Thesis Portfolio

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(Technical Report)

Using Field Programmable Gate Arrays to Find Innovation of Diffusion Characteristics of the Computing Space
(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

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Department of Electrical and Computer Engineering

INNOVATION CHARACTERISTICS IN THE COMPUTING SPACE

A Sociotechnical Synthesis (Level 1)
In STS 4600
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Computer Science

By
Alexander Tomiak

November 17, 2021

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: AT Date: 11/17/2021

Alexander Tomiak

Approved: [signature] Date: 12-04-21

Richard Jacques

My STS research attempts to find design principles for new products in the computing space. My technical project is a system that controls the ambient light levels in a particular area of the room by actuating blinds and driving smart lights. Since the result of my technical work is a computing product, my STS research provides sociotechnical design principles to follow while developing my technical project. Together, these projects offer a way to analyze a new computing product in a lens outside of meeting technical specifications or standards.

My technical topic produced a system that automatically controls the ambient light in an area of the room around a user's preference. It prioritizes natural light because of the associated health benefits. This system is composed of two nodes: a window node and a remote node. The window node goes on the top of the blinds, and uses a microcontroller to drive a servo that directly turns the rod inside the blinds. The remote node is placed by the user in the area of the room where the ambient light level is of interest. It tracks the light level in that area, and wirelessly communicates with the window node to drive the blinds. If additional light beyond available natural light is required, it also communicates with smart lights. This system provides a user interface to set preferences such as how bright the zone should be and toggle options such as "night mode" where the blinds are closed until daytime.

My STS research studied Field Programmable Gate Arrays (FPGAs) using Diffusion of Innovation Theory (DOI) to find design considerations important for widespread adoption in the computing space. This research was in response to the observation that more traditional hardware chips, such as the Central Processing Unit (CPU) or Application Specific Integrated Circuit (ASIC) may soon fail to meet the computing demands that trends like Big Data and machine learning place on computing infrastructure. Because addressing this problem will require innovation, it is important to ensure engineers design new solutions around holistic design points. My STS research used FPGAs as a case study to find some of these design points and to demonstrate the usefulness of analyzing computing products through the lens of DOI. I found the story of FPGAs demonstrates providing performance improvements at the cost of reduced accessibility and increased complexity—so future processing units should be designed specifically to minimize any learning curve associated with using the product, even at a slight cost to performance.

As I worked on my technical project and STS research simultaneously, I found that much of the insight I gained from one project informed and contextualized my findings on the other. My STS research encouraged our team to ensure that the system's user experience (setup and interface) had minimal complexity and high accessibility without compromising any core functionality. This ensured that the system still properly controlled the light levels in the room, but that the user was given very clear instructions and simple options on how to set preferences. On the flipside, my technical work helped inform what kinds of computing products could be analyzed through DOI. Initially I was only considering processing units; however, after thinking about how DOI applied to my technical work, I realized looking at all sorts of computing products (like cloud computing) would be useful as a comparison for my study of FPGAs. Given that my technical work was also a specific product that implemented a particular kind of processing unit (in particular, a microcontroller), it provided the context to my STS study of FPGAs that the FPGA is a platform, and that any ethical considerations should include thinking about how that platform will be used. I would encourage future students interested in thinking about holistic design to consider using Diffusion of Innovation Theory as a sociotechnical framework, as I was surprised at its richness throughout my analysis of FPGAs. In particular, I found that explaining the evolution, diffusion, and adoption of different technologies was extremely straightforward through this lens, and that I could have easily gone deeper given time and a larger word count limit.

Thank you to my capstone groupmates (Peter Morris, Mason Notz, and Steven Peng) for building our technical project, and to Professor Powell for guiding and helping us through the process.

Portfolio Table of Contents