Prospectus

Low Power, Long Range IOT Product Development
(Technical Topic)

Actor Network Theory and the Vulnerability of the Nest Power Project
(STS Topic)

By

Anna Haikl

11-13-19

Technical Project Team Members: William Lupton, Corey Nolan, Allison Renehan, Bryan Rombach, and Eric Timmons

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

Signed: ____

Approved: _______________________________________ Date ________________________
Ben Laugelli, Department of Engineering and Society

Approved: _______________________________________ Date ________________________
Reid Bailey, Department of Engineering Systems and the Environment

Sociotechnical Problem

Forbes estimated that by the end of 2020 there will be more than 50 billion Internet of Things (IoT) capable devices. An IoT device is typically classified as a "…[device] or [object] that [is] connected to the Internet, like your smartwatch, Fitbit, or even your refrigerator" (Marr, 2015). These devices collect data that is then transmitted via the Internet and can be used to inform decisions, ultimately improving the efficiency of our everyday lives. Additional advantages of the IoT include conservation and personalization (IEEE, 2017).

Yet, currently the impact of IoT devices is restricted to those who have access to them. Namely, those that are within range of the protocols that are used to connect the devices, such as Wi-Fi, Bluetooth, and Z-Wave/Zigbee. Inherent power and range limitations of these protocols make it so that the benefits of the IoT are often solely limited to within the home, eliminating the possibility of extending the benefits any further. In order to address this problem I will work within a team to develop an IoT capable system that serves to extend the IoT beyond the range of the home.

In order to successfully extend IoT connectivity, it is not only necessary to understand the technical factors but also several other factors that influence the success of the technology. In particular, ignoring the non-technical factors influencing the IoT system could lead to the neglect of the social factors jeopardizing the system. To demonstrate this concept I will examine how the Nest Power Project, an initiative in which Google Nest is providing low-income households with smart thermostats, is an example of an IoT connectivity solution that is exposing itself to vulnerability due to the neglect of greater social factors. Understanding how certain non-technical factors are increasing the vulnerability of IoT connectivity inside the home will influence the development of IoT connectivity beyond the home.

Thus, in order to truly expand IoT capability we need to understand the technical and social factors impacting this project's success. More specifically, I will outline how my team will use low-power wide area network (LPWAN) capable devices to extend the advantages of IoT connectivity beyond the range of the home. Additionally, I will use Actor Network Theory to examine how the neglected factors of international climate policies, institutional income inequality, and housing disparities are exposing the Nest Power Project to vulnerability.

Technical Problem

Since the 1990s, the concept of the IoT has grown from location tracking on packages of lipstick (Maney, 2015) to include a plethora of everyday objects (watches, refrigerators, doors, etc.) that are "interconnected via the Internet … [through] computing devices … [that] enable them to send and receive data" (Lexico, n.d.). In order to connect all of those devices, not only to each other but also to the Internet, a wide variety of protocols have been developed. Traditionally, protocols such as Bluetooth, Wi-Fi, and Z-Wave/ZigBee were used to create an IoT network. Yet each of these protocols has a relatively short range and/or a high power requirement. In an attempt to address these disadvantages of traditional protocols, a new set of IoT protocols have been developed. Amongst these new protocols are a set considered to be LPWAN capable. This includes Narrowband-IoT (NB-IoT), Long Range Wide Area (LoRA), and Category M (CAT-M) LTE protocols. These LPWAN protocols promise low-cost hardware, ubiquitous coverage, and several years of battery life (Mekki, Bajic, Chaxel, & Meyer, 2019). Despite their advantages, this set of protocols is fairly new and has yet to make a huge entrance into the IoT sphere, particularly into smart home and automation applications.

Currently, many smart home and home automation systems use the traditional protocols to connect a variety of technologies to the Internet to allow users to interact with their homes.

Though these traditional technologies have served many users well, their limited ranges of, at most, approximately 300 feet (Vidales, 2017) and their high power requirements that necessitate direct wiring or battery replacements every three years at best (D'Mello, 2019) have made it so that their applications outside the home are extremely limited. With these limitations, traditional protocols fail to address the needs of other IoT applications, such as in agricultural technology, smart cities, and smart park applications.

By not extending IoT networks beyond the home, society fails to realize the advantages that the IoT can provide. Amongst these advantages are efficiency, conservation, and personalization (IEEE, 2017). Current home automation and security IoT networks are capable of performing several actions through one command, optimizing heating and cooling based on user patterns, and even providing alerts when something unaccustomed occurs. Likewise, similar functionalities could be extended beyond the home. For example, an IoT network could allow a farmer to track the soil and weather conditions of their crops, providing them with the ability to adjust irrigation accordingly. With the use of the LPWAN protocols, this information could be delivered to the farmer without them having to visit the fields.

In an attempt to extend the benefits of IoT networks outside of the home, our team will propose an IoT capable LPWAN system. Though the exact parameters will be discussed with our client, Alarm.com, our team is focusing on applications outside of the home where there is no easy access to power. Potential applications include smart agricultural technology, smart cities, and smart park technologies. We will develop a working prototype to address a particular use case by utilizing a form of LPWAN protocols – LoRA, NB-IoT, or CAT-M. The prototype will be capable of collecting and transmitting sensor data that is relevant to the defined use case. To determine the best use case for our prototype, we will first conduct market research focusing on current LPWAN IoT solutions and the needs of users in a wide variety of applications. Through this research we will be able to identify two use cases that are predicted to be the best applications of an LPWAN system. We will develop demonstrable prototypes for each of these use cases. The demonstrations will also include mock-ups of user interfaces highlighting how the user will interact with our technology. The prototypes will be presented to various stakeholders– end users, managers, and Alarm.com– to obtain feedback and better identify the singular best use case. Once the best use case is identified, it will be further developed, based upon feedback, into a fully functional prototype which will consist of the technology and a user interface. The final prototype will use at least one of the LPWAN protocols in an application outside of the home to showcase the capability and value-add of the LoRA, NB-IoT, or CAT-M protocols.

Science, Technology, and Society (STS) Problem

The Nest Power Project is a company initiative that "… is committed to installing one million energy- and money-saving thermostats in homes that need them most… to bring energy efficiency to everyone." Nest, the smart home and automation company that has recently been acquired by Google to form Google Nest, will be providing low-income families with "…special pricing on the Nest Thermostat E so they can be given to eligible households at little or no cost" (Nest Power Project, n.d.). The Nest Thermostat E functions like other smart thermostats in that it has adaptive and diagnostic capabilities based on which temperature adjustments and maintenance alerts can be generated, ultimately saving the household money (Rawes, 2019). Google Nest attempts to alleviate the energy burden that many low-income households face by providing low-income families with these smart thermostats. Energy burden is defined as the percentage of household income that is allotted for energy bills. Google Nest already views the Power Project as a success, as it has made over one million thermostats available to those in need and has given $750,000 in donations to various aid programs and initiatives. In addition, the project has gained 150 million impressions and 50 business partners through various media and publicity channels (WP engine, n.d.).

Yet the Nest Power Project is overlooking the greater social problems that are influencing the success of the project. These social problems include international climate policies (Mekki, Bajic, Chaxel, & Meyer, 2019), institutional income inequality, and housing disparities that are affecting low-income families (Drehobl, 2016). If Google Nest continues to fail to address these factors contributing to high energy burdens, then it will not fully understand the precarious status of the project. By continuing to ignore these factors, the Power Project will expose itself to vulnerability, potentially becoming incapable of ever resolving the problem of high energy burdens for low-income families and individuals.

In an attempt to better understand the greater social and political factors that could contribute to the demise of the Nest Power Project, I will use Actor Network Theory (ANT) to examine these relationships. ANT allows a researcher to examine any interconnected system or network that is brought together by a network builder to accomplish a goal. Integral to ANT is the notion that actors can be both human and non-human and that any type of actor plays an equally important role in supporting the overall network architecture (Cressman, 2009). I will use ANT to understand what factors are exposing the Nest Power Project to vulnerability. In particular, I will show how the actors of international climate policies, institutional income inequality, and housing disparities are impacting the effectiveness of the Nest Power Project.

Conclusion

As a whole, this paper serves to address the technical and social problems associated with expanding IoT connectivity beyond the home. That is, the technical report will deliver an IoT capable LPWAN system that extends connectivity beyond its current range. The working prototype of the system will use LoRA, NB-IoT, or CAT-M protocols in an application outside of the home where there is no easy access to power. Through the use of Actor Network Theory, the STS report will evaluate how the effectiveness of the Nest Power Project is being impacted by international climate policies, institutional income inequality, and housing disparities.

The results of the technical problem will help to resolve the broader socio-technical goal of expanding the advantages of the IoT beyond the range and accessibility of the home. Specifically, it will allow us to understand how technology can be expanded to bring efficiency, conservation, and personalization to a greater number of individuals and applications. The results of the STS problem will allow us to better understand what greater social factors are impacting current IoT initiatives and how to account for them.

Word count: 1736

References

Cressman, D. (2009). A brief overview of Actor-Network Theory: Punctualization, heterogeneous engineering & translation. Simon Fraser University. Centre For Policy Research on Science and Technology. Retrieved from https://collab.its.virginia.edu/access/content/group/f45c4ba8-1b6a-46c1-ad2c-146c5702f305/Readings%20-%20Frameworks/Actor%20Network%20Theory/Cressman.OverviewANT.pdf.

D'Mello, A. (2019, February 11). The real-life applications of IoT and why battery life is critical. Retrieved from IoTNow: https://www.iot-now.com/2019/02/11/92898-real-life-applications-iot-battery-life-critical/

Drehobl, A. (2016, May 20). Explaining the unique energy burden of low-income households. Retrieved from American Council for an Energy-Efficient Economy: https://aceee.org/blog/2016/05/explaining-unique-energy-burden-low

IEEE. (2017, July 27). 6 ways you'll directly benefit from the Internet of Things. Retrieved from IEEE Innovation at work: https://innovationatwork.ieee.org/6-iot-benefits/

Lexico. (n.d.). Definition of Internet of Things in English. Retrieved from Lexico: https://www.lexico.com/en/definition/internet_of_things

Maney, K. (2015, March 4). The Internet of Things: Meet the British salesman who gave real-world items a virtual life. Retrieved from Independent: https://www.independent.co.uk/life-style/gadgets-and-tech/features/the-internet-of-things-meet-the-british-salesman-who-gave-real-world-items-a-virtual-life-10086218.html

Marr, B. (2015, October 27). 17 "Internet of Things" facts everyone should read. Retrieved from Forbes: https://www.forbes.com/sites/bernardmarr/2015/10/27/17-mind-blowing-internet-of-things-facts-everyone-should-read/#360532d23505

Mekki, K., Bajic, E., Chaxel, F., & Meyer, F. (2019, March). A comparative study of LPWAN technologies for large-scale IoT deployment. *ICT Express, 5*(1), 1-7.

Nest Power Project. (n.d.). About Nest + The Power Project. Retrieved from Nest Power Project: https://nestpowerproject.withgoogle.com/about

Rawes, E. (2019, April 16). What is a smart thermostat and how does it work? Retrieved from Digital Trends: https://www.digitaltrends.com/home/what-is-a-smart-thermostat/

Vidales, M. (2017, May 16). 802.15.4 wireless for Internet of Things developers. Retrieved from Helium: https://blog.helium.com/802-15-4-wireless-for-internet-of-things-developers-1948fc313b2e

WP engine. (n.d.). Nest Power Project. Retrieved from The Webby Awards: https://www.webbyawards.com/winners/2019/websites/general-websites/corporate-social-responsibility/nest-power-project/?/