Thesis Portfolio

Low Power Wireless Networks in Vineyards

(Technical Report)

A Framework for Emotion and Trust Between Humans and the Internet of Things

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

My systems engineering capstone team has researched and designed a wireless sensor network for vineyards. The network consists of nodes capable of sensing temperature, humidity, soil moisture, and more inside the area of the grapevine where grapes grow. Each network of nodes would connect only across the vineyard or vineyards owned by a vineyard manager, but this is still an example of the Internet of Things (IoT). The spread of the IoT into an industry as traditional as winemaking is indicative of how wide-ranging IoT technology is. The Internet of Things is present in almost every corner of our lives and its influence will only continue to grow and deepen. Grapevines may not concern themselves with privacy or trust, but the millions of people who interact with IoT devices daily should. Before internet-connected devices number in the trillions, governments, companies, and users, must establish common rules for best practices.

The vineyard sensing network takes advantage of a new Low Power Wide Area Network (LPWAN) known as LoRa (Long-Range). This radio technology—and its accompanying communication protocol LoRaWAN—can enable small battery powered devices to transmit up to 10km to a central gateway and the internet. Additionally, each gateway can support hundreds of devices simultaneously. This lends itself well to agricultural solutions where conditions vary throughout the growing area, such as a vineyard. Sensor nodes can be placed densely throughout a vineyard and relay data regularly to a gateway located near the tasting room or farm office. Models have been developed by organizations such as the University of California Davis to predict the risk of pests, pathogens, and frost based on data from the growing zone of the vine. Using the combination of sensor network, research-backed models, and mobile and web

interfaces, vineyard managers will be able to reduce manual labor, chemical use, and operating costs while improving grape quality.

Every day, people interact more frequently with internet-connected devices. Besides the smartphones which can occupy hours of the day for adults and children alike, devices such as smart thermostats, smart toothbrushes, and smart vehicles are increasingly a part of our lives. These devices are usually offering improvements and conveniences to our lives, but they are often simultaneously sending data to a centralized database for storage and insights. It is increasingly important that companies are regulated in the data they collect, but regulation can only do so much. Consumers must learn how to identify devices which they can trust and use their purchasing power to move companies towards designing devices with these same principles of trust. The interconnections between the commercial sector, the government, consumers, and the Internet of things are examined through a lens of actor-network theory and technological momentum. This growing problem of privacy and trust straddles the line between technical innovation and societal values: one must bend.

This vineyard sensing capstone project has featured more human interaction than I've ever previously had for a technical project. My team has spoken with more than 10 vineyards across Virginia, California, and Argentina. We've regularly consulted with a technology company. We visited one of the largest national vineyard and wine symposiums in California to interview representatives of 25 companies. It is fascinating to see how ingrained technology has become even in the agricultural process. The Internet of Things can bring thousands of dollars of yearly value even to a small vineyard, but doing this project has made me more conscious than ever of the way users interact with internet-connected devices, key design principles, and privacy

concerns—even for a vineyard. A well designed IoT device must take the user into account at every step, but many companies' human-centered design process ends at ergonomics without seriously considering the user's emotions, trust, or personhood.