Prospectus

Development of a Low Power Long Range Modular Sensory Hub

(Technical Topic)

The Impact of Specialty Coffee on Colombia's Coffee Industry

(STS Topic)

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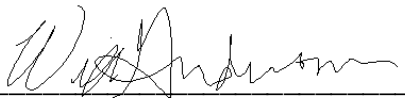
On my honor as a student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed:  Date: _____

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I. Introduction:

Internet of Things (IoT)technology caters to a large variety of consumers by using sensors and a communication protocols to provide security and intelligent automation services. As more customers are choosing to automate security in their homes and workplaces, companies need to be able to customize their systems to meet the advancing needs of the customer. They have asked an interdisciplinary team of engineering students at the University of Virginia to create a series of reference designs for a data hub that can connect to a variety of sensors in a variety of different ways using IoT technology. An outside client will use the reference designs to create a highly customizable data hub that will allow them to better serve a growing number of clients. The final deliverable is a series of reference designs that emphasize the modularity and customizability of the future hub.

A key use case for a modular IoT wireless sensory hub is agriculture. A perfect example of this is Colombian coffee farms, which are located all across Colombia's remote and rugged interior. As specialty coffee demand rises, data is becoming a more important part of the farming process.

The global coffee industry is going through many changes as customers are drawn towards higher quality coffee. Coffee is a major export of Colombia, and the developments in market demand, farming practices, and environmental conditions have had a rippling effect all across the country (Baum et al., 2019). A recent rise in the consumption of specialty coffee has led to significant changes in the coffee industry that have a dramatic effect on the Colombian coffee exports (Doga, 2019). Changes in the Colombian coffee, partnered with the economic power of consumers in North America, Europe, Japan, and Australia, indicate specialty coffee could support this struggling industry (Doga, 2019). This STS research paper will explore the

effect of specialty coffee consumers on the Colombian coffee trade and the potential impact they will have.

Technical:

This capstone is focused on designing a modular gateway for various applications in IoT. This building block will be a Low Power Wide Area Network (LPWAN) hub to which users can connect multiple sensors through a variety of wireless protocols. "LPWANs allow solutions providers to design IoT systems for use cases that require devices to send small amounts of data periodically over often-remote networks that span many miles and use battery-powered devices that need to last many years" (Wedd, 2020). A number of LPWAN solutions, such as LoRa, Sigfox, and NB-IOT are gaining market popularity (Mekki et al., 2019). The capstone team will specifically explore Bluetooth 5.0, LoRA, and a proprietary protocol provided by the client.

LPWAN gateways take a considerable amount of time and resources to develop from scratch. With the growing investments of different industries in IoT (Dahlqvist et al., 2019), there is a need to architect a system of designs that can support a heterogeneous mix of sensors that feed data into a hubthen does a data backhaul for analytics. While the project is centered on completing the design of a wireless hub, the focus is on the modularity and variability of the hub for more efficient transitions to different use cases. Small packets of sensory data do not require significant bandwidth. The cost of maintaining a large connection to the internet is an unfortunate effect of using Wi-Fi or cellular connections. The ability to inexpensively enable remote monitoring over a greater range is an interesting and valuable addition to the family of IoT devices.

An outside client has asked an interdisciplinary team of engineering students at the University of Virginia to create a series of reference designs for a data hub that can connect to a variety of sensors in a variety of different ways using IoT technology. The proposed solution will be a hub designed from the ground up using a plug-and-play approach. The capstone team will select each individual component within the hub and build a series of reference designs that will allow engineers to easily generate a customized hub for a new or unique consumer use case. The block diagram below was to illustrate the different components included in the hub.

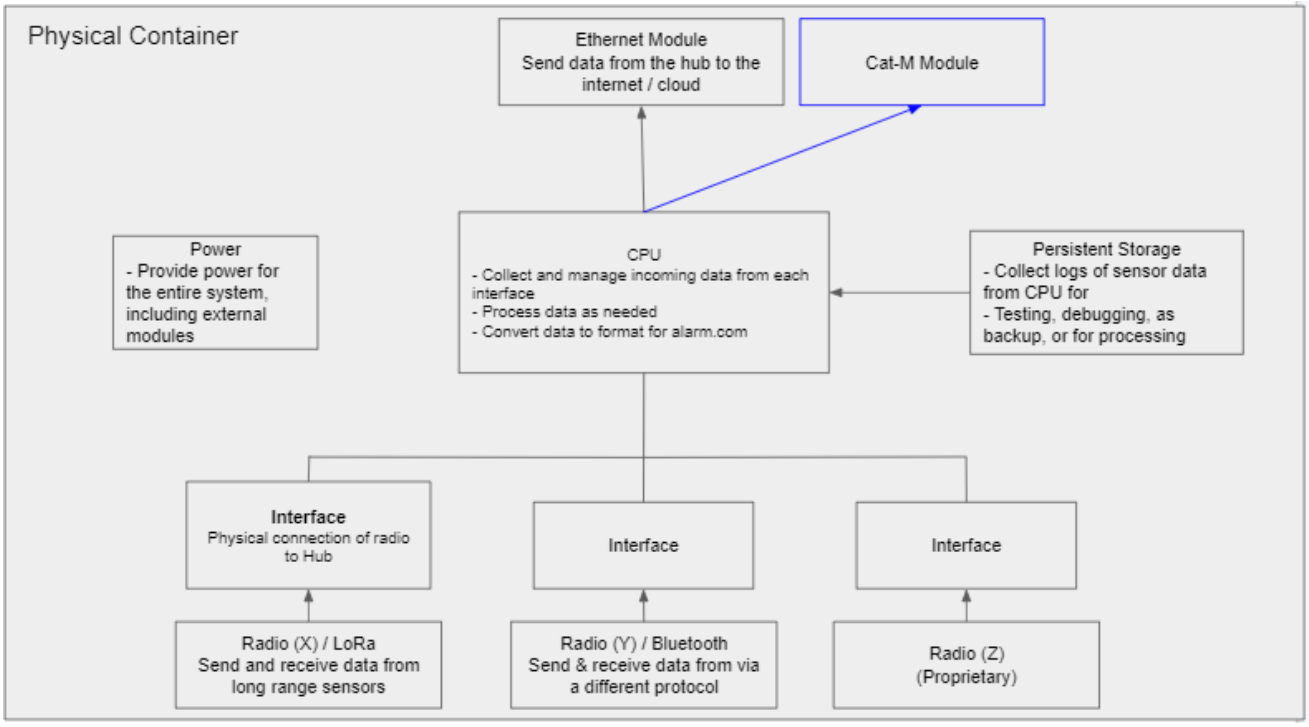

Figure 1: Block Diagram of the modular LPWAN hub (Created by Carley, D'alessandro, Donastein, El-Sheik, Gunderson, Rodriguez, and Staten, 2020)

The reference designs will show how the core of the system can be interchanged with multiple third-party sensors, and support a variety of different wireless protocols ,with minimal change in the circuit design. Using a hub based on LPWAN technology can dramatically lower the financial and power cost to the user without sacrificing functionality.

In order to develop a series of high-quality reference designs, the capstone team will have to do significant research on compatible protocols and sensors. Regular feedback from the client and the technical advisor will be incredibly important as design work gets underway. While a prototyped hub is not the final deliverable of the project, the team will create a prototype to ensure that the reference designs the team is providing to the client can be used to create a highly functional modular LPWAN data hub. Iterative testing using a variety of sensors and all three communication protocols will be conducted to ensure the client is able to fully customize the hub for a variety of applications.

STS Topic:

The field of specialty coffee has gained considerable traction in recent years and is defined by its focus on a higher quality of coffee bean and care with which coffee is prepared (Kesa et al., 2019). Colombia is one of the world's leading coffee producers and the considerable stake coffee holds in the economy gives the commodity price and export quantity dramatic influence in the state of the nation (Edwards, 1984). Despite the important role coffee plays, production and commodity price of coffee have been declining for the past three decades, wreaking havoc on the lives of the Colombian farmers (Doga, 2019). The STS research project is to use apply Actor-Network Theory answer a broad question; how has specialty coffee financially and socially effected the Colombian coffee industry? A deeper investigation into the network surrounding the specialty coffee will then pose a new question. Can the rise of specialty coffee bring new life to the struggling coffee trade in Colombia? By answering these questions, the affect of the specialty coffee can be better understood and the potential impact they have on Colombia can be fairly assessed.

The global coffee industry is estimated to be worth US $173.4 billion (Borella et al., 2015) so the list of actors on even a single producing country like Colombia is significant, not to mention the numerous actors in the field of specialty coffee. The individual farms, farmers, and coffee beans in Colombia will be grouped together for the purpose of this thesis as "farms," "farmers," and "beans." Two key actors act tie the farmers to buyers: the Colombian government and private grower's associations. The majority of coffee in Colombia is still traded as a commodity, and that commodity is sourced the federal government. As commodity-traded coffee is rarely specialty coffee, the grower's associations, groups of farmers that sell and export their crop together, have an integral role in the Colombian coffee trade. The influence of the largest growers' association, FEDECAFE, is undeniable, and has been the subject of substantial analysis in recent years for its role in diminishing small farms (London, 1994).

Specialty coffee as an industry also has significant actors that must be considered to fully understand the impact specialty coffee will have on Colombia. As specialty coffee culture is most prominent, in Europe, North America, Japan, and Australia, the majority of consumers and stakeholders are located in these places (Borella et al., 2015). Organizations like Cup of Excellence and the Fairtrade Foundation were born out of the specialty coffee movement and have significant impacts on coffee producing countries. Specialty coffee consumers value responsible sourcing of coffee and have helped to raise the income of specialty coffee farmers across the world (Bookman, 2014; Scudder, 2020). Though the consumer has significant impact, not all consumers have a positive one. In her 2019 paper, Melina Doga introduces the concept of the "Bad Consumer" and its counterpart the "Good Consumer" for the different manner consumer habits effect the coffee supply chain (Doga, 2019). Finally, the geographical location the environmental factors must be considered as crucial actors in the trade of specialty coffee.

The quality and quantity of coffee are extremely dependent on rainfall and altitude, and environmental factors can have a greater impact on coffee than any other single actor (Biswas-Tortajada, 2015).

The rise of specialty coffee has led to a significant amount of research on the coffee industry and the ensuing market trends that effect coffee growers across the world. Significant academic literature is available on both topics, though attempts to mathematically analyze the coffee industry in Colombia have failed (Baum et al., 2019). Research for this thesis will begin with the exploration of current published works on the specialty coffee industry as well as Colombian coffee and expand to explore the current state and impact of specialty coffee.

Timeline and Expected Outcomes:

The technical capstone aims to deliver a series of reference designsthat detail how to create a modular hub that uses LPWAN technology to collect data from a variety of sensors using a variety of communication protocol. Additionally, the capstone team will create a report to be presented at the Systems and Information Engineering Design Symposium (SEIDS) in April of 2021.

The STS research project will use be an analysis of academic literature and studies that illuminate the social and financial impact that specialty coffee is having on the Colombia Coffee Industry. This complete paper will show the effects of the many actors in the Colombian Coffee industry and demonstrate ways the consumers can responsibly help a struggling industry. Should this paper clearly demonstrate a link between consumer trends in specialty coffee and the livelihood of farmers in Colombia, it could be published in an agricultural publication.

The technical project and the STS project will be carried out simultaneously over the course of the 2020-2021 academic year and will culminate in the technical presentation at SEIDS. Both projects will be completed by April, 2021.

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