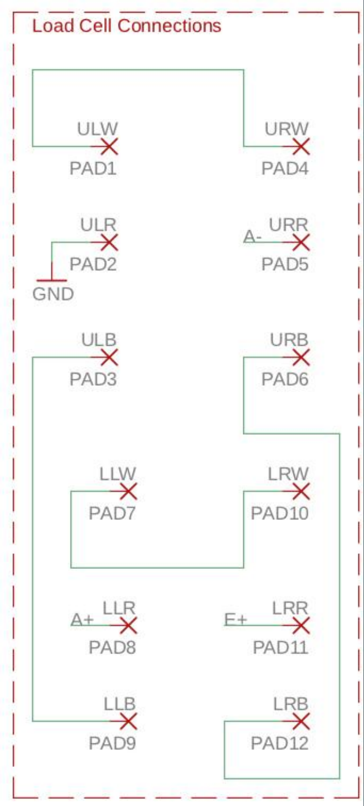
- Measures voltage from load cells and sends it to microcontroller to measure weight
- HX711 provides serial interface for data retrieval via two control pins:
  - Clock line
  - Data line

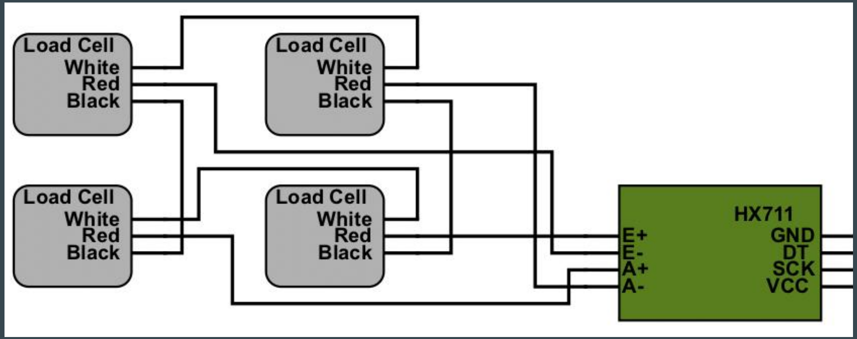


Load Cell Configuration

- 4 half bridge load cells will solder to wire pads on board for more reliable connection
- Connected in series

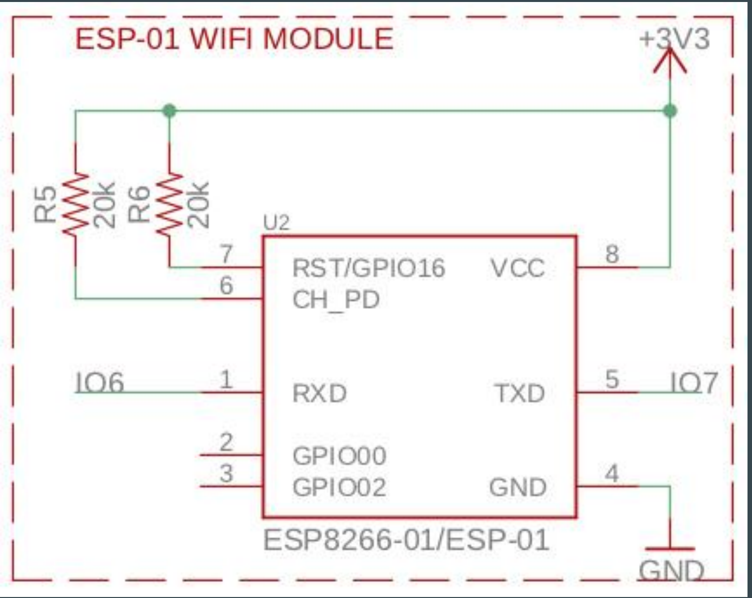






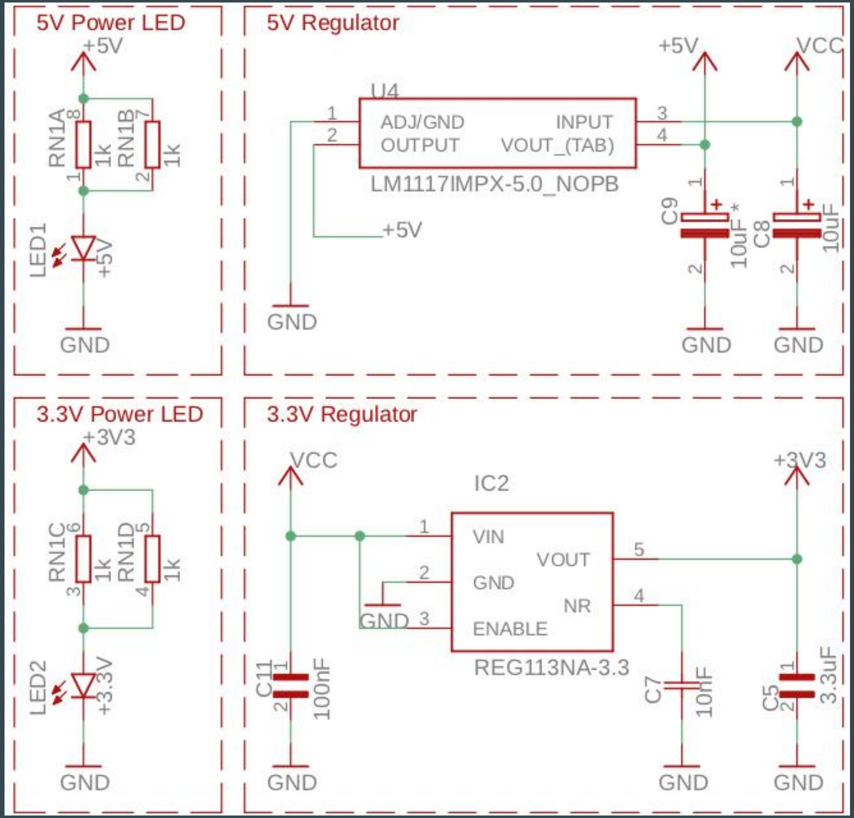
Wireless Connection

- ESP8266 ESP-01 Wifi Module
- Powered by 3.3V
- Pull up resistors for Reset and Chip Enable pins
- Connects to ATMEGA through UART at a baud rate of 9600 on pins 6 and 7
- Communicates with ATMEGA using SoftwareSerial open source library



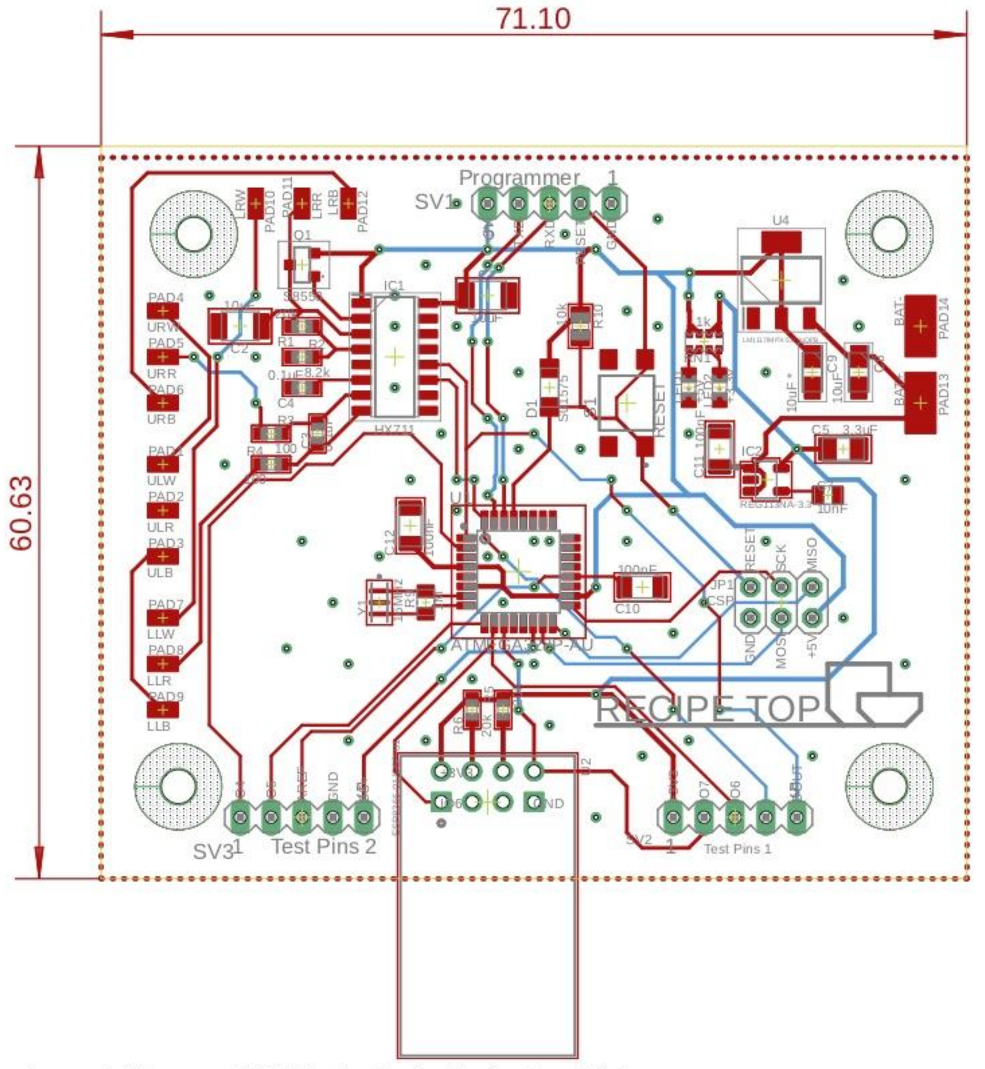
Power

- Power to be received from 4 AAA batteries attached to a switched case
- 5V regulator to power microcontroller and HX711 (ADC)
- 3.3V regulator to power Wifi Module
- Decoupling Capacitors are placed in the design to smooth out noise prevent interference



PCB

- Created in Eagle
- 60.63mm x 71.10mm
- Microcontroller is centered in board design
- Surface mount wire pads for four 3-wire load cells
- ICSP, programmer and testing points for quick troubleshooting and code upload
- Multiple vias to have an even ground plane everywhere and for heat dissipation purposes

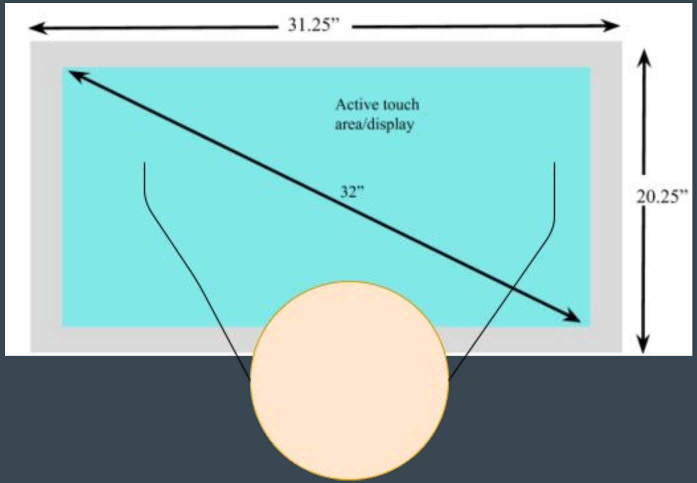


Hardware Challenges

- Soldering efficiency
- Component assembly
  - Inventory
  - Organization
- Gera’s laptop....
- Datasheets - component orientation

Software Design: Approach

- Front-end: HTML5, CSS3, Javascript, Materialize
- Back-end: Django
- Design UI for a counter-top
- Similar to tablets/phones but on a bigger scale
- Hardware independence



Software Design: Stack Choice

	WISA	MEAN	LAMP	LAMP+Django
OS	3	5	4	4
WebServer	2	1	2	3
Database	4	1	3	3
CGI Language	3	2	1	4
Learning Curve	4	1	3	3
Project Compatability	4	5	2	5
Total	20	15	15	22

Database Memory Optimizations: Naive Approach

- Naive approach is multiplicative in memory O(#recipes*#ingredients*...)

RecipeID	RecipeTitle	IngredientID	IngredientName	Utensil	UtensilText
1	Mac & Cheese	1	Pasta	1	Pot
1	Mac & Cheese	2	Butter	1	Pot
1	Mac & Cheese	3	Cheese	1	Pot
1	Mac & Cheese	4	Cream	1	Pot
1	Mac & Cheese	1	Pasta	2	Colander
1	Mac & Cheese	2	Butter	2	Colander
1	Mac & Cheese	3	Cheese	2	Colander
1	Mac & Cheese	4	Cream	2	Colander

Memory Optimized Approach

- Optimized approach is linear in memory: O(#recipes+#ingredients+…)

Table: Recipes

RecipeID	RecipeTitle
1	Mac & Cheese

Table: RecipeToIngredient

RecipeID	IngredientID
1	1
1	2
1	3
1	4

Table: Ingredients

IngredientID	IngredientName
1	Pasta
2	Butter
3	Cheese
4	Cream

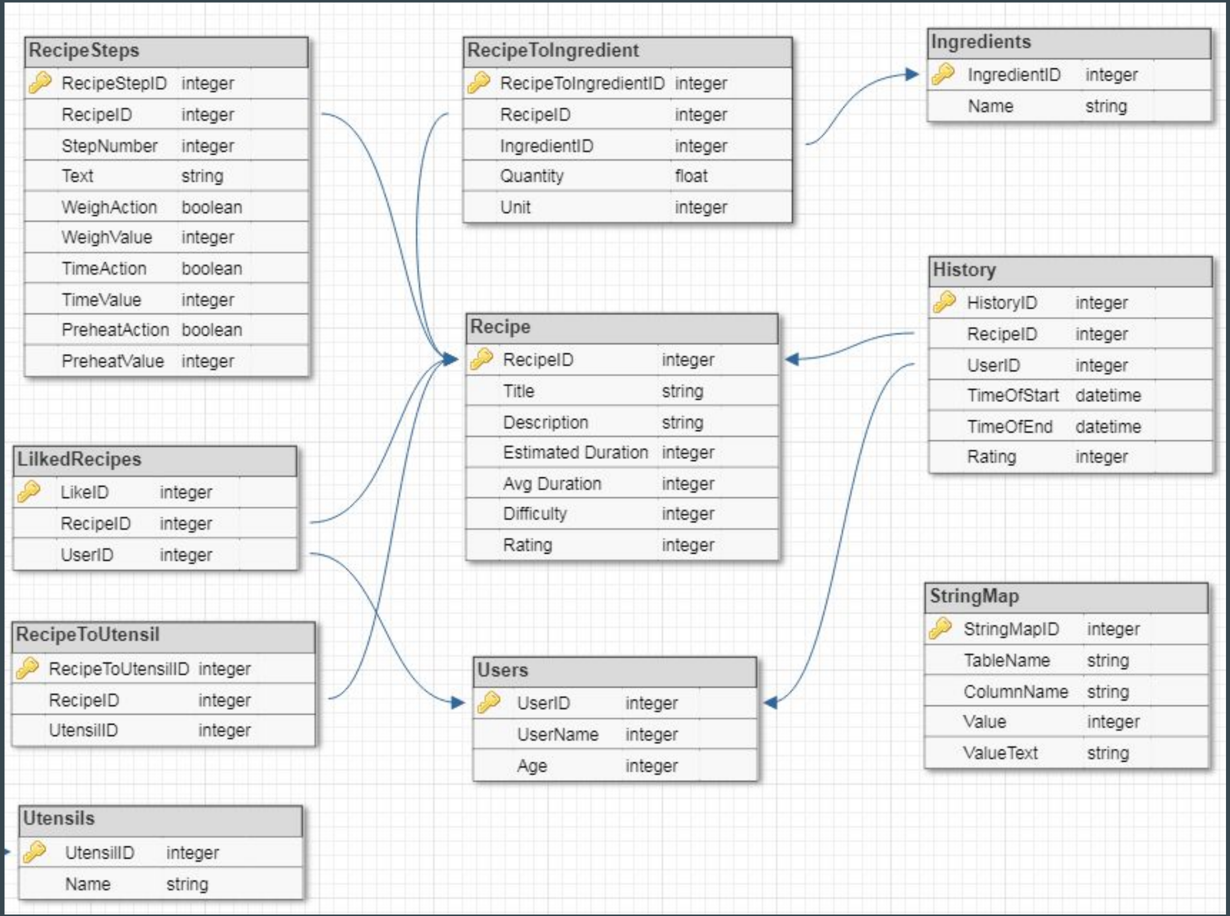
Table: RecipeToUtensil

RecipeID	UtensilID
1	1
1	2

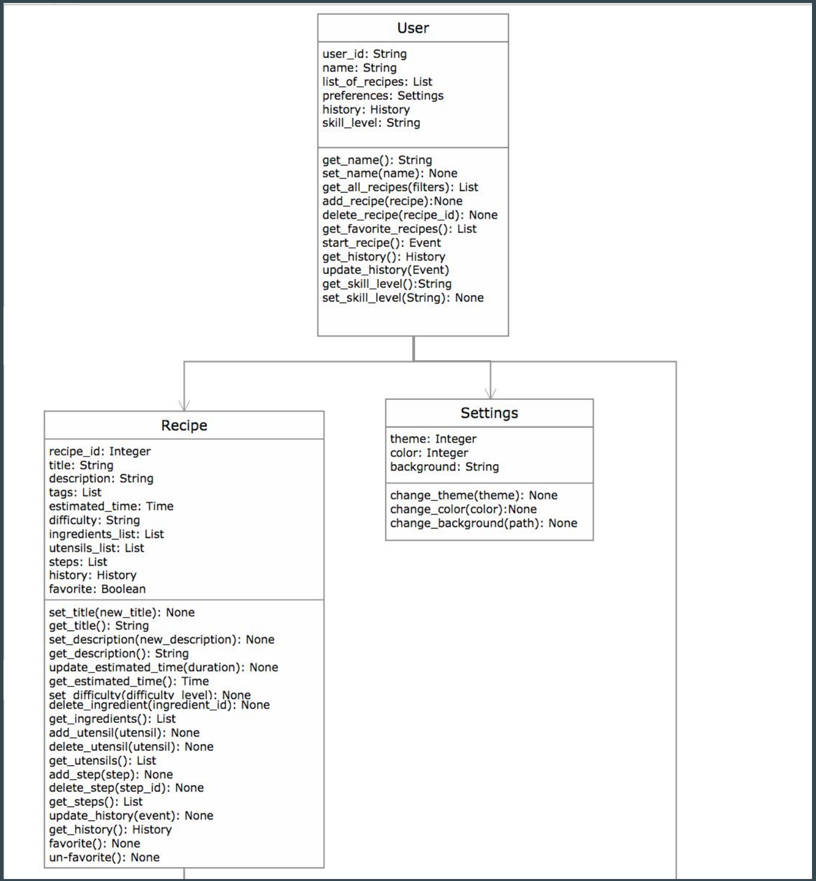
Table: Utensils

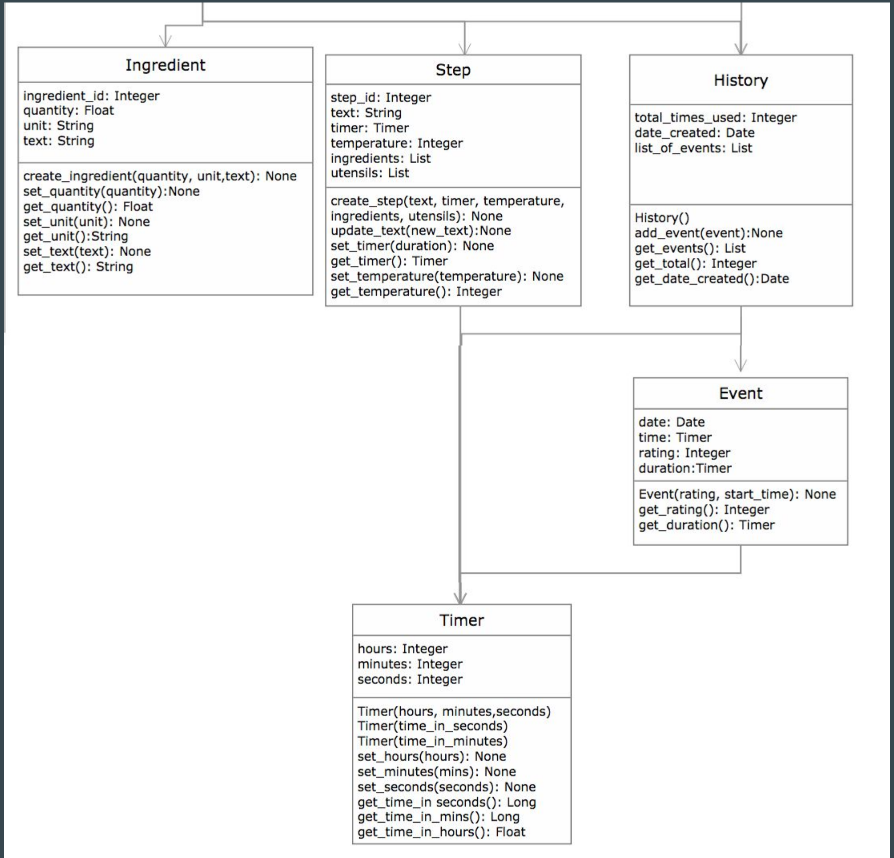
UtensilID	UtensilName
1	Pot
2	Colander

Database Design



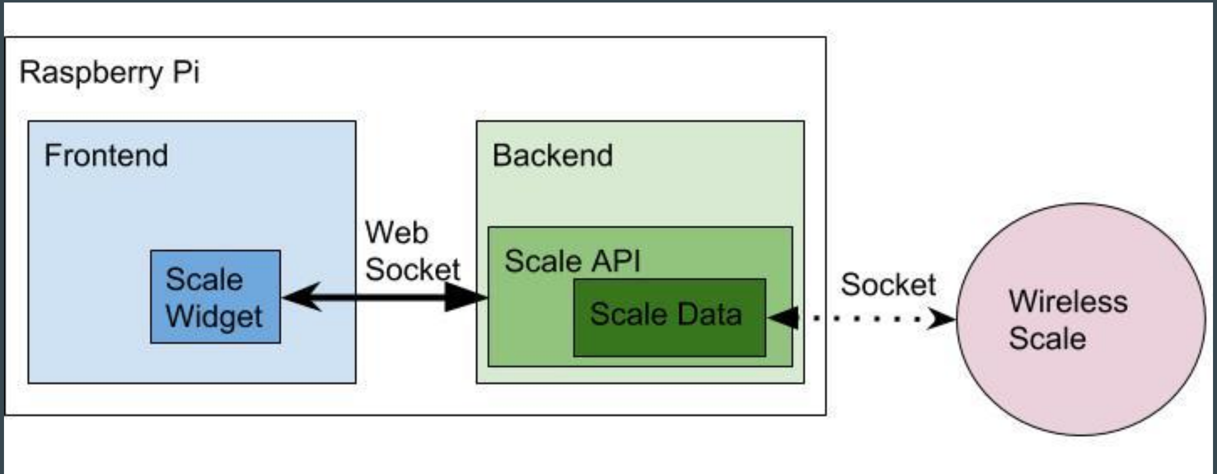
Software Design: Class Diagram



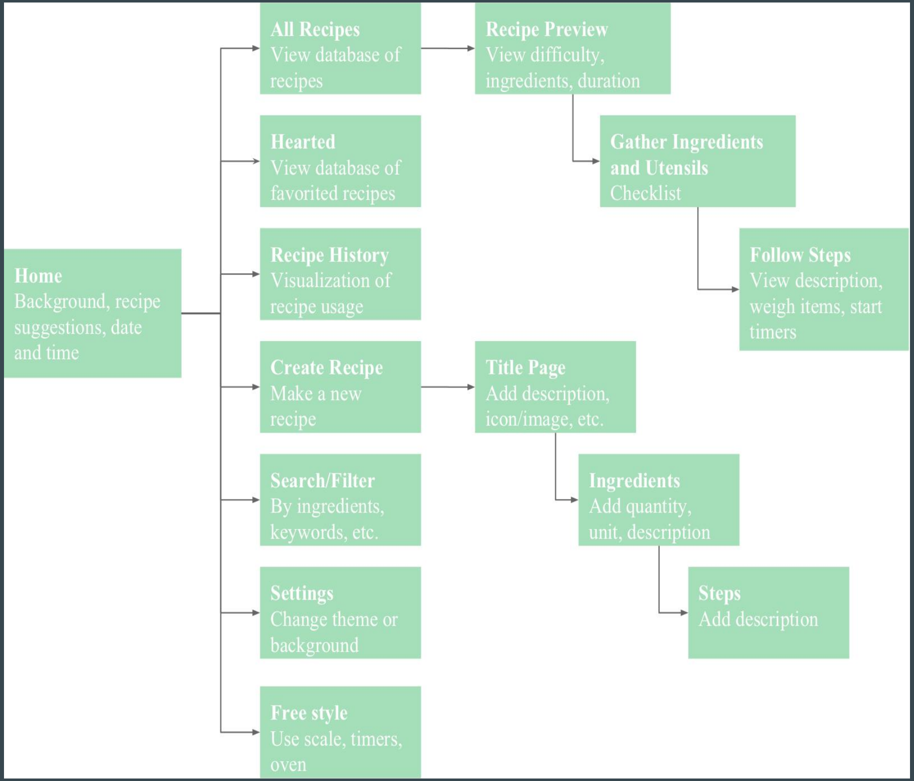


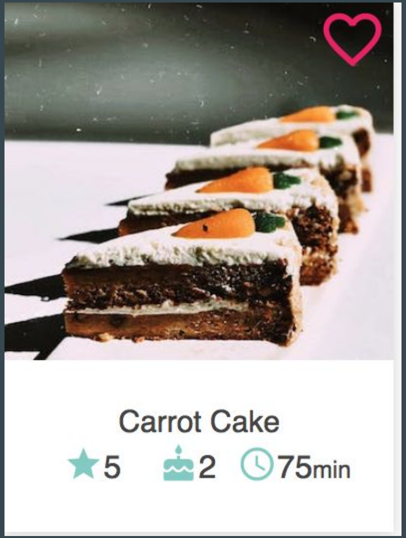
Software Design: Wireless Interface to Scale

- WiFi enabled scale
- Communicates with the Raspberry Pi via a socket
- Django Channels on top of Django
- WebSocket used to send data to the frontend



Software Design: UX Flow

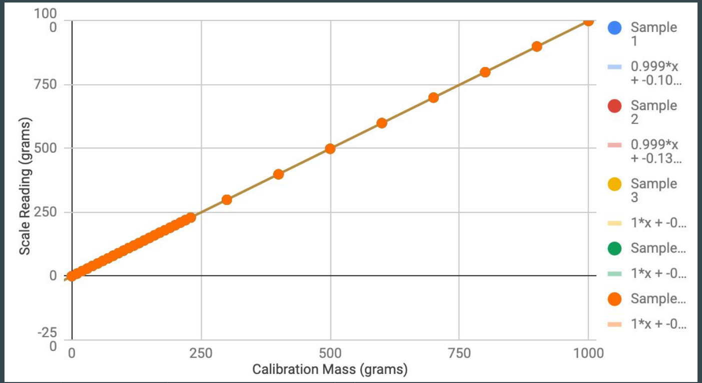




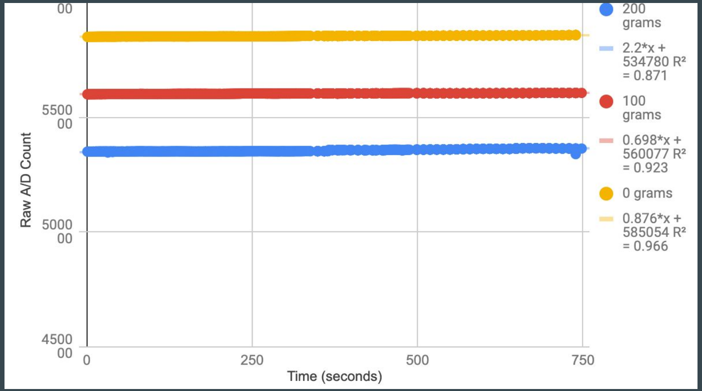
Software Challenges

- Wifi Communications
- Limited processing power and memory on the raspberry PI
  - reduce image quality
  - remove animations
  - minimize js and css files
- Resolution of the touch foil - larger buttons and UI features

Testing



Scale Readings vs Calibration Masses



Scale Readings over time

#	Specification	Target	Actual Value
1	Diagonal Display Size	≥30”	32”
2	Touchscreen Multi-touch Capability	≥ 2 touch points	8 touch points
4	Scale Accuracy	≤ 5g	±0.39 grams
5	Touch response time	≤ 100ms	10ms *
7	Countertop Diagonal	≥ 35”	37.2”
8	Total Prototype Cost	≤ $2000	$347.95

*datasheet value

Suggestions for Future Improvements

- Use microprocessor with built in wifi capability
- Use more powerful single board computer
- Implement recipe suggestions and importation of external recipes through computer vision
- Connect to home assistants like Amazon's Alexa or Google Home

Budget

- Proposed budget of $2000
- Self funded, wanted to minimize cost

Part	Total Cost	Unit Cost	Our Unit cost
Monitor	$0 (donated)	$109	$0 (donated)
Kitchen Cart	$0 (donated)	$159	$0 (donated)
Raspberry Pi 3 b+(kit)	$80.00	$80.00	$80.00
Load Cells	$31.96	$7.99	$7.99
Tempered Glass	$136.00	$68.00	$68.00
Touch foil	$240.00	$120.00	$120.00
ATMEGA328p	$19.60	$1.96	$1.96
HX711 A/D Converter	$24.00	$5.00	$5.00
PCB	$80.00	$23.00	$23.00
Wifi module	$26.00	$4.00	$4.00
Misc. Electronic Components	$140.00	$10.00	$10.00
Wood, screws, etc	$250.00	$50.00	$50.00
Total	$1,027.58	$637.95	$369.95

Group Member Responsibilities

	Jason	Gera	Miguel	Edwin
Hardware Design		Primary		Primary
Software Design	Primary	Primary	Primary	
Front End Implementation	Primary	Primary	Primary	
Back End Implementation	Primary	Secondary	Secondary	
Embedded Software	Primary	Primary	Secondary	Secondary
Manufacturing/ Hardware Assembly		Secondary		Primary
PCB		Primary		Primary
Communications Development	Primary			

Questions?

Demo

References

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