Thesis Portfolio

A Solar-Powered Fleet Tracking System for Rural IoT Applications

(Technical Report)

The IoT and the Environment: A Paradigm Shift in Sustainable Development

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

The world is on the brink of a new technological revolution, one that will transform a society dominated by manufacturing and human-controlled electronic devices to one centered on computer-controlled systems continually collecting data and controlling the environment around them. This new technology space is broadly known as the Internet of Things (IoT), a domain encompassing all network-connected objects from fitness trackers to smart home sensors. Over the last twenty years, the number of IoT devices has grown exponentially. Such technology has the potential to solve many sociotechnical problems, by allowing sensors and communications to exist in the background of our daily lives as well as reach the remotest locations. Meanwhile, the ubiquitous nature of the IoT means its effects will impact the entire world, regardless of whether individuals choose to purchase and install such devices. Both the technical project and STS research in this portfolio are focused on exploring and pushing the boundary and limits of the IoT. In the capstone project, a solar-powered GPS tracking device was developed to test whether novel energy harvesting techniques may be combined with low-power circuit design to create a "self-powered" IoT system. In the STS paper, the environmental implications of the IoT were analyzed through the paradigm shift lens, to determine how society would use the IoT to mitigate the effects of climate change.

Technical Summary

One of the largest impacts of the Internet of Things (IoT) is its ability to bring the benefits of electronic technology to communities that lack access to the electric grid. The goal of this capstone project is to expand the applications of self-powered IoT systems to fleet- and asset-tracking by developing a solar-powered fleet-tracking device that encrypts and transmits its GPS location to a central node for decryption and visualization on a map. Such a system is useful

in situations involving valuable objects that move frequently, such as school buses, manufactured cars, and farm vehicles. The project deliverable was two solar-powered nodes attached to separate vehicles that send encrypted GPS data to a central node that decrypts and displays the data on a laptop. By using solar power and long range (LoRa) communication technology, this system can be deployed in remote, off-grid locations without constraints arising from powering the system or maintaining the system through battery replacement. More broadly, this project seeks to expand IoT technology to benefit off-grid communities that lack access to reliable energy or cellular connection. In doing so, the IoT brings the valuable applications of electronic technology to areas that lack access to the electric power grid.

STS Summary

The Internet of Things (IoT) is revolutionizing the interactions between humans and the environment; by establishing a network of background sensing and actuating devices, humans are able to better read and control their environment. While current applications of the IoT have been human-centered, a growing field of research suggests the IoT can potentially revolutionize sustainability efforts to reduce climate change. As concerns over climate change and global warming continue to escalate, it is important to analyze the environmental impact of the exponential rise of the IoT. The STS research seeks to answer the following question: what are the environmental and sustainability implications of the exponential rise of the IoT and how can individuals and society as a whole use the IoT to help the environment? By analyzing the rise and proliferation of the IoT as a paradigm shift in society, the current and future effects of the IoT on the environment can be seen as the negative effects of technology on climate change (through waste and pollution) being growingly counterbalanced by solutions humans are implementing *using* IoT technology to reverse these damaging environmental effects. The research examined

previous studies about electronic waste and its impacts on the environment and assessed current IoT technology to compile all positive and negative environmental effects of the IoT. It was found that while currently the negative effects of the IoT have been significant, including dangerous electronic waste and increases in energy usage, the current trend of IoT technology shows its potential to increase the efficiency of many destructive human processes, including manufacturing and building energy usage. These results of this study seek to better inform the future path of IoT technology and where to focus future IoT engineering efforts.

Conclusion

By working on both technical and STS projects related to the IoT, a broader understanding of the field was achieved. The technical project was a hands-on approach to exploring the possibilities within the IoT, whereas the STS research focused on the environmental implications of such exploration. The joint work better represented the nature of work engineers must undertake to make a positive change in the world: rigorous technical projects that innovate a particular field combined with a thorough analysis of the societal effects of such projects.