IoT in Vending Machines and Coolers

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Team Member Backgrounds

Jiazhuo Chen: Jiazhuo earned her Bachelor’s degree in Construction Management from Tongji University and is currently pursuing a Master of Engineering in Engineering Management at Cornell University. She previously did internships at construction and real estate companies. After graduation in May, she will work as a Real Estate Investor in Kaisa, Shanghai.

Kelsey Graves: Kelsey earned a Bachelor of Science in Biomedical Engineering from the University of Connecticut in May 2017. At Cornell University, she is currently pursuing a Master of Engineering in Engineering Management with a specialization in Biomedical Engineering. She has strong interests in medical devices and operations, and plans to blend the two together in BD’s Engineering Development Program after graduation.

William Loo: William is currently pursuing a Master of Engineering in Engineering Management after previously completing a Bachelor of Science in Operations Research and Information Engineering from Cornell University in 2017. He has previously worked as a Logistics and Operations Intern at T-Mobile and LMI, and will be working at Wayfair as a Product Associate following the completion of his degree in May 2018.

Chuanjue Ma: Chuanjue earned his Bachelor’s degree in Civil Engineering from Tsinghua University in July 2017. He previously worked as an Analyst Intern in the investment department at China Insurance Company CIC. He is now pursuing a Master of Engineering Management at Cornell University, focusing on investment management. After graduating from Cornell in December 2018, he would like to work as a fund manager.

Eunji Song: Eunji obtained her Bachelor of Science in Operations Research Engineering from Cornell University in 2017. During her undergraduate years, she was a Summer Analyst at two boutique investment banks and was heavily involved in the Cornell Alpha Fund, a student-run investment club on campus. Upon completing her Master of Engineering in Engineering

Management degree in May 2018, she will pursue a career in the finance industry as an Investment Banking Analyst at Layer 7 Capital in White Plains, NY.

Ishaan Tiwari: Ishaan finished his Bachelor's degree in Mechanical Engineering from Nagpur University, India in 2017. He is pursuing his Master's in Engineering Management from Cornell University. After graduation he hopes to work in the eCommerce industry using his skills to find data driven insights. Apart from academics, he enjoys swimming and playing badminton.

Vinaya Venkatesh: Vinaya graduated with a Bachelor's of Chemical Engineering from the Institute of Chemical Technology in May 2014. She then joined Pfizer's Rotational Development Program in India and has three years of work experience. She is currently pursuing a Master of Engineering in Engineering Management at Cornell University. Vinaya is passionate about pharmaceutical operations and quality systems and looks forward to advancing her career in the pharmaceutical industry after graduation.

Introduction

Problem Statement and Scope

Vending machines and coolers have been used in the beverage industry for over half a century. If you have been around one recently, you may have noticed they essentially look the same as they did back then. Not only has their appearance gone unchanged, but the technology used is not up to par with today's advanced technological standards. When these machines were first introduced, not much thought was given into improving their operations. However, competition among businesses is ever-increasing, and the advances in technology and industrial engineering call for a desperate need to adapt. Needless to say, it is about time they get an update - not only for consumers' preference, but also to improve business operations.

In an attempt to spark this much-needed update to their machines, Pepsi has partnered with a team of graduate students in Cornell University's Engineering Management program. Specifically, Pepsi's lack of sufficient microscale data to inform decisions regarding coolers and vending machines in the United States and Canada created an opportunity to explore new technologies that can reduce operating costs and improve their bottom line. The main goals for these technologies were to improve asset tracking, inventory monitoring, energy management and consumer engagement. Keeping these objectives in mind, the team performed extensive research and analysis to recommend technologies for implementation in vending machines and coolers.

To begin solving this problem, the team first determined the scope of the project. This project focuses on the North America Beverage (NAB) division of Pepsi, and therefore the team did not acknowledge their other global divisions (e.g. food-related divisions, beverage-related divisions in other geographical segments) in the analysis of this project. The goal was to reduce operating costs and improve Pepsi's bottom line; in regards to this goal, out of scope factors that were not considered are how the beverage products themselves are produced or physically delivered. Furthermore, the team did not evaluate changes in price or improvements to the beverage products. In scope, however, were any valuable technologies that could be implemented in vending machines and coolers that are up-and-coming or already in use by competitors or other industries to reduce operating costs and enhance consumer engagement.

Project Approach and Metrics of Success

To tackle this problem, the team decided to follow three distinct procedures: the exploration of viable technologies, determination of their key benefits, and finally the development of a recommendation based on this analysis. Initially, the team selected eight technologies that had the potential to reduce Pepsi's operating costs and improve their bottom line. After thorough research and analysis, the team gained a comprehensive understanding of these technologies and was able to eliminate some technologies from consideration. Based on the scope provided by their sponsors, the team selected three technologies that could adequately address Pepsi's needs. These were determined by weighing the implementation costs and benefits of each technology through information gathered from industry reports and provided by their sponsors. Finally, the team made a recommendation consisting of two technologies, and created an ROI matrix to display the potential impact this recommendation would have on Pepsi's bottom line.

Three benchmarks that would constitute success for the team by the end of the project were:

1. Increased understanding of new and existing technologies available to Pepsi, especially understanding of their potential effect on vending machines and coolers.

2. Identification of at least 3 viable technologies that adequately meet the previously stated needs of Pepsi.

3. Creation of an informed recommendation of whether or not to implement a technology.

Current State

Background

Coolers and vending machines are two kinds of machines that are widely used around the world in the beverage industry. Pepsi is a global company and household name that produces and sells these machines to customers like Walmart, 7-Eleven, and colleges and universities to sell their beverage products.

Pepsi is a Fortune 500 company, and a household name in the food and beverage industry. There are numerous products developed under the Pepsi name, and their main source of distribution is external vendors such as Walmart, 7-11, and universities like Cornell. Pepsi has two main avenues through which they sell products, coolers and vending machines, and they sell these machines to various retailers while bringing in a portion of the revenue generated.

Coolers are generally found in large retail stores or restaurants, and have an appearance resembling a standard refrigerator. Because the doors of a cooler are manually operated and the products in a cooler simply sit on a shelf, there are significantly fewer moving parts and incorporated technologies, leading to a much cheaper production cost than vending machines. The use of a cooler requires the assistance of a human vendor, where the consumer would select the product from the cooler and pay the vendor at a cash register. These machines are typically data-free, so once they leave Pepsi's facilities, the store owner is solely responsible for orders and restocking. In more recent years, some areas of the world have begun producing and implementing smart coolers. These coolers enable connectivity with a variety of sensors along with internet capabilities, which paves the way for the potential usage of IoT technologies.

Vending machines, on the other hand, are almost completely self-contained. The products sit in movable coils within a refrigerated machine. To purchase an item, the consumer inputs money and a product-associated command directly into the machine, after which the product is placed into a "drop-box", where the consumer then retrieves their item. As mentioned previously, this added complexity contributes to vending machines' greater production costs. These machines do, however, have built in telemetry and vending management systems that provide an assortment of useful information to the owner, such as inventory data or energy consumption. These current technologies enable the owner to track the vending machine's current status, manage vending machines remotely, and access machines that require service or maintenance.

Market Analysis

To address the state of the vending machine and cooler market, the team broke down the market into three categories: total addressable market (TAM), service addressable market (SAM), and target market (TM). In Figure 1 below, the calculated numbers are shown, while an in-depth look at the calculations follows.

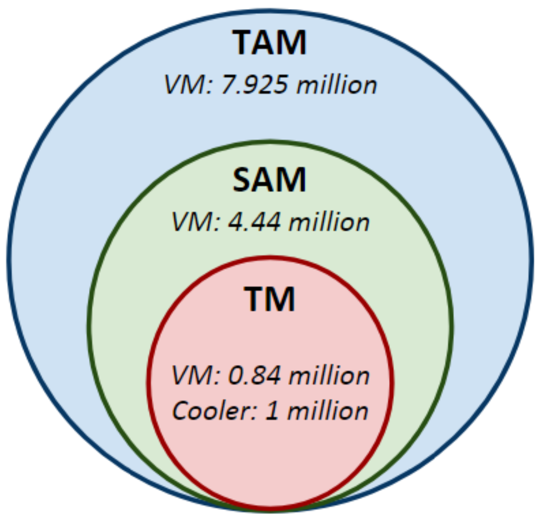

Figure 1**:** Market breakdown by TAM, SAM, and TM of vending machines and coolers.

The total addressable market was defined as an estimated number of coolers and vending machines in the United States and Canada. The team was able to find the total number of vending machines in the United States to be 7.125 million, however there was no corresponding data for Canada. To develop an estimate for the Canadian market, that 7.125 million was divided by the U.S. population of 323.1 million people to get a value of 0.02 vending machines per capita. Using the Canadian population of 36.29 million people, the team calculated the total number of vending machines in Canada to be 0.8 million. Adding these two numbers together, the total number of vending machines in North America was assumed to be 7.925 million. The team was unable to find the equivalent numbers for coolers.

Because the project focused the North American beverage market, the service addressable market was specified to be the total number of beverage vending machines and coolers. In North America, 56% of operational vending machines were beverage-only [1]. Therefore, the total addressable market of 7.925 million was multiplied with this ratio to obtain a service addressable market size of 4.44 million vending machines in the United States and Canada. Cooler data was unknown.

Breaking down the market even further, the team defined the target market as Pepsi-only beverage vending machine and coolers. Due to the lack of information about the number of Pepsi beverage vending machines, the team made an assumption that Pepsi's North American Beverages market share of 19% would similarly apply to the number of vending machines [2]. Multiplying this percentage by the service addressable market of ~0.44 million, the target market for vending machines equalled approximately 0.84 million.

Additionally, according to Pepsi's Program Manager Yong-Jin Serock, there are approximately 5 million Pepsi beverage coolers worldwide, including about 1 million in North America as of May 2018. This provided the target market value for coolers.

Stakeholder Analysis

Before implementing any new technologies, it was first important for the team to understand how various parties would be affected by this change. To do so, several key stakeholders were identified and divided, based on their associations with the project, into five groups: Cornell University, Pepsi employees, Consumers, Customers such as grocery stores and convenience stores, and concerned third parties like manufacturers of the machines and deliverers. To analyze these stakeholders even further, the team developed a stakeholder analysis tool, as shown in Figure 2, plotting influence on the project versus interest in the project.

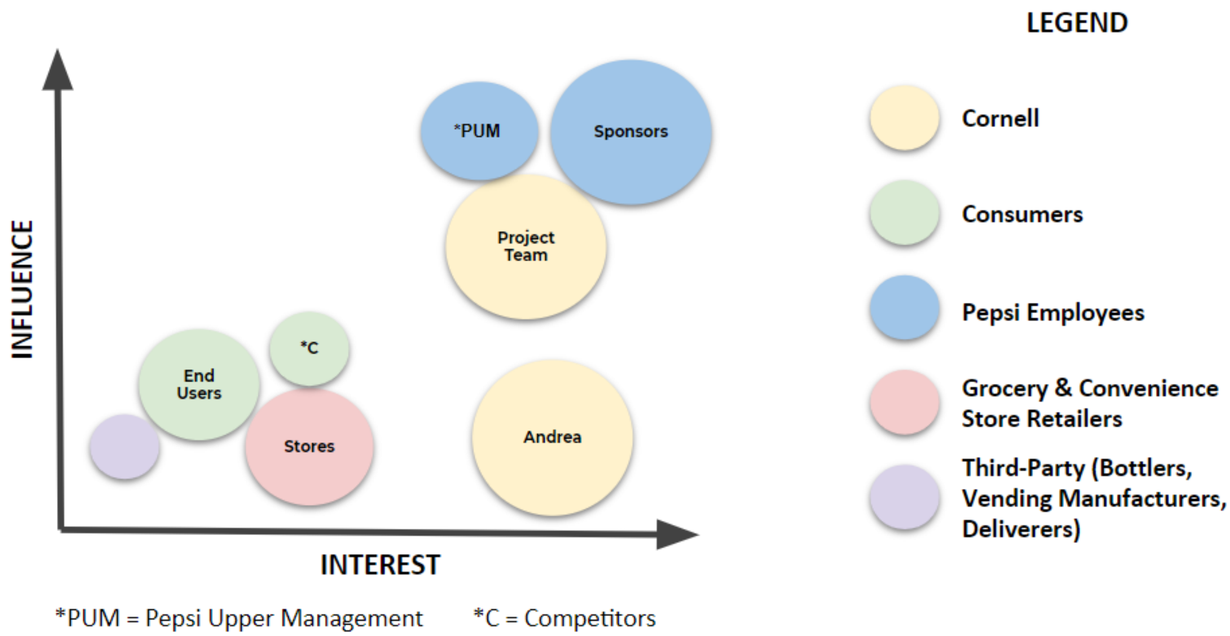

Figure 2: Stakeholder analysis performed by the team.

Influence is defined as the ability of each stakeholder to affect the final outcome of the project, while interest was defined as the impact the project would have on the stakeholder, showing how much they would care about the project's overall progress.

To get a better sense of how each stakeholder viewed our project problem and scope, as well as listen to potential ideas and suggestions, the team conducted several interviews. From these interviews, several key insights were gathered:

"Even with all of this readily available technology, it may not necessarily be
in the best interest of every stakeholder to implement something new."

"The overall experience, from supplier to consumers, using vending machines
and coolers is outdated and not evolving at the same pace as the rest of the world."

"There are endless possibilities of new technologies out there…
We just need to figure out which ones would work best."

"There are already structures in place to gather data and make decisions, but there may be room for improvement."

"There must be a way to leverage all of the technologies out there to not only improve Pepsi's bottom line, but also impact their other divisions, such as marketing."

These insights helped to establish a better sense of how vending machine and cooling technologies are perceived by both customers and consumers, as well as the challenges that the team would need to keep in mind as they researched technologies. In general, it was found that majority of people interviewed felt that implementing new technologies in vending machines and coolers would be well-accepted.

Ultimately, the team's most important stakeholders are the Pepsi sponsors and related Pepsi employees. For these stakeholders, the team developed five key value propositions to illustrate how the team would add value to Pepsi as an organization. Their needs are of the utmost importance, and the team was sure to focus their research of technologies around these requirements. The value propositions defined are:

1. Innovation: The team will either come up with new ways to leverage existing technologies or propose new technologies to accomplish the goals set forth by Pepsi.

2. Customer Experience: Through improved inventory management and greater health and maintenance sensors, customers like Walmart and 7-11 would be able to avoid out-of-stock events and operational issues. This would reduce the overall revenue loss associated with these unfortunate instances, increasing Pepsi's bottom line.

3. Data Accessibility: Key data points such as machine health and condition, machine location, and machine supply and demand would be provided through our technology to assist Pepsi in the decision-making process.

4. Business Case: The team will provide a robust and quantitative case for whichever technology recommendation is proposed, ensuring the value to Pepsi through an ROI

calculation and cost-benefit analysis. This case would illustrate ways in which the technologies can reduce operating costs, increase revenues, and provide long-term benefits to Pepsi.

5. Consumer Engagement: The proposed technology would include an aspect of consumer engagement, whether this be through tailored coupons, an improved machine aesthetic, or an overall enhanced consumer experience. This would aim to increase Pepsi's reach in North America and improve the revenue stream.

Technology Analysis

Researched Technologies

Camera

A camera is an electronic and optical instrument that can capture and record images. Cameras have been in use since the early 1800’s, however recently they have become increasingly more advanced, leading to a wide range of types and sizes to tailor-fit it for the desired purpose.

A camera has a wide range of applications depending on when and where it is being used. For the purpose of this project, the team will be considering the camera technology for vending machines and coolers in order to manage inventory. Not only will this help in improving the supply chain but also reduce the operating cost and inventory holding costs drastically.

Logistically, the camera would be integrated to the door of the machines in one of two ways to help monitor the products in these machines closely. The first method of implementation would be to install a camera at the corner of each shelf of the vending machine or cooler that would take snapshots at a set frequency or upon every sale. The second method consists of installing a single camera on tracks on the door of the machine, allowing it to move both vertically and horizontally along it. When activated, the camera would take a video or snapshots of each level and then return to its base location at the top of the door. These images can be stored locally or transmitted to another location, upon which they would be transmitted through an algorithm to gain insights.

Voice Recognition

The growth of artificial intelligence has created the opportunity for smart technologies like voice recognition to grow. Voice recognition helps customers make more informed purchases while engaging with machines. One example of this is a new type of vending machine being implemented in Japan. The machine provides a brief introduction for each product selected, relaying information such as calorie count and ingredients. This gives consumers a better understanding of the product they plan on purchasing or the all of products available, as people tend to hesitate when purchasing things they have very little knowledge of.

In countries as racially and ethnically diverse as Canada and the United States, language barriers are a huge concern in the consumer goods industry. Voice recognition technology can help address this issue by helping consumers with little to no knowledge of the English language. In Canada, for example, vending machines exist with different language options, greatly enhancing the customer experience [3].

This machine also allows for increased engagement as a whole, since the experience of having a conversation with a machine is a novelty in and of itself [4]. Hypothetically, people using these machines would want to to use them more simply because they are fun, driving up sales.

Digital Display

As touch screen displays, computer softwares, and other technologies have advanced rapidly in the past decade, incorporation of digital displays have become increasingly popular throughout the vending industry. Also known as digital signage technology, these displays stray from the traditionally transparent and plastic exterior of a vending machine by replacing it with an interactive LCD touchscreen technology (Figure 3). The graphic displays play an important role in entertaining and engaging consumers, thus creating an immersive consumer experience with the machines and potentially increasing sales.

Figure 3: Fuji Electric's digital signage vending machine [5].

There are a number of companies that focus on digital signage kiosks for retail or quick service restaurant industries. On the other hand, companies such as Scala, AirVend, Crystal Display Systems, Strateche, and Fuji Electric have been focusing their research and development on creating digital signage solutions that focus specifically on vending machines. These products include features such as image processing technologies to detect a consumer's smile, network technologies that enable product selection via a smartphone [6], programs that show nutritional info, and live telemetry that sends product-level data and alerts wirelessly [7].

Facial Analysis

Through the combination of sensors and cameras, this technology allows for a thorough analysis of a consumer's face. The technology will have a built-in algorithm designed to pull insights from facial expressions, such as age, emotion, gender, beverage preference, and frequency of purchases. This would improve the consumer experience in the future by organizing inventory in the vending machines and coolers according to consumer preference. In addition, it could increase consumer engagement by targeting coupons to certain audiences based on their various traits obtained through the sensors. It is important to note, however, that this technology is different than facial recognition softwares. Facial analysis would not retain any distinct information related to an individual's face; it would only retain the data points from the sale.

Radio Frequency Identification (RFID)

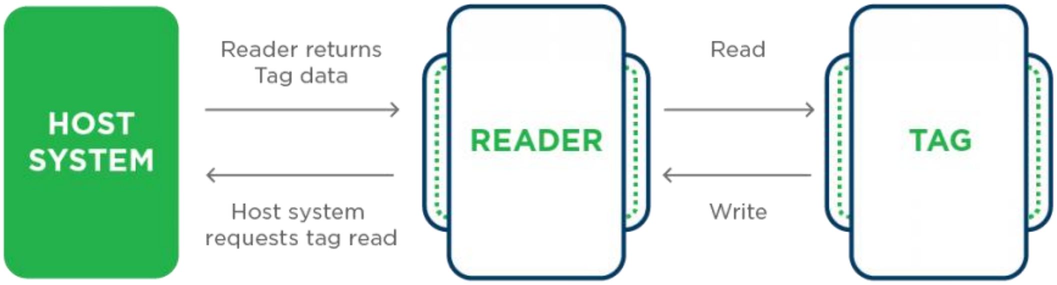

Figure 4: RFID system depiction [8].

RFID is an acronym for "radio-frequency identification" and refers to a technology whereby digital data encoded in RFID tags or smart labels are captured by a reader via radio waves and transmitted to a host system, as depicted in Figure 4.

RFID is similar to barcoding in that data from a tag or label are captured by a device that stores the data in a database. RFID, however, has several advantages over systems that use barcode asset tracking software. The most notable is that RFID tag data can be read outside the line-of-sight (Figure 5), whereas barcodes must be aligned with an optical scanner [9]. This technology is widely being used in the supply chain industry to facilitate accurate and quick tracking of assets. It has the potential to very accurately monitor the inventory of beverages in coolers and vending machines.

Figure 5**:** Sample RFID tag [10].

According to the Material Handling Institute's 2015 annual industry report, logistics companies are using RFID today to achieve near 100% accuracy in shipping, receiving, orders, and inventory accuracy, 30% faster order processing, and 30% reduction in labor costs [11]. RFID-enabled pull-based supply chain could effectively achieve a 6.19% decrease in the total inventory cost and a 7.60% increase in the inventory turnover rate [12].

Within the RFID umbrella, there are multiple types of technology, varying in frequencies and systems, to best fit the technological needs. The types of RFID frequencies are low frequency (LF), high frequency (HF), and ultra-high frequency (UHF). LF RFID bands are most practical in livestock tracking and access control applications. HF RFID bands are frequently used in payment, data transfer, and ticketing applications. UHF RFID bands have a faster read rate than LF or HF RFID bands, making them ideal in a wide variety of applications, including retail inventory managements, wireless device configuration, and anti-counterfeiting applications. UHF tags are generally cheaper and easier to manufacture than LF and HF tags, but are more sensitive to radio interference.

In addition, there are both active and passive RFID systems. Active RFID systems are typically used for large applications, such as railway cars, that need to be monitored over long distances. In most cases, an active RFID system will operate on the ultra-high frequency (UHF) band. Active RFID tags have their own power source (usually a battery) and transmitter, allowing them to emit their own signal and send the information stored on their microchips.

On the other hand, passive RFID systems can be used with LF, HF, and UHF radio bands. Passive RFID tags tend to be smaller and less expensive than active tags, as they do not require a power source or transmitter. Instead, passive systems use a tag chip and antenna to transmit a radio signal to the RFID system. The tag powers on when a radio signal is received, and reflects the signal back to the reader. These passive RFID systems are commonly used to track inventory assets in retail applications, to monitor goods in a supply chain, and to identify products such as pharmaceuticals.

Proximity Sensor

A proximity sensor is a sensor able to detect nearby objects without physical contact. When the proximity sensor is on, an electromagnetic field or infrared signal will be emitted. The sensor will then perceive changes in the electromagnetic field or the return signal of infrared to detect objects getting closer. The distance on which the proximity sensor can detect varies greatly depending on the type of sensors and the object being sensed, but since there is no need for physical contact, these sensors are extremely reliable and have a long functional life. A schematic of the infrared signal detection can be seen in Figure 6.

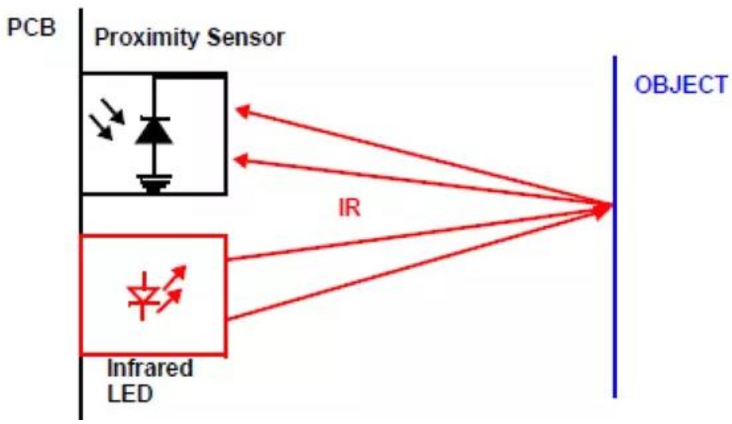

Figure 6**:** Infrared signal proximity sensor [13].

The applications of proximity sensors to vending machines and coolers are becoming increasingly widespread. Because of their object detection capabilities, proximity sensors have the potential to collect massive amounts of data. Machines can obtain relative data such as consumer arrival rate and usage duration, which can help evaluate and address the overall profitability of each machine. The sensors would be connected to the compressor of the vending machines or coolers, which is used to control the heating and cooling process. When no one is detected nearby, it would turn off the compressor for a period of time until a new consumer arrives. This would allow the machine to maintain its internal temperature while decreasing energy consumption, lowering operating costs without taking away from the consumer experience.

Bluetooth Beacon (BLE)

Bluetooth beacons are transmitters that broadcast a signal to nearby portable electronic devices. A modern smartphone in the vicinity can pick up the signal being emitted by the beacon and gain some insight into its own positioning based on knowledge of the beacon’s placement [14].

Bluetooth Classic is the standard bluetooth system used in everyday life, which is mainly used to stream music on a speaker or facilitate a phone call through a headset. Unlike Bluetooth Classic, BLE is designed for periodic transfers of small amounts of data, such as providing proximity in a store or a medical device providing glucose measurements to a doctor's tablet or patient monitor. For this reason, it uses significantly less power than Bluetooth Classic. In addition, BLE solutions use what is known as a System-on-a-Chip (SoC), in which the chip includes both the transceiver and the microcontroller running the Bluetooth software.

BLE beacons use proximity sensing to transmit a universally unique identifier picked up by a compatible application or operating system. The identifier can be used to determine the device's physical location or trigger a location-based action on the device such as a check-in on social media or a push notification [15], similar to that seen in Figure 6. These unique identifiers can be recognized by multiple observing devices at once, as seen in Figure 7.

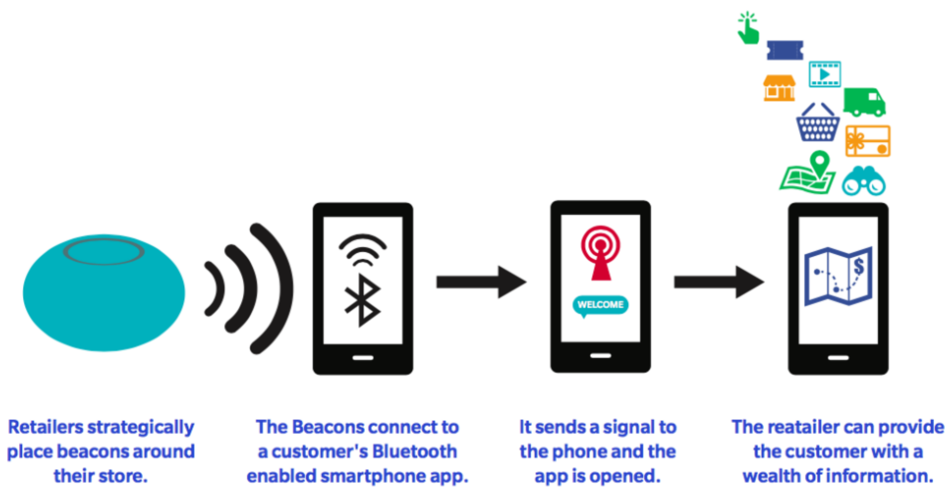

Figure 6: Bluetooth beacon technology depiction [16].

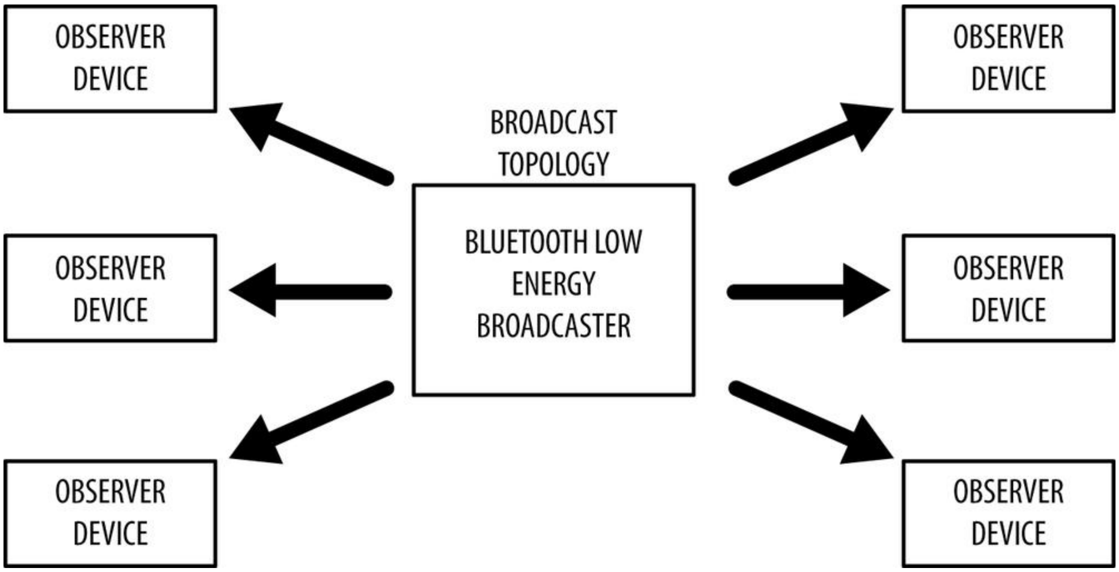

Figure 7: BLE beacon broadcast topology [17].

BLE beacons differ from some other location-based technologies as the broadcasting device (i.e. the beacon itself) is only a one-way transmitter to the receiving smartphone or receiving device, necessitating a specific application installed on the device to interact with the beacons. This ensures that only the installed application, not the beacon transmitter, can track users as they passively walk near transmitters.

One application of beacons is the distribution of messages at a specific point of interest, for example a store, a bus stop, a room or a more specific location like a piece of furniture or a vending machine. This is similar to previously used geo-push technology based on GPS, but with greater precision and a much-reduced impact on battery life. Another application is an indoor positioning system, which helps smartphones determine their approximate location or context. With the help of a beacon, a smartphone's software can approximately find its relative location to a beacon in a store. Brick and mortar retail stores use the beacons for mobile commerce, offering customers special deals through mobile marketing, and can enable mobile payments through point of sale systems.

Energy Management Device (EMD)

Energy management devices (EMDs) have been used in vending machines and coolers for almost two decades now. Traditionally, EMDs are known to reduce energy consumption of the machine by turning off compressors, thermostats, lights, or other energy-using aspects when they are not needed. Furthermore, through sensors, EMDs can provide information regarding machine health, including temperature and maintenance, and provide alerts when machines need to be serviced. All of these abilities allow for in-depth, real-time knowledge of the current status of a machine. Because EMDs are already standard in vending machines and coolers, it should be clear that for all intensive purposes of this project, the team will only be evaluating Smart EMDs as a possible technology.

In recent years, Smart EMDs have surfaced in many industries because they add new capabilities to the older, "Classic" EMDS. These new capabilities are in part due to more advanced sensors. For instance, proximity sensors have been implemented to track the footfall of people walking by the machine. In coolers, door open/close sensors were partnered with the footfall sensors to create a conversion rate metric. This allows the owner to see how frequently people walk by the cooler actually open the door and take a drink out.

Recent Smart EMDs also incorporate Bluetooth beacon (BLE) technology. As they were explained above, these beacons allow for increased interaction between the consumer, the machine, and Pepsi to create better consumer engagement and asset control. Due to the fact that Smart EMDs incorporate BLE technology, it will not be considered a separate technology for the remainder of the report; it is assumed that Smart EMDs incorporate the costs of BLE beacons and would provide all of the benefits that beacons would provide alone.

Viable Technologies

When determining which researched technologies would be viable for this project, the team's main consideration was whether or not each individual technology would meet at least one of the stakeholder's goals. Therefore, if the technology could not be used for consumer engagement, machine health, asset control, or inventory management, it was no longer considered. The technologies determined to be viable are described in further depth below.

Camera

The inventory management benefit provided by cameras consists of three major aspects:

1. Inventory Tracking: This will enable Pepsi to track products in coolers and vending machines at all times. This would allow for real-time decision making regarding the products that should be manufactured and shipped.

2. Space Management: This will ensure that products are strategically stocked in the machines based on the information collected regarding their sales patterns. This would further help in promoting consumer sales.

3. Restock Alerts: In order to avoid out-of-stock events, an algorithm will be set-up to determine the machine's inventory situation and notify store managers that a specific machine needs to be restocked.

From the team sponsors, the cost of cameras for vending machines and coolers was given as $80 to $90. The team identified a few camera technologies available in the market for use in coolers:

1. CoolR has smart vision cameras that provide cooler health and inventory monitoring. These cameras can help to increase sales and decrease operating costs through less out-of-stock events and better control of machine maintenance.
2. eBest IOT has a product named Cooler X that deploys sensors in the machine to monitors sales in real-time. This technology can also provide data to improve engagement, map

consumer behavior, track cooler health, and negate cooler misusage. This real-time data is transferred to a cloud-based Business Intelligence (BI) system, which gives an accurate representation of market forces.

3. Trax uses cooler-mounted cameras or robots to capture images at preset intervals**.** The pictures are sent to the Trax cloud to be analyzed. Within minutes, the front-line staff gets automated alerts on in-store issues, while back-office and management teams get detailed assessments online. All of this information is determined by using an in-depth algorithm created by Trax.

The main benefit of a cheap inventory management system like cameras is the reduction in operating costs. If the inventory inside a machine is always known, deliveries can be optimized and extraneous orders, delivery trips, and time during deliveries would be therefore minimized. From a more comprehensive inventory management system, Pepsi would also be able to generate increased sales, as optimized stocking would lead to better supply levels, limiting the amount of sales lost due to out-of-stock.

A few challenges associated with cameras are the fact that it relies highly on electricity, and therefore will be costly in terms of electricity and power fees, and that the technical nature of the technology may lead to frequent glitches. These glitches may require extensive maintenance, which can be costly. Additionally, obstacles such as an error in the algorithm or issues with the images produced may cause the conclusions pulled to be inaccurate.

Radio Frequency Identification (RFID)

RFID was considered a viable technology due to its inventory management ability. As a data capture technology, RFID promises more accurate inventory tracking, faster inventory picking, and reduced out-of-stocks. Furthermore, while it began as a tracking tool for inventory and assets, the emergence of real-time networks has since enabled RFID to deliver insights in areas such as product status reports and inefficiencies in the supply chain. RFID enables faster and more comprehensive views into potential inventory problems, allowing companies to take pre-emptive action and reduce the need for costly expedited freight.

In terms of costs, they range according to the specific capabilities of each component. For tags, the overall price ranges from $0.10 to $20. Specifically, basic passive tags cost $0.10 each and can be used for paper, non-metal, and liquid materials. Metal passive RFID tags cost $1 each, are larger than basic passive RFID tags, and can be used on metal assets. Active RFID tags require no human intervention - they are completely automated. For this reason, these tags are also the most expensive at $15 to $20 apiece.

As for the costs of the readers, they can cost anywhere between $1,250 to $20,000 each, depending on the level of automation offered. Active RFID readers are the least expensive option at $1,250 to $1,500 each. Passive and handheld RFID readers are more expensive, with costs ranging from $3,000 to $20,000 each [18].

Energy Management Device (EMD)

EMDs reduce a machine's costs by improving its energy efficiency. Given that a vending machine consumes approximately 3,000 kWh/year of energy without an EMD and energy costs $0.12 per kWh, this adds up to an approximately $360 cost. When an EMD is implemented, energy consumption is decreased by anywhere from 15 to 45%, depending on occupancy in the area, environment temperature, and usage pattern [19]. Therefore, the savings per year could range from $54 to $162. It is important to note, however, that this cost savings would not be realized by Pepsi. Instead, it is the customer (i.e. store owner) that would realize these cost savings due to a decrease in energy consumption.

On top of energy consumption reduction, Smart EMDs would provide other benefits that the stakeholders were looking for. As discussed above, Smart EMDs have begun to incorporate BLE beacons and other advanced sensors. Via the BLE beacons, asset control and consumer engagement become possible. The added advanced sensors - e.g. proximity sensors to track footfall outside the machine, or door open/close sensors - further enhance the machine's consumer engagement tracking ability by using these metrics to determine a conversion rate. This enhanced consumer engagement could drive up sales from the machines, a pro for both Pepsi and the customer.

Classic EMDs cost around $15 to $20, whereas Smart EMDs cost around $35 to $40. The added benefits of a Smart EMD certainly make them more worthwhile at as little as $15 more than a Classic EMD. Figure 8 shows a sample dashboard of a Smart EMD brand called Nexo. The top row shows the monitoring provided by a Classic EMD, and the bottom row shows the added capabilities of a Smart EMD.

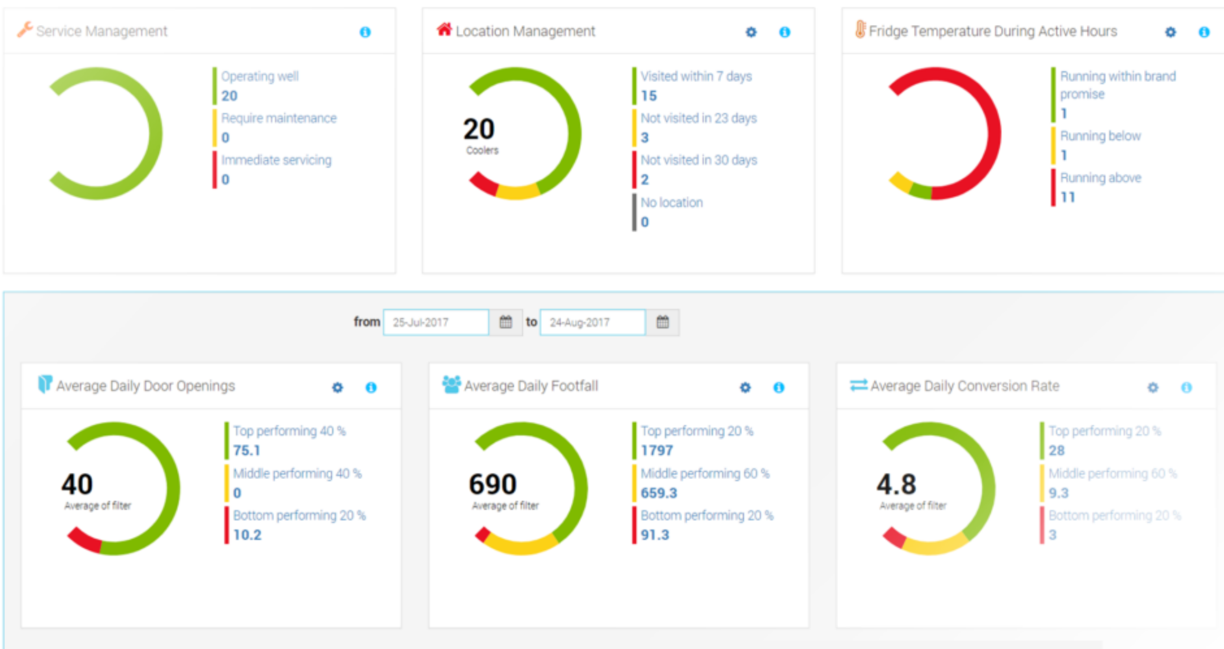

Figure 8: Sample Smart EMD dashboard [20].

Recommended Technologies

To meet all of the requirements set forth by the stakeholders, the team recommended implementing a bundle of technologies consisting of cameras and smart EMDs. This bundle was the cheapest way to adequately meet the needs of Pepsi immediately. While some of the other newer technologies - e.g. RFID - might have provided equal or additional benefits, their price was too high. When these technologies become more common and their prices drop, however, it may be worthwhile for Pepsi to reconsider their use in vending machines and coolers.

As for why these technologies were chosen, Smart EMDs alone provided a majority of the factors Pepsi was looking for: enhanced consumer engagement, asset control, and machine health. Explained above, Smart EMDs have recently begun to incorporate other technologies like Bluetooth Beacons, proximity sensors, and door open/close sensors. This would allow Pepsi to get extensive benefits just by replacing the EMD already in use in vending machines and coolers with a Smart EMD. Therefore, the return on investment (ROI) for smart EMDs would be high due to negligible added labor costs but high returns.

The one requirement that Smart EMDs do not satisfy is inventory management. While this issue is not as particularly significant for vending machines as it is for coolers, the inventory management system in vending machines could always be improved. For these reasons, the team recommended a concurrent implementation of a camera. Though its cost of $80 to $90 is relatively high, it is considerably lower than RFID, which was the other inventory management technology researched. In addition, the implementation costs of cameras are much lower than other inventory management systems. To install in machines, one would simply apply an adhesive (many already come with a sticker in place) to the camera and stick it onto the door of the machine; therefore the added labor costs are negligible. For easy implementation and pertinent benefits, cameras seemed to be the obvious choice.

Return on Investment (ROI)

To evaluate the ROI for this bundle of technologies, the team utilized sample data provided by their Pepsi sponsors. The data was collected from a typical vending machine and cooler from a

Midwestern state in the United States, and although not representative of our overall market, provides a good sense of what the effect of these technologies may potentially become.

To begin, the current cost and revenue data for a single cooler and vending machine is shown in Figure 9, using numbers provided by Pepsi. These numbers will be the basis for the calculation of value added to Pepsi from implementing our bundled technology.

COOLER		VENDING MACHINE	
Revenue	$ 3,000	Revenue	$ 5,000
Product Delivery Cost	$ (400)	Product Delivery Cost	$ (1,000)
Maintenance Cost	$ (100)	Maintenance Cost	$ (75)
Machine Cost	$ (700)	Machine Cost	$ (3,000)
Profit Margin	**$ 1,680**	**Profit Margin**	**$ 925**

Figure 9: Profit margin for coolers and vending machines.

The value added for a single cooler was split up into cost savings and revenue increases (Figure 10). On the savings side, the team estimated a 10% savings on product delivery costs as a result of the new inventory management software. This software, as previously mentioned, would allow Pepsi to optimize their delivery routes. The health and maintenance sensors in Smart EMDs would provide a 10% savings on maintenance costs, as unnecessary check-ups would be minimized. With the enhanced asset tracking, Pepsi would be able to write-off coolers that they knew had been stolen, saving an estimated 1% on lost asset costs. Ultimately, this would add up to a total cost savings per cooler of $57.

When looking at the revenue increase, there would be an estimated 3% increase from both consumer engagement and product quality. The capabilities provided by the Smart EMD to understand consumer behavior through footfall and door open/close data would allow Pepsi to better cater their products to the consumers. Additionally, the inventory management provided by the camera would decrease out-of-stock events, limiting the instances in which the cooler does not have enough product to satisfy consumer demand. Adding all of the numbers together, the team found the total value added to one cooler to be $237.

COOLER		
Cost Savings		
Product Delivery Cost Savings	10%	$ 40
Cooler Maintenance Cost Savings	10%	$ 10
Lost Asset Cost Savings	1%	$ 7
Total Operating Cost Savings		**$ 57**
Revenue Increase		
Consumer Engagement Data Lift	3%	$ 90
Product Quality Improvement	3%	$ 90
Total Revenue Increase		**$ 180**
Total Value Added		**$ 237**

Figure 10: Value added for coolers.

Figure 11 provides the corresponding data for vending machines. The percentage value added is assumed to be the same as it was for coolers, except for the lost asset cost savings. Since vending machines are extremely heavy and unwieldy machines, there is little to no risk of a machine being stolen. As a result, Pepsi has no lost asset cost savings to account for. From the same calculations, the team found the total value added for a single vending machine to be $407.50.

VENDING MACHINE		
Cost Savings		
Product Delivery Cost Savings	10%	$ 100
VM Maintenance Cost Savings	10%	$ 7.50
Total Operating Cost Savings		**$ 107.50**
Revenue Increase		
Consumer Engagement Data Lift	3%	$ 150
Product Quality Improvement	3%	$ 150
Total Revenue Increase		**$ 300**
Total Value Added		**$ 407.50**

Figure 11: Value added for vending machines.

To calculate the final ROI, the cost of implementing the technology bundle on a single machine was subtracted from the total value added per machine. This implementation cost was calculated by combining the previously stated costs of the camera and Smart EMD systems. According to

Pepsi, the bundle of these technologies would allow for the team to receive the low end of each cost. After taking the costs into account, the total ROI for a single cooler and vending machine was calculated to be $122 and $292.50 respectively (Figure 12). This calculated ROI only applies to the first year of implementation, as each subsequent year will not include the implementation costs calculated. According to the team's Pepsi sponsors, the recurring costs associated with these technologies would be negligible, so the ROI after the first year would end up as the original Total Value Added number.

It is evident from the ROI percentages, that this technology would increase total profit by roughly 7% and 31% for a single cooler and vending machine respectively, which is a sizeable increase. To get a better sense of how this ROI relates to Pepsi's overall bottom line, the team multiplied this per cooler and per vending machine ROI by the total market size calculated previously in Figure 1. From this rough calculation, the total value added to Pepsi across North America after the first year from the implementation of our recommended technologies is shown to be $579 million, with $237 million coming from coolers and $342 million coming from vending machines.

COOLER		VENDING MACHINE	
Total Value Added	$ 237	Total Value Added	$407.50
Implementation Cost	$ (115)	Implementation Cost	$ (115)
ROI (First Year)	**$ 122**	**ROI (First Year)**	**$ 292.50**
As % of Profit	**7.26 %**	**As % of Profit**	**31.62 %**
As % of Investment	**106.1 %**	**As % of Investment**	**254.3 %**

Figure 12: ROI for coolers and vending machines.

Engagement Strategy

Timeline

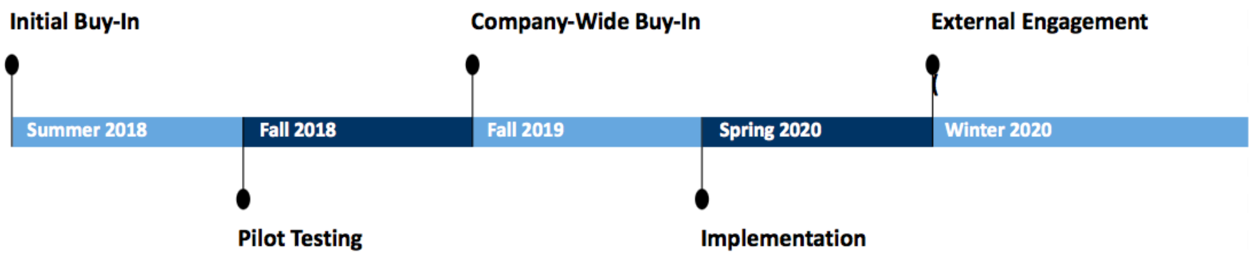

Figure 13**:** Timeline for the implementation of proposed technologies.

To ensure the recommended technologies are implemented, a timeline was created for the engagement strategy (Figure 13). As recommended by the team, the whole implementation process should last two years and include the following steps: Initial Buy-in, Pilot Testing, Company-Wide Buy-in, Implementation, and External Engagement. These stages are further broken down below.

Internal Engagement

The internal engagement strategy would strive to gain support within the company. The team broke down internal engagement into two categories: initial and company-wide. The goal, methods, metric of success, and targeted audience are different for the two different phases.

For the initial internal engagement, the goal would be to convince immediate management of the validity of the implementing the new technologies. Specifically, the target audience would be the Senior Director of R&D, Emad Jafa. The methods consist of presenting the business case through internal meetings and direct conversations with key stakeholders. In order for this segment to be considered successful, a pilot testing phase would have to be approved and push forward.

For the company-wide internal engagement, the goals would be to generate company-wide excitement regarding the new technologies and ensure that departments have a clear understanding of the guaranteed benefits. This would accomplished through company emails, internal conferences, direct conversations with key stakeholders, and explaining benefits to each department.

Success in this phase would be signified by the new technologies being implemented, operating cost decreasing, and benefits being realized by other departments. The target audiences for the company-wide internal engagement are: Kirk Tanner, President and Chief Operating Officer of North America Beverages; Greg Lyons, Chief Marketing Officer; and David Lapp, Senior Vice President of Supply Chain and Operations.

Pilot Testing

The pilot test would be a way for Pepsi to evaluate the potential effect of the proposed technologies on the bottom line through a preliminary test. In order for this to be an effective test, however, it is important to establish a representative group on which to implement the technology. The team recommends a small town or city in the United States that would emulate the overall country's ethnic and racial makeup. There would also be a roughly even number of males and females, with people from varying socioeconomic backgrounds, contributing to the diversity of the target audience. Ultimately, this would allow Pepsi to assess the effect of the Smart EMD and camera system on all types of customers and consumers, pulling relevant sales and cost data for further analysis.

After the pilot is completed, this data will be run through a similar cost-benefit analysis to determine a more realistic and representative Return on Investment (ROI) matrix. If the ROI is calculated to be greater than 5% of the current machine's profit, the team believes Pepsi should consider this to be successful and move onto the company-wide buy-in.

External Engagement

The external engagement strategy would aim to build a more robust relationship with Pepsi's customer base and consumers. It should be noted that this strategy would be of secondary importance due to the fact that the new technologies would mostly benefit Pepsi's internally and does not necessarily enhance the consumer's experience like digital signage would. However, it is a step that Pepsi must take after the implementation process to develop awareness of and excitement for the new technologies that intend to increase the effectiveness of vending machines and coolers.

Several ways of approaching this objective would be through the use of social media (e.g. Instagram, Facebook, Twitter, and Snapchat), online and paper coupons, and guerilla marketing. These marketing strategies would focus not only on engaging the consumers' interests in Pepsi beverage products, but also advertise its new technologies. For example, a promoted Instagram advertisement could include contents about Pepsi's appreciation for nature and its new efforts to reduce energy spent; online or paper coupons could attract consumers with a buy-one-get-one-free coupon at stores with the new coolers and vending machines; and guerilla marketers could reach out to people on the streets and inform them about Pepsi's new technologies. In addition, Pepsi could hold customer conferences with its main retail customers to educate them in detail about the results of the pilot tests and the reasons behind the implementation process.

The engagement strategy would be deemed successful if it created significant online buzz, in which people on social media start talking more about Pepsi, and an increase in North America beverage sales.

Limitations

Barriers and Challenges

To reach the goals above, the team needed to overcome some significant barriers and challenges. First, the logistics of the project proved to be difficult from the very beginning. This project was given a short timeline of only one semester, so the ball needed to get moving quickly. However, legal issues with non-disclosure agreements prevented the team from working closely with the Pepsi sponsors for about four weeks.

Furthermore, due to the nature of the project logistics, the team was not given extensive data to work with in their analyses, forcing the team into making reaching assumptions or finding a new way to determine the value added. Lastly, details of newer technologies are often proprietary, so in-depth information (e.g. costs) were lacking.

Assumptions

Specific assumptions were noted in the appropriate sections throughout the report. The overarching assumptions for the purposes of this project were as follows:

1. First and foremost, it was assumed that all stakeholders were acting in good faith and speaking the truth. The team relied heavily on their sponsors for guidance regarding the project goals and requirements, as well as quantitative aspects like cost data.

2. The quoted implementation costs are directly from the team's sponsors based on their experience with bulk ordering. Furthermore, the implementation cost is solely for the parts. It was assumed that the infrastructure and labor costs would be negligible.

3. When distinguishing viable technologies, it was assumed that Pepsi had the capacity to implement all technologies, both in terms of costs and labor.
4. The recurring costs of implementing a camera and Smart EMD solution were assumed to be negligible. The team's sponsors from Pepsi have indicated that these costs such as

maintenance or software costs would be negligible given the nature of the technology and the capabilities Pepsi already has in place.

5. Though the operational optimization provided by some of these technologies would likely reduce environmental emissions, the environmental effects were ignored in the analyses altogether for simplicity. Instead, the analyses were strictly financial.

Risks and Mitigation

A major risk of implementing this recommendation could be technological obsolescence. At the rate technology is advancing, there is a chance that the camera or Smart EMD technologies could become irrelevant before the full value has been gained. In this case, the ROI would plummet and little to no value would be realized. Furthermore, since a pilot would need to be performed before full implementation, the window for obsolescence is further increased. In effect, there truly is no method of mitigating this risk. Perhaps the best way to attempt to do so would be to stay up to date with technological trends, or stop the project process immediately before it gets too far along if obsolescence becomes a concern.

In addition, it is possible that the assumptions made in regards to the costs of the technologies have skewed the results of the analyses. Because these costs were given to the team directly from their project sponsors, in-depth discussions or facts regarding what these costs consisted of was not available. To mitigate the risks associated with possibly skewed numbers, additional research and analyses should be performed to confirm the figures quoted in this report.

Lastly, the engagement timeline provided in this report may be optimistic. If the recommended technologies were in fact accepted by immediate management, a more realistic timeline should be constructed that accurately aligns with Pepsi's corporate structure to mitigate the risks associated with improperly scheduled projects.

Conclusion

Pepsi's lack of sufficient microscale data to inform decisions regarding coolers and vending machines in the United States and Canada created an opportunity to explore new technologies that can reduce operating costs and improve their bottom line. More specifically, the goals for the technologies to be implemented would allow for enhanced asset control, inventory tracking, energy management, and consumer engagement.

Based on this, the team explored eight technologies, including cameras, voice recognition, digital displays, facial analysis, radio frequency identification (RFID), proximity sensors, Bluetooth low energy (BLE) beacons, and energy management devices (EMD). After assessing the potential benefits of these technologies, the list was reduced to three viable technologies - cameras, RFID, and Smart EMDs - that adequately addressed Pepsi's key requirements. The team then weighed the implementation costs of these three technologies against the value they provided to the project, and constructed a bundled technology consisting of Smart EMDs and cameras to recommend to Pepsi. This recommendation was based on the ability of Smart EMDs and cameras to provide sufficient data regarding machine health, inventory, and consumer engagement for a reasonable cost. The ROI from this investment for Pepsi as an organization was calculated to be $579 million after the first year of implementation, which would be a substantial addition the bottom line and demonstrates the overall worth of this project.

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