Boston University
Electrical & Computer Engineering
EC464 Capstone Senior Design Project

User's Manual

Halo Smart Drink Protector

Submitted to

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by

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Halo

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Executive Summary

In recent years, the occurrence of drink spiking has increased globally, with college students being the primary targets. Drink spiking involves surreptitiously adding drugs or other substances to someone's drink without their knowledge or consent, which can have serious short and long-term health consequences, including memory loss, inability to speak, and blurred vision. Moreover, the long-term effects could permanently damage the victim's health, leading to psychological trauma, and other complications.
To address this issue and prevent drink spiking incidents, we have developed the Halo Smart Drink Protector, a battery-powered device that can seal the top of common glass types. It is a portable and user-friendly device that aims to offer a proactive solution to the problem. The device comes with a smartphone app that provides users with important information about drink spiking, including how to recognize the signs of a spiked drink and what to do if they suspect their drink has been spiked. The app also allows users to easily connect to the device via Bluetooth and offers the option to contact authorities in case of emergency. Additionally, there will be a website where users can provide feedback about their experience with the Halo Smart Drink Protector. This feedback will be used to improve the device and make it more effective at preventing drink spiking.
Halo's innovative features include a detection algorithm with a high success rate and a flexible and adjustable cover that fits various cup sizes. The device is easy to use and can be carried around, making it a convenient option for people who want to prevent drink spiking. We hope that the Halo Smart Drink Protector will be accessible and affordable to everyone who wants to prevent the potential harm caused by drink spiking. We believe that this device can make a significant difference in reducing the number of drink spiking cases globally and help people feel safe while enjoying their drinks.

1 Introduction (Alan Dautov, Pengyu Wu)

Drink spiking is the act of adding drugs or alcohol to someone's drink without their knowledge or consent. The drugs or alcohol used in drink spiking can be various substances, including prescription drugs, illegal drugs, or alcohol. With this large number of incidents happening each year, and not to mention the cases that have not been discovered or reported, 90% of the incidents recorded are from beverages that people drink every day. Still, there has not been a viable solution that can protect everyone.

To prevent this rampant crime from happening, this project aims to resolve the issue by introducing the Halo Smart Drink Protector, which has the ability to detect and report when an intruder attempts to tamper with a drink. In addition, Halo Smart Drink Protector is needed because consuming a drugged drink has short-term side effects including memory loss, inability to speak, and blurred vision but also significant long-term effects that could permanently damage the victim's health.

The plan is to design a product that is low cost, effective, and adjustable, that can be easily purchased and replaced in case of it being stolen. This product will be able to fit over most drinking cups and glasses and will not only reduce the number of spiked drinks incidents but will also raise overall awareness of the crime. This solution will allow people to worry less about leaving their drink unattended since Halo will let every user know that there might be a possibility of spiking. The idea is to create something that will truly impact society and reduce the number of drink-spiking victims.

The final product consists of four primary components, which are the Arduino nano 33 BLE, the outer layer cover, an app, and strain gauge sensor. The Arduino has two built-in sensors, a gyroscope and an accelerometer, which can sense rotations and acceleration, and a strain gauge with the amplifying module connected to it. By combining the accelerometer and gyroscope with the strain gauge module, Halo is able to recognize and detect potential cover removals and eliminate false positives, such as simple cup movement. The Arduino is equipped with a Bluetooth module that is capable of sending signals and connecting to the iOS app, which will send a notification to the user whenever the device senses a potential cover removal.

2 System Overview and Installation (Alan Dautov, Chenyuan Zhao, Gabrielle Kuntz, Pengyu Wu)

2.1 Overview block diagram

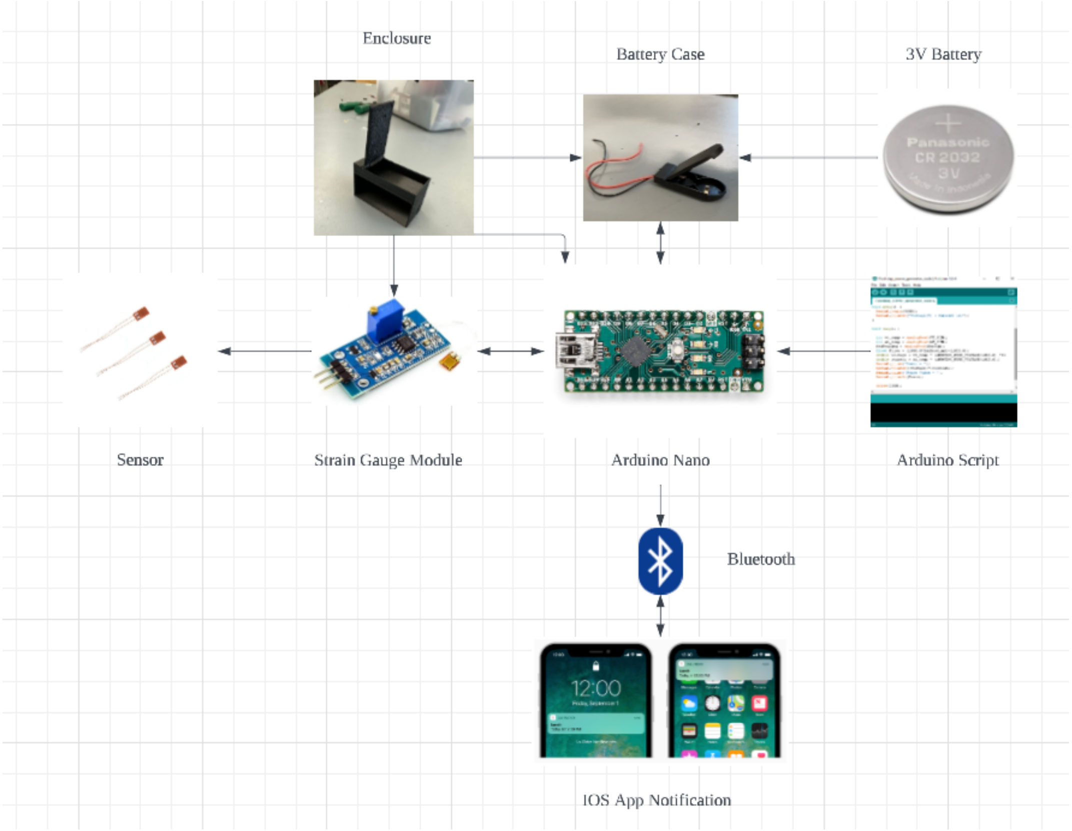
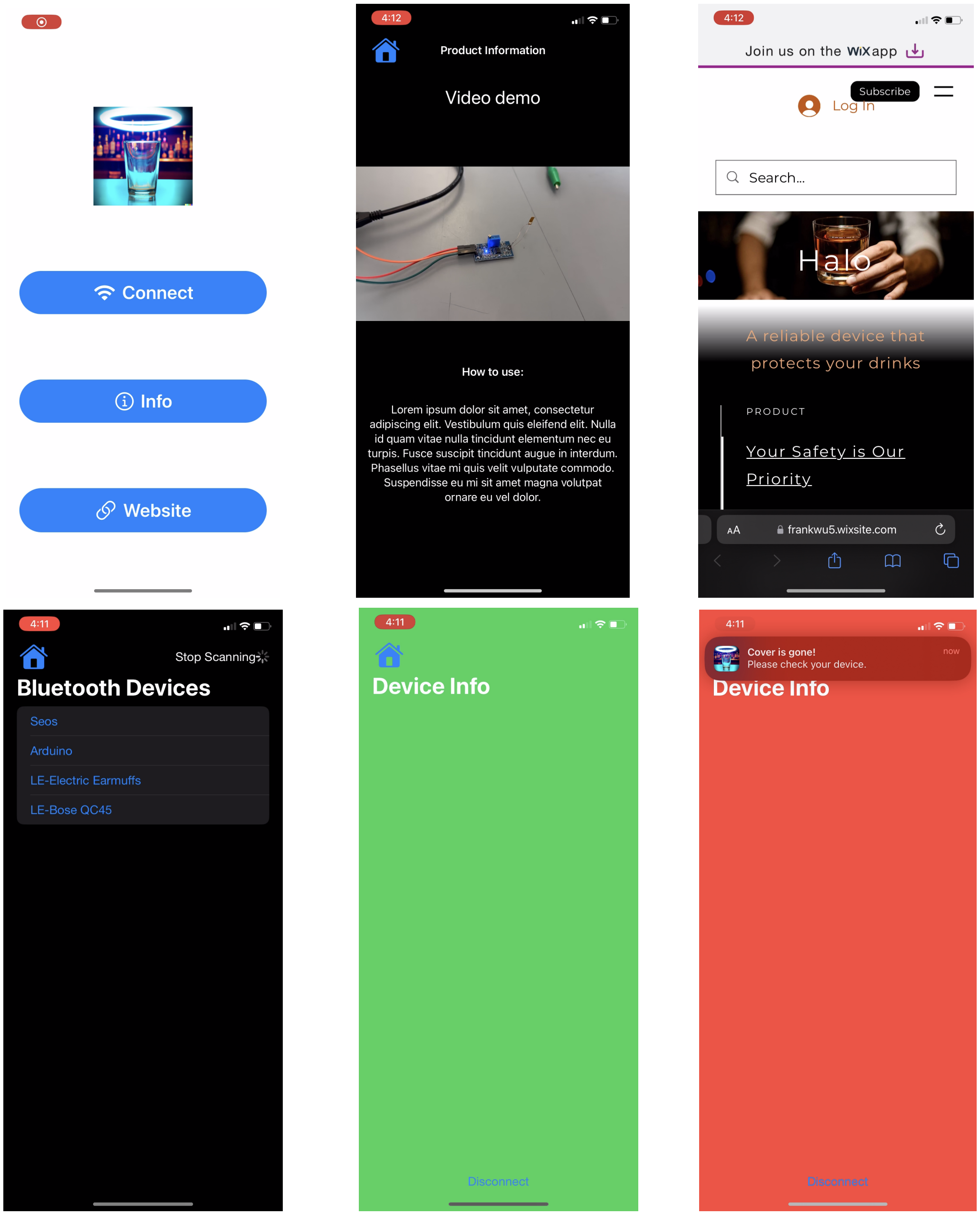


Figure 2.1: System Overview of the Halo Smart Drink Protector

2.2 User interface.

The iOS application allows the user to connect the Smart Drink Protector to their phone, view information about the product, and access the website. The info button allows the user to watch a video demonstration as well as view instructions to better understand how to use the product. The website button takes the user to the website. The connect button allows the user to connect their device to their phone. The app features a start scanning button which will then show a list of discovered devices. Once connected the app will display whether the cover is on the drink. A green light means the cover is still on. A red light means the cover has been removed. If the cover is removed a notification will be sent to the user.



How to use:

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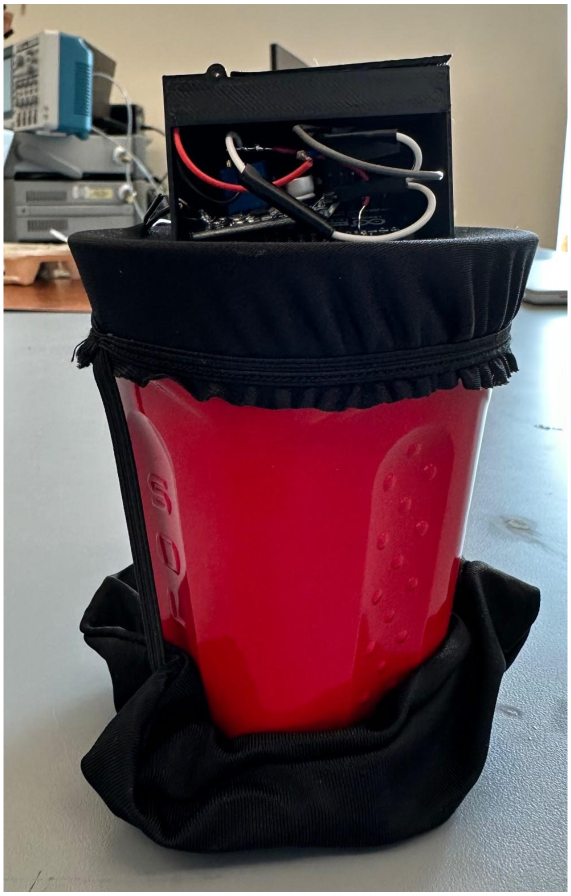
Cover is gone!
Please check your device.

Figure 2.2: iOS Application UI

2.3 Physical description.



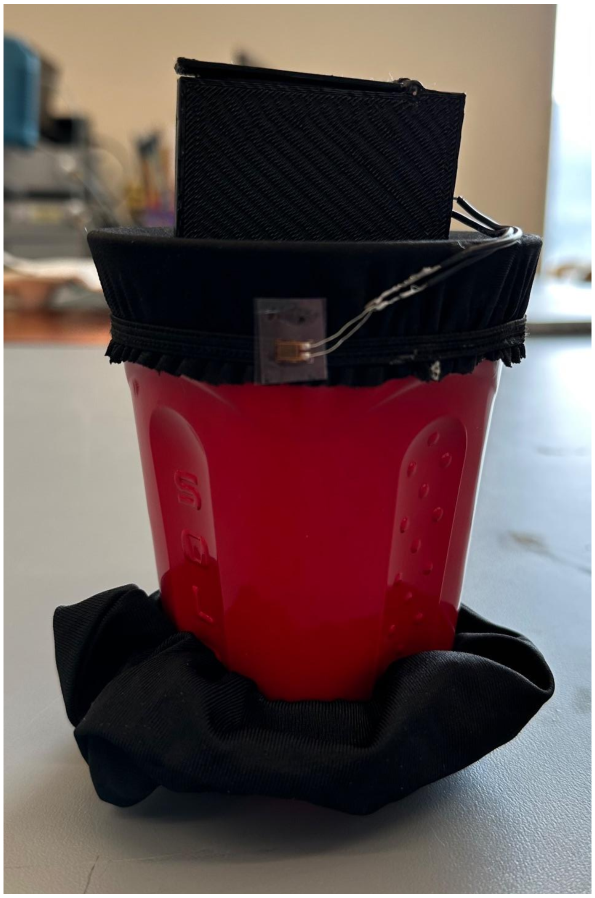


Figure 2.3: Halo Side View (With exposed components) *Figure 2.4: Halo Side View (The strain gauge)*

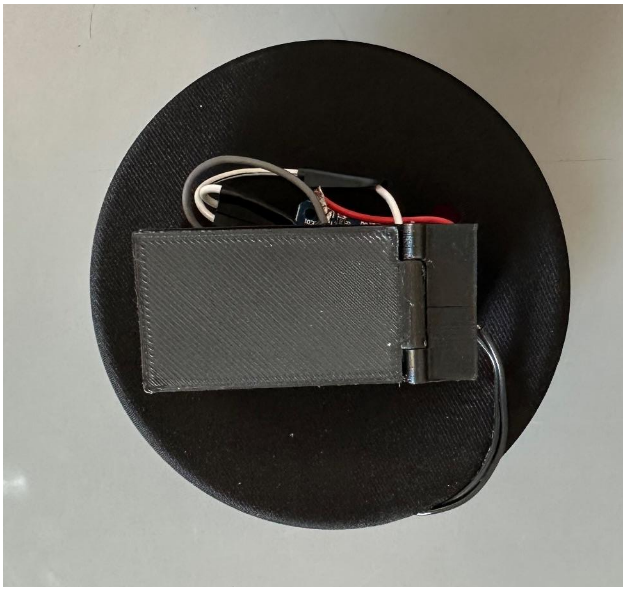


Figure 2.5: Top View

After researching the market, we have concluded that there are no devices like Halo in the market that have similar functions of using strain gauges to detect drink spiking. Therefore, we believe that new users could be facing challenges when using the device, so we have included an information tab that guides the users step by step to understand the functionality of the device and quickly adapt to it. A video demonstration of the device is included in the iOS app and illustrates its basic concept. Furthermore, the Halo device is designed to last about 5 hours, so in case of running out of battery when using the device at a party, we have started to implement the battery level monitor that will warn the user ahead of time when the battery is dying. Also, to protect the Arduino and Strain gauge module inside the cover, we have used waterproof materials that are suitable for different types of drinks like alcohol and lemonade.

Figures 2.3, 2.4, and 2.5 show the main physical components of the Halo. Figure 2.3 shows the side view of Halo with the components exposed on purpose. Figure 2.4 shows how the strain gauge is attached to the side of the cloth cover and its connection to the main unit . Figure 2.5 shows the top view of the Halo, it is where the battery compartment is located. It is closed in the picture, but can be easily open and safely closed if the battery replacement is needed.

2.4 Installation, setup, and support

Hardware & Software Setup

Each Halo device will have the Arduino with preloaded software. Once published to the App Store, the iOS app installation is simple and can be done by downloading the app from the App Store. The app will ask to access bluetooth and to enable notifications. Bluetooth is required for the app to operate. The notifications are optional but it is best to enable them to ensure the user knows when the cover has been removed.

To install the app without using the App Store:

- Download the code from the Github repository https://github.com/dautal/HaloApp
- Open the project in Xcode
- Make the build, connect the device and upload the app onto it

- For the app to be successfully installed from the build, one should let the iOS device trust the developer certificate in the settings.

Detailed description of the whole setup:

- The Halo Smart Drink Protector uses two CR2023 3V lithium batteries to operate. Load two batteries into the battery cover located on the top of the device.
- To protect the drink, simply unwrap the cloth of the protector, stretch the elastic band of cloth, and cover the cup.
- Turn on the power switch located at the top of the protector. The processor in the protector will then send Bluetooth signals to the user’s cell phone.
- The name of the protector will soon appear on the Bluetooth device list inside the application. Simply connect the device to the user’s phone by tapping its name.
- The protector will then detect any attempt to open the protector. When one tries to lift the cloth of the protector, the strain gauge on the elastic band of the cloth senses the change and alerts the user.
- The protector detects any kind of action that includes the removal of the cloth. However, actions such as pressing on the cover, tapping the cup, or moving the cup will not send out an alert.
- When not using, turn off the power switch and simply wrap the protector with its cloth and carry it in your bag or in your pocket.

3 Operation of the Project (Chenyuan Zhao, Pengyu Wu, Gabrielle Kuntz)

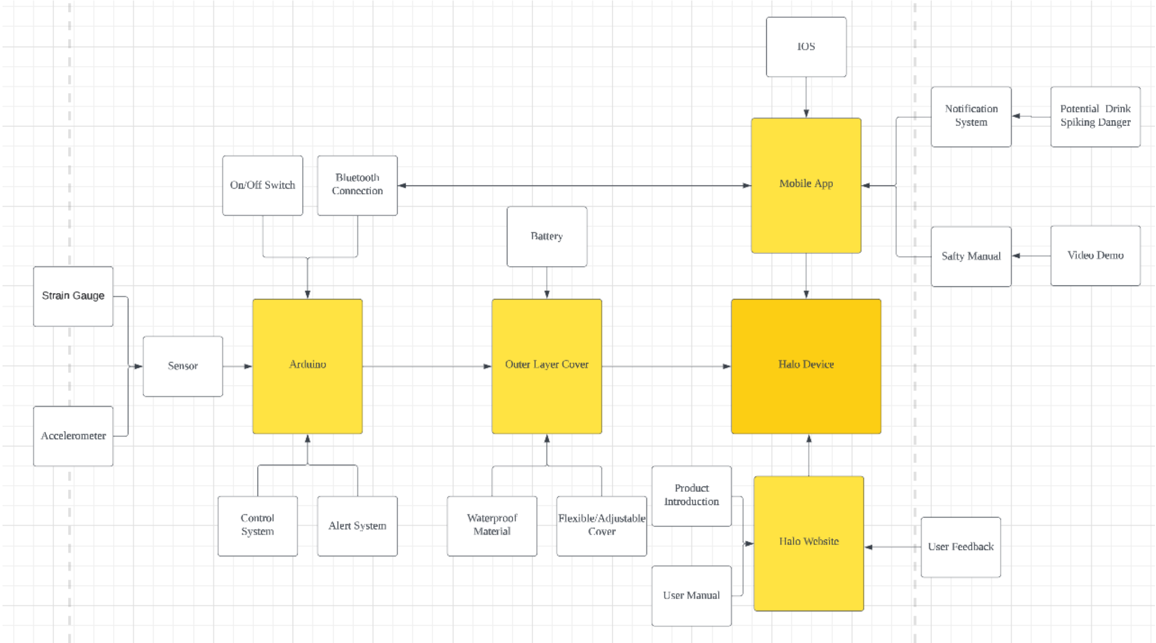


Figure 3.1 An overview of Halo's functionality

3.1 Operating Mode 1: Normal Operation

Normal operation requires the user to correctly set up the cloth on the cup that needs to be protected. The protector's cloth is adjustable for different sizes of cups. For the protector to work properly. The size of the cup should be greater than a diameter of 5 cm and should not exceed a diameter of 12 cm. For cup sizes under 5 cm, the cloth cover may not properly seal and can be easily taken off without causing significant change in tension on the cloth, thus movement trying to open the protector will not be detected. For cup sizes over 12 cm, the cloth has a risk of being stretched too much and causing damage to the strain gauge. To accurately detect the attempt of opening the protector, there cannot be any damage to the strain gauge. The cloth needs to completely wrap the opening of the cup, so the drink cannot be accessed unless the cloth is taken off. The plastic/circuit part of the device needs to be at top of the structure to access the power switch. If the protector is set up upside down, the structure will become unstable and cause false alarms. After turning on the protector, the user should not be farther than 10 m (assuming no obstacles or other bluetooth interference) away from the device, or there will be a chance of losing connection. The expected battery life of the protector using two-button batteries is 8 hours. The battery needs to be changed after this time period. Low battery will cause disconnections and false alarms.

Under normal operation, once the user sets up the protector on the cup and turns on the power switch, the device records the voltage of the strain gauge. Once the tension of the protector's cloth changes by a certain threshold, the device's UI changes, indicating that there is an attempt of opening the cup. The application will also send a notification alert through the system of the phone.

When the alarm is triggered by mistake, the user can simply power off and on the switch and start another connection. The device will reset to the not-opened phase and record the new voltage as the initial/safe value.

3.2 Operating Mode 2: Abnormal Operations

Our team has expected errors caused by the environment and people and implemented a series of functions that prevent errors from happening. To illustrate, one of the fundamental features of the Halo device is the ability to distinguish between drink spiking and random movement of the cup. For example, when the drink is unattended and the Halo device is turned on, the cup could be unintentionally moved, tilted, or rotated by the bartender or a friend of the user who has no intentions of tampering with the drink. Considering the Halo device is based on strain gauge sensors to detect forces when the drink cover is being open, our team has expected random forces applied to the cup sensor under circumstances like dropping the cup on the ground or hitting random objects. Therefore, in the Arduino code, we have used the accelerometer function in the Arduino Nano and implemented code that detects real-time acceleration and movement of the Halo and cup. By adding the accelerometer to the device, the device is included with two factors of measure that will ignore the signals triggered by movement and unrelated forces. When dropping and smashing the cup on the ground or table, the Halo device will recognize them as a false alarm, and our team managed to effectively prevent false positive cases related to accidents caused by the user and increase the accuracy of the Halo device.

Another issue that could be faced is going out of range of the device and getting disconnected from Bluetooth. The bluetooth usually has a range of around 10 meters. If this range is exceeded or the Bluetooth connection is lost the device will no longer communicate with the app. When the device becomes disconnected from the user’s phone a notification is sent to alert the user.

Finally, considering the Halo device is very sensitive and still has many unpredictable errors, our team can not guarantee there is no unexpected error. Therefore, in order to promptly update the iOS app and the device and to perfect the design after the first version of the product is released, our Halo website included a feedback page that allows users or people who are interested in the product to send messages to us and report any abnormal activities and possible upgrades that will benefit the users through emails. This will allow our team to quickly respond to errors caused by Halo and make sure the users are satisfied with the product.

3.3 Safety Issues

One safety concern that needs to be addressed is the risk of overheating. The Arduino and the strain gauge module both generate heat during operation, which could cause damage to the components or create a fire hazard. To mitigate this risk, a solution has been developed where both parts will be encased in epoxy that has a 140°C temperature rating. This should ensure that the heat generated by the electrical components will not be a safety issue.

Another concern is the potential damage to the strain gauge. The strain gauge is attached to the side of the cloth cover where the elastic band is located. When the strain gauge breaks, the voltmeter in the program can no longer detect the change in voltage of the strain gauge, so there will not be feedback when the protector is taken off. We have added physical protections to increase the toughness of the strain gauge; however, once the strain gauge is broken, the only option is to replace the whole device. To prevent this from happening, it's important to ensure that the cloth cover is not stretched beyond its maximum capacity. Additionally, the Halo team will reinforce the strain gauge attachment point to provide extra support and protection.

4 Technical Background (Zirui Chen)

In order to prevent the alarming occurrence of drink spiking, this project endeavors to tackle the issue through the introduction of the Halo Smart Drink Protector. This innovative device is designed to detect and report any attempts of tampering with a drink by an intruder. The primary objective is to create a product that is cost-effective, efficient, and adjustable, with easy accessibility for purchase and replacement in case of theft. On the software front, an iOS app will be developed to clearly indicate when the cover of the protector has been removed. The app will be connected to the protector via Bluetooth technology.

Accurately detecting the removal of a cup cover poses a significant challenge in device design, primarily due to the need to avoid false positives and negatives. It is essential to ensure that the device only triggers an alert when the cover is genuinely removed, and not influenced by other minor movements or actions that might cause the cover to shift slightly but remain intact. However, if the cover is partially or fully removed and then replaced, the sensor must activate an alert. Thus, the main hurdle in designing such a device is to identify a solution that can detect cover removal without being influenced by other movements that leave the cover in place.

Given the specified constraints and requirements, the Arduino Nano 33 BLE is the optimal choice of microcontroller due to its compact size, 2.4GHz Bluetooth capability, and inclusion of an IMU (inertial measurement unit) with a 3D accelerometer, gyroscope, and magnetometer. These features enable the device to effectively process data and seamlessly connect to the iOS app via Bluetooth technology. To improve the accuracy of the product's detection, a strain gauge and an amplifier module will be used in conjunction with the Arduino.

Utilizing the gyroscope and accelerometer data, which are capable of sensing rotation and acceleration, respectively, built into the Arduino, our device can detect and recognize the opening of a cup rather than just movement. However, the issue of false positives and negatives can still arise with only this data. To address this, a strain gauge was attached to the elastic of the cloth cover to detect any force applied to it. When the cover is removed, the elastic band will be bent inward, leading to a change in the electrical resistance of the strain gauge. The Arduino can be programmed to monitor this resistance change and trigger an alert only if it exceeds a certain threshold. By combining the strain gauge data with the IMU data from the Arduino, our product can provide much more accurate detection of the drink protector's movement and eliminate the possibility of false positives and negatives. An algorithm is developed to merge these two sets of data, allowing the Arduino to determine if there is a risk of the protector being removed. In case of a potential threat, the Arduino will communicate with our iOS app via Bluetooth, which will send a notification to alert the user that their drink may be exposed.

5 Relevant Engineering Standards (Alan Dautov, Gabrielle Kuntz)

- Bluetooth standard IEEE 802.15
  - The project used the IEEE 802.15 standard, specifically the 802.15.1 Bluetooth wireless protocol, to establish a wireless connection between an Arduino and an iOS app. This enabled data exchange between the two devices, allowing for remote control and monitoring of the Arduino-based system using the iOS device.
- Swift 5.8
  - Swift is a high-level programming language that is used to develop applications for Apple's iOS, macOS, watchOS, and tvOS operating systems. The code written in Swift for the iOS app was designed to enable communication with the Arduino-based system over the Bluetooth connection. The code utilized the CoreBluetooth framework, which provides an interface for interacting with Bluetooth devices on iOS devices. The code included functionality for discovering and connecting to nearby Bluetooth peripherals, as well as for reading and writing data over the Bluetooth connection.
- Arduino
  - On the Arduino side, the code was written in the Arduino programming language, which is based on C/C++. The code utilized the Bluetooth module to enable communication with the iOS app over the Bluetooth connection. The code on the Arduino side included functionality measuring the voltage of the strain gauge, interpret accelerometer and gyroscope data, as well as sending this data to the iOS app over the Bluetooth connection.

6 Cost Breakdown (Alan Dautov, Zirui Chen)

Project Costs for Production of Beta Version (Next Unit after Prototype)			
Item	Quantity	Description	Unit Cost
1	1	Arduino Nano 33 BLE	$30
2	1	Jumper Wires Pack	$1.58
3	1	Voltage Amplifier Module	$5.89
4	1	Strain Gauge	$.89
5	1	CR2032 Battery holder	$1.29
6	1	Cloth cover	$0.99
Beta Version-Total Cost			$40.64

Although the unit cost of the Halo Smart Drink Protector is higher than that of a regular cloth cover, it provides an additional layer of protection compared to traditional covers that can be easily removed without notice. To make the product more accessible to consumers, the desirable unit cost which the Halo team wants to achieve should be in the $20-$25 range. This price range is achievable when the quantity of the Halo protectors produced is relatively large, allowing for the components required to build the device to be ordered in bulk, thereby reducing the unit cost of each device. Furthermore, the fixed cost of producing the product can be shared between more units, leading to a lower unit cost for the consumer. Another approach to reduce the price of the device is to integrate all the components onto a PCB. This approach not only reduces the size and weight of the device, but it also helps lower the cost of manufacturing. By optimizing the design of the PCB, the number of components required can be reduced, leading to a reduction for the overall cost of each unit. Additionally, with fewer components, the manufacturing process will be simplified, leading to a reduction in assembly cost.

7 Appendices

7.1 Appendix A - Specifications

Specification	Performance
Arduino establishes bluetooth connection with iOS app	Pass
Arduino transmits the data to the iOS app	Pass
When the cover is removed, the app sends a notification	Pass
The app directs users to the website with the website button press	Pass
Users can press the info button to learn more about the product and how to use it	Pass
The Arduino does not send out a cover off signal when the cup is moved vertically or horizontally	Pass
The Arduino does not send out a cover off signal when the cup is rotated or flipped upside down.	Pass
The Arduino is powered by batteries which last at least 5 hours	Pass
Fits on most of the cups	Pass

7.2 Appendix B – Team Information

Name	Phone Number	Email	Major
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Chenyuan Zhao	301-979-1353	zhaoc23@bu.edu	Computer Eng. ‘23