Research Statement

I want to pursue Computer Security as an enduring academic subject. In particular, I am interested in studying **Anti-censorship Internet Measurement**, **Secure Designs for Infrastructure Systems**- such as **Supervisory Control and Data Acquisition** (SCADA), **Cloudless Computing**, and **Internet of Things** (IoT)- and **privacy-preserving adversarial methods** to defend against privacy violation attacks from commercial Machine Learning (ML) models. These topics captivate me because they directly adhere not only to my technical interest in building reliable systems, but also address the challenges of information freedom and data privacy that have been central to my commitment to employ computing as a levitation towards the betterment of societal well-being.

Previous Research: I was offered the opportunity to work under the supervision of doctoral student **Patrick Kon** and **Prof. Ang Chen** during the winter of my 3rd year of undergraduate studies at the University of Michigan (UMich). We co-led a project titled ***'Unveiling the Nexus: Harnessing IoT Ecosystems for Evading Internet Censorship,'*** presented at the 2024 UROP Spring Symposium at UMich [1]. In this fruitful collaboration, I primarily focused on devising a research proposal utilizing the heterogeneous architectures of IoT, which has witnessed exponential growth over the past eight years [2; 3] and introduced complex security concerns with great potential for future studies [3–7]. I was responsible for designing and implementing the topology of the IoT system's distributed framework, which could utilize the redundant amount of computability as edge computers and IPv6 spaces to fragment and obfuscate packet-level network traffic. With this design, we aimed to introduce IoT devices into the scene of internet censorship circumvention research.

Distinguished from traditional circumvention techniques such as the centralized Virtual Private Network (VPN) and the Tor Project based on distributed systems formed by volunteers' personal computers, our usage of an IoT-based distributed network could complicate the **Deep Packet Inspection** (DPI), **Device Fingerprinting** (DFP), and other traffic-correlation analyses sanctioned by nation-states. We hypothesized possible attack models based on the all-inclusive review of pieces of literature ranging from ML classifiers—e.g., AdaBoost and Support Vector Machines (SVMs)—deployed to detect high-throughput obfuscated traffic [3; 5; 6; 8; 9] to known techniques utilized by nation-states to fingerprint possible VPN tunnels [10; 11].

Besides the model of circumvention, we also discovered **kernel-level vulnerabilities** for physical and over-the-air hacking: the lack of usage of eFuse to protect from firmware downgrade attacks [12]; vulnerabilities related to UART port hot-wiring [13]; REST API-based control hijacking [14; 15]. These findings unveiled IoT devices' alarming yet prolonging state, where malicious firmware and unauthorized software can be injected with very few defenses.

Future Research Agenda: Despite my wide range of interests, I have numerous focused topics and detailed plans regarding my research direction for the coming years.

Decentralized Censorship Circumvention: I plan to utilize the rationale stated in an article by **Prof. Amir Houmansadr** et al. [16] as the ground truth. The authors contemplated that seeking obfuscation methods beyond mimicry but a higher layer of covert communication, i.e., network binary data into a sound wave, is direly essential. Based on the rationale, as a doctoral researcher, I aim to continue my research on developing novel circumvention models based on distributed systems against regional Internet censorship, one of the few direction research directions that can

possibly levitate anti-censorship research beyond a ”cat-and-mouse-race.” This subject holds significant weight to advancing the free flow of information as a fundamental human right and is an academically niche yet intriguing venue to discover innovative means of internet measurement and characterization of network fingerprints.

Privacy-perserving Methods Against ML Models: I look forward to expanding upon the work by **Shawn Shan** and **Prof. Ben Zhao** et al. [17], where they utilized a data augmentation technique that applies imperceptible perturbations to artists' images and protects them from diffusion-based text-to-image models from mimicking their unique artistic styles. I would also like to explore **ML masking or watermarking techniques** further as defensive mechanisms for the privacy of individuals subjected to ML training data collections.

IoT Security and Novel Applications: I want to explore IoT security of governmental, infrastructural, and commercial avenues. For instance, despite extensive research efforts in Smart City initiatives, severe embedded-level protocol vulnerabilities still haunt governmental and civilian users [18; 19]. Another overlooked cybersecurity area in this domain is the vulnerability of military-related IoT devices, namely the **Internet of Battlefield Things** (IoBT) and **Internet of Medical Things** (IoMT), which are subjected to heavy interferences during Cyber Warfare and on battlefields [20]. This rather under-explored domain includes **short-distance and long-distance drones, military robots, wearable sensors, etc.**

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