Beverage Coaster

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1 Introduction

1.1 Objective

IOT and smart connected devices have been successfully infiltrating the food & consumer services market. These devices are able to provide restaurants the ability to monitor chefs, food preparation time and identify & limit inefficiencies [1]. Connected devices in restaurants have a slight overhead cost of getting started but the value that they provide to both the customer and management far exceeds its initial investment [2]. Using these smart devices also provides insights to management that could not have been benchmarked before. Through the use of specific sensors and data collection mechanism, software is better able to track and organize data so that trends and conclusions can be made to better serve people. These trends could have to do with saving costs, time or being better prepared during peak hours [3]. It is our goal to tap into this smart sensing IOT market and produce something worth using in the restaurant space. Restaurants compete in a very competitive food services industry where innovation is needed to acquire and retain customers.
By producing a beverage coaster with sensing capabilities, we are able to produce not only an object that is already used in restaurants, but able to collect useful beverage consumption data and enact better service protocols from the beverage coaster data.

1.2 Background

When looking into this project, we took a look at other projects that were similar in line to the idea we were thinking. A group came up with a coaster that protects your drinks at bars. This bluetooth enabled coaster connects to your phone and notifies you if someone tampers with your drink when you enable the feature. This works by putting the coaster on top of the drink and motion sensors [4]. This device is available for purchase at $39.99, showing that there is a viable market for these type of enhanced coasters.

We felt that the solution of putting the coaster on top of the drink is stupid and felt that it can be more useful if the drink always sat on top of the coaster. Our goal is to produce a more affordable coaster that instead uses it weight sensing capabilities to send accurate liquid information to a central hub that management can use to service tables in a priority queue style.

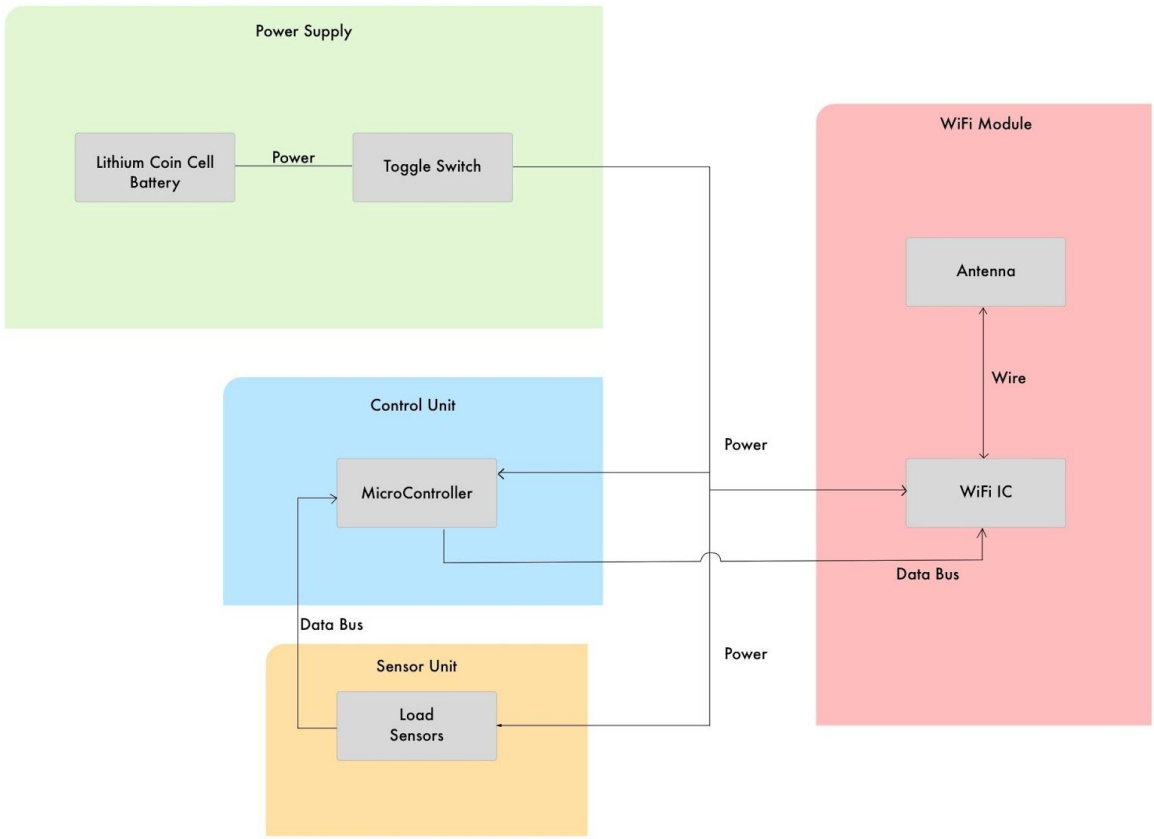
1.3 High Level Requirements

- The coaster should be able to accurately measure the amount weight of the cup
- The coaster should be able to transmit that data to a central hub for analysis and determining who needs service
- The coaster should remain within the small size of a standard coaster

2 Design

Our coaster requires five main modules: a control module, a communication unit, a sensor unit, a power supply and a central hub. The power supply will be a small coin cell battery that can fit inside the form factor of the coaster and power the other three modules and provide 3V, The control unit will handle collection of data from the load sensor as well as storage of the average weight in the storage. The communication module will collect the data to be transmitted through WiFi from the control unit to a central hub. The central hub will collect data from all coaster in the vicinity that are on and determine if any drinks are empty or almost empty and alert any necessary restaurant staff which drinks might be empty and need refills.

BLOCK DIAGRAM



2.1 Control Module

The control unit will control the sensor operation as well as the storage of its previous measurements on flash storage so that we can have an average weight over a certain time. On top of that, the control unit will also control the antenna and determine when to transmit data to the hub.

2.1.1 Microcontroller

The microcontroller, currently chosen to be an ATMega, will collect data from load sensor and add it to the current average weight in flash storage and then transmit average to the communication antenna when it is ready to be sent.

Requirement : The microcontroller must have enough pins to communicate with all load sensors in coaster

2.2 Sensor Module

The sensor unit will collect the weight of the drink currently sitting atop the coaster

2.2.1 Load Sensors

A set of load sensor evenly spaced apart will collect the weight of the drink and send raw weight data to the microcontroller.

Requirement: The load sensor must be small enough to fit inside the form factor of a beverage coaster but still be able to collectively track a weight of an average drink and cup

2.3 Communication Module

The average weight which should be stored on flash memory will be sent to the communication module via UART from the microcontroller.

2.3.1 Hardware

We are going to use a WiFi or Bluetooth IC chip that has memory on the microchip and will communicate to the microcontroller on our PCB board using UART protocol. Each chip will have a transmitter and receiver so that it is able to send and receive information.

2.3.2 Software

We are looking to incorporate ideas of a mess network into our protocol. Our use case will be when the coaster is out of range of the central hub. When this happens and an ACK packet is not received for the sent data, the coaster will broadcast the packet out to all coasters and one will be picked up and sent from there to the central hub. This effectively increases the range of the network.

Requirements: Network range is at least 10 feet, memory on IC large enough to handle data packets. IC chip does not consume a large amount of power.

2.4 Power Module

A power supply will be used to power the components of the coaster while the coaster is in use.

2.4.1 Lithium Coin Cell Battery

The lithium ion battery will be the size of a coin and be able to power the load sensors and communication antennas. The battery does not need to power it continuously since our coaster will not be continuously used.

Requirements: The battery should be able to provide around 20 μA on average at 2.7-3.3 V for around 2-3 hours at least

2.4.2 Power Switch

A toggle switch will control the circuit and determine whether the coin cell battery will power the rest of the circuit and allow us to control when the coaster is on.

Requirements: The switch should be small and unobtrusive so that it is not noticeable to an average user but can still be toggled by staff who know it is there

3 Safety and Ethics

3.1.1 Hardware Safety

For this project, we will be using a lithium-based coin cell battery. In general, any energy storage device (battery), carries the risk of overheating or exploding. Cells with ultra-thin separators of 24μm or less are more susceptible to impurities, so we will make sure we don't use such batteries.[5]

A common issue with using lithium-ion batteries tends be thermal runaway. This occurs when microscopic metal particles converge to one spot and a short develops and a sizable current will flow between the positive and negative plates. The temperature rises; this is also referred to as 'venting with flame.' [5] In order to avoid this, we will closely monitor the temperature of the lithium-ion coin cell temperature and keep the cell away from sensitive technology. This also means that we have to be very careful with our calculations and ensure that we don't have too much voltage going through, prior to attaching the battery.

Our goal with this product is to make this as versatile as possible. As a result, we aspire to create a product that functions with any beverage. Therefore, we must take into account the varying temperatures that this coaster may be exposed to. This poses a risk as there will be technological components such as batteries and sensors in close proximity with somewhat hot or cold temperatures. As a result, we need to ensure that the coaster is thick enough or is of some material that shields the battery and sensors from the potentially extreme temperature.

Similar to the previously raised concern, since this is a beverage coaster, there will be inevitable exposure to liquids. We must ensure that the components consisting of charge or electrical components are secluded and separated from any liquid exposure potential. This means that the coaster itself must have no leaks or gaps that expose the internal circuitry.

3.1.2 Network Security Safety

When using a number of connected devices, sometimes, with the large numbers of devices that have wireless communication capabilities, we run into danger of overloading the network causing it to fail to deliver data packet. If too many IOT/bluetooth devices try to send packets at the same time, the congestion could cause a buffer overload, if there even is a buffer. The reliability and functionality of the network would be broken, thus is a risk we need to hedge against.

3.2 Ethics

IOT DOS attacks - Since all of these coasters have wireless communication capabilities, it opens them up to being hacked and if they are on WiFi, they can be used as a botnet and launch an DOS attack using them. This is something we have to consider when producing a mass quantity of them since they can be used to do something bigger and malicious.

4 References

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