LaundryConnect: Utilizing IoT Device to Connect Everyday Hardwire Wirelessly

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Introduction

The Internet of Things (IoT) has been used in a wide array of applications ranging from infrastructure management to environmental monitoring. The prevalence of hardware such as SparkCore, a microcontroller, has facilitated the development of wireless applications that can deliver information directly to the user when connected to a remote device. Many of these devices have never been connected wirelessly before, and have previously relied on the user to manually check the device while it is in use for monitoring purposes. Such devices that have been connected wirelessly using SparkCore include simple home automation using a Wifi enabled switch and a cloud controlled thermostat. **These examples of applications of SparkCore provide the underlying motivation for using the hardware to exploit a currently existing infrastructure at Harvard.**
One application that has not been researched or implemented extensively via the Internet of Things is the use of laundry machines specifically for gathering data about usage. This paper aims to describe one of many possible implementations that involve connecting the user with the laundry machine wirelessly as well as receiving data about its usage. In this paper we discuss the underlying motivation as well as clarify the role of the SparkCore in this system's design. This paper will also describe further applications of this implementation especially with respect to other IoT-based devices and will compare our implementation to previous work completed in the field. Next section will describe the main aspects of implementation in more depth.

Background

Our implementation of connecting laundry machines (in our testing of our implementation, we were limited to washing and drying machines, but the device can be used for a variety of different machines) wirelessly was conducted in a college laundry area which is frequently used by undergraduates, providing a suitable setting to test the implementation in the hopes of gathering substantial information to provide usage data to users. Our use of the SparkCore, a cloud-powered, Arduino-compatible, and WiFi enabled device (simple board connected to a microcontroller that provides an easy introduction to IoT-based devices) allowed the user to let the system know when laundry machines were beginning their cycles. The next section aims to describe the underlying motivation for pursuing this implementation.

Motivation

For this project, we wanted to hone in on a current system. Specifically, we wanted to see how we could improve such a system via wireless connection without tampering with the system already in place. We thought it would be best and more efficient to work with a problem that we encounter in our daily lives. When one goes to use a laundry machine, especially a remote public one, they primarily rely on assumptions in order to determine the best time frames for laundry machine availability. In addition to machine availability, the user is more likely to be concerned with cycle time especially since many laundry machines are located in a remote region. Users have typically made these assumptions by attempting to casually keep track of which machines have correct cycle times and which times are best to use the machines. These supposed patterns are almost always unreliable as they are dependent on a very small, undocumented data set. We wanted to have such a data set available for potential usage features as well as simply have the ability to track laundry machines wirelessly via the internet. This removes the need to have to guess or keep track of cycle time manually and once again reinforces the idea of providing more usage time information to the user. We believe that the motivation and fundamentals behind this application can be applied to a broader set of devices increasing its usability. Furthermore, there is a significant lack of software that provides the abovementioned features, even with something as basic as keeping track of cycle times wirelessly. The following section will discuss related work in the field and how our implementation is distinct.

Related Work

While there have been plethora of information and implementations of IoT-based systems, there is limited background on the preliminary stages before implementation, the design stages. An article entitled, “Modeling IoT-Based Solutions Using Human-Centric Wireless Sensor Networks” by the University of Chile discusses the numerous problems with designing IoT-based systems and how to identify possible limitations and bottlenecks that are specific to IoT-based systems before transitioning into the implementation stage. As discussed in the article, many of these limitations are due to the heterogeneity of many of the devices involved in an IoT-based system and the different specifications and requirements that each device has. In addition to discussing these limitations, the article discusses how it designed an IoT-based alarm system to respond to emergencies more effectively. This involved extensive classification of all the devices involved in the system. After carefully considering the trade-offs involved in designing such a system, reading the article allowed us to determine that having the SparkCore interface only with the Internet and without any direct connection to nearby mobile devices was the best option. Our goal was to remove as many bottlenecks as possible so we could focus on designing the implementation’s more complex and distinctive features. There have been numerous patents regarding similar type of systems that involve monitoring of laundry machines. One of the questions that we aimed to answer in the introduction was what made LaundryConnect different. In our preliminary presentation of our project proposal, it was noted by one of our peers that software that involves wireless monitoring of laundry machines already exists, LaundryView. After preliminary research and investigation into the site, it was determined from using the website as well as reading user reviews, that the website was inaccessible and not fully functional. The website did not have any reliability and is based on a complicated system of wireless connections whereas our implementation is just a direct connection to the internet via the SparkCore. Remote laundry machine monitoring has also been tested and implemented by various large corporations as well. A patent filed in 2007 by LG Corporation involves the use of a remote device for laundry machine monitoring. The product included a modem board provided for transmitting/receiving data via electric wire. When compared to LaundryConnect, LG's design also employs a similar monitoring concept to determine how exactly washing is detected. However, instead of using an electric wire, we simply use SparkCore removing additional bottlenecks that come with using an electric wire. Furthermore, LG's device only sends this monitoring information locally and is not connected to the Internet, whereas for LaundryConnect information about a laundry machine in one location can be accessed via a web application in a remote location. Similarly, Mac-Gray Corporation filed a patent in 2011 for a laundry payment and monitoring system. There is one laundry machine controller that is in communication with each of the diagnostic collection meters. This is to provide remote credit service, which is a very similar concept to what we have with the exception that LaundryConnect implements monitoring. However, LaundryConnect removes any bottlenecks associated with having so many devices involved in credit service implementation (for this patent there are dozens of processors and modules involved). LaundryConnect offers more reliable and direct IoT connection. The following section will emphasize the distinctions made in this section in order to show the intellectual point being made by implementing LaundryConnect.

Intellectual Point (Secret Weapon)

As discussed in the related work section, we were only able to find three patents filed for laundry machine monitoring in the past decade in addition to LaundryView. Our system offers direct and reliable internet connection via the SparkCore's connection to the cloud that bypasses the use of electrical wires and goes further than just a simple local connection. Furthermore, SparkCore has not yet provided documentation for data analytics (LaundryConnect needs data to provide usage information) and has no machine learning component in its current iteration. SparkCore plans on providing data analytics and usage component when its later version comes out this year. By tracking data we are able, LaundryConnect is able to stay ahead and build upon SparkCore's current build and data capabilities. The next section will discuss how we factor in these desired features into our general approach.

Approach

After reading and evaluating the paper from the University of Chile, we decided to follow a simple approach that involved direct connection from the device to the internet using the SparkCore hardware. Our initial approach was to create a web-based application once we had enough data. Instead we used twitter for our initial stages of testing in order to maintain easy connection between the SparkCore and the internet. Although we initially planned on using a separate button and LED light, we found it useful to use the ones that could be found directly on the SparkCore board. When considering our approach in the design stage we identified a possible limitation. A user could theoretically continuously press the button, leading to false data that would not be particularly useful. In our system description, we will go into depth about how we addressed this issue as well as identify limitations that we encountered when using the SparkCore.

System Description

As mentioned previously in the summary of our approach, the only main piece of hardware aside from the laundry machine was the SparkCore, which simply had to be connected to a wireless network (ex. Personal hotstop or Harvard University Internet connection). Once the user began their cycle on their laundry machine they would press the button that exists on the SparkCore board. The SparkCore (which was tested on more than one machine) was located right next to the display that contained estimated cycle times. In order to have the SparkCore communicate with the internet, we used the SparkCore build environment (we coded in C). We used the PushingBox API to process this data. This decision was made because the only necessary piece of data that was required to launch a scenario of notifications via HTTP request or email was the ID of the device (our SparkCore). Using this simple interface API allowed us to prevent users from pressing the button repeatedly by looking at the timestamps for when the button was activated. If the button is pressed less than 30 minutes after the last button activation, then the data will not be added/considered for the user. While this is not a foolproof strategy, it allowed us to remove a potential bottleneck that could occur with an inundation of unhelpful data. Once the user pressed the button, a blue light would come on the LED SparkCore. This would indicate that a working connection was established between the SparkCore and the internet and that this data was being transmitted. Using the PushingBox API, information about Machine X would be published. In

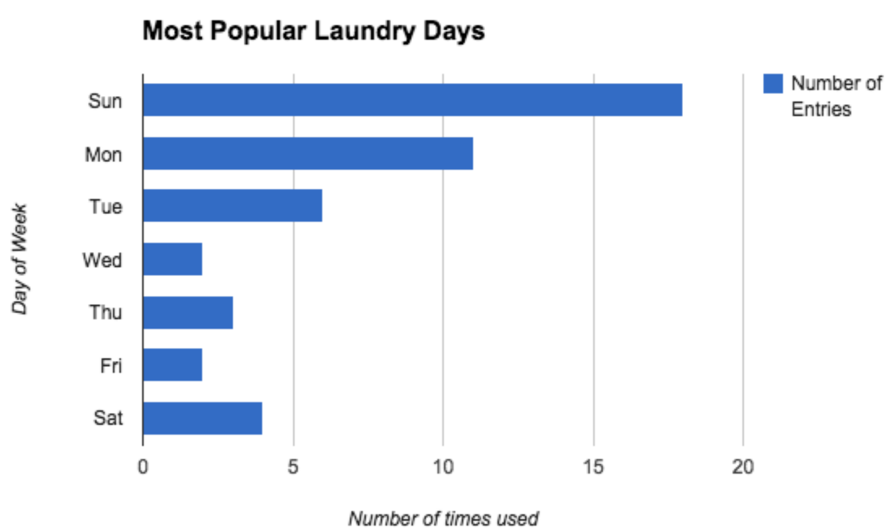

Figure 1

addition, cycle end time would be posted as well while usage data would be collected. *Figure 1* shows a sample graph generated from collected user data. To create the [dynamic] graph, we used a function in the excel spreadsheet that acted as a counter for each datapoint sent to the Sparkcore. We also used another function to generate the most frequent laundry hour also the average hour at which people do laundry. The data can be viewed here.

Performance Evaluation - Limitations

While we had originally intended to provide an expansive user interface, we wanted to prioritize the transmission of data from the SparkCore to the internet using the PushingBox API. One of the more difficult aspects was setting up the SparkCore, which required a small amount of electrical engineering knowledge. Often, the SparkCore had very poor connectivity; especially with the Harvard network and even with the personal hotspot it was quite difficult to have a long period of established connection. Data concerning the laundry machine cycles was easily transmitted from the SparkCore to our spreadsheet when a proper connection was established. Given the current time frame of the project, it was difficult to obtain large amounts of data, especially since we wanted to avoid any physical tampering with the SparkCore. This significantly reduced the machine learning aspect of our project, even though it is functional. We also found it difficult to transition between laundry rooms (we wanted to use the SparkCore in one laundry room for at least a week) given the time frame we had for the project.

Conclusion

Our goal for this project was to exploit a current existing Harvard system and connect it wirelessly to gather data seamlessly and provide usage data. By implementing this idea, we realized the merit of having direct wireless connection and realized how this basic implementation can be applied to other devices. We hope that as this project progresses in the future we are able to gather more data in a more cohesive manner.

Implementation Examples

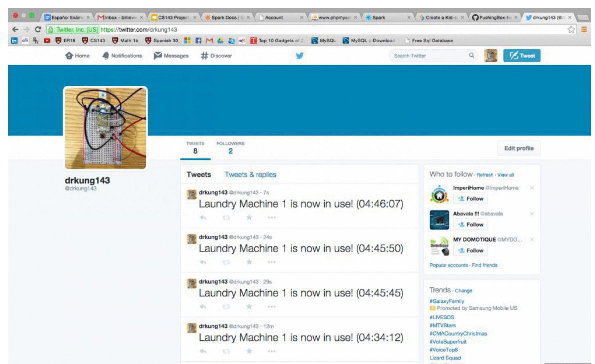

Figure 2

Figure 3

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