A NETWORKED DISPLAY FOR COMMUNAL SPACES

THE TENSION OF ECO-FRIENDLY ENERGY TRANSMISSION

A Thesis Prospectus 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 Electrical Engineering

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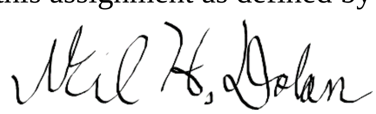
On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.



Social interactions are shaped by the spaces in which they occur are in and the broader context of their use. In communal spaces boundaries and limitations are helpful to prevent an overgrazing of the commons, as 19th century English economist William F. Lloyd famously described (Clerke and Yoshioka, 2012). A system to inform users of the present scheduled purposes of a space may assist in establishing said boundaries. Likewise as new renewable power generation and transmission infrastructure is planned, there is debate over what constitutes over-grazing. A tension between the commons of mankind in the climate, and the commons of a locality in specific habitat or ecological concerns arises (Wuebben, 2017). Sharing resources offers efficiencies, and collective advantage however, “resource sharing is not easy to implement because it is information intensive” and often requires technological support (Orman, 2017, p. 52).

The technical research and the loosely coupled STS research seek to address how societies use spaces and resources shared in the common to benefit. On the technical side, the team will construct a networked device capable of displaying current time, and the presently scheduled use(s) of a given space. The device will accept the dates, times, repetition, and descriptions of uses from a self-hosted web interface. In addition to the construction of a self contained wireless system, the design decisions to address competing users of an area, area accessibility, and how communications systems change habits. Loosely coupled, the STS research investigates the interactions with power transmission lines and the broader community. The STS research will examine the role the transition toward renewable power generation, and the concerns of local communities and interactions with technologists.

A NETWORKED DISPLAY FOR COMMUNAL SPACES

Under the supervision of Electrical and Computer Engineering Professor Harry C. Powell, Neil H. Dolan, Tahsin Kazi, and William McCullough will explore the implementation of a system for resource sharing. Existing systems at the University often require accessing an internet site, use of spaces within libraries requires accessing a website library system (University of Virginia Library 2022). Such existing systems are difficult to use, and do not adequately facilitate the sharing of spaces without prior planning and deliberate action to check regularly. The new system will enable individuals to quickly apprise the status of a communal space, and whether it is appropriate for them. Said system will consist of a Raspberry Pi Pico W to be used for interfacing with a Real Time Clock (RTC) module, control of a digital 7 segment display and a Light Emitting Diode (LED) matrix, as well as the hosting of a web interface. A rudimentary outline of the system can be seen in Figure 1 on page 3.

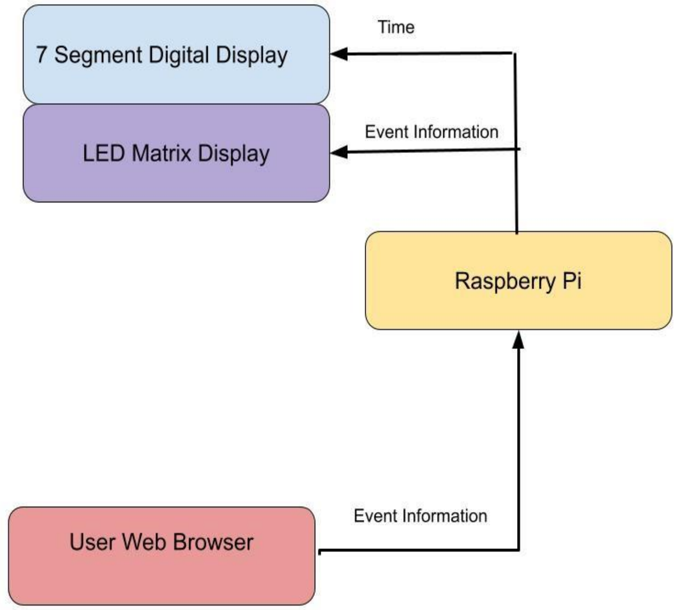


Figure 1: General System Overview for Networked Display for Communal Spaces. Depicts flow of information between user and displays (Dolan, 2022)

The technical project will be developed over the course of a single semester capstone course. The display system will require the creation of a printed circuit board (PCB) that will allow for the distribution of power to two displays and micro-controller, a Raspberry Pi Pico W, provide for interface with a real time clock (RTC), and allow the micro-controller to control the displays and accept wireless inputs. One of the two displays will be based upon an LED matrix. The RTC is to limit drift in timekeeping and limit or wholly eliminate the need to utilize synchronization protocols common to wireless embedded systems (Hong and No, 2003). The acceptance of wireless inputs will require a degree of testing to demonstrate the full functionality of the system even in a noisy environment.

The design will rely on a Raspberry Pi Pico W to form the computing center of the system. Offering integrated networked capability, and a wide variety of GPIO systems, as well as systems configured for RTC use, the Pico manages to be more than sufficient for use while maintaining some expansion capability (Raspberry Pi ltd. 2022).

The displays of the system will be LED based, with a LED matrix acting to display relevant information. LED matrices are logic-controllable arrays of LEDs common in a variety of commercial uses (Marghescu and Drumea, 2016). In this system an LED matrix will be used to display scrolling characters indicating the start and end times of a given activity and a user entered description of said activity. This will enable clear communication of present uses of a space to the casual user of the space without the need to locate a specific interface panel or website. This will further the fundamental goal of the system to ease the strain of multiple uses, and prevent undue confusion on the part of individuals seeking to utilize the space.

Even when semi-independent, wireless embedded systems are fundamentally reliant on clock systems to properly function and interface with other devices, and require systems to account for clock drift (Hong and No, 2003). In order to limit such drift and further capabilities an RTC will be utilized. RTCs are independently powered systems that accurately measure and reported time over extended periods, and enable greater timekeeping accuracy than a less specialized micro-controller. They are useful for ensuring time is kept through potential power failures, and ensuring that synchronization is needed as little as possible. Synchronization will still be vital for ensuring the proper function of the web-interface, however limiting the need for it will help to limit strain upon the Pi.

Wireless embedded systems are often associated with, or explicitly a part of, the Internet of Things (IoT). While the IoT is greatly useful to users, the systems have a tendency to overload local radio bandwidth and cause failure (Ganji, Page, and Shahzad, 2019). One of the goals of this system is to act as part of a local network, without an overriding need to maintain the connection at all times. The Pi will be self-hosting the web interface, creating a need for a local network for the input of activities, but eliminating a requirement for a connection to the broader internet. Though said self hosting does add some complexity and workload for the Pi itself it limits the system's use of local radio spectrum.

The technical system will be constructed utilizing a $500 budget proffered by the Department of Electrical and Computer Engineering as a part of the Capstone course. The National Instruments Laboratory, and entailing lab equipment, will also be used to further enable construction, testing, and analysis of the system and designated subsystems. University of Virginia equipment for additive manufacturing will also be used in manufacturing the system. The system will be ready for evaluation by Harry C. Powell at the end of the semester, accompanied by an IEEE formatted paper describing the design, and process to construction.

THE TENSION OF ECO-FRIENDLY ENERGY TRANSMISSION

In the past decade, the mid-late 2010s and early 2020s, power transmission lines have grown in prominence as talk of a green energy transition has become commonplace. Notably a proposed transmission line for Quebec-based hydro-power through the state of Maine has experienced public debate and litigation up to the present day(Sharp, 2022). This STS research seeks to evaluate the competing interests at hand when building power transmission infrastructure, in the form of a scholarly paper. Though controversies like the aforementioned one in Maine are common, and increasingly so, existing literature is disparate and there is a lack of generalized or otherwise comprehensive coverage of the systems. In a 2022 study of opposition to power lines 70% of instances involved ecological concerns (Hess, McKane, and Pietzryk, 2022 p. 674). Renewable energy offers massive potential generation capabilities, with the Department of Energy assessing land based wind as capable of generating 6 times the total electrical production of the United States in 2020 (Brooks, 2022 p. v,3). This poses a systemic question regarding trade-offs (Wuebben, 2017). Local citizen scientists and conservationists exist in a system with climate activists, and greater business and governmental policy concerns.

The objective of this paper is to examine the pressures involving power transmission infrastructure, contextualized within the Social Construction of Technology (SCOT) model, as depicted in Figure 2 on page 6.

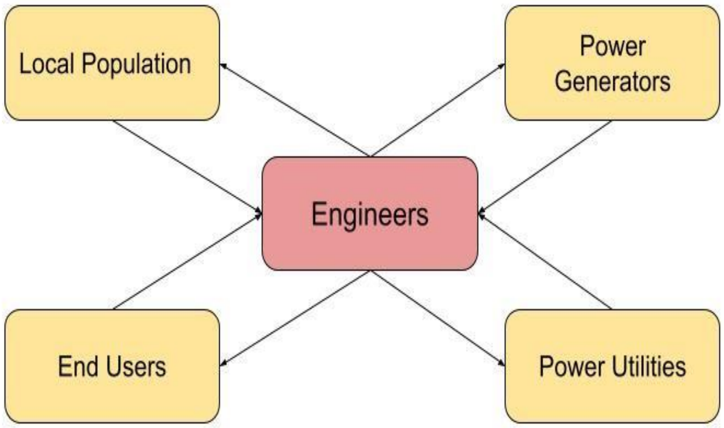


Figure 2: Power Transmission Line SCOT model. The engineer negotiates and balances the interests of the groups. (Adapted by Dolan (2022) from Baritaud, 2009)

Social Construction of Technology is a model wherein a central engineer, or engineers, negotiates with and balances the needs and interests of several groups. In the circumstance of power transmission lines there are four such groups. Power utilities, who will be responsible for the upkeep and use of the lines. Power generators who need lines in order to distribute their product, electrical power. End users who require transmission lines in order to receive power. Lastly the local population, who are impacted by the route, construction, and operation of the lines. In this paper the primary subject of concern will be the local population, seeking to evaluate the negotiations that take place between them and the engineers.

To further that evaluation Actor Network Theory (ANT) will also be utilized to examine the interactions between groups. ANT is a model wherein a variety of groups and individuals function as actors. An ANT model for the STS research is shown in Figure 3 on page 8.

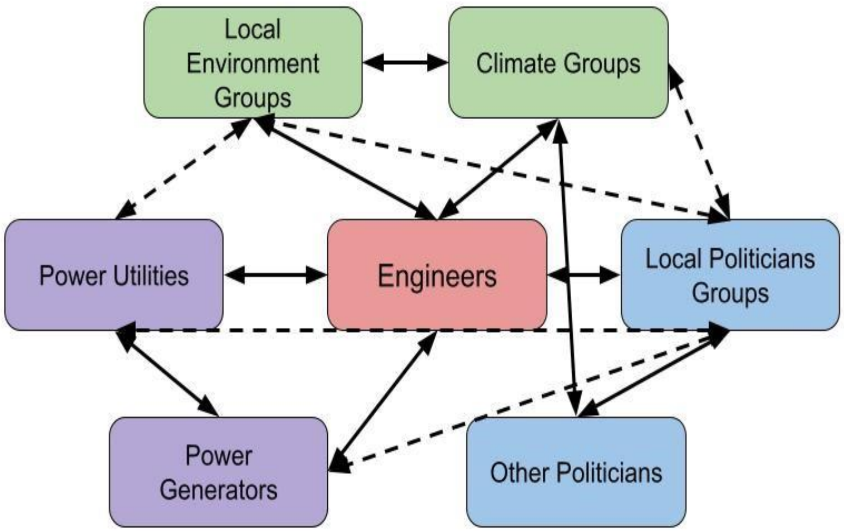


Figure 3: Power Transmission Line ANT model. A network of groups interacts regarding a technology. (Adapted by Dolan (2022) from Baritaud, 2009)

In the ANT model shown above, there are four primary groupings, technologists, power, environment, and politics. The technologists, in red, are those responsible for designing any system, here they are engineers. The power grouping, in purple, is composed of power utilities, and power generators, both concerned with creating systems to serve their business interests and customers. The environment grouping, in green, is composed of local environment groups and broader climate groups, both concerned about the Earth but in locality and writ large respectively. The political grouping, in blue, is concerned with representing the interests of their constituents, local to the project or otherwise, and maintaining their electoral coalitions.

CHANGES TO CONTEMPORARY TIMES

Modern power transmission infrastructure faces different obstacles as compared to historical examples. Though the farmers of California also were experiencing impacts from the construction of power transmission infrastructure for renewable, hydro, power there was widely supported (Williams, 1988, p. 13). This is attributable to the greater conferred benefits of said infrastructure, enabling greater irrigation and providing an affordable source of energy, while meeting utilities desire to have greater load factors (Williams, 1988, p. 13-14). Though rural electrification is no longer a major priority, or problem, in much of the developed world the manner in which Californian power companies garnered support by addressing local needs is an exemplar of SCOT. More contemporarily, the Western United States faces issues regarding the transmission of new and emerging wind and solar resources to population centers (Gardner 2013, p. 250). Lacking the significant agricultural needs of California's Central Valley, and needing interstate transmission capabilities, modern utilities and producers must find new manners in which to be provide for local concerns of isolated communities (Gardner 2013, p. 267).

SHARING IS CARING: MAKING BEST USE OF THE COMMONS

19th century English economist William F. Lloyd famously described the tragedy of the commons, however it was left to society to determine best use (Clerke and Yoshioka, 2012). Information may help determine usage of shared spaces, but when conflict arises information is not communication, and communication is not understanding.

In order for comprehensive resource sharing to be successful parties must be willing to support the endeavour fully and with proper technologies (Orman 2008, p. 52). The technological system to be built will be a great facilitator of clear and enabled use of common areas, it is only a facilitator of such an aim. Capable of displaying entered events and their duration, but otherwise relegated to the status of simple clock without user input. The technological system is but a tool, that requires a broader bureaucratic process to reach its potential. Likewise the STS examination of pressures concerning power transmission lines enables the viewer to see said lines for more than their constituent components or the power they carry. Given context the lines are an instrument to connect distant partners, and must be consented to by local powers that may or may not have interests that coincide with the broader group.

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