Thesis Project Portfolio

Designing and Building a Virtual Cyber Security Range

(Technical Report)

Analyzing the Competition Between Internet Protocol Versions 4 and 6

(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

Emil Baggs

Spring, 2023

Department of Computer Science

Table of Contents

Sociotechnical Synthesis

The primary focus of both my technical and research work this year has been on computer networking. Compared to many aspects of computer science, computer networking is a field that is used by almost everyone in their everyday lives, yet very few people in today's age actually have to understand how it functions. For this reason, I used these two papers to deepen my understanding of computer networks by focusing on two different goals that both relate to the future of computer networking. In my technical project, I designed a computer virtualization cluster and built an array of modular tools to automate building virtual networks on the cluster. With this project, I hoped to understand the future of how computer networking is starting to be abstracted away by software and automation tools to simplify and quicken the steps needed to build a functioning network with legitimate services running. In my research project, I examined the competition between the two predominant Internet Protocols: version 4 and version 6. During this research, I worked to answer the question of why Internet Protocol version 6 is taking so long to replace Internet Protocol version 4, despite its superior technical design. This question examines a larger trend in engineering to identify the impact nontechnical factors can have in the competitiveness of a technology.

Within my technical project, I used my existing knowledge of computer networking and virtualization to dive in depth into new tools that exist to help automate the manual work needed to set up a computer network. The specific goal for using these tools was to make it significantly easier and quicker for the UVA Cyber Defense Team to build example "real-world" networks that closely mimic both what you might see in a small business and what the team has to defend during a competition. The two predominant automation tools I researched and used for my

technical project were Terraform and Ansible, both of which are widely used tools in the industry. The primary design principle for much of the project was to make it as modular as possible, which makes it easier to design or modify individual chunks of the project without impacting the overall design flow.

Within computer networking, most of my experience has been with Internet Protocol version 4, rather than the "newer" version 6 that is supposed to be the future. When engineers realized that Internet Protocol version 4 wouldn't scale properly to accommodate billions of users, they designed version 6 to address the issues with version 4 and pushed to transition the internet to the newer and better protocol. That was in the late 90s, but as of 2023 most of the world's internet traffic still utilizes the older protocol version. My research searches for the factors that have kept version 4 so predominate, as well as what factors will continue to contribute to the pace of the transition between the technologies. The competition between these two technologies is also very unique in that both technologies are abstract and not owned by anyone, since they are essentially languages that only function properly because of a collective adoption of the technology.

Both of these projects gave me more insight into how to continue to learn as an engineer, even when outside of a classroom environment. In my technical project, I had to practice figuring out the best design process for the technology, as well as build a functioning tool by combining many smaller modular projects. Especially when working on larger projects, it is important to work consistently and utilize best practices to make it easier to return to individual parts of it later. As I was using tools more unfamiliar to me, it took time to learn these best practices, so I often had to go update older parts of the project to keep everything consistent, but learning the ins and outs of a tool makes it easier to approach in the future. On top of that, my

research topic shows the insane amount of impact that a technology can have on the world, often with unintended consequences. Internet Protocol version 4 wasn't designed to become the primary way that everyone on the Earth communicates with each other, but that's what it is now. And once it became clear that the internet would be the future, engineers hoped to patch the known problems of the technology, but failed to do it in a way that beat the massive rush to use it. While the push to transitioning towards Internet Protocol version 6 is still ongoing, the timeline has continued to stretch further and further past what was imagined.